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ANASAZI DIET:
THE COPROLITE EVIDENCE

by

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B.A., University of Colorado, 1975

A thesis submitted to the Faculty of the Graduate
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Anasazi Diet: The Coprolite Evidence

Thesis directed by Professor David A. Breternitz

Prehistoric coprolites (dessicated human fecal material) from the Anasazi region of the American Southwest are examined for the purpose of dietary reconstruction. Using published reports and unpublished data on 179 coprolites from Basketmaker (A.D. 600) to late Pueblo III (A.D. 1250) proveniences, a widespread cultural-ecological adaptation to the plateau area of the Four-corners area is illustrated through diet.

A few major trends through time are noted for the Anasazi populations. Changes in the use of cultivated plants are increasing use of seed crops (i.e. corn and cotton), and decrease of squash in the diet. In addition, later populations utilized a wide variety of weed plants that would be found around disturbed areas and concentrated less on pinon nut consumption.

These trends are seen as a shift in subsistence strategies due to population pressure and widespread ecological disturbance, attributed to temperate latitude swidden farming methods and cultural effects on the ecosystem. The Anasazi, due to these ecological imbalances were forced to eventually abandon the area

This abstract is approved as to form and content.

Signed David A. Breternitz

Faculty member in charge of thesis

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My typing chores on the rough draft were primarily done by Steve Emslie, who put many hours into this tedious job.

Kellie Masterson gave excellent criticisms and provided the talent for the figures.

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CHAPTER I

INTRODUCTION

Reconstructing prehistoric subsistence bases is an important means for understanding extinct cultures. Steward (1955: 34-37) considers the elements of the culture core, those features of a society most closely linked to economic activities, to be of maximum explanatory value to cultural ecological adaptations and the concomitant creative processes. One such cultural ecological adaptation is diet. The most direct and unequivocal means of examining an ancient diet is by analysis of coprolites or dessicated fecal material. Coprolites may not only reveal the composition of the meals of the prehistoric peoples, but parasites and cultural practices may also be shown.

History of Coprolite Research

The first speculation on the potential of fecal studies for prehistoric dietary reconstructions was made by Harshberger (1896: 150) upon his initial definition of ethnobotany. However, actual coprolite studies began in 1910 when B. H. Young examined fecal remains of the aboriginal inhabitants of Salts Cave, Kentucky. By breaking open the dried pellets, Young was able to identify several seeds that had been ingested as food by the prehistoric Indians (Young, 1910: 324).

Few other people were concerned with fecal remains either to recover them or to study them in the lab, until E. O. Callen devised a method of reconstituting the dried stools with water and a chemical salt (Callen and Cameron, 1955). This process was adapted from a standard biological practice for reclaiming dried zoological specimens. The advantage of this particular chemical rehydration, utilizing trisodium phosphate and water, was that even delicate microscopic structures would not be damaged by this gentle procedure (Van Cleave and Ross, 1947; Benninghaff, 1947). By using this method the feces returns to a fresh-like consistency. With continued soaking the fecal pellet will fall apart to allow the different components to be separated. As can be imagined, the wet or rehydration separation, gives the investigator the added boon of not breaking up the elements into a smaller, more indistinguishable size as a dry or crushing separation does. After segregating the components, Callen would then wash the various seeds and tissues and then discard the liquid part of the coprolite. Essentially this is the procedure still used by coprolite analysts today.

Several people have become involved with the study of paleofecal material since Callen. All have made some innovations and taken the research possibilities a little further. R. F. Heizer and his University of California students became disatisfied with Callen's method of quantifying results. With the Tehucan coprolites from Mexico, Callen would indicate an element in a coprolite and give it a subjective ranking of either absent, trace, co-dominant, or dominant. Heizer, in order to facilitate a more rigorous comparison of elements between the individual coprolites, made use of graded sieves and weighed the components (Heizer, 1967).

A more recent researcher, Gary Fry, has dealt in some depth with the temporal extent of prehistoric parasitism as revealed in prehistoric coprolites. Fry has demonstrated several types of worm infections extending back as far as 10,000 B.P. for Enterobius vermicularis in the New World (Fry and Moore, 1969; Fry, 1970; 1974; Fry and Hall, n.d.).

Although pollen studies of scats were first done by Paul Martin and Floyd Sharrock (1964), they have published no further work along this line of inquiry. However, this area of paleoscatology caught the attention of Vaughn Bryant and he has done work centered on the palynological aspect of human coprolites since 1969 (Bryant, 1969; 1974a; 1974b).

Along with most other subdisciplines in archaeology, coprolite analysis has finally had statistics introduced to it. The first and only statistical treatment of coprolites dealt with contingency, correlation, and factor analysis of components (Marquardt, 1974).

Previous Work with Anasazi Coprolites

Unfortunately, work on paleofecal material from the American Southwest has been rather limited (Fig. 1). Although material has been collected from various sites across the Anasazi region, rehydration studies are practically nonexistent. The only published reports are two from Glen Canyon (Callen and Martin, 1969; Fry, 1970), and one from Antelope House in Canyon de Chelly (Fry and Hall, 1975). There are, in addition, unpublished rehydration studies from Inscription House (Fry and Hall, n.d.), Mesa Verde (Colyer, n.d. a,

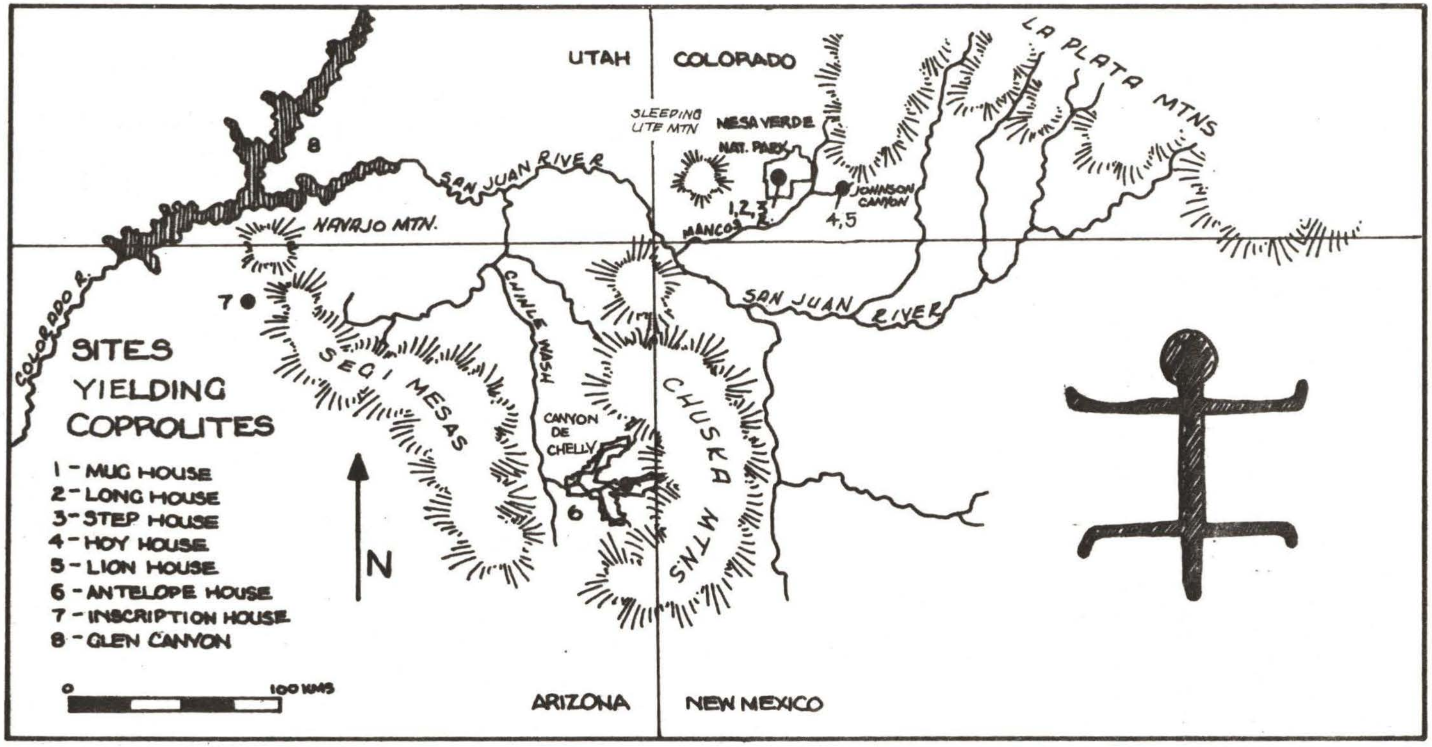

Figure 1.
Map of study area

b, and c), Hoy House, and Lion House south of Mesa Verde (Stiger, 1975; 1976). A few other papers have been written on specialized topics such as coprolitic pollen (Martin and Sharrock, 1964; Williams-Dean and Bryant, 1975), trace element analysis of feces from Mesa Verde (Sabels, n.d.), and prehistoric parasite determination (John Ware, personal communication; Samuels, 1965); however, the value of these specialized papers is limited with respect to this thesis.

CHAPTER II

METHODS OF COPROLITE ANALYSIS

There are no definite means of determining fecal origin. Only specimens from desiccated human remains can unquestionably be assumed to have gone through a human gastro-intestinal tract. However, there are several qualities that allow one to be reasonably sure of a coprolite's donor species. General inspection of size, shape, color, and visible contents can give a nearly perfect identification. An additional check can be made by a color test during rehydration. Fry (1970: 17-19) has found during testing with known fecal specimens from zoos and modern humans, that only human and Coatimundi (Bassariscus astutus) feces will turn the immersing fluid dark and opaque. Also, the context of deposition may yield clues to the source of the fecal matter (Wilke and Hall, 1975: 10).

Before analysis, the feces is cleaned of dust and postdepositional inclusions. Descriptions of size, weight, color, and shape are then recorded. The coprolite is halved, one piece is retained for future use and the other, destined for rehydration, is weighed and placed in a screw-mouthed jar.

Rehydration, using a 0.5% aqueous solution of trisodium phosphate (Na_3PO_4) is the most common method used by coprolite researchers today. Soaking of the feces for 72 hours in a sealed jar of the solution allows the coprolite to return to a fresh consistency. This standard biological procedure has been used on dried zoological and botanical specimens without any microscopically observable damage (Van Cleave and Ross, 1947; Benninghoff, 1947; Callen, 1967).

Additional soaking further softens the fecal matrix and allows easy fragmentation of the stool. Samples are then screened on various sized screens to aid in the separation of components and to allow fine materials, unidentifiable with the naked eye, to pass through. The material stopped by the screens is put into petri dishes and examined under a stereoscopic microscope at ten power. The macroscopic elements of each pellet are segregated and put into vials of alcohol to await identification. All material is saved including the finest debris which is dried and put into vials. This debris is saved for later microscopic studies.

Identification of macroscopic items deals mainly with seeds, bones, and leaves. The major part of the botanical identifications was done with comparative collections made by the author during field seasons in the Mesa Verde area. The comparative collections were supplemented by Martin and Barkley's book of seed photos (1961). Bone was graciously identified by William B. Gillespie and Judith Van Couvering of the University of Colorado. Invertebrate identifications were aided by Willford Olsen of Colorado State University and Url Lanham of the University of Colorado Museum.

Microscopic Identifications

During the course of work done in the spring of 1975, with the Hoy House coprolites, it was realized that a large percentage of a fecal sample consists of material either too minute or unrecognizable after digestive processes to be identified. Other researchers have found that about 70% of a coprolite's weight consists of unidentifiable materials (Fry, 1970: 72). The general consensus has been that there were no sources of identification for this material (Gary Fry, personal communication; William Weber, personal communication). However, Callen has done microscopic identifications with coprolite materials from Mexico and Peru and was able to identify 23 plants to genus and another five to family (Callen, 1973: 30). He also has described hair identification in his report on Tehuacan coprolites, but no specific technique was delineated.

After a discussion with Dr. O. Williams of the University of Colorado, it was decided that microtechnique is a feasible approach to the identification of animal hair and plant tissues. This can significantly increase the data retrieved from coprolite samples.

Hair

Brothwell and Spearman wrote "Only a human scalp hair has yet been studied in sufficient detail to be of value in anthropology or archeology (1963: 428)." Comparative studies of animal hair date back to 1920 (Hausman, 1920). Perhaps the best keys are the detailed studies by Brown (1942) and Mayer (1952). Brown's work is an excellent key for California mammals that will easily allow identification of an unknown hair to family or order. Still, there is a need of a comparative collection and familiarity with the specimens to allow genus or species identification. Douglas (1969) and Callen (1963) both deal with hairs from coprolites. Both have used a simple comparative method with type slides from museum animals.

