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DIET AND PARASITISM AT DUST DEVIL CAVE

Karl J. Reinhard, J. Richard Ambler, and Magdalene McGuffie

*Analysis of 100 desiccated feces of the Desha Complex (6800–4800 B.C.) from Dust Devil Cave near Navajo Mountain in southern Utah shows high proportions of *Chenopodium* seed and an absence of parasitic roundworms. Conversely, fecal remains from other sites in the Great Basin and Colorado Plateau show high incidences of parasite infection and low frequencies of *Chenopodium*. The implications of *Chenopodium* as a vermifuge are discussed.*

Human parasitism has obvious relationships to group size and composition, mobility, subsistence patterns, and rates of culture change. At their best, human endoparasites may be annoying; at their worst, some can cause death. Thus, an overall view of the parasite load of a prehistoric population can yield insights useful in interpreting past lifeways. With these thoughts in mind, we undertook a study of Desha Complex (6800–4800 B.C.) human feces recovered from Dust Devil Cave in southern Utah.

The recovery of helminth parasite remains is now standard practice in the analysis of archaeologically recovered feces, commonly called “coprolites” even though not fossilized. Mummified eggs and worm larvae are readily recovered from desiccated feces (Callen and Cameron 1960; Fry 1974, 1976; Fry and Hall 1973, 1975; Fry and Moore 1969; Heizer 1967; Hevly et al. 1979; Moore et al. 1969, 1974; Pike 1967; Reinhard 1983, n.d.; Samuels 1965; Stiger 1977; Taylor 1955); some dating to 8,000–10,000 years old (Fry and Moore 1969).

From the New World, 11 parasites have been identified. Among the nematodes (roundworms) these include *Trichuris trichiura* (whipworm), *Ascaris lumbricoides* (giant intestinal roundworm), *Strongyloides* spp. (threadworm), *Trichostrongylus* spp. (sometimes called hairworm), and *Enterobius vermicularis* (pinworm). Among the cestodes (tapeworms), both taeniids (which include the bovine and porcine tapeworms) and hymenolepids (which commonly cycle between insects and mammals) have been found. Tapeworms are very difficult to identify by egg remains but the hymenolepid worm *Railietina* (?) spp. and *Diphyllobothrium* spp. (fish tapeworm) are known from prehistoric sites. One acanthocephalan (thorny-headed worm), *Moniliformis clarki*, parasitized ancient Amerind populations in the desert West. Of the trematodes (flukes), a single unidentified egg has been found, apparently not parasitic on humans. Examination of a Peruvian mummy has produced one more nematode, the hookworm *Ancylostoma duodenale*.

In the first study of prehistoric New World feces that produced parasite remains, Callen and Cameron (1960) note the possible consumption of native species of *Chenopodium*, a plant that can be used as an anthelmintic. The utility of *Chenopodium* seed in curing infections of hookworm, ascarids, and pinworm has long been known (Hegner et al. 1938; Millspaugh 1972; Schery 1972; Wahl 1954), although in recent decades more effective cures have been discovered. Prehistoric groups of the Colorado Plateau of Utah, Colorado, Arizona, and New Mexico not only had access to *Chenopodium* but commonly consumed it as a part of the dietary regime, thus potentially limiting infection with roundworm parasites. This is particularly evidenced in 100 feces studied from Dust Devil Cave, an Archaic site in southern Utah.

RESEARCH AT DUST DEVIL CAVE

Dust Devil Cave, located between Navajo Mountain and the San Juan River, was first tested in 1961 as part of the Museum of Northern Arizona Glen Canyon Project (Lindsay et al. 1968:102–

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Figure 1. Plan of Dust Devil Cave, showing activity areas within Desha Complex stratum (6800-4800 B.C.).

