1994

Sanitation and Parasitism at Harpers Ferry, West Virginia

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ABSTRACT

One focus of historical archaeology at Harpers Ferry National Historical Park, West Virginia, is tracing the development of sanitation at the town through the 1800s and 1900s. Historical documentation indicates that there was a degree of resistance to the modernization of village sanitation. This study attempts to verify this resistance through examination of privy soils for parasites indicative of fecal-borne disease, specifically the helminth species *Ascaris lumbricoides* and *Trichuris trichiura.* The presence of these parasites in the early 1900s would indicate that fecal-borne disease due to poor sanitation continued to be an aspect of town life. The analysis revealed the eggs of both species in all three privies, indicating that resistance to modern sanitation resulted in the maintenance of fecal-borne disease.

Introduction

The study of archaeoparasitology has been used to address several important issues in historical archaeology in Europe and North America. The analysis of the eggs of parasitic worms has been used to elucidate aspects of Medieval epidemiology and health (Herrmann 1986), evaluate the depositional origin of soils (Jones 1985), and address differential health for socioeconomic groups (Reinhard et al. 1986). More recently, parasitological data combined with archaeological data have been used to address the effects of changing sanitation practices on parasitism in Colonial Philadelphia (Reinhard and Spawn 1990) and Wilmington, Delaware (Fries et al. 1990). For Eastern North America, there is a growing body of parasitological data for historic sites that will be of continued use in assessing historic health and hygiene as reviewed by Reinhard (1990). The range of parasitological data applications to archaeology is summarized by Reinhard (1992).

Archaeological research at Harpers Ferry addresses the question of health and sanitation practices at the turn of the 20th century (Ford 1991; Ford, this volume). Historical documentation indicates that Harpers Ferry as a whole resisted modernization of sanitation facilities, although certain individuals upgraded sanitation on a household basis. Archaeoparasitology possesses the unique ability to assess the resistance to improved sanitation by examination of site soils for the remains of fecal-borne infective organisms, an approach previously applied with success by Fries et al. (1990).

The examination of privies for parasite eggs is a useful gauge of fecal-borne disease. Fecal-borne disease includes disease agents that are transmitted by fecal contamination of food, water, or other objects that come in contact with people. The presence or absence of such organisms is ''smoking gun'' evidence of fecal-borne disease resulting from poor sanitation. Such evidence is clearly relevant to the question of Harpers Ferry sanitation at the turn of the 20th century. To assess the efficiency of sanitation, soils from three areas were examined for evidence of *Ascaris lumbricoides* and *Trichuris trichiura.* These two nematode species are the most common fecal-borne helminth parasites of humans. Although *T. trichiura* (whipworm) is a small intestinal worm that is hardly noticeable in casual examination of intestinal mucosa, *A. lumbricoides* (giant intestinal roundworm of humans) is a large nematode parasite approximately 5–7 mm in diameter and 25 cm in length. Although these parasites are themselves relatively benign, their presence is evidence of fecal-borne disease.

Methods

The soil samples were processed for the recovery of parasite eggs following the protocol presented by Warnock and Reinhard (1992) with the exception that sonication was not used. The processing dissolves certain soil components leaving organic debris containing eggs. Parasitological examination of processed samples was accomplished by placing a drop of glycerol with suspended microscopic remains onto a microscope slide. A cov-

Historical Archaeology, 1994, 28(4):62–67.

erslip was placed over the drop and sealed with commercial nail polish. After the polish dried, the slides were examined with a binocular compound microscope at 200X. The number of eggs per milliliter (ml) of soil was calculated on the basis of the ratio of parasite eggs to the known number of tracer spores added to the soil sample at the beginning of processing. Macroscopic remains were examined with a binocular dissecting microscope.

The interpretive value of archaeoparasitological data is dependent on several factors. First, the value of parasitological data is directly dependent on the detail of documentation of households that used specific privies. Knowing the socioeconomic status, occupation, and size of the family or group that used the privy provides a base for assessment of the epidemiology of historic populations (Jones 1985; Herrmann 1986; Reinhard et al. 1986). Secondly, it is essential to know whether or not sediments submitted for analysis came from fecal deposits. Often, the field archaeologists can make this assessment. In the absence of a field assessment, independent laboratory observations can be used to determine fecal origin. Typically, seeds are abundant in fecal deposits and seed counts can be an indicator of fecal origin. Experience with historic privies has shown that seeds, especially of the genus *Rubus* which includes several fruits such as raspberry, are abundant in fecal-derived soils. Therefore, *Rubus* seeds were counted in each soil sample as an independent measure of fecal origin. Jones (1985) determined that parasite egg density can be used to determine fecal origin of soils. Thus, both seed counts and parasite egg concentration are important measures of fecal origin. Thirdly, one must assess the preservation conditions of the parasite eggs recovered. Although Jones et al. (1988) determined that parasite eggs are very resistant to decomposition, they are nonetheless susceptible to decomposition in certain environments as described by Herrmann and Schultz (1987) and Reinhard et al. (1986). To assess the extent of decomposition of parasite eggs, it is essential to monitor the preservation condition of microscopic remains such as pollen grains, fungal spores, and plant cuticle fragments, as well as macroscopic remains such as seeds. Finally, it is essential that the fecal deposits be dated. Deposits that accumulated over short spans of time are of greater interpretive value than those that accumulate over longer periods of time. Short-duration accumulations are of greater value because they represent discrete defecation behavior that can often be traced to specific households. Long-duration accumulations present interpretive problems because the eggs do not necessarily represent a single household unit and cross-contamination of early and late use has a high probability due to admixture of deposits during cleanings.