For this study, type slides were made from hair obtained by Dr. David Armstrong from the University of Colorado Museum pelts.

Permanent mounts were made using a glycerin-jelly medium (Weefner, 1960: 68-69). Slides made using this method have several advantages; they have a low melting point and the slides can be remade. With the glycerin-jelly medium no staining or cuticle impressions were needed as with other mountants. In addition, the materials are easily obtainable and simply prepared.

The hair shaft is made of four constituent parts: 1) medulla, 2) cortex, 3) pigment granules, and 4) cuticle (see Fig. 2). The medulla, or central tube of the hair, is composed of air spaces which give it a distinct pattern according to species. The cortex is the main wall of the hair which contains the pigment granules that give hair its color. The cuticle is the outer scale pattern of the cortex (Brown, 1942).

Archaeological specimens were mounted in the same manner and compared to type slides. Almost all identifications could be made on the distinguishing medulla or cuticle.

Botanical Remains

Several wildlife biologists have found that when working with small rodents that chew their food finely, normal laboratory procedures for the study of stomach and fecal contents are inadequate. However, a method has been developed whereby these fragments of plant epidermis can be compared to type specimens and identified, sometimes to the species level (Baumgartner and Martin, 1939; Dusi, 1949; 1952; Williams, 1969).

Permanent reference slides of leaf and stem epidermis were made from plants collected and identified in the summer of 1975. Pieces of epidermis were stripped from both the top and bottom of

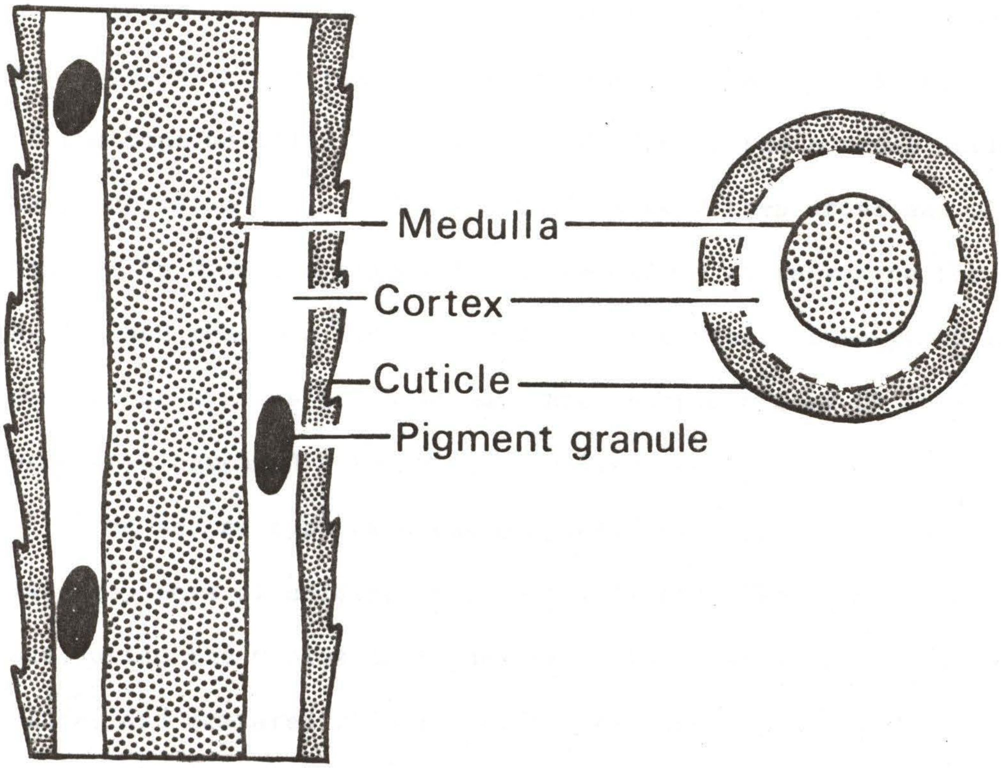

Figure 2. Cross-section of an idealized hair.

the leaves and from the stems using a razor blade and a teasing needle. The mesophyll was ignored because it lacks distinguishing characteristics (Fig. 3). These small fragments were then mounted in glycerin-jelly.

Archaeological materials recovered from the feces consisted of two types of plant remains, debris and epidermis. Debris consisted of the fine material that had passed through the screens during the macroscopic analysis. These materials were then dried and placed in vials. To make the slides it was necessary to rehydrate the debris again, and remove a random pinch from the vial. This pinch was mounted on a slide and scanned. Microscopic pieces of epidermis were then compared with the type collection.

The second type of archaeological plant materials were the larger pieces of unidentified epidermis and fiber that were separated out during the macroscopic analysis. These were also mounted on slides and compared with identified samples.

While working on identifications, it was found that comparisons are difficult with the microscope when first learning the patterns of hairs and epidermal structure. By using a camera hook-up it was possible to photograph type specimens to facilitate rapid reference.

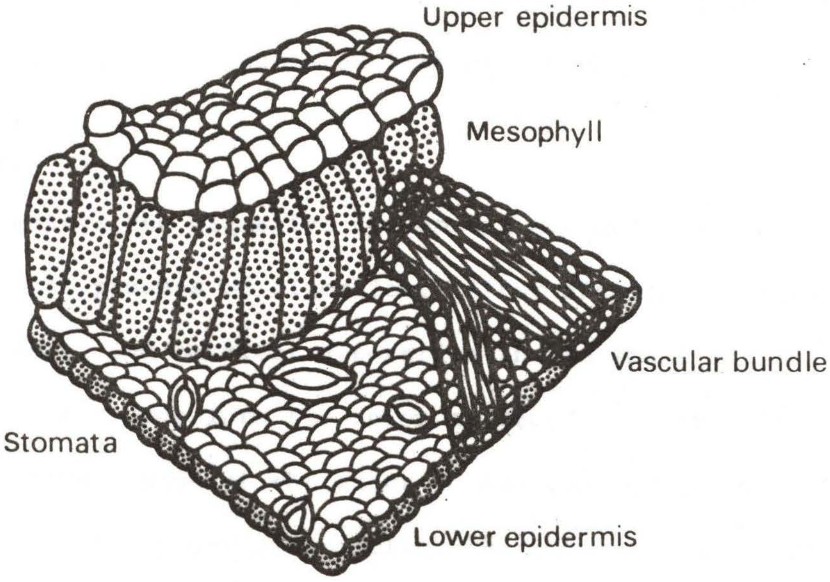

Figure 3. Cross-section of an idealized leaf.

CHAPTER III

THEORETICAL CONSIDERATIONS IN COPROLITE RESEARCH

Before an interpretation of the paleofecal study results can be done, it is necessary to discuss the limitations of such studies and examine what may be extrapolated from an ancient stool.

Physiology

Food enters the digestive system via the mouth and there begins to undergo the process of digestion. After chemical disintegration in the stomach, and nutrient absorption in the small intestine, the remaining matter goes into the colon as feces. In the large intestine, five-sixths of the water is absorbed until the feces is 30 to 40 percent dry material (Arlin, 1972: 47). A daily output of 25 to 50 grams of dry material is normal (Watson, 1974: 239), of which one third is bacteria from the normal flora of the gastrointestinal tract (Arlin, 1972: 47). The remaining substances are by-products of digestive secretion and undigested food elements.

Timing in elimination of wastes is variable among individuals. Generally however, it takes approximately 24 hours for the food-to-feces conversion. After the swallowed food spends two to four hours in the stomach, the remains of the meal stays four hours in the small intestine, and fourteen hours in the large intestine (Portis, 1953: 172; Watson, 1974: 239). Watson feels that due to the timing of the digestive system and resultant mixing of meals in the body, that one coprolite is indicative of one to four meals or one day's ingestion (1974: 240).

Limitations

Just how accurate and how to interpret a coprolite in terms of food intake is a major issue in fecal studies. Modern researchers of animal diet deal with herbivore feces and do counts in microscope fields of ground feces yielding percentages similar to pollen counts. These percentages are assumed to be the relative importance of the plants in the diet (Sparks, 1968; Dusi, 1949; 1952; Williams, 1962; 1969; Baungartner and Martin, 1939; Brusven and Mulkern, 1960). This, however, is an oversimplification of the problem. Differential digestion, omnivorous habits, and over-representation of some components all add to the distortion of the picture.

Differential digestion is the process by which different plant species and different parts of an individual plant digest to different degrees of complete breakdown. In developmental work with kangaroo feces, Storr (1961: 160-162) found that due to cutin location, perennial plant epidermis was undigestable when compared to the epidermal layers of annuals. Cutin is found on all the epidermal cell walls of perennials, but only on the outer wall of annual epidermal cells. It is an acid resistant and hence undigestable substance. Therefore, if man eats the leaves of various plants, the perennials, e.g.; shrubs, will probably be over-represented when compared to weedy annuals.

Fry (1970: 63-64) found only one bean occurrence in 40 Anasazi and Fremont coprolites from Glen Canyon. The one nearly intact seed coat is macroscopically recognizable as a bean. Fry accounts for this absence by stating the bean was apparently unimportant in the Glen Canyon diet unless, as he cites E. O. Callen (from personal communication), the bean is normally destroyed during the digestive processes. No further consideration is given to the problem by Fry. In dealing with another Anasazi population, Stiger (1975a, b; 1976) noted a similar absence of bean residues in coprolites. Because of its importance in the diet in the traditional archaeological view and the bean's importance in amino acid balance in the diet, this problem was given some experimental consideration in the laboratory. After simulating digestive fluid with hydrochloric acid on cooked beans, microscope slides were prepared. Minute tissue fragments from the coprolites were found to be identical with the prepared bean testa. Additionally, the prepared bean lost its color and fragmented into pieces too small to be recognizable to the naked eye. Also, the consumption of flowers is almost never detectable except by the presence of pollen (Bryant, 1974a). It is suggested here that, because of the high digestability of some diet components, in particular the common bean (Phaseolus vulgaris), and the absence of applicable experimental work and microtechniques, some elements of the diet have been and will continue to be overlooked in coprolite research, possibly with major interpretive consequences.

Unless there is digestive disfunction or meat is bolted down in large chunks, the distinctive striated muscle tissue is always absent in feces (Fry, 1970: 97). To obtain an indication of the meat intake, one must use non-direct means. Hair and bone are two lines of evidence that best provide a picture of animal protein consumption. While bone is very accurate for determining species and amount eaten, it is only indicative of those small creatures eaten whole such as rodents. For larger game such as deer, hair is the only evidence for consumption. Unfortunately, there is no positive method to determine if a hair was ingested with meat due to careless skinning and cleaning or whether it was ingested as it was floating around the habitation. This is a subjective judgment. I have accepted Callen's view (1967: 285) and assumed that, in most cases, "the presence of hair in human coprolites . . . (is) an indication of the actual meat that was eaten." However, with Hoy House and Lion House I have made the subjective judgment that human, dog, and a single bear hair were "ambient hair," or due to free circulation in the environment. Although the dog was eaten by Puebloan peoples (Emslie, 1977), if fair numbers of this animal food source were kept around the habitation, dog hair would undoubtedly be overrepresented in the coprolites. A single bear hair is rather tenuous evidence to be used in indicating a dietary component. Human hair is expected in human coprolites and is not necessarily demonstrative of cannibalism, even though there is evidence known for this practice by the prehistoric Anasazi (Nickens, 1975). The quantity of meat in the diet as represented by animal hairs could not be determined.

Seasonality

Seasonality of deposition is an important consideration when using coprolites to explain a prehistoric seasonal-round subsistence pattern. Even permanently sedentary farming people such as the Rio Grande Pueblos and the Tarahumara have seasonal dietary shifts as food resources change during the year (Ford, 1974; Robert Bye, personal communication). Therefore, before any statements as to dependence upon specific resources can be made, either the season in which the feces was formed must be determined or assumptions must be made as to how representative the coprolite is of the entire seasonal round. The two methods by which season of deposition has been determined are pollen analysis and coprolite component availability.

