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**DIETARY AND PARASITOLOGICAL ANALYSIS OF
COPROLITES RECOVERED FROM MUMMY 5,
VENTANA CAVE, ARIZONA**

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ABSTRACT

Four coprolites were excavated with Burial 5 at Ventana Cave, a partially mummified five-year-old child. Two coprolites were granular and dark in color and two were fibrous and light in color. The coprolites are remains of the child's intestinal contents and were submitted for dietary and parasitological analysis. No parasites were found. The fibrous coprolites proved to be remains of highly masticated mesquite pods (*Prosopis*). The granular coprolites consist of seeds of saguaro cactus (*Carnegiea gigantea*). Pollen analysis reveals two dietary pollen types, both derived from cactus. No evidence of cultivated plants except for a trace amount of corn pollen was found.

RESUMEN

*Cuatro coprolitos fueron excavados con el Enterramiento 5 en Ventana Cave, un niño de cinco años de edad parcialmente momificado. Dos coprolitos eran granulares y oscuros, los otros dos fibrosos y de color claro. Los coprolitos son restos del contenido intestinal del niño y fueron sometidos a análisis parasitológico y de dieta. No se encontró parásito alguno. Los coprolitos fibrosos demostraron ser restos de vainas de mezquite (*Prosopis*) sumamente masticadas. Los coprolitos granulares consisten en semillas del cacto saguaro (*Carnegiea gigantea*). El análisis polínico revela dos tipos de polen en la dieta, ambos derivados de cactus. No se encontraron evidencias de plantas cultivadas, con excepción de una mínima cantidad de polen de maíz.*

The analysis of coprolites has long been recognized a source of dietary information (for reviews see Bryant and Williams-Dean 1975; Callen and Cameron 1960; Fry 1977; Reinhard 1988), medicinal information (Holloway 1985; Reinhard and others 1985; 1991), and recently parasitological data (Horne 1985; Reinhard 1985a, 1985b, 1985c, 1988, 1990; Reinhard and others 1987, 1988). Coprolites preserved in mummies (actually colon and intestinal contents) have the potential of providing similar data and can be analyzed with the same techniques used in coprolite analysis.

Several studies of mummified colon contents have demonstrated the potential of recovering dietary, parasitological and pharmaceutical data. For example, analysis of coprolite fragments from mummies in Peru and Brazil have revealed

evidence of prehistoric hookworm infection (Allison and others 1974; Ferreira and others 1983) and tapeworm infection (Callen and Cameron 1960). Palynological and macrobotanical analysis of colon contents found in a Mimbres burial revealed evidence of willow tea, probably consumed for its medicinal properties (Reinhard 1986; Shafer and others 1989). Dietary studies have been carried out in the analysis of Anasazi mummies (Fry 1977), a mummy recovered from the Lower Pecos area of west Texas (Turpin and others 1986) and a mummy from the Ozarks of Arkansas (Wakefield and Dellinger, 1936).

Colon contents of a burial excavated from Ventana Cave were examined for parasitological and dietary remains. This partially mummified child, Burial 5, was excavated from Ventana Cave in the Papago Reservation of Southern Arizona. The burial was recovered in excavations in 1941 and 1942 and has since been curated at the Human Identification Laboratory, Arizona State Museum. The burial is ascribed to the Hohokam culture and probably dates between A.D. 1000 and 1450 (Haury 1950). The child was five to six years of age at death. It is partially mummified and consists of a nearly complete skeleton, some soft tissue, and hair.

Four coprolites, preserved by desiccation, were found with the burial and represent preserved intestinal contents. Two were dark colored and granular. Two were light brown and fibrous. One-gram fragments of each type were submitted for analysis. As demonstrated by this analysis, very small coprolite fragments (1.0 gram) can be utilized for holistic macroscopic and microscopic analysis of both zoological and botanical remains. The analysis is important in demonstrating the potential of the Ventana Cave mummies in yielding dietary data. It is also significant in that it is the first coprolite analysis from the Sonoran Desert in general and the Hohokam area in specific.

MATERIALS AND METHODS

The analysis of coprolites has been well established by several researchers (Callen and Cameron 1960; Fry 1977; Bryant and Williams-Dean 1975; Reinhard and others 1987, 1988) and follows several stages. The first stage consists of reconstitution in 0.5 percent trisodium phosphate for 48 hours. In the case of the Ventana Cave coprolites, one-gram fragments of one dark granular coprolite and one light-colored fibrous coprolite were reconstituted. To each fragment, a *Lycopodium* spore tablet was added. The tablet contains 11,200 plus or minus 400 spores. The addition of the spores allows for the quantification of microscopic remains by calculating ratios with the known number of spores added to each gram of material.

The coprolites are typically screened to separate macroscopic material from microscopic detritus. In the case of the Ventana Cave coprolites, two screen-mesh sizes were used. A larger mesh of 300 microns separated macroscopic remains

from microscopic remains. A second screening through a 150-micrometer mesh separated large microscopic remains from smaller remains such as pollen and parasite eggs. The macroscopic remains were dried on blotter paper at room temperature and were analyzed after drying. The different size microscopic components were sedimented individually in acetic formalin alcohol (AFA). Microscope preparations were then made from these sediments.

The examination of macroscopic sediments was accomplished with a biocular dissecting scope. Identification of seeds was based on a seed comparative collection.

Microscopic remains were examined with a compound binocular microscope. The larger microscopic remains were examined for the presence of plant cuticle, seed fragments, phytoliths and other identifiable objects. The smaller microscopic sediments were examined for parasite eggs.

After the parasite examination, the smaller microscopic remains were treated for the extraction of pollen. This was accomplished by treating the samples in hydrofluoric acid to dissolve silicates, followed by heavy density flotation in zinc bromide (specific gravity 2.0). The floated remains were then treated with an acetolysis solution to dissolve cellulose, hemicellulose, and chitin. The residue from this process was transferred to glass vials in alcohol and sedimented. The sediments were used to make microscope pollen preparations and the pollen grains were counted.

In general application to coprolites, different size components provide different types of data. The macroscopic material contains bone and scales that reflect animal consumption, seeds and fiber from plant consumption, and grit from grinding stones. Microscopic analysis provides evidence of helminth parasites, fungal organisms and mites that decompose feces, lice and pollen. Both types of analysis provide evidence of hair, insects, plant cuticle (epidermis), and phytoliths (crystals that form in and between the cells of plants).

RESULTS

The macroscopic remains of the dark, granular coprolite consisted of saguaro cactus seed (*Carnegiea gigantea*) and to a lesser amount the fibers of mesquite pods (*Prosopis* sp.). The seeds were probably ground as evidenced by the extreme fragmentation of the seeds which exceeds that of normal mastication. Whole seeds were rare. When ground, the hilum of each seed tends to break off and preserve in recognizable form. Based on the count of hila and whole seeds, at least 439 saguaro seeds per gram of coprolite are present. Also present in this gram of coprolite were 11 insect fragments, 13 mesquite pod fragments, one grass leaf, and 5 seeds unidentified to genus but in the Solanaceae (potatoe family).

The macroscopic remains of the fibrous coprolite fragments contained a predominance of mesquite fiber with a few saguaro seeds. Two peduncles of mesquite pods were found, as well as 46 mesquite pod fragments. Remains of 105 saguaro

seeds were identified. In addition, a mesquite leaf was present, as was a human hair.

The examination of the larger microscopic remains revealed several components. Extremely tiny saguaro seed coat fragments were very common. Mites were common and may have been involved in the decomposition of the mummy. Unidentifiable plant tissue was also common, as were trachieds which are formed in plant water conducting tissue. Phytoliths were rare, but those that were found appear to be from prickly pear or cholla (*Opuntia* spp.). One fragment of plant epidermis was found and may be derived from *Agave* spp. This possible identification is based on comparative examination of modern epidermis sections of *Agave*, *Yucca*, and *Dasylyrion*.

Extensive examination of 12 microscope preparations from the small microscopic debris failed to reveal any parasite eggs. This examination indicates that the child was not parasitized by reproductive stages of intestinal worms.

Cactus pollen was very common and pollen grain per gram calculations were made. In the dark, granular coprolite, 500,000 pollen grains per gram of coprolite were present. Of these, about 11,000 were from prickly pear or cholla (*Opuntia* sp.) and 1,500 were from non-dietary, wind pollinated plants. The remainder are from an unknown ceroid-type cactus which may be saguaro, judging from the abundance of saguaro seed in the macroscopic remains. The morphology of the pollen is consistent with that of saguaro pollen samples from modern flowers. A trace amount of corn pollen (*Zea mays*) was present.

The fibrous coprolite contained only 60,000 pollen grains per gram. Of these, 35,000 are from the unknown ceroid-type cactus noted above and about 6,000 are from prickly pear or cholla. The remaining pollen is from non-dietary, wind pollinated plants.

DISCUSSION

One of the most interesting findings is the near absence of evidence of cultigens in the colon contents. The Hohokam are generally typified as being horticultural peoples, and the lack of corn is noteworthy. The major dietary components are mesquite pods and ground saguaro seeds, both non-cultivated gathered foods. The fact that different coprolites contain varying amounts of saguaro seed and mesquite pod suggests that two meals are also represented, one of mesquite and another of saguaro seed.

The presence of *Opuntia* pollen suggests that cactus flowers also were eaten. *Opuntia* pollen in coprolites typically signals dietary use of prickly pear flowers (Bryant and Williams-Dean 1975). Unlike the saguaro cactus, the flowers of prickly pear and cholla do not remain on the mature fruit. Based on our analyses of coprolites from Archaic and Anasazi sites on the Colorado Plateau (Reinhard 1985; Reinhard and Jones 1991; Reinhard current research), and analyses of Archaic coprolites from the lower Pecos area of west Texas (Reinhard, Jones and

Barros 1991), *Opuntia* pollen is not consumed with either *Opuntia* seeds, fruits, or pads. It is introduced in large quantities into the intestine only by the consumption of flowers. Consequently, although pollen can be consumed when saguaro fruits are eaten, this does not occur with *Opuntia*. Thus the presence of *Opuntia* pollen in the Ventana Cave coprolites indicates flower consumption. Conversely, the ceroid-type pollen was probably introduced into the intestine by the consumption of saguaro cactus seeds (*Carnegiea gigantea*).

Cactus flowers are completely edible and are a good source of several nutrients including calcium, iron, and vitamin C (Winkler 1982). As a source of vitamin C, cactus flowers are of special importance with respect to iron absorption. In desert plants, iron occurs in bound form and is liberated for intestinal absorption in the presence of vitamin C. Cactus flowers contain small amounts of proteins, fats, and only moderate amounts of carbohydrates.

Cactus seeds are high in carbohydrate. Mesquite pods are 19.1 percent sugar and 13 percent protein (Winkler 1982). Consequently, even though only non-cultivated foods were included in the diet of the dying child, they composed a diet that was not nutritionally substandard.

Determining the season of death is problematical. The mesquite pods and saguaro cactus seeds would be available in the fall, but *Opuntia* flowers would be available in the spring. It is possible that the ground seed and mesquite pods were stored foods which were collected in the fall and were eaten in the spring. Thus, we tentatively conclude that the child died in spring when *Opuntia* flowers were available.

The findings are consistent with Haury's (1950) dietary inferences that cactus seeds and mesquite pods were consumed at Ventana Cave. Although the burial contains remains of only two meals, if these meals were typical of the Ventana Cave Hohokam, then one might be tempted to infer a heavy reliance on wild foods and reduced dependence of cultigens as Haury believes (personal communication). Only the analysis of more coprolites from the cave can verify this hypothesis.

The fact that these foods were prepared during the last few days of this child's life may hint that they were preferred foods, for it seems unlikely that undesirable foods would be served to an ailing child (assuming the child died of chronic sickness and not acute sickness or trauma).

The lack of parasites is not surprising. Typically, only 15 percent to 25 percent of coprolites from any given agricultural site contain helminth remains. Consequently, we would not be willing to draw conclusions regarding the presence or absence of parasites at Ventana Cave until more coprolites are examined. Considering the aridity of the Ventana Cave area, it is unlikely that many species of parasitic worms could survive in the human population. However, the sites of Danger Cave and Hogup Cave were equally inhospitable to parasites, yet three species of intestinal parasite were found in coprolite analyses (Fry 1977). One of these, the acanthocephalan *Moniliformis clarki* is potentially life threatening.

Birkby (personal communication) reports that lice are present in the hair of the Ventana Cave mummies. These ectoparasites are transferred in conditions of poor personal hygiene and close living conditions. These are the same conditions suitable for the transmission of pinworm (*Enterobius vermicularis*); it is probable that at least this intestinal worm infected the inhabitants of Ventana Cave.

The analysis of coprolites from Burial 5 of Ventana Cave provides a tantalizing glimpse at one child's meals immediately preceding death. From coprolite analysis, very specific data regarding food availability and perhaps food preference have been obtained.

Analysis of colon contents from other mummies excavated from the cave would enhance the view of diet at Ventana Cave and perhaps uncover evidence of endoparasitic disease. It is therefore strongly recommended that consideration be given to coprolite analysis of other mummies from Ventana Cave.

It is suggested that, at some future date, small coprolite fragments be extracted from the mummies for analysis. Such a study would result in the accumulation of dietary and parasitic data that would greatly clarify our current view of life at this important prehistoric habitation.

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