IV. INADEQUACY OF COPROLITES AND RANDOM FECAL SPECIMENS AS DIETARY INDICATORS

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Introduction

The first caucasian explorers of the vast reaches of western Nevada, northeastern California, and southern Oregon found that the region was occupied by scattered bands of Northern Paiutes. These Indians were nomadic food gatherers who had no permanent habitation and left no writing or engravings that could lead one to understand their food habits. All that is known about the Paiutes today is from two main sources: archaeological and anthropological findings in the Lovelock Cave located in the Nevada Great Basin area, and recent interviews and observations.

According to Powers (1877)in 1877, the diet of the Northern Paiute living near Pyramid Lake, Nevada, consisted approximately 50% sucker (probably Cui-ui or Kuyui, Casmistes Cujus), 25% game (species not given) and 25% vegetable products. In 1861 Wright (1963) observed Northern Paiute living in the Carson River basin. They called themselves the "Toitekade" or "Tule-eaters" and they sustained themselves by gathering wild seeds and roots; hunting wild fowl and game, and fishing, Other more or less vague references to foods consumed by a number of various Northern Paiute bands living in Nevada during the Historic Period are given by Hopkins (1883), as well as Steward (1940: 445-502), Stewart (1938: 405-407) and Lowie (1924: 185-314).

In order to investigate the diet eaten in prehistoric times it is necessary to turn to archaeological finds such as coprolites. These dried lumps of human excrement, which have been protected from erosion and from bacterial decomposition by the process of dessication, have provided valuable clues as to the type of food consumed by these early American Indians (Heizer and Napton 1969: 563-568). Food fragments extracted from samples of 250 Lovelock Cave coprolites covering a time range from A. D. 50 to A. D. 1820 indicate that the diet of the cave population included fish, (Gila siphateles bicolor, Rhinichthys osculus robustus, Catostomus tahoensis); coot or mudhen (Fulica Americana), ducks, and other waterfowl; antelope, squirrel, big horn sheep; bulrush seeds (Scirpus sp) and cattail seeds and pollen (Typha latifolia), other seeds, roots and acquatic tubers.

Some of these foods derived from the lacustrine biome are known to be high in nutrient content and could have formed the basis of a nutritionally adequate diet if they were consumed in sufficient amounts. It is this piece of information, the amount

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eaten of foods within a food class, that is needed to estimate the quality of the indigenous peoples diet.

It is known that the volume of feces differs according to type of diet, being increased with coarse diets rich in poorly absorbed components, particularly dietary fiber, and to a lesser extent, with increased amounts of food eaten (Calloway 1972: 197-202). Fecal matter includes the residue remaining in the intestine after the digestion and absorption of food, together with components of intestinal secretions, epithelial debris, bacterial cells, and products of their metabolism and decomposition. The relationships of endogenous and bacterial components to the amount and nature of foods ingested are recognized but poorly known. In attempting to use coprolites as a clue to ascertaining the quality of the diet, some additional problems are evident. Coprolites have been subjected to an unknown amount of continued action of enteric bacteria and to the action of all manner of invading organisms, as well as to the effects of oxidization and other less obvious environmental variables. Thus, it is unlikely that analysis of isolated fresh fecal specimens or coprolites would indicate reliably the types and amounts of foods that made up the individual's diet, but this possibility has been raised. We report here the negative outcome of a small study designed to check this possibility, and provide comparative data on the composition of fresh feces and coprolites from the Lovelock Cave.

Procedure

Fresh fecal specimens were obtained under controlled laboratory conditions from human male subjects consuming their normal, self-selected diets, a controlled formula diet, and test meals composed of two of the most common staple foods of the Lovelock Lacustrine diet, bulrush seeds (Scirpus robustus) [1] and common coot or mudhen (Fulica americana) [2]. The test meals were fed with a balanced low residue formula diet in order to increase the probability of detecting variations due to different amounts and types of foods. Feces voided by the men in this experiment were compared, by chemical analysis, with Lovelock Cave coprolites.

The subjects were four healthy young men 21 to 25 years of age, weighing between 60 and 70 kg. The men were given a standard, nutritionally balanced, low residue formula diet (Calloway and Margen 1971: 205-216) on the first day of the experiment and between the different test meals. The test foods were given in random order to each of the men as the breakfast meal.