Pollen analysis of coprolites has occasionally been used to make inferences of seasonality for nomadic groups (Bryant, 1974). The first such study for a sedentary group was that of Williams-Dean and Bryant (1975) at Antelope House, an Anasazi habitation. Their pollen analysis of human coprolites indicated that most fecal specimens represented a spring/summer season. This conclusion was based on relative abundance of pollen and macro-remains. However, more recently, the role of pollen analysis in coprolite studies has been examined with modern experimental samples (Kelso and Solomon, 1976). This new evidence indicates that "differences in coprolite relative pollen frequency values previously used to describe changes in diet, season, and environment are meaningless" (Ibid.: 142). Kelso and Solomon conclude that coprolitic pollen is only sufficient as an indicator for dietary reconstruction.

The other method for determining seasonality is based on the assumption that particular components are only available at certain times of the year. Callen (1967) and Napton (1971) have used this method for non-sedentary groups in conjunction with botanical remains from archaeological sites. However, as Wilke and Hall (1975: 12) note, all of the foods thus found can be stored; ethnographic records show that the aboriginal technology had this capability. As all the foods may be eaten at any time of the year, seasonality remains a moot question. The time of year of deposition may be postulated but it must be noted that it remains a subjective classification.

Quantification

Once the identification of dietary components is completed there arises the problem of quantification of data. Different coprolite researchers have used weights, counts, subjective dominance ratings, and percentages of fecal constituents in dealing with this question. All of these methods are used in some manner to show that one element is more important in the diet than another. In the opinion of this author, the question of relative dietary importance of components is the most valuable and most poorly understood. Watson (1974: 240-241) outlines a proposed four-step program for interpretation of data. She concludes that, with coprolites, inter-component comparisons are seldom possible and with the present state of knowledge, quantitative reconstructions of diets are impossible. Differential digestion necessitates that a simple formula for complete dietary illustration be based on untested assumptions.

It is unfortunate that archaeologists dealing with paleofecal material have ignored the fecal studies of wildlife biologists. Indeed, the same research problems are shared by both disciplines. The question of quantification is answered by a double-sampling technique (Peden _et al_., 1974) in wildlife biology. Peden used fistulated herbivores to measure dietary intake. In the same animals, differential digestion was measured and formulae were devised for use in fecal research with wild animals.

Only one modern test of human differential digestion has been done (Stapleton, 1969). In a brief discussion of this paper Wilke and Hall (1975: 12-13) indicated that Maori food items were tested for complete digestability. The methods discussed in Stapleton's paper are applicable to this thesis. A simple program with humans could be done to derive formulae for each component. Measured intake and output with humans would greatly enhance the utility of paleofecal research. Until this is done, quantification and relative values of fecal components must remain within the realm of conjecture.

In spite of all the beforementioned limitations, coprolites do present a direct picture of what was eaten by prehistoric peoples. In this thesis two blatant assumptions will be made. First, it is assumed that the coprolites do not represent a special diet, i.e. seasonality. Secondly, cultural differences are overlooked among the various branches of the Anasazi culture. It is the aim of this thesis to present a picture of a generalized Anasazi adaptation. Hopefully, these two untested assumptions will not negate the value of this line of investigation.

CHAPTER IV

THE COPROLITE EVIDENCE

The bulk of data collected from the Johnson Canyon coprolite study and the other investigations dealing with Anasazi feces is presented here in tabular form. Appendix C gives individual coprolite compositions from those unpublished reports written by the author. Ethnobotanical information is found in Appendix A. Table I gives the common names used here with their scientific equivalent. A discussion of all the coprolite programs used in this chapter and the results of a parasitic examination of Hoy House coprolites are given at the end of this chapter.

TABLE I

COMMON AND SCIENTIFIC NAMES OF PLANTS AND ANIMALS ENCOUNTERED IN ANASAZI COPROLITES

Common Name	Scientific Name	Family
Plants		
Amaranth	Amaranthus sp.	Amaranthaceae
Bean	Phaseolus vulgaris	Leguminosae
Beeweed	Cleome serrulata	Capparidaceae
Buffaloberry	Sheperdia argentea	Elaeagnaeae
Bugseed	Corispermum sp.	Chenopodiaceae
Bulrush	Scirpus sp.	Cyperaceae
Cactus	Undifferentiated	Cactaceae
Chokecherry	Prunus virginianus	Rosaceae
Composite	Undifferentiated	Compositaceae
Corn	Zea mays	Graminaceae
Cotton	Gossypium hirsutum	Malvaceae
Cryptantha	Cryptantha sp.	Boraginaceae
Dropseed	Sporabolus sp.	Gramineae
Goosefoot	Chenopodium sp.	Chenopodaceae
Grass	Undifferentiated	Graminaceae
Groundcherry	Physalis sp.	Solanaceae
Hackberry	Celtis occidentalis	Ulmaceae
Horsetail	Equisetum sp.	Equisetaceae
Juniper	Juniperus osteosperma	Pinaceae
Knotweed	Polygonum sp.	Polygonaceae

TABLE I (continued)

COMMON AND SCIENTIFIC NAMES OF PLANTS AND ANIMALS
ENCOUNTERED IN ANASAZI COPROLITES

Common Name	Scientific Name	Family
Legume	Undifferentiated	*Leguminosae*
Mormon Tea	*Ephedra* sp.	*Gnetaceae*
Panicum	*Panicum* sp.	*Graminaceae*
Peppergrass	*Lepidium* sp.	*Cruciferaceae*
Pinon	*Pinus edulis*	*Pinaceae*
Prickly Pear	*Opuntia* sp.	*Cactaceae*
Purselane	*Portulaca retusa*	*Portulacaceae*
Ricegrass	*Orysopsis hymenoides*	*Graminaceae*
Sagebrush	*Artemesia tridentata*	*Compositaceae*
Saltbush	*Atriplex canescens*	*Chenopodiaceae*
Skunkbush	*Rhus trilobata*	*Anacardiaceae*
Squash	*Cucurbita pepo*	*Cucurbitaceae*
Sunflower	*Helianthus annus*	*Compositaceae*
Wild Buckwheat	*Erigonum* sp.	*Polygonaceae*
Animals		
Antelope	*Antilocapra americana*	*Antilocapridae*
Bear	*Ursus americanus*	*Ursidae*
Cicada	*Platypedia putrami*	*Homoptera*
Deer	*Odocoileus hemionus*	*Cervidae*
Dog/Coyote	*Canis* sp.	*Canidae*
Gopher	*Thomomys bottae*	*Geomyidae*

TABLE I (continued)

COMMON AND SCIENTIFIC NAMES OF PLANTS AND ANIMALS ENCOUNTERED IN ANASAZI COPROLITES

Common Name	Scientific Name	Family
Human	*Homo sapiens*	*Homididae*
Jackrabbit	*Lepus* sp.	*Leporidae*
Mouse	*Peromyscus* sp.	*Cricitidae*
Red-legged Grasshopper	*Melanoplus femurrubrus*	*Orthoptera*
Turkey	*Meleagris gallopavo*	*Meleagrididae*

TABLE II

COMPONENT OCCURRENCE PER 56 COPROLITES
AT HOY HOUSE (PIII ca. A.D. 1240)

	N=56	(%)
Domesticated Plants		
Corn	56	(100.0)
Bean	10	(17.86)
Squash	11	(19.64)
Non-Domesticated Plants		
Amaranth	5	(8.93)
Beeweed	3	(5.36)
Buffaloberry	3	(5.36)
Chokecherry	2	(3.57)
Goosefoot	6	(10.71)
Grass	1	(1.79)
Groundcherry	15	(26.79)
Pinon	7	(12.50)
Prickly Pear	14	(25.0)
Purselane	10	(17.86)
Ricegrass	2	(3.57)
Sagebrush	1	(1.79)
Saltbush	10	(17.86)
Sunflower	1	(1.79)
Wild Buckwheat	1	(1.79)
Unidentified Tissues	15	(26.79)

TABLE II (continued)

COMPONENT OCCURRENCE PER 56 COPROLITES
AT HOY HOUSE (PIII ca. A.D. 1240)

	N=56	(%)
Animals		
Human Hair	21	(37.5)
Dog/Coyote Hair	12	(21.43)
Deer Hair	4	(7.14)
Jackrabbit Hair	4	(7.14)
Unidentified Hair	4	(7.14)
Feathers	4	(7.14)
Bone		
Turkey	1	(1.79)
Mouse	1	(1.79)
Squirrel	1	(1.79)
Small Rodents	4	(7.14)
Cicada	1	(1.79)
Non-mammal, Non-bird Bone	1	(1.79)

TABLE III

COMPONENT OCCURRENCE PER 4 COPROLITES AT LION HOUSE (PIII ca. A.D. 1240)

	N=4	(%)
Domesticated Plants		
Corn	3	(75)
Squash	1	(25)
Non-Domesticated Plants		
Groundcherry	1	(25)
Prickly Pear	1	(25)
Purselane	1	(25)
Saltbush	1	(25)
Unidentified Tissues	1	(25)
Animal		
Dog Hair	1	(25)
Gopher Hair	1	(25)

TABLE IV

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES AT STEP HOUSE (Colyer, n.d.a)

	BMIII ca. A.D. 600		Early PIII ca. A.D. 1150		Late PIII ca. A.D. 1250		All PIII	
	N=20	(%)	N=4	(%)	N=13	(%)	N=17	(%)
Domesticated Plants								
Corn	13	(65)	3	(75)	12	(92.31)	15	(88.24)
Bean	1	(5)	1	(25)	1	(7.7)	2	(11.77)
Squash	8	(40)	2	(50)	3	(23.08)	5	(29.41)
Non-Domesticated Plants								
Amaranth	1	(5)	-	(0)	2	(15.38)	2	(11.77)
Beeweed	2	(10)	1	(25)	-	(0)	1	(5.88)
Bugseed	-	(0)	1	(25)	-	(0)	1	(5.88)
Chokecherry	1	(5)	-	(0)	1	(7.7)	1	(5.88)
Goosefoot	5	(25)	2	(50)	4	(30.77)	6	(35.29)

TABLE IV (continued)

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES
AT STEP HOUSE (Colyer, n.d.a)

	BMIII		Early PIII		Late PIII		All PIII	
	ca. A.D. 600		ca. A.D. 1150		ca. A.D. 1250			
	N=20	(%)	N=4	(%)	N=13	(%)	N=17	(%)
Grass	1	(5)	-	(0)	1	(7.7)	1	(5.88)
Groundcherry	4	(20)	1	(25)	3	(23.08)	4	(23.53)
Juniper	-	(0)	-	(0)	1	(7.7)	1	(5.88)
Pinon	7	(35)	1	(25)	2	(15.38)	3	(17.65)
Prickly Pear	8	(40)	2	(50)	9	(69.23)	11	(64.7)
Purselane	5	(25)	1	(25)	3	(23.08)	4	(23.53)
Ricegrass	1	(5)	-	(0)	1	(7.7)	1	(5.88)
Sagebrush	1	(5)	-	(0)	-	(0)	-	(0)
Skunkbush	-	(0)	-	(0)	3	(23.08)	3	(17.65)
Sunflower	-	(0)	-	(0)	1	(7.7)	1	(5.88)

TABLE IV (continued)

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES AT STEP HOUSE (Colyer, n.d.a)

	BMIII ca. A.D. 600		Early PIII ca. A.D. 1150		Late PIII ca. A.D. 1250		All PIII	
	N=20	(%)	N=4	(%)	N=13	(%)	N=17	(%)
Unidentified Seed	2	(10)	1	(25)	-	(0)	1	(5.88)
Unidentified Tissue	2	(10)	2	(25)	8	(14.29)	9	(52.94)
<u>Animal</u>								
Human Hair	5	(25)	2	(50)	4	(30.77)	6	(35.29)
Unidentified Hair	5	(25)	1	(25)	1	(7.7)	2	(11.7)
Mouse Bone	1	(5)	-	(0)	2	(15.38)	2	(11.7)
Unidentified Bone	6	(30)	3	(75)	1	(7.7)	4	(23.53)
Cicada	-	(0)	-	(0)	1	(7.7)	1	(5.88)
Eggshell	1	(5)	-	(0)	-	(0)	-	(0)

TABLE V

COPROLITE COMPONENTS
AT MUG HOUSE (Coyler, n.d.b)

The following were found in unknown quantities in Mug House feces; all coprolites were recovered from PIII deposits (ca. A.D. 1250).

Domesticated Plants

- Corn
- Squash

Non-Domesticated Plants

- Amaranth
- Cactus
- Goosefoot
- Grass
- Groundcherry
- Prickly Pear
- Skunkbush
- Unidentified Seeds
- Unidentified Plant Matter

Animal

- Hair
- Bone
- Egg Shell
- Cicada

TABLE VI

COPROLITE COMPONENTS
AT LONG HOUSE (Colyer, n.d.c)

The following whole seeds were found in an unknown number of samples; all coprolites were recovered from PIII deposits (ca. A.D. 1250).