Results

Sixteen samples from three privies were processed and analyzed. The practice of submitting multiple samples for analysis is critical to effective sampling of any given privy. Usually, the sediments containing fecal remains are restricted to 10–30-cm-thick strata (Reinhard et al. 1988). Through analysis of multiple samples, one helps ensure that fecal deposits are sampled. Of the samples, three came from Feature 21, a privy used in the early 1900s and possibly up to the 1930s; seven came from Feature 99, a privy used from 1884 to the 1920s by the Hurst household; and the remaining six samples came from Feature 132, a privy used between 1891 and 1907 by boarders (Table 1; Ford, this volume).

It is apparent that fecal deposits were sampled in all features. The concentrations of parasite eggs and *Rubus* seeds are given in Table 1. *Rubus* seed counts are presented in Table 2. The seeds appeared in varying quantities between samples. The seeds were in an excellent state of preservation in all samples except those of Feature 21. In addition, a variety of other seeds were observed. These included various grains and grape pits. Fly pupa cases were found in the Feature 21 soil samples but nowhere else. Within features, egg concentrations tend to be highest where *Rubus* seeds were most abundant. This indicates that fecal deposits were sampled. In the boardinghouse privy (Feature 132), there is a general correspondence between concentration values of eggs and seeds. However, in the

TABLE 1
EGG CONCENTRATION VALUES

Feature No.	Layer	Bag/Lab No.	Species		Eggs N/ml of Soil
			T. trichiura	*A. Lumbricoides*	
20th-Century Privy					
21	J	5	280	850	3
21	K	6	—	—	none present
21	L	7	—	—	none present
Hurst Privy					
99	F2	9	—	—	none present
99	F3	10	—	—	none present
99	G	11	none	141	1
99	G2	12	570	5,650	11
99	G3	14	1,130	21,470	40
99	H2	15	none	2,260	4
99	I	16	—	—	none present
Boardinghouse Privy					
132	E	18	570	570	2
132	E2	19	none	90	1
132	E3	20	none	2,260	1
132	E4	21	none	570	3
132	E5	22	570	5,090	10
132	E6	23	570	1,130	3

Hurst privy (Feature 99), eggs seem to concentrate more in samples 12 and 14 whereas seeds are most common in samples 14 and 15. This may indicate the percolation of microscopic remains upward in the soil.

Although the egg concentrations are low in most samples, they approach levels in the Hurst privy (samples 12, 14, 22) that clearly demonstrate that fecal-derived soils were sampled by criteria established by Jones (1985). The presence of *Rubus* seeds in most samples, especially from the boardinghouse privy, indicates that fecal material was present. Only in Feature 21 were eggs sparse in all samples. However, the pronounced lack of microscopic biological remains in the soil from Feature 21 was markedly different from the other features. This is most evident in samples 6 and 7. In addition, seeds recovered from this feature were less well preserved than the other two privies.

The following conclusions based on soils analysis can be made with regard to fecal deposit sampling and preservation of parasite eggs. Although some samples were barren of parasite remains, at least one sample in each privy contained eggs. From Feature 21 one of three samples contained eggs, from the Hurst privy (Feature 99) four of the six samples contained eggs, and from the boardinghouse privy (Feature 132) all six samples contained eggs. Both *A. lumbricoides* and *T. trichiura* eggs were found in all privies. Poor preservation of parasite eggs, fungal spores, plant tissue, and seeds was evident in Feature 21. Therefore, the relative egg paucity of Feature 21 is not a result of incomplete sampling of fecal remains, but rather a result of extensive decomposition that destroyed most microscopic biological remains. Compared to other historic privy studies summarized by Reinhard (1990), there are high concentrations of eggs in some samples from the Hurst and boardinghouse privies.

Discussion

Although fecal deposits were sampled in three privies, their interpretive value is variable. Poor

TABLE 2
CONCENTRATION OF *RUBUS* SEEDS

Feature No.	Layer	Bag/Lab No.	*Rubus* Seeds N/ml of Soil
20th-Century Privy			
21	J	5	214
21	K	6	3
21	L	7	0
Hurst Privy			
99	F2	9	0
99	F3	10	10
99	G	11	11
99	G2	12	5
99	G3	14	14
99	H2	15	15
99	I	16	0
Boardinghouse Privy			
132	E	18	26
132	E2	19	33
132	E3	20	120
132	E4	21	36
132	E5	22	99
132	E6	23	5

preservation of eggs is evident from Feature 21. The Hurst privy was used for a particularly long period of time and may represent the parasite burden of its users at any time between the late 1800s and early 1900s. Nonetheless, all three latrines provide data relevant to the issue of sanitation and fecal-borne disease at Harpers Ferry.

Clearly, the presence of parasite eggs in all privies, and in abundance in two (Hurst and boardinghouse), indicates that the users of all privies were susceptible to fecal-borne disease. This susceptibility extended