121). Also excavated in the same season was Sand Dune Cave (Lindsay et al. 1968:30-102). Materials recovered from these caves provided the basis for the definition of the Desha Complex, an early Archaic assemblage characterized by distinctive sandals and with probable relationships to contemporary Great Basin assemblages. The Desha Complex appears to have been limited geographically to the Glen Canyon region; the only other site known with appreciable amounts of Desha materials is Cowboy Cave, 70 km to the north of Dust Devil Cave (Jennings 1980). A radiocarbon age of 6800 to 4800 B.C. for the Desha Complex in the Navajo Mountain area is indicated by a series of 13 dates (Ambler 1984).

In an attempt to define more precisely the subsistence patterns, material culture, relationships to other assemblages, and chronology of the Desha Complex, most of the remainder of Dust Devil Cave was excavated in 1970. As excavations progressed, it became apparent that several activity areas were evident within Stratum IV, the Desha horizon (Figure 1). The rear of the cave, well out of the wind, was used for grinding seeds, the central area was used for cooking, the front, well lit portion was used as a locus for flaking stone, and an area near the front, at the northeast part of the cave, was used as a defecatory area.

Within an area of approximately 10m², 66 separate lots of human feces were recovered, containing at least 230 different specimens with fragments probably accounting for several hundred more. Specimens deemed suitable for analysis on the basis of size and good provenience numbered 143. Of these, 100 were selected for analysis, the first 50 on the basis of a simple random sample, the other 50 by selection from the remaining 93 those most likely to yield useful information. This paper reports the results of the parasite analysis, with reference to pertinent aspects of the botanical analysis. In progress or completed are analyses of the macrofloral remains, pollen, phytoliths, faunal remains, and mycological remains from these 100 specimens.

Initially, samples for parasite analysis were taken from the interior of each specimen, and three microscopic slide preparations with 24 × 50 mm glass cover slips were made of each sample. Zinc

phosphate flotation and formalin-ether separation (Fry 1976) were attempted with about half of the specimens in the hope that these clinical techniques would isolate parasite eggs more effectively.

Approximately 210 hours of microscopic examination revealed only one parasite ovum in the 100 feces, tentatively identified as *Trichostrongylus* spp. This could well have been derived from the eating of rabbit viscera and probably was not parasitic on humans. Two non-parasitic nematode ova were also found. Although the low frequency (or absence) of many species of human endoparasites could perhaps be explained by cultural or environmental patterns, the complete lack of pinworm, *Enterobius vermicularis*, was an unexpected surprise given the presence of this ubiquitous parasite in seven of eight analyses of fecal series from other sites on the Colorado Plateau (Fry 1976; Fry and Hall 1973, 1975; Hevly et al. 1979; Reinhard 1983, n.d.; Samuels 1965; Stiger 1977). Since we (Rienhard and McGuffie) had consistent success in isolating parasitic ova in feces from other sites on the Colorado Plateau, we did not believe a problem in technique was indicated. Nevertheless, a second attempt to isolate pinworm eggs was conducted. Because pinworm ova will most likely be near or on the surface of a fecal pellet, portions of the surface of each stool saved for additional analyses were scraped, rehydrated, and analyzed. Again, no pinworm ova were found.

EVALUATION OF PINWORM INFECTION

Despite the fact that the life cycle of *Enterobius vermicularis* is not particularly conducive to detection of ova in feces, pinworm is a commonly reported parasite in human paleofeces. Gravid females migrate outside the body at night to lay their eggs in the perianal folds. The resulting itching causes the host to scratch, transferring the eggs to the hands, from whence they are easily transmitted to friends and relatives either directly or in food. Eggs also become dislodged into bedding and clothing, and, since the ova are very light, they can be wafted on air currents to contaminate food. Once ingested, the cycle starts anew, so it is not surprising that many historic and prehistoric populations were heavily infected.

Pinworm ova are only fortuitously mixed with feces when they are scraped off of the perianal folds in defecation (most frequently in morning defecations). Since this may not occur regularly, not all feces, even of individuals known to carry pinworm, will contain pinworm ova. Indeed, pinworm ova are found in only 5% of feces from infected individuals (Faust 1947). Conversely, it can be inferred that if 5% of a collection of feces exhibit pinworm ova, the great majority of the population was probably infected.