Domesticated Plants

- Corn
- Beans
- Squash

Non-Domesticated Plants

- Amaranth
- Beeweed
- Goosefoot
- Groundcherry
- Prickly Pear
- Purseland
- Skunkbush
- Unidentified Seeds

TABLE VII

COMPONENT OCCURRENCE PER 16 COPROLITES AT INSCRIPTION HOUSE (Fry and Hall, n.d.)(PIII [ca. A.D. 1250])

	N=16	%
Domesticated Plants		
Corn	11	68.75
Bean	4	25.0
Squash	-	-
Cotton	5	31.75
Non-Domesticated Plants		
Cactus	8	50.0
Dropseed	3	18.75
Grass	1	6.25
Groundcherry	2	12.5
Hackberry	3	18.75
Panicum	1	6.25
Peppergrass	9	56.25
Purselane	1	6.25
Ricegrass	5	31.25
Skunkbush	1	6.25
Sunflower	3	18.75
Unidentified Seed	6	37.5
Unidentified Epidermis	3	18.75
Unidentified Fiber	16	100.0
Unidentified Stem	7	43.75

TABLE VII (continued)

COMPONENT OCCURRENCE PER 16 COPROLITES AT INSCRIPTION HOUSE (Fry and Hall, n.d.)(PIII [ca. A.D. 1250])

	N=16	%
Animal		
Human Hair	3	18.75
Unidentified Hair	11	68.75
Feather	5	31.25
Unidentified Insect	3	18.75
Bone	4	25.0

TABLE VIII

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES
AT ANTELOPE HOUSE (Fry and Hall, 1975)

	PII (ca. A.D. 1100) N=20	(%)	PIII (ca. A.D. 1250) N=26	(%)
Domesticated Plants				
Corn	18	(90)	25	(96.15)
Bean	-	(0)	4	(15.39)
Squash	8	(40)	5	(19.23)
Cotton	1	(5)	6	(23.08)
Non-Domesticated Plants				
Amaranth	2	(10)	5	(19.23)
Beeweed	4	(20)	6	(23.08)
Cactus	10	(50)	6	(23.08)
Dropseed	-	(0)	1	(3.85)
Goosefoot	-	(0)	2	(7.69)
Grass	1	(5)	1	(3.85)
Groundcherry	8	(40)	2	(7.69)
Horsetail	-	(0)	4	(15.39)
Legume	-	(0)	1	(3.85)
Panicum	-	(0)	1	(3.85)
Peppergrass	-	(0)	1	(3.85)
Pinon	10	(50)	3	(11.54)
Prickly Pear	3	(15)	4	(15.39)
Purselane	9	(45)	4	(15.39)

TABLE VIII (continued)

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES AT ANTELOPE HOUSE (Fry and Hall, 1975)

	PII (ca. A.D. 1100) N=20	(%)	PIII (ca. A.D. 1250) N=26	(%)
Ricegrass	-	(0)	3	(19.23)
Skunkbush	-	(0)	1	(3.85)
Sunflower	-	(0)	2	(7.69)
Unidentified Seed	4	(20)	10	(38.46)
Unidentified Fiber	20	(100)	25	(96.15)
Animal				
Human Hair	6	(30)	2	(7.69)
Unidentified Hair	14	(70)	18	(69.23)
Feathers	7	(35)	8	(30.77)
Bone	13	(65)	10	(38.46)
Red-legged Grasshopper	1	(5)	-	(0)

TABLE IX

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES AT GLEN CANYON (Fry, 1970: 72)

	BMII (ca. A.D. 300?)		BMII-PIII		PIII (ca. A.D. 1250)	
	N=3	(%)	N=3	(%)	N=24	(%)
Domesticated Plants						
Corn	-	(0)	3	(100)	15	(62.5)
Bean	-	(0)	-	(0)	-	(0)
Squash	2	(66.7)	2	(66.7)	16	(66.67)
Cotton	-	(0)	2	(66.7)	7	(29.17)
Non-Domesticated Plants						
Amaranth	-	(0)	1	(33.3)	10	(41.67)
Beeweed	1	(33.3)	2	(66.7)	2	(8.33)
Bulrush	-	(0)	-	(0)	1	(4.17)
Composite	-	(0)	-	(0)	8	(33.3)
Cryptantha	-	(0)	-	(0)	1	(4.17)

TABLE IX (continued)

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES AT GLEN CANYON (Fry, 1970: 72)

	BMII (ca. A.D. 300?)		BMII-PIII		PIII (ca. A.D. 1250)	
	N=3	(%)	N=3	(%)	N=24	(%)
Goosefoot	-	(0)	1	(33.3)	15	(62.5)
Grass	1	(33.3)	2	(66.7)	11	(45.83)
Hackberry	-	(0)	1	(33.3)	4	(16.67)
Knotweed	-	(0)	-	(0)	1	(4.17)
Mormon Tea	-	(0)	-	(0)	1	(4.17)
Peppergrass	-	(0)	1	(33.3)	4	(16.67)
Pinon	-	(0)	-	(0)	1	(4.17)
Prickly Pear	2	(66.7)	3	(100)	11	(45.83)
Purselane	-	(0)	1	(33.3)	1	(4.17)
Ricegrass	-	(0)	-	(0)	5	(20.83)
Unidentified Seed	2	(66.7)	3	(100)	12	(50.0)

TABLE IX (continued)

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES AT GLEN CANYON (Fry, 1970: 72)

	BMII (ca. A.D. 300?)		BMII-PIII		PIII (ca. A.D. 1250)	
	N=3	(%)	N=3	(%)	N=24	(%)
Unidentified Epidermis	3	(100)	3	(100)	18	(75.0)
Unidentified Fiber	3	(100)	3	(100)	22	(91.62)
Unidentified Stem	2	(66.7)	1	(33.3)	10	(41.67)
Animal						
Antelope Hair	-	(0)	-	(0)	2	(8.33)
Unidentified Hair	2	(66.7)	3	(100)	19	(79.17)
Feather	-	(0)	-	(0)	6	(25.0)
Unidentified Insect	-	(0)	-	(0)	7	(29.17)
Bone/Sinew	2	(66.7)	1	(33.3)	12	(50.0)
Reptile Scale	-	(0)	-	(0)	1	(4.17)

TABLE X

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES
ALL ANASAZI COPROLITES BY PHASE

	BMII-III (ca. A.D. 300-600)		PII-Early PIII (ca. A.D. 1100-1150)		PIII (ca. A.D. 1250)	
	N=23	(%)	N=24	(%)	N=139	(%)
Domesticated Plants						
Corn	13	(56.52)	21	(87.5)	122	(87.77)
Bean	1	(4.35)	1	(4.17)	19	(13.67)
Squash	10	(43.48)	10	(41.67)	36	(25.9)
Cotton	-		1	(4.17)	23	(16.55)
Non-Domesticated Plants						
Amaranth	1	(4.35)	2	(8.33)	17	(12.23)
Beeweed	3	(13.04)	5	(20.83)	11	(7.91)
Buffaloberry	-		-		3	(2.16)
Bugseed	-		1	(4.17)	-	

TABLE X (continued)

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES ALL ANASAZI COPROLITES BY PHASE

	BMII-III (ca. A.D. 300-600) N=23	(%)	PII-Early PIII (ca. A.D. 1100-1150) N=24	(%)	PIII (ca. A.D. 1250) N=139	(%)
Bulrush	-		-		1	(0.72)
Cactus	-		10	(41.67)	14	(10.07)
Chokecherry	1	(4.35)	-		3	(2.16)
Composite	-		-		8	(5.76)
Cryptantha	-		-		1	(0.72)
Dropseed	-		-		4	(2.88)
Goosefoot	5	(21.74)	2	(8.33)	27	(19.42)
Grass	2	(8.70)	1	(4.17)	15	(10.79)
Groundcherry	4	(17.39)	9	(37.5)	23	(16.55)
Hackberry	-		-		7	(5.04)
Horsetail	-		-		4	(2.88)

TABLE X (continued)

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES
ALL ANASAZI COPROLITES BY PHASE

	BMII-III (ca. A.D. 300-600)		PII-Early PIII (ca. A.D. 1100-1150)		PIII (ca. A.D. 1250)	
	N=23	(%)	N=24	(%)	N=139	(%)
Juniper	-		-		1	(0.72)
Knotweed	-		-		1	(0.72)
Legume	-		-		1	(0.72)
Mormon Tea	-		-		1	(0.72)
Panicum	-		-		2	(1.44)
Peppergrass	-		-		14	(10.07)
Pinon	7	(30.44)	11	(45.83)	13	(9.35)
Prickly Pear	10	(43.48)	5	(20.83)	39	(28.06)
Purselane	5	(21.74)	10	(41.67)	20	(14.39)
Ricegrass	1	(4.35)	-		16	(11.51)
Sagebrush	1	(4.35)	-		1	(0.72)

TABLE X (continued)

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES ALL ANASAZI COPROLITES BY PHASE

	BMII-III (ca. A.D. 300-600) N=23	(%)	PII-Early PIII (ca. A.D. 1100-1150) N=24	(%)	PIII (ca. A.D. 1250) N=139	(%)
Saltbush	-		-		11	(7.91)
Skunkbush	-		-		5	(3.60)
Sunflower	-		-		7	(5.03)
Wild Buckwheat	-		-		1	(0.72)
Animal						
Human Hair	5	(21.74)	8	(33.33)	30	(21.58)
Antelope Hair	-		-		2	(1.44)
Deer Hair	-		-		4	(2.88)
Dog/Coyote Hair	-		-		13	(9.35)
Jackrabbit Hair	-		-		4	(2.88)

TABLE X (continued)

COMPONENT OCCURRENCE PER NUMBER OF COPROLITES ALL ANASAZI COPROLITES BY PHASE

	BMII-III (ca. A.D. 300-600)		PII-Early PIII (ca. A.D. 1100-1150)		PIII (ca. A.D. 1250)	
	N=23	(%)	N=24	(%)	N=139	(%)
Gopher Hair	-		-		1	(0.73)
Unidentified Hair	7	(30.44)	15	(62.5)	53	(38.13)
Feather	-		7	(29.17)	23	(16.55)
Turkey Bone	-		-		1	(0.73)
Squirrel Bone	-		-		1	(0.73)
Mouse Bone	1	(4.35)	-		3	(2.16)
Unidentified Bone	8	(34.78)	16	(66.67)	32	(23.02)
Cicada/Grasshopper/Insect	-		1	(4.17)	12	(8.63)
Eggshell	1	(4.35)	-		-	
Reptile Scale	-		-		1	(0.73)

Parasites

Many prehistoric populations have been shown to have been infected by pinworm. Infestation is indicated by the presence of eggs in the feces (Fry and Moore, 1969). The coprolites analyzed in this study indicate Anasazi populations were often infected (Fry and Hall, 1975: 94). Three of 56 coprolites from Hoy House had adult worms present and one infection was indicated by eggs only. This is a 7% positive showing by direct fecal examination. Today, when a population with 100% known infection is examined by direct fecal examination, a result of 5% positive is expected. In other words, direct fecal examination is not an effective method for determining Enterobius vermicularis infection. Therefore, by using this modern data, it can be assumed that nearly all Hoy House inhabitants were infected.

Normally, pinworm infection has little impact on an individual's health. While some people will suffer intense perianal itching and consequent loss of sleep, most authors assume such an infection has little effect on a person's health (Fry, 1970: 86). However, few people have looked at the effects a massive infection might have on a person under stress. In such extremes a person may become anemic, and resultant death is recorded for untreated cases in wartime Europe (Craig et al., 1951: 374). It is possible that in fact, the pinworm was more of a health hazard for the Anasazi than has previously been thought.

In the past there has been some professional interest in the possibility of live bacteria surviving in prehistoric feces after many years. Several attempts have been made to culture organisms from coprolites by many researchers. All such studies have had negative results (Stiger, 1975).

In 1975, Colvin reported that he had succeeded in getting anaerobic bacterial growth from Hoy House stools (Colvin, 1975). Colvin used an alternate method to get the bacteria culture started. Instead of merely innoculating the growth media with a fragment from the center of a coprolite to insure against modern contamination, Colvin also treated (heat shocked) the sample. Heat shocking a sample involves putting the innoculating piece to be used into a thioglycollate tube and applying heat. A temperature of 60 to 70 degrees centigrade is maintained for about ten minutes. The advantages of heat shocking are two-fold. First, vegetative cells are killed. Vegetative cells associated with prehistoric feces would be modern contaminants. Second, spores formed by anaerobic bacteria when the feces was deposited are activated by the heat.

Identifications were made by Colvin to the genus level. All were of _Clostridium_ spp., possibly some _C. tetani_. While all _Clostridium_ are normal inhabitants of the human gastro-intestinal tract, _C. tetani_ is the organism that causes tetanus upon invasion of the circulatory system.

Critique of the Source Materials

The major criticism of the Hoy House and Lion House coprolite project is the absence of a pollen study. Due to a lack of funds and a lack of experience on the part of the author, this line of inquiry was not pursued. Certainly, evidence of some plants were not found because of this deficiency. However, it is a rare coprolite study that is complete in this respect.

The reports on paleofeces from Mesa Verde National Park are incomplete. The Step House feces analyses are well done but hair, tissue, and bone identifications are lacking. The Mug House and Long House reports, in addition to the above omissions, lack a complete recording of corn fragments. Evidently, well-ground or masticated corn present in the feces was overlooked. After reviewing some of the materials at Mesa Verde from Step House, Mug House, and Long House it was noted that several misidentifications of seeds and of donor species were made. The tables in this thesis correct the misidentifications. However, it is not known how many coprolites from Mug House and Long House contained the fine corn particles.

Gary Fry's and H. J. Hall's work at Antelope House and Inscription House, and Fry's at Glen Canyon neglect the microtechnique approach to identification. However, excellent pollen work has been done on Antelope House feces (Williams-Dean and Bryant, 1975) to be a companion report to Fry and Hall's report.

The work of Callen and Martin (1969) is complete in its use of methods. However, due to Callen's unfamiliarity with local plants, the identifications are necessarily incomplete. Callen and Martin (1969: 329) indicate that the nine coprolites they deal with are all of Anasazi Pueblo III (A.D. 1250) origin. However, when the proveniences are checked against an earlier report on the same feces (Martin and Sharrock, 1964) it appears that dating of the coprolites could range from A.D. 600 to present and include other cultures such as Navaho, Ute, or Anglo. Therefore, this sample of poorly provenienced coprolites is disregarded for this thesis.

CHAPTER V

INTERPRETATIONS AND CONCLUSIONS

This concluding chapter will make some generalizing statements about Anasazi diet. These statements will be based on the results of the various coprolite studies presented earlier. Also, a model of the cultural ecosystem of the Mesa Verde branch of the Anasazi will be presented as a possible explanation for the dietary shifts seen.

Traditional views of the Anasazi envision groups of the peaceful sedentary farmers subsisting almost entirely (e.g.; 90% estimate by Driver, 1961: 60) on the corn-beans-squash triad. Clearly the coprolites show that wild plants were important contributors to the prehistoric menu. It is not reasonable at this time to give percentages of food items in the day-to-day diet as has been done for Tehuacan (Callen, 1967: 284-285).

While "wild plants" were obviously common in the diet, it is important to note where these plants are found in the environment (see Appendix B). Almost all of the forbs that were used were weeds, that is, plants that depend to some degree on human disturbance of the environment. Additionally, all of the shrubs found in coprolites were either characteristic of secondary seres or they were shrubs indigenous to canyon bottoms and talus, two areas unfavorable to agriculture.

The animal remains from PIII coprolites are similarly those species attracted to areas of human disturbance such as farm plots and granaries. Around villages, animal pests such as deer and rodents would be hunted in order to protect the crops, both in the fields and in storage facilities. Such hunting practices would provide meat for the diet. Hair and bones in the feces indicate small rodents were eaten whole perhaps after being crushed in a deadfall trap such as the Hopi use today (Beaglehole, 1936: 17-18). Animals approximately the size of gophers and rabbits were evidently butchered first, then eaten.

Willey (1966: 211) feels the archaeological record indicates a trend in Anasazi subsistence; that the prehistoric population "grew increasingly dependent on farming and relied less on hunting and collecting."

Although based on a low sample number, it appears that from each site where two or more time periods are represented, there is intensification of corn utilization and a concomitant decrease in pinon nut consumption by late populations. Pinon nuts are a high protein fat food source. Corn, however, is a better producer per acre of high carbohydrate food. In an area of low population density, as for most hunting and gathering groups, a subsistence based on pinon nut gathering is possible. However, with a higher density of people, alternate methods of subsistence must be used (Binford, 1968: 313-341). Corn, being a good producer, would gradually increase in importance as a food source in a semi-farming culture experiencing population pressures. An increase in corn usage with a concurrent pinon decline would lower the protein intake unless beans or meat were consumed in increasing amounts; there is no evidence from the coprolites for this increase. In fact, an unpublished trace element analysis of a few Mesa Verde Pueblo III coprolites indicates a drop in protein consumption from early to late (Sabels, n.d.).

Other trends in food sources are the decreasing use through time of squash, and an increase in cotton seed, insect, grass seed, and general diversity in the diet.

Robert Bye (personal communication) has noted a similar decline in the use of squash among the present day Tarahumara of Mexico. This decline is in part attributed to replacement in the diet by the less frost sensitive peppergrass. Squash also requires a large area for growth with a small yield.

Cotton seed is a high protein food that also produces the raw material for cotton cloth. The result is in effect, a double crop. The growing season at Mesa Verde is not suitable for cotton as it is farther west and south.

Insects appear to have gained in importance in the diet through time. It is possible that the environment changed enough to allow a grasshopper population expansion. This will be discussed in more detail later, however such an environmental shift could be a grassland invasion which would also account for the increase in grass seed consumption. Winter (1976) has noted a similar shift towards grassland environments and grass seed eating in Fremont populations. Winter feels that the Fremont dietary shift is due to natural environmental changes. In the later part of this chapter an alternative hypothesis will be presented.

The major points of this thesis are:

1) Anasazi diet relied heavily on corn but made use of a wide variety of "wild plants,"

2) these "wild plants" are mainly plants which grow in disturbed areas or are found where farmlands are not practical, and

3) the Anasazi intensified their use of high production crops through time and decreased their use of pinon nuts and other low yield resources.

A possible explanation for the forces that changed the subsistence pattern of these prehistoric farmers lies in the ecosystem itself. By taking a case example I will try to illustrate the cultural ecology of a group within the present study area. Using the Mesa Verde itself I propose the following explanation.

Mesa Verde Cultural Ecology

The Natural Model

In actuality the Mesa Verde is not a single land mass but a series of small mesas separated by deep side canyons of the Mancos River. Rising abruptly from grassland plains to the north and west and a river canyon to the south and east, the level topped mesas attain their highest elevation on the north at about 8500 feet and gently slope for fifteen miles to the south end at 6500 feet. The underlying rock is mostly Cretaceous sandstones and shales. At the juncture of the impervious shale and the aquaferous sandstone, springs and seeps occur, as well as an occasional alcove suitable for prehistoric habitations such as the well-known cliff dwellings. Soils are predominantly loess; their depths are variable depending on several factors of location on the mesa tops. Deeper soils are found at canyon heads, canyon floors, and on the mesa tops away from the rims (Erdman _et al._, 1969: 15-17; Arrhenius and Bonatti, 1965). Leaching is not a problem due to the limited amount of rainfall (Erdman _et al._, 1969: 17). Precipitation in the area is approximately eighteen inches per year but varies greatly from locale to locale because of relatively small storm epicenters. The temperature regime of the area maintains an average annual mean of 50.2° F.; yearly extremes are 102° and -15° F. The growing season averages 158 days with the shortest season on record being 134 days (Hayes and Lancaster, 1975: 4).

The biotic community of the Mesa Verde is dominated by a climax pinon-juniper forest overstory (Shelford, 1963: 283). Various successional stages change from annuals through grasses to shrubs as dominant plant cover. Due to past fires on the mesa all seres are represented and well dated by dendrochronology (Erdman, 1970). In the northern part of the Mesa Verde it appears to take approximately 350 years for complete regeneration of the climax forest after the single disturbance of a forest fire (Erdman, 1970: 18).

Mammals of the area follow a general pattern of mostly geographically wide-spread species being present (Anderson, 1961: 66). Important animals are mule deer and bighorn sheep as dominant grazers, coyote as the major predator, and various rabbits and rodents as minor influents (Shelford, 1963: 287-288; Anderson, 1961).

Generally speaking, most authors concur that the above description of the present day Mesa Verde environment is also an applicable description of the prehistoric environment between the seventh and thirteenth centuries (Hayes and Lancaster, 1975: 185; Erdman _et al._, 1969: 57).

The Cultural Model

The earliest positive evidence for occupation on the Mesa Verde is approximately A.D. 610 during the Anasazi Basketmaker III stage (Hayes and Lancaster, 1975: 182). These late Basketmakers are characterized by the pertinent literature as living in permanent villages and being dependent on a diet of both wild plants and animals and domesticated plant foods (Wormington, 1948: 56-57; Martin and Plog, 1973: 204-205; Birkedal, 1976). Agriculture was important; cultigens comprised an estimated 50% of the Basketmaker diet (Schiffer, 1972). Cultivation was accomplished by forest clearance of the farm plot with stone axes and the ground was broken for the seed with the only agricultural tool known from this time, the digging stick (Martin and Plog, 1973: 204). There is no evidence that any form of water control is being used at this time. The fields are assumed to have been located near the habitation sites on the mesa tops; the prime agricultural areas are located along the ridge lines that run down the middle of the mesas. These locations have the deepest soils and are well insulated against the wind coming out of the canyons. The rainfall is adequate to grow corn by using dry farming methods except in extreme drought years (Hack, 1942: 23).

After a gradual transition lasting several hundred years (A.D. 900), the Mesa Verde Indians reached their population peak. A few basic cultural changes occurred. Large villages seemed to disappear, and the settlement pattern became one of diverse locations away from the ridge lines (Hayes, 1964; Birkedal, 1976). The tool kit remained essentially the same. Social reorganization occurred as is evidenced by architecture. Some water and soil control devices were used (Rohn, 1964: 455). The coprolite evidence indicates that the Anasazi intensified their use and dependence on corn.

At the culmination of Mesa Verde culture a few hundred years later (A.D. 250), additional changes had taken place. The total mesa population was minimal. While villages were the largest seen at any time, they still housed a maximum of only 200-250 people (Hayes, 1964: 110; Martin and Plog, 1973: 306). The settlement pattern continued to change with sites being located at increasing distances from the ridge lines. Most of these late sites are on the mesa edges or at the cliffs either in rincons or on the talus slopes (Hayes, 1964: 109-110). A new tool type is introduced at this time, the tchamahia (Rohn, 1971: 248).

Much debate over the use of the tchamahia has gone on in the literature (see Rohn, 1971: 247-248 for a discussion). However, from personal observation, from discussion with lithic analysts, and from the weight of published data (Woodbury, 1954: 166-167; Judd, 1954: 245; Morris, 1939: 139), it can be presumed that the majority of these objects are hoes. Additionally, a few well-preserved specimens have been found hafted on the tips of shafts that appear similar to digging sticks (Mesa Verde Museum display; Kellie Masterson, personal communication; Morris, 1939: 139).

The coprolite evidence again indicates an increase in the dependence and utilization of corn. The faunal remains show changing ratios of animals killed and brought to the habitation sites. The two most conspicuous shifts are in the relative importance of bighorn sheep-mule deer and jackrabbit-cottontail and in the turkey remains. From early to late periods on the mesa, there is an increase in mule deer and jackrabbit utilization in proportion to bighorn sheep and cottontail (Emslie, 1977). In addition, there is an indication that turkeys were kept in increasingly large numbers on the sites.

The thousands of ruins in the Mesa Verde region can open up speculation as to the actual permanence of the Anasazi farming villages. Abandonment by small populations occurred throughout time and the apparent shifting of homesteads has led some people to describe the Pueblos as semi-nomadic (Parsons, 1939: 14). Cordell (1975: 189-190) has correctly pointed out that an explanation for these steady abandonments lies not in a cataclysmic answer but in a repeated systemic element of the Anasazi culture. She sees a fluctuating environment as evidenced by tree-rings as the answer. However, some aspects of the continuing abandonments are linear and not cyclic as would be expected with a fluctuating climate.

As an alternative hypothesis I propose a much simpler solution that also accounts for the documented changes in the cultural and environmental systems. The hypothesis presented here is that the Mesa Verde farmers were practicing a form of slash-and-burn or swidden agriculture. This statement seems rather unacceptable at first glance to those who erroneously associate swidden systems only with tropical areas, but a closer look at the properties of this agricultural method will show that indeed the term swidden can be applied to Anasazi farming.

Swidden Agriculture

Harris (1973: 2-4) has characterized slash-and-burn agriculture by eight major attributes: 1) initial cutting and burning of vegetation, 2) temporary cultivation in the cleared area, 3) a fallow period to allow old field succession to regenerate the vegetation, 4) these techniques are done on a small scale, 5) these techniques give a land extensive-labor intensive-return, 6) these techniques are highly productive for the amount of labor invested, 7) because swidden is land extensive, it necessarily will only support a low density population, and 8) villages supported by swidden have upper population limits of near 250 people. The many variations in this agriculture system can (may) add to or mellow the environmental impact of the farmer. Seed or root crops affect the soil exhaustion rate; topography and climatic considerations limit the extent of the fields. Population parameters determine length of fallow. Latitude and ecotone also affect the fallow period as does the natural succession. Technology determines which successional stages can be used and which are most economically productive. All these factors make up the local cultural-ecosystem.

The agricultural systems of the Mesa Verde Anasazi fall within Harris' characteristics of temperate latitude swidden. In addition, the strict use of seed crops by the prehistoric farmers would speed soil exhaustion rates. Almost all fields would have been on the mesa tops. Because of cold air drainage which limits growing seasons in canyons. The utilization of the stone axe and dibble stick as primary agricultural tools is most effective in cultivating recently cleared primary forests. The success of the Anasazi agricultural system is indicated by a population explosion on the mesa within several hundred years after the first farmers arrived.

"Postdiction" or Predicting the Past

If the Mesa Verde Anasazi are examined with the assumption that the environment of today is similar to that with which the Indians contended, a few direct environmental effects may be predicted.

Undoubtedly, the major consequence of swidden agriculture on the Mesa Verde would be the deforestation of the mesa tops. As one field would wear out, the farmer would shift his efforts to another tillage. As the new field wore out, in turn, another field might be prepared or an old field, sufficiently "recharged" by succession, would be re-used. However, the re-use of an old field would involve correct timing to get the most economically valuable sere. Whereas in the tropics it takes two to 25 years for vegetation rejuvenation to make a field usable again, in the temperate zone of Mesa Verde the rate is much slower because of climatically influenced succession rates (Harris, 1973: 7-8). By using Erdman's data (1970) it seems that after a field was abandoned for four years a grass-forb stage would predominate. A fallow period of 25 years would produce a shrub dominated environment. The period of 100 to 300 years after field abandonment would see a shrub stage with increasing tree cover, ending finally in a climax situation. With an axe and digging stick tool kit (technology), it would be most economically advantageous to utilize a forest ecozone. The shrubs of the Mesa Verde area crown sprout and consequently cannot be eradicated by fire (Erdman, 1970: 20). The deep root systems of secondary shrub growth, which would be hard to dig out and reproduction by stem layering and sprouting, would certainly be troublesome in a field. The additional effects of soil exhaustion and continued clearance might slow the succession rates further.

As the prehistoric farmers exhausted their best farming areas and moved their fields out to more marginal areas, they also moved their settlements so they could protect and tend their crops. As the fields advanced the forest retreated.

A prehistoric deforestation is indeed indicated in the palynological record. Using pollen studies done on the mesa tops, the major vegetational changes are summarized by Martin and Byers (1965: 133), "The pollen record during Pueblo times is dominated by cheno-ams, grasses, and compositae . . . After abandonment, the disturbance plants decline and juniper followed by pine pollen rise in frequency." Pollen samples from the earliest Basketmaker site in the region show no difference from modern percentages in pine and juniper pollen (Scott, 1974: 14). Evidently there are no major pollen fluctuations until the Anasazi population was well settled into the area.

The changed vegetal environment had major repercussions in several other environmental areas, and had serious consequences for the Indians. The forested lands of the climax sere were suitable for bighorn sheep and cottontail rabbits. In the pinon-juniper woodland of the Kaibab Plateau, Utah, bighorn sheep and cottontail are found almost exclusively in the forested areas. Jackrabbits are only occasionals as they subsist almost entirely on grass and prefer an open shrubby habitat. Deer are found throughout both shrublands and forest (Shelford, 1963: 285-289). It is obvious that deforestation on the Mesa Verde would reduce the local habitat for bighorn sheep and cottontail and favor the dominance of an alternate fauna, deer and jackrabbits. This change in habitat and fauna is indicated in bone refuse from later archaeological sites.

A modern arthropod survey of Mesa Verde indicated that no grasshoppers were present in the modern climax forest (Shelford, 1963: 292). Farther west in Zion National Park, Utah, however, 3% of arthropods were orthopterons. The diet of locusts and grasshoppers consists of shrubs and grasses; extensive damage to grasses, sagebrush, and cliffrose has been observed there (Ibid.: 290-291). If indeed, the prehistoric Mesa Verde was mainly a shrub-grassland, it would have been a desirable habitat for grasshoppers. Coprolite evidence demonstrates grasshoppers were present on the mesa (Graham, 1965: 171). The potential crop destruction from insects would seem indefensible by a society not having chemical pesticides. However, in Arizona in 1917 the recommended method of controlling grasshoppers, "the worst pest with which the Arizona farmer has to contend" (Paschall, 1917: 335-336), was the use of the turkey. By driving a flock of these birds over a cropland or grassland, the grasshopper and other insect populations could be controlled and a future meat source could be fattened. As the shrub-grassland expanded and a large enough area became suitable for grasshoppers, the turkey became a much more important animal from a pest control, and therefore a meat source perspective, as is shown in archaeological faunal deposits.

The hydrology of the Mesa Verde would have been effected by the deforestation process. The evapo-transpiration rates of a mature forest are higher than that of a grassland. With clear cutting of the pinon-juniper overstory, the relatively deep root systems of the trees would be replaced by the shallow ones of the grasses in the early stage of vegetative replacement and shrubs later on. According to studies cited by Kramer (1969: 339-340), clear cutting can increase runoff and stream yield 30 to 100 percent or clear cutting may raise a shallow water table significantly. On the Mesa Verde there is evidence for both conditions. Although not accurately dated, caliche formations and leached soil horizons indicate a higher water table prehistorically. At some post-Tsegi time (this would include the period of final abandonment), the water table fell to the present level of three feet (Arrhenius and Bonatti, 1965: 98). The depletion of the water table could have two explanations. The first is that after abandonment, the natural succession of forest lands tapped, and consequently lowered the water level. The second possibility is that fields near the edges of the mesa were more susceptible to erosion than fields in the middle of the mesa surrounded by forest. Arroyo formation would have dissected the water table and lowered the water levels.

The higher water table of late Pueblo times would have caused springs and seeps to flow with an increased volume. The Hopi must occasionally deal with drying springs on Black Mesa. The major cause is vegetation growing on the recharge areas of the spring. The Hopi solve this problem by denuding the soils above the seep, thereby allowing water to soak into the ground and recharge the revitalized spring (Hack, 1942: 13). It seems no coincidence that most of the late major prehistoric ruins of the Mesa Verde have a seep or spring very nearby, or in the case of the cliff dwellings, in the alcove itself. Pecked grooves and basins indicate that the seeps in the back of many caves ran faster during occupation than today. Hack believes the recharge area for a spring may be only a few acres immediately above the spring (Hack, 1942: 13). Therefore it is possible that it was only in late Pueblo times, when field areas were near the mesa edges, that the springs in the backs of the caves had sufficient flow to support the large communities.

The increased runoff, another by-product of deforestation, would have altered the Mancos River system into which the Mesa Verde drains. If the side canyons of the Mancos River began carrying increased water loads, the cutting ability of the river would increase and entrenchment would have resulted. Evidence from Mancos Canyon indicates the Anasazi were using flood water farming and irrigation (Hallisy, 1974). A degrading and entrenched river would have been unusable for the Mancos agricultural system (Gillespie, 1976). If it was not until the forest was cleared on the edges that runoff increased, perhaps the late prehistoric abandonment of Mancos Canyon can also be explained by changes in the Mesa Verde cultural-ecosystem.

In late Pueblo times there is the first evidence of runoff control (Rohn, 1963: 454). Terraces and check dams make their appearance. Being in a less desirable location, they seem to parallel the dispersal pattern of the late Anasazi agricultural fields. However, they would also be less marginal and more productive in a situation of increased runoff.

The final point I would like to make in support of my hypothesis is on the use of the tchamahia. If indeed, it is a hoe, which should be tested with replication studies, then it represents the first field agricultural innovation in Mesa Verde tool technology. While the hoe may be just a more efficient tool for weeding, it has some implications as far as swidden systems go. Is the hoe more efficient in a pioneer swidden situation? Smith (1973: 4) contends that digging sticks are characteristic of forest fallows and hoes are usually characteristic of shorter grass fallows. The reasons for the shortening of the fallow period is a Boserupian argument of population increase and a need for intensifying land use. Ways of avoiding this intensification are "emigration, predation against neighbors, development of other resources such as . . . trading" (Smith, 1973: 3). Evidence for all three alternatives being used is present by the late Mesa Verde Anasazi culture, as well as the shortening of the fallow time so grasslands must be used for agricultural plots. A population increase may not have been the driving force behind increased usage of grassland ecozones for the prehistoric Indians. Instead, the loss of arable land to secondary seres would have simulated such an increase as the ratio of arable land to population decreased. Since grasslands would have been exploitable with a hoe, and shrubland would have been still unusable, the fallow could be shortened to use the younger old fields. However, the constant reuse of fields that were not allowed to fully recuperate would cause a decline in productivity to the inevitable end of being economically unjustifiable.

Conclusions

The nature of the prehistoric Anasazi diet has been examined by the use of coprolite analysis. An increased use of weeds and domesticated corn is suggested as an adaptation to a changing environment due to human disturbance. Intensification of the use of corn was also a response to a situation of mounting population pressures.

In the future it is hoped that work with modern material will add to the value of coprolite studies in the realm of quantification. Also, better samples from stratified sites will give more time depth and fill in the gaps of prehistoric dietary research.

BIBLIOGRAPHY

Anderson, S.
1961 Mammals of Mesa Verde National Park, Colorado. *Univ. Kansas Publ. Mus. Nat. Hist.* 14:3. Lawrence.

Arlin, M. T.
1972 *The Science of Nutrition*. Macmillan Publ. Co., Inc. New York.

Arrhenius, G. and E. Bonatti
1965 The Mesa Verde loess. *In*: "Contributions of the Wetherill Mesa Archeological Project," assembled by D. Osborne. *Memoirs of the Soc. Amer. Arch.*, No. 19, pp. 92-100. Salt Lake City.

Baumgartner, L. L. and A. C. Martin
1939 Plant histology as an aid in squirrel food-habit studies. *Jour. Wildl. Manage.* 3: 266-268.

Beaglehole, E.
1936 Hopi hunting and hunting ritual. *Yale Univ. Publ.* No. 4. New Haven.

Benninghoff, W. S.
1947 Use of trisodium phosphate with herbarium material and microfossils in peat. *Science* 106: 325-326.

Binford, L. R.
1968 Post pleistocene adaptations. *In*: "New Perspectives in Archaeology," ed. by S. R. and L. R. Binford, pp. 313-341. Aldine Publ. Co., Chicago.

Birkedal, T. G.
1976 Basketmaker III Residence Units: A Study of Prehistoric Social Organization in the Mesa Verde Archaeological District. Unpublished Ph.D. dissertation, University of Colorado, Boulder.

Brothwell, D. and R. Spearman
1963 The hair of earlier people. *In*: "Science in Archaeology," ed. by D. Brothwell and E. Higgs, pp. 426-436. Basic Books, New York.

Brown, F. M.
1942 The microscopy of mammalian hair for anthropologists. *Proc. of the Amer. Phil. Soc.* 85: 250-274.

Brusven, M. and G. B. Mulkern
1960 The use of epidermal characteristics for the identification of plants recovered in fragmentary condition from the crops of grasshoppers. North Dakota Agric. Exper. Station Research Report No. 3. Fargo.

Bryant, V. M., Jr.
1969 Late Full-glacial and Postglacial Pollen Analysis of Texas Sediments. Unpublished Ph.D. dissertation, University of Texas, Austin.

1974a Prehistoric diet in southwest Texas: the coprolite evidence. Amer. Antiquity 39: 407-420.

1974b Pollen analysis of prehistoric human feces from Mammoth Cave. In: "Archaeology of the Mammoth Cave Area," ed. by P. J. Watson, pp. 203-209. Academic Press, New York.

Callen, E. O.
1963 Diet as revealed by coprolites. In: "Science in Archaeology," ed. by D. Brothwell and E. Higgs, pp. 186-194. Basic Books, New York.

1967 Analysis of Tehuacan coprolites. In: "The Prehistory of the Tehuacan Valley, Vol. I: Environment and Subsistence," ed. by D. S. Byers, pp. 261-289. Univ. of Texas Press, Austin.

1973 Dietary patterns in Mexico between 6500 B.C. and A.D. 1580. In: "Man and His Foods," ed. by C. E. Smith, pp. 29-50. Univ. of Alabama Press, Alabama.

Callen, E. O. and T. W. Cameron
1955 The diet and parasites of prehistoric Huaca Prieta Indians as determined by dried coprolites. Royal Soc. Canada Proc. 5: 51-52. Ottawa.

Callen, E. O. and P. S. Martin
1969 Plant remains in some coprolites from Utah. Amer. Antiquity 34: 329-331.

Colvin, J.
1975 Results of a bacteriological study of human coprolites. Unpublished report submitted to M. A. Stiger, April 12, 1975.

Colyer, M.
n.d.a Macroscopic constituents of human and bear feces, Step House. Unpublished report on file at Mesa Verde National Park, Colorado.

n.d.b Untitled list of coprolite components from Mug House feces. Unpublished report on file at Mesa Verde National Park, Colorado.

Colyer, M.
n.d.c Untitled list of coprolite constituents from Long House feces. Unpublished report on file at Mesa Verde National Park, Colorado.

Cordell, L.
1975 Predicting site abandonment at Wetherill Mesa. *The Kiva* 40 (3): 189-202.

Craig, C. F., E. C. Faust, and A. Miller
1951 *Clinical Parasitology*. Lea and Febiger Pub., Philadelphia.

Douglas, C. L.
1969 Analysis of hairs in Lovelock Cave coprolites. *In*: "Kroeber Anth. Soc. Papers Special Publ." No. 2, ed. by R. V. Kemper, pp. 1-8. Berkley.

Driver, H. E.
1961 *Indians of North America*. Univ. of Chicago Press, Chicago.

Dusi, J. L.
1949 Methods for the determination of food habits by plant microtechniques and histology and their application to cottontail rabbit food habits. *Jour. Wildl. Manage.* 13: 295-298.

1952 The food habits of several populations of cottontail rabbits in Ohio. *Jour. Wildl. Manage.* 16: 180-186.

Emslie, S. D.
1977 *Interpretation of Faunal Remains from Archaeological Sites in Mancos Canyon, Southwestern Colorado*. Unpublished Master's thesis, Univ. of Colorado, Boulder.

Erdman, J. A.
1970 Pinon-juniper succession after natural fires on residual soils of Mesa Verde, Colorado. *Brigham Young Univ. Sci. Bull. Biol. Series* Vol. 11, No. 2. Provo.

Erdman, J. A., C. L. Douglas, and J. W. Marr
1969 *Environment of Mesa Verde, Colorado*. Archeological Research Series F-B, National Park Service, Washington, D. C.

Fradkin, W. Z.
1947 *The Diagnosis and Treatment of Diarrheal Diseases*. Grune and Stratton, Inc. New York.

Fry, G. F.
1970 *Prehistoric Human Ecology in Utah: Based on the Analysis of Coprolites*. Unpublished Ph.D. dissertation, University of Utah. Salt Lake City.

Fry, G. F.
1974 Ovum and parasite examination of Salts Cave human paleofeces. In: "Archaeology of the Mammoth Cave Area," ed. by P. J. Watson, p. 61. Academic Press, New York.

Fry, G. and H. J. Hall
1975 Human coprolites from Antelope House: preliminary analysis. The Kiva 41: 87-96.

n.d. The Analysis of Human Coprolites from Inscription House. Unpublished preliminary report submitted to the National Park Service. Tucson.

Fry, G. F. and J. G. Moore
1969 Enterobius vermicularis: 10,000 year-old human infection. Science 166: 1620.

Gillespie, W. B.
1976 Culture Change at the Ute Canyon Site. Unpublished Master's thesis, Univ. of Colorado. Boulder.

Graham, S. A.
1965 Entomology: an aid in archaeological studies. In: "Contributions of the Wetherill Mesa Archeological Project," assembled by D. Osborne. Memoirs of Soc. Amer. Arch. No. 19, pp. 167-174. Salt Lake City.

Hack, J. T.
1942 The changing physical environment of the Hopi Indians of Arizona. Papers of the Peabody Mus. Amer. Arch. and Ethn., Vol. 35, No. 1. Harvard.

Hallisy, S.
1974 Salvage Excavation of Sites 5MTUMR 2344 and 5MTUMR 2347 in Mancos Canyon, Southwest Colorado. Unpublished report submitted to the Bureau of Indian Affairs. Albuquerque.

Harrington, H. D.
1964 Manual of the Plants of Colorado. Swallow Press Inc., Chicago.

Harris, D. R.
1973 Swidden systems and settlement. Reprint RF in Ecology and Agricultural Settlements, ed. by R. Tringham. Warner Modular Publ., Andover, Massachusetts.

Harshberger, J. W.
1896 The purposes of ethno-botany. Botanical Gazette 21: 146-154.

Hausman, L. A.
1920 Mammal fur under the microscope. Amer. Nat. 20: 434-444.

Hayes, A. C.
1964 *Archaeological Survey of Wetherill Mesa*. Archeological Research Series F-A, National Park Service, Washington, D.C.

Hayes, A. C. and J. A. Lancaster
1975 *Badger House Community*. Archeological Research Series F-E, National Park Service, Washington, D.C.

Heizer, R. F.
1967 Analysis of human coprolites from a dry Nevada cave. *Univ. of California Arch. Survey Reports* 70: 1-20.

Hocking, G. M.
1956 Some plant materials used medicinally and otherwise by the Navaho Indians in the Chaco Canyon, New Mexico. *El Palacio* 43: 146-165.

Judd, N.
1954 The Material Culture of Pueblo Bonito. *Smith. Misc. Coll.* Vol. 124, Washington, D.C.

Kelso, G. K. and A. M. Solomon
1976 Pollen analysis of human coprolites: implications of experimental evidence from modern fecal samples. *In*: "Amer. Quat. Assoc. Abstracts of Fourth Biennial Meeting," p. 142. Tucson.

Kramer, P. J.
1969 *Plant and Soil Water Relationships: A Modern Synthesis*. McGraw Hill, New York.

Martin, A. C. and W. D. Barkley
1961 *Seed Identification Manual*. Univ. of California Press, Berkley.

Martin, P. S. and W. Byers
1965 Pollen and archaeology at Wetherill Mesa. *In*: "Contributions of the Wetherill Mesa Archeological Project," assembled by D. Osborne. *Memoirs of the Soc. Amer. Arch.* No. 19, pp. 122-135. Salt Lake City.

Martin, P. S. and F. W. Sharrock
1964 Pollen analysis of prehistoric human feces: a new approach to ethnobotany. *Amer. Antiquity* 30: 168-180.

Martin, P. S. and F. Plog
1973 *The Archaeology of Arizona*. Doubleday, New York.

Marquardt, W. H.
1974 A statistical analysis of constituents in human paleofecal specimens from Mammoth Cave. *In*: "Archaeology of Mammoth Cave Area," ed. by P. J. Watson, pp. 193-202. Academic Press, New York.

Mayer, W. V.
1952 The hair of California mammals with keys to the dorsal guard hairs of California mammals. The Amer. Midland Nat. 48: 480-511.

Minnis, P. E. and R. I. Ford
1977 Paleo-ethnobotany of Black Mesa, Arizona: I. Ethnobotany Lab Report No. 490, Michigan.

Morris, E. H.
1939 Archaeological Studies in the La Plata District. Carnegie Inst. of Washington, Publ. No. 519. Washington, D.C.

Napton, L. K.
1971 Archaeological Investigations in Lovelock, Nevada. Unpublished Ph.D. dissertation, University of California. Berkley.

Nickens, P. R.
1975 Prehistoric cannibalism in the Mancos Canyon, southwestern Colorado. The Kiva 40 (4): 283-293.

Parsons, E. C.
1939 Pueblo Indian Religion. Univ. of Chicago Press, Chicago.

Paschall, A. L.
1917 How to combat rabbits, gophers, prairie dogs, coyotes, ants and grasshoppers. Univ. of Arizona Agric. Exper. Station Bull. No. 81. Tucson.

Portis, S. A.
1953 Diseases of the Digestive System. Lea and Febiger, Philadelphia.

Peden, D. G., R. M. Hansen, R. W. Rice, and G. M. Van Dyne
1974 A double sampling technique for estimating dietary composition. Jour. Range Manage. 27: 323-325.

Rohn, A. H.
1964 Prehistoric soil and water conservation on Chapin Mesa, Southwestern Colorado. Amer. Antiquity 28: 441-455.

1971 Mug House. Archeological Research Series F-D, National Park Service, Washington, D.C.

Sabels, B. E.
n.d. Manganese and Phosphorus Abundances in Wetherill Mesa Feces and Soils, with some Implications Concerning the Prehistory of the Mesa Verde Cliff Dwellers. Unpublished report on file at Mesa Verde National Park Museum, Colorado.

Samuels, R.
1965 Parasitological study of long-dried fecal samples. In: "Contributions of the Wetherill Mesa Archeological Project," assembled by D. Osborne, pp. 175-179. Memoirs of Soc. Amer. Arch. No. 19. Salt Lake City.

Schiffer, M. B.
1972 Cultural laws and reconstruction of past lifeways. The Kiva 37: 149-157.

Scott, L. J.
1974 Palyontological Analysis of Site 5MTUMR 2344. Unpublished report on file at the University of Colorado, Boulder.

Shelford, V. E.
1963 The Ecology of North America. Univ. of Illinois Press, Chicago.

Smith, P. E. L.
1973 Land-use, settlement patterns and subsistence agriculture: a demographic perspective. Reprint RIO in Ecology and Agricultural Settlements, ed. by R. Tringham. Warner Modular Publ. Andover, Massachusetts.

Sparks, D. R.
1968 Diet of black-tailed jackrabbits on Sandhill Rangeland in Colorado. Jour. Range Manage. 21: 203-208.

Stevenson, M. C.
1915 Ethnobotany of the Zuni Indians. Government Printing Office, Washington, D.C.

Steward, J. H.
1955 Theory of Cultural Change. Univ. of Illinois Press, Urbana.

Stiger, M. A.
1975a The coprolites of Hoy House: a preliminary analysis. Abstract in Jour. of Colorado-Wyoming Acad. Sci. 7. Denver.

1975b The coprolites of Hoy House: a preliminary analysis. In: "The 1974 Johnson-Lion Canyon Project: Report of Investigations I," ed. by P. R. Nickens. Report submitted to Four-Corners Regional Commission. Copy on file Univ. of Colorado, Department of Anthropology, Boulder.

1976 The application of microtechnique to the analysis of coprolites. In: "The Johnson-Lion Canyon Project: Report of Investigations III," ed. by P. R. Nickens. Report submitted to Four-Corners Regional Commission. Copy on file Univ. of Colorado, Department of Anthropology, Boulder.

Storr, G. M.
1961 Microscopic analysis of feces, a technique for ascertaining the diet of herbivorous mammals. Australian Jour. Biol. Sci. 14: 157-164.

Van Cleave, H. J. and J. A. Ross
1947 A method of reclaiming dried zoological specimens. Science 105: 318.

Watson, P. J.
1974 Theoretical and methodological difficulties in dealing with paleofecal material. In: "Archaeology of the Mammoth Cave Area," ed. by P. J. Watson, appendix pp. 239-241. Academic Press, New York.

Weefner, F. M.
1960 General Zoological Microtechniques. Williams and Wilkin, Baltimore.

Welsh, S. L. and J. A. Erdman
1964 Annotated checklist of the plants of Mesa Verde, Colorado. Brigham Young Univ. Biol. Series Vol. 4, No. 2. Provo.

Whiting, A. F.
1939 Ethnobotany of the Hopi. Museum of Northern Arizona, Bull. No. 15. Flagstaff.

Wilke, P. and H. J. Hall
1975 Analysis of Ancient Feces: A Discussion and Annotated Bibliography. Unpublished report on file at the Univ. of California, Berkley.

Willey, G. R.
1966 An Introduction to American Archaeology Vol. I: North and Middle America. Prentice-Hall, Inc. New Jersey.

Williams, O.
1962 A technique for studying microtine food habits. Jour. Mamm. 43 (3): 365-368.

1969 An improved technique for identification of plant fragments in herbivore feces. Jour. Range Manage. 22: 51-52.

Williams-Dean, G. and V. M. Bryant, Jr.
1975 Pollen analysis of human coprolites from Antelope House. The Kiva 41: 97-112.

Winter, J. C.
1976 The Processes of Farming Diffusion in the Southwest and Great Basin. Amer. Antiquity 41: 420-429.

Woodbury, R. B.
1954 Prehistoric Stone Implements of Northeastern Arizona. _Papers of the Peabody Mus. Amer. Arch. and Ethn._ Vol. 34. Cambridge.

Wormington, H. M.
1947 _Prehistoric Indians of the Southwest._ Denver Mus. Nat. Hist. Denver.

Young, B. H.
1910 The Prehistoric Men of Kentucky. _Filson Club Publ._ No. 25, Louisville.

APPENDIX

APPENDIX A

ETHNOBOTANY OF PLANTS FOUND IN FECES

SOURCES: Hopi--Whiting (1939)

Zuni--Stevenson (1915)

Navaho--Hocking (1955)

Archaeological (Black Mesa)--Minnis and Ford (1977)

Amaranthaceae

Amaranth: Hopi--eaten as greens and seeds used.

Zuni--seeds ground, mixed with corn and cooked by steaming.

Navaho--none.

Archaeological--none.

Anacardiaceae

Skunkbush: Hopi--berries used to flavor beverage.

Zuni--none.

Navaho--berries eaten, juice used as beverage.

Archaeological--none.

Boraginaceae

Cryptantha: Hopi--medicinally for pains and swellings.

Zuni--none.

Navaho--medicinally as childbirth aid.

Archaeological--none.

Cactaceae

Prickly Pear: Hopi--eaten after being dethorned and boiled.

Zuni--thorns are removed and pads are eaten raw or boiled. Fruit is dried and stored, ground, mixed with corn meal for mush.

Navaho--eaten after being boiled or dried.

Archaeological--both pads and fruit eaten.

Capparidaeae

Beeweed: Hopi--young plants boiled and eaten.

Zuni--young leaves boiled, dried for winter use.

Navaho--young plants used for greens, young seedpods used.

Archaeological--seeds and greens eaten.

Chenopodaceae

Bugseed: None

Goosefoot: Hopi--boiled and baked, commonly eaten.

Zuni--seeds ground, mixed with corn meal and steamed. Also plants boiled and eaten.

Navaho--parched seeds eaten, seed meal eaten as well as leaves cooked or raw.

Archaeological--as a potherb and seeds in a gruel.

Saltbush: Hopi--ash in piki bread, leaves eaten as greens.

Zuni--seeds eaten raw and cooked.

Navaho--parched seeds used for flour, leaves eaten.

Archaeological--none.

Compositaceae

Sagebrush: Hopi--leaves baked and eaten, medicinal for upset stomach.

Zuni--seeds ground.

Navaho--seed ground and medicinally for corns.

Archaeological--none.

Sunflower:

Hopi--seeds eaten.

Zuni--medicinally for snakebite.

Navaho--seeds eaten.

Archaeological--none.

Cruciferaceae

Peppergrass:

Hopi--none.

Zuni--none.

Navaho--used as disinfectant.

Archaeological--none.

Cyperaceae

Scirpus:

Hopi--ceremonial.

Zuni--none.

Navaho--none.

Archaeological--none.

Elaeagraeae

Buffaloberry:

Hopi--none.

Zuni--none.

Navaho--medicinally for fever, eaten fresh and dried.

Archaeological--none.

Equisetum

Horsetail:

Hopi--used for sacred bread.

Zuni--none.

Navaho--none.

Archaeological--none.

Gnetaceae

Mormon Tea: Hopi--medicinal.

Zuni--medicinal and for beverage.

Navaho--medicinal.

Archaeological--none.

Graminaceae

Dropseed: Hopi--easily harvested grain, starvation food.

Zuni--roofing material.

Navaho--seeds used for tortillas and dumplings.

Archaeological--none.

Panicum: Hopi--food?

Zuni--none.

Navaho--none.

Archaeological--none.

Ricegrass: Hopi--excellent food, collected in quantity especially in times of famine.

Zuni--none.

Navaho--ground seeds eaten.

Archaeological--none.

Pinaceae

Juniper: Hopi--medicinal tea and ceremonial uses, firewood, berries eaten and used in stews.

Zuni--ceremonial and medicinal.

Navaho--seed medicinal, seeds eaten.

Archaeological--berries eaten whole or ground.

Pinon: Hopi--nuts eaten.

Zuni--nuts eaten, important, choice food supply.

Navaho--nuts eaten and sold to Pueblos.

Archaeological--important food source.

Polygonaceae

Knotweed: Hopi--eaten?

Zuni--none.

Navaho--none.

Archaeological--none.

Wild Buckwheat: Hopi--eaten, used medicinally.

Zuni--none.

Navaho--roots eaten, medicinal, seeds eaten.

Archaeological--none.

Portulacaceae

Purselane: Hopi--plant cooked, used as a gravy.

Zuni--none.

Navaho--leaves used as potherb, seeds for mush and flour.

Archaeological--used for greens, seeds also.

Rosaceae

Chokecherry: Hopi--replaced by cultivated cherry.

Zuni--none.

Navaho--none.

Archaeological--berries eaten fresh and stored.

Solanaceae

Groundcherry: Hopi--fruit eaten in olden times.

Zuni--highly prized, boiled with onions.

Navaho--eaten fresh and dried.

Archaeological--none.

Ulmaceae

Hackberry: Hopi--none.

Zuni--none.

Navaho--none.

Archaeological--none.

APPENDIX B

ECOLOGY OF PLANTS FOUND IN FECES

SOURCES: Welsh and Erdman (1964)
Harrington (1964)

Disturbed Areas--Fields, Trash

Amaranth, Beeweed, Bugseed, Compositaceae, Cryptantha, Goosefoot, Graminaceae, Knotweed, Panicum, Peppergrass, Prickly Pear, Purseland, Ricegrass, Sagebrush, Sunflower.

Canyons

Dropseed, Mormon Tea, Hackberry, Juniper, Pinon, Prickly Pear, Sagebrush, Saltbush, Skunkbush, Wild Buckwheat.

Marshes and Riverside

Buffaloberry, Bulrush, Horsetail.

Undisturbed Forest

Cryptantha, Juniper, Pinon, Prickly Pear, Wild Buckwheat.

APPENDIX C

Individual Hoy House Coprolites

	Specimen Number							
	2-1	2-2	3-1	5-1	5-2	5-3	5-4	10-1
Domesticated Plants								
Corn Cobs			X					
Coarse Corn	X		X		X	X	X	X
Finely Ground Corn		X		X				
Corn Husk	X	X	X	X		X		X
Squash						X	X	
Non-Domesticated Plants								
Amaranth						X		
Groundcherry						X		
Pinon	X					X		
Prickly Pear			X	X	X	X		
Purselane						X	X	
Ricegrass					X			
Saltbush		X			X	X		
Unidentified Tissue				X				
Animal								
Human Hair		X	X					
Dog/Coyote Hair	X							X
Cicada								X

	Specimen Number							
	10-2	10-3	10-4	10-5	14-1	14-2	14-3	4-4
<u>Domesticated Plants</u>								
Coarse Corn	X	X	X	X		X		X
Finely Ground Corn					X		X	
Corn Husk			X		X		X	
Bean							X	
Squash								X
<u>Non-Domesticated Plants</u>								
Amaranth								X
Buffaloberry								X
Goosefoot				X				
Groundcherry	X		X	X				
Pinon								X
Prickly Pear						X		
Saltbush		X			X			
Unidentified Tissue		X			X			
<u>Animal</u>								
Human Hair						X	X	X
Dog/Coyote Hair	X	X	X	X				
Deer Hair			X	X				
Jackrabbit Hair					X			
Unidentified Hair		X						
Squirrel Bone		X						
Unidentified Mammal Bone								X

	Specimen Number							
	14-5	14-6	19-1	19-2	19-3	28-1	32-1	32-3
Domesticated Plants								
Coarse Corn	X		X	X	X		X	X
Finely Ground Corn		X				X		
Corn Husk	X	X	X	X	X	X	X	
Bean				X		X		
Non-Domesticated Plants								
Beeweed					X			
Buffaloberry			X					X
Goosefoot					X			
Groundcherry					X		X	X
Juniper Bast		X						
Pinon								X
Prickly Pear			X	X (pollen)				
Ricegrass							X	
Saltbush			X					
Sagebrush							X	
Wild Buckwheat			X					
Animal								
Human Hair	X	X				X	X	X
Dog/Coyote Hair		X	X					
Jackrabbit Hair		X		X				
Bear Hair							X	
Unidentified Hair				X	X			
Feather		X				X		

	Specimen Number (cont.)							
	14-5	14-6	19-1	19-2	19-3	28-1	32-1	32-3
Animal (cont.)								
Mouse Bones	X							
Unidentified Rodent Bones						X		
Non-Mammal and Non-Bird Bone				X				

	Specimen Number							
	32-4	36-1	36-2	36-3	36-4	42-1	42-2	42-4
Domesticated Plants								
Coarse Corn	X					X	X	
Finely Ground Corn		X	X	X	X			X
Corn Husk		X	X	X	X	X	X	X
Bean		X			X	X		
Squash	X						X	
Non-Domesticated Plants								
Amaranth							X	
Goosefoot				X		X		
Groundcherry	X						X	
Pinon						X		
Prickly Pear	X		X					
Purselane						X	X	
Saltbush			X					
Unidentified Tissue				X	X	X		X
Animal								
Human Hair						X	X	X
Dog/Coyote Hair		X			X			
Deer Hair					X			

	Specimen Number							
	42-5	57-1	57-2	57-3	57-4	57-5	57-6	57-8
Domesticated Plants								
Coarse Corn			X	X				X
Finely Ground Corn	X	X			X	X	X	
Corn Husk		X	X	X	X	X		X
Bean					X	X	X	
Squash			X					
Non-Domesticated Plants								
Beeweed	X							
Goosefoot							X	
Grass						X		
Juniper Bast				X				
Pinon			X					
Prickly Pear					X			
Purselane			X			X		
Saltbush			X					
Unidentified Tissue				X		X		
Animal								
Human Hair					X	X		X
Dog/Coyote Hair				X				
Deer Hair				X				
Jackrabbit Hair			X					
Feather				X				
Turkey Bone			X					
Unidentified Rodent Bone		X						
Cartilage/Sinew				X				

	Specimen Number							
	60-1	60-2	60-3	60-4	60-5	60-6	60-7	60-8
Domesticated Plants								
Coarse Corn	X	X	X		X	X		
Finely Ground Corn				X			X	X
Corn Husk		X		X	X		X	X
Squash			X		X	X		X
Non-Domesticated Plants								
Amaranth				X				
Beeweed				X				
Goosefoot			X					
Groundcherry			X	X	X	X	X	
Prickly Pear		X						X
Purselane						X		
Saltbush	X							
Unidentified Tissue	X	X					X	
Animals								
Human Hair					X	X	X	X
Feather				X				
Unidentified Rodent						X		
Cartilage/Sinew						X		

	Specimen Number							
	60-9	60-10	60-12	60-13	64-1	64-2	65-1	65-2
Domesticated Plants								
Coarse Corn	X	X		X		X		X
Finely Ground Corn			X		X		X	
Corn Husk	X	X		X	X			X
Bean							X	
Squash			X					
Non-Domesticated Plants								
Amaranth					X			
Chokecherry		X	X					
Groundcherry		X						
Pinon							X	
Prickly Pear				X	X			
Purselane	X	X				X		
Saltbush						X		
Sunflower					X			
Unidentified Tissue			X			X		X
Animal								
Human Hair							X	
Dog/Coyote Hair						X		
Unidentified Rodent Hair							X	

Individual Lion House Coprolites

	Specimen Number			
	9-1	10-1	10-2	13-1
Domesticated Plants				
Finely Ground Corn		X	X	
Corn Husk		X	X	X
Squash	X			
Non-Domesticated Plants				
Groundcherry				X
Prickly Pear		X		
Purselane	X			
Saltbush		X		
Unidentified Tissue	X			
Animal				
Dog/Coyote Hair	X			
Gopher Hair				X