The mudhen was deboned and baked at 220°F for one-half hour. Test portions were 50 and 100 g of roasted muscle. The bulrush seeds were toasted or parched over a burner with low heat for about 30 minutes until the seeds attained a brownish cast similar to that observed on the bulrush seeds found in the Lovelock Cave coprolites. The seeds were virtually inedible in this state. In order to simulate one of the probable methods of processing (pulverizing with mortar and pestle) the seed was passed through a hammer mill with a coarse (50 mesh) sieve. The coarse flour, 25 and 50 g portions,

was mixed with pure wheat starch and served as wafers.

Each individual defecation was collected separately from each individual and pooled by 24 hr timed intervals beginning not less than 6 hrs after the first test meal. Feces were also collected during 24 hr of uncontrolled normal food intake. The fecal samples were mixed with equal parts of distilled water (w/v) and homogenized using a colloid mill.

Samples of the cooked wet food items[3] and feces were analyzed for energy content, after lyophilization, using a ballistic bomb calorimeter (Miller and Payne 1959: 501). Total nitrogen content was determined by the micro Kjeldahl method (Block and Weiss 1956: 11) and ash content by the AOAC procedure. Dry coprolites were analyzed, without further treatment, for content of ash and energy.

Results and Discussion

The men easily tolerated the 50 and 100 g test meals of mudhen although it was very strong in flavor and somewhat disagreeable. The bulrush seeds were not well tolerated. The subjects experienced marked discomfort and difficulty in swallowing, and sensations of irritation in the esophagus. The composition of the foods is given in Table 1.

The stools were not loose or watery; on the contrary, they were bulky and well formed and none of the subjects reported any untoward gastrointestinal symptoms. Because of marked individual variability, there was not significant difference between feces reflecting 50 and 100 g meals of mudhen nor between 25 and 50 g meals of bulrush seeds; therefore, the data have been presented by subject and dietary main treatment (Table 2).

The fecal wet weight and dry solids were considerably lower with the control formula diet, in comparison to the rest of the diets tested. Computation on a moisture- and ash-free basis shows energy value of fecal organic matter to be the same for all subjects and treatments, about 6.0 kcal/g. This energy content is virtually identical with published values (Heizer and Napton 1970: 1-86). Because the fecal organic matter varies little in energy content, the variation in daily energy loss in the feces was a function of the amount of organic matter excreted. The lowest value was 104 kcal/day with the formula diet and the highest values, 186 and 175 kcal/day, occurred with the normal diet and the test doses of bulrush seeds.

Feces from subjects fed formula alone or with bulrush seeds or mudhen contained about 8% nitrogen on a dry solids basis and this value was somewhat (although not significantly) higher than with the normal diet (6.5%). Ash made up 15% of fecal dry solids with normal diet, formula, and bulrush-seed meals. Ash was higher in mudhen samples (19%). However, variation among subjects fed the four food treatments was as great as variation among dietary treatments. Thus, the fecal composition did

not reflect even major differences in diet.

Nitrogen content suggests that the fecal organic matter is about half "protein" (including nucleic acids, amines, etc.). The remainder of the fecal matter must be equally divided between carbohydrates and fats based on energy value.

Coprolites were higher in ash content than fresh fecal samples (Table 3). The organic matter of coprolites has apparently been reduced during the time that has elapsed since the feces were deposited in the cave. The high ash and low organic content of coprolites probably results from post-depositional bacterial action, prior to the time desiccation slowed the rate of bacterial activity and from contamination by cave sediments adhering to the coprolite specimens. With one exception, the several specimens of coprolites examined were lower in energy value than fresh materials, on an ash-free basis, indicating that they contained a higher percentage of oxidized compounds. Oxidation of materials exposed to air would be expected even after the bacterial action ceased; however, there may have been greater bacterial utilization of fats in the feces than of the carbohydrates present, or the primitive diet may have been exceptionally low in fat content.

Summary

Food items ingested by the Northern Paiute Indians or their cultural predecessors have been identified by examination of dessicated fecal remains (coprolites) found in Nevada caves. Fresh samples of two of these foods were fed to men in an attempt to relate composition of fecal matter to the presence and amount of these foods in the diet, with an ultimate objective of quantifying food intake based on the contents of prehistoric human coprolites. The total amount of fecal matter excreted was affected by the diet. Fecal analyses revealed no differences in composition or energy content of the fresh specimens that could be related to the type or amount of food consumed. Thus isolated fecal specimens cannot be used to make quantitative inferences concerning the diet.