The total lack of pinworm remains in these specimens, coupled with the essential absence of any other internal parasites, leads us to the conclusion that the Desha Complex inhabitants of Dust Devil Cave were remarkably free of endoparasites, and that they would have been unlikely to have escaped this near-universal human condition without the aid of anthelmintics, chemicals toxic to parasitic worms.

CHENOPODIUM AS A VERMIFUGE

Chenopodium (also called goosefoot or lamb's quarter) has long been known as a vermifuge. Both seeds and foliage of several species contain the simple carbon ring compound ascaridol, a potent toxin for roundworm genera, including *Ascaris* (for which it is named) and pinworm. As an anthelmintic, the seeds can be eaten whole or powdered. Oil of *Chenopodium* can be distilled from the seeds and used as a vermifuge. Ascaridol is aromatic and toxic, explaining the avoidance of some species by grazing animals (Muenscher 1951).

Chenopodium ambrosioides var. *anthelminthicum* has been cultivated in Maryland from at least the 1800s (Wood et al. 1894) until today (Schery 1972), and the seeds (known as "wormseed") used as a vermifugic medicine. The use of *Chenopodium* by the Aztecs as a vermifuge has been discussed by de Montellano (1975), and also noted among the Natchez (Vogel 1973) and probably the Maya (Roys 1931). *Chenopodium* remains a widespread folk remedy for worm infection among native and European-American groups (Lewis and Elvin-Lewis 1976; Schery 1972).

Certain species are more potent than others. The Aztecs used *Chenopodium graveolens*, which is a very common species on the Colorado Plateau and grows in the vicinity of Dust Devil Cave.

Unfortunately, the difficulties in distinguishing species of *Chenopodium* from one another in seed form are compounded by the grinding of seeds by the Desha inhabitants of Dust Devil Cave; no specific identifications could be made with assurance, although some seeds compare favorably with *C. graveolens* and others with *C. ambrosioides*.

Chenopodium has been successfully used to treat pinworm infection (Faust 1947; Hegner et al. 1938), but its toxicity for pinworm is less than for other roundworm genera. Gravid females are recorded as being directly killed, but immature individuals may not be seriously harmed (Faust 1947). Consequently, only repeated consumption of *Chenopodium* will result in the absolute purge of pinworms by killing females prior to egg deposition. Two doses of "wormseed" daily for three to four days were recommended for worm infection when the seed was commonly used in the late 1800s (Wood et al. 1894). Oil distilled from the seeds was also used as a vermifuge and three to 10 drops of the oil taken three times a day for three days was prescribed for worm infections (Millsbaugh 1974).

EVIDENCE OF *CHENOPODIUM* CONSUMPTION AT DUST DEVIL CAVE

Sixty-three of 100 feces examined from Dust Devil Cave contained the seeds of *Chenopodium* and 13 had large amounts of the seed. The estimation of relative volume was complicated by the fragmentary nature of the seeds, which had been ground to dust in some cases, with only seed coat fragments surviving the intestinal journey. Initial processing of the samples involved washing the smaller fragments through a 0.5 mm screen to be collected with other microscopic remains. Fortunately, the fragments of *Chenopodium* seed are light and rest on top of the heavier sediments. Estimation of the total volume of sediments is based on examination of microscopic and macroscopic remains. Volume percentages are estimated as follows: one sample each of 100%, 90%, 80%, 70%, 60%, 35%, three samples of 20%, two samples of 15%, two samples of 10%, 50 samples of less than 10%, and 37 samples of 0%.

A stool containing 70% or more *Chenopodium* seed undoubtedly represented consumption of seed cake, with some residue from other foods or meals. Consumption of such cakes would have been lethal to worms, and if eaten in successive meals, would have eliminated them entirely. Since a fecal pellet can represent either one or several meals, or even a full day's consumption (Watson 1974), specimens with 70% or more *Chenopodium* represent considerable ingestion of the seed. Even lesser amounts of seed, 10–70%, may have matched the dosage prescribed for worms when *Chenopodium* was used as an anthelmintic. The large number of feces containing up to 10% of *Chenopodium* reflects the importance of chenopod seed in the diet of Dust Devil Cave inhabitants, and probably explains the absence of roundworm parasites in the feces.

As noted previously, the Desha Complex is related to Archaic developments in the Great Basin. Although pickleweed (*Allenrolfea occidentalis*) of the family Chenopodiaceae was consumed in quantity at Hogup and Danger caves (Fry 1976), *Chenopodium* is not noted, and inhabitants of these caves were parasitized by pinworm (2–4% of the feces contained ova), acanthocephalans, and taeniid tapeworms. The presence of parasites in the Great Basin where *Chenopodium* was not consumed underscores our suggestion that consumption of *Chenopodium* limited parasitism.

ANASAZI PARASITISM AND DIET

Agricultural groups succeeded Archaic hunter-gatherers on the Colorado Plateau, but the extent to which Anasazi peoples depended on agriculture was variable. In some regions, wild foods made up a substantial portion of the prehistoric diet and *Chenopodium* was prominent in some Anasazi diets.

It is significant that where *Chenopodium* was extensively consumed, parasitism was lessened, and where *Chenopodium* was not heavily utilized, parasites flourished. The rate of nematode parasitism, as seen in pinworm frequency, may therefore be diet dependent among the Anasazi as well. Fifty-three percent of Glen Canyon Anasazi feces contain *Chenopodium* seed (Fry and Hall 1973). Pinworm is absent in this locality, although tapeworms and acanthocephalans have been noted. In the Navajo National Monument and Canyon de Chelly area, *Chenopodium* was rarely eaten. In these areas, 12–16% of the feces studied contained pinworm (Fry and Hall 1973, 1975; Reinhard 1983).

Other areas, where pinworm and *Chenopodium* frequency are both relatively moderate, include Mesa Verde, Colorado (Samuels 1965; Stiger 1977), and Salmon Ruin, New Mexico (Reinhard, current research). At these sites *Chenopodium* seed is present in 6–11% of the feces and pinworm is found in 5–11%. Regression analysis of these fecal series from the Colorado Plateau, including Dust Devil Cave, shows a significant negative relationship between *Chenopodium* consumption and infection with pinworm ($F_{(1,6)} = 8.2$, $R^2 = .72$) at the $p < .05$ level.

There is evidence that the Anasazi deliberately used *Chenopodium* seed as a vermifuge. At Antelope House in Canyon de Chelly, *Chenopodium* was only a minor dietary item. Among the 140 feces examined in two studies (Fry and Hall n.d.; Reinhard 1983), only one contained large quantities of *Chenopodium* (about 80% of the volume of this sample consisted of *Chenopodium* seed). This sample also contained a defecated mass of roundworm larvae (Reinhard 1983). These larvae are most likely those of *Strongyloides stercoralis* (threadworm), a parasite that can cause the death of humans and other mammals. Although only one example, it is noteworthy that at a site where *Chenopodium* consumption is insignificant and nematode parasitism is high (15% pinworm, 2% *Strongyloides*, 2% *Trichostrongylus*), the only finding of high quantities of *Chenopodium* seed in a fecal specimen is accompanied by defecated worms.

SUMMARY AND CONCLUSION

Sixty-three of 100 fecal specimens from Dust Devil Cave contained some *Chenopodium* seed, and 13 of these had large amounts of the seed. The quantity and frequency of occurrence of this anthelmintic seed in the feces reflect dietary practices that limited parasitism. Of course, the Desha inhabitants may not have been aware of the anthelmintic properties of *Chenopodium* seed; food habits of these Archaic people may well have been geared more toward what was available than to deliberate purging. Indeed, the lack of parasites in these specimens and the large quantities of *Chenopodium* are strong indications that *Chenopodium* was simply a regular part of the diet. The results, in any case, left them remarkably free of endoparasites in contrast to other Archaic populations in the desert West as well as many later Anasazi peoples of the Colorado Plateau.

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