Compared with fresh fecal specimens, coprolites were high in ash content. Energy content of the organic matter in coprolites was variable and was generally lower than the uniform value of about 6 kcal/g obtained for fresh feces.

Acknowledgement

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FOOTNOTES

1 The bulrush seeds were obtained from Stillwater Wildlife Management area near Fallon, Nevada, through the courtesy of Mr. Larry Worden, superintendent of the management area. The seeds were identified as Scirpus robustus and exhibit no morphological differences when compared to seeds recovered from coprolites found in Lovelock Cave.

2. The fowl also were obtained under authority of Federal permit at the Stillwater Wildlife Management area, Nevada. These mudhens were the same species of fowl taken by the Northern Paiute in historic times at the Carson and Humboldt Lakes.

3. Fish (Gila Sipateles bicolor, Tui Chub) procured for the study were not fed but were analyzed after baking. The fish were obtained from Lake Almanor in northern California through the cooperation of Mr. Jack Hansen, California Department of Fish and Game.

TABLE 1. Composition of Cooked Foods

Products	% of Dry Solids		Dry Organic Matter	
	Nitrogen	Ash	Nitrogen,%	kcal/g
Bulrush seeds (Scirpus robustus)	1.19	2.18	1.22	5.8
Fish, Tui Chub (Gila Siphateles bicolor)	12.66	4.21	13.22	6.4
Mudhen (Fulica americana)	11.86	8.06	12.89	6.1

Subjects	Wet Wt. g	Dry Solids g	Nitrogen g	Ash g	Organic Matter g	Kcal	H_2O, %	Nitrogen, % dry basis	Ash % dry basis	Organic % Nitrogen	Matter kcal/g
Subject Means, all treatments											
A	132	33.5	2.63	6.07	27.4	167	72.3	8.00	18.6	9.91	6.05
B	204	42.5	3.23	6.97	35.6	215	77.4	7.66	25.9	9.16	5.97
C	92	20.4	1.44	2.55	17.8	103	76.4	7.59	14.3	8.92	5.82
D	99	21.5	1.48	2.97	18.5	112	78.3	6.84	13.6	7.95	6.05
Treatment Means, all subjects											
Normal diet	189	36.7	2.41	5.55	31.1	186	77.9	6.54	14.8	7.83	5.97
Formula diet	89	20.6	1.52	3.00	17.6	104	77.0	7.60	14.6	8.93	5.90
Mudhen	104	27.4	2.16	5.05	22.5	134	73.1	8.03	18.6	9.87	5.90
Bulrush seeds	144	33.5	2.66	5.03	28.5	175	76.4	7.91	14.5	9.32	6.12
Study mean	131	29.5	2.18	4.65	24.9	159	76.1	7.52	15.6	8.98	5.97
Standard deviation	±45.0	±7.1	±0.48	±1.13	±6.06	±37.8	±2.09	±0.67	±1.97	±0.86	±0.10

TABLE 2. Fecal Composition of Individual Subjects in Comparison to Different Meals Tested

TABLE 3. Composition of Human Coprolites from Lovelock Cave, Nevada

Coprolite sample [1]	Ash %	Organic Matter kcal/g
NV-Ch-18, WA-A 10'-11' [2]	25.22	4.7
NV-Ch-18, CR-1	25.93	6.6
NV-Ch-18, CR-2	24.92	5.4
NV-Ch-18, CR-3	22.99	4.1
Mean	24.76	5.2
Standard deviation	1.25	1.07

1 The approximate age of the "WA 10-11" coprolites is A.D. 50, based on radiocarbon determinations of sample specimens obtained at a depth of eleven to twelve feet beneath the surface of the cave floor in the "West Alcove" of Lovelock Cave. See Heizer and Napton (1970: 1-86) for discussion of the stratigraphy of the West Alcove and its significance. The CR-1, CR-2, and CR-3 samples were obtained from the "West Crevice" of Lovelock Cave and are probably slightly older than the West Alcove coprolites.

2 This sample contained 10.8% moisture and 4.9% nitrogen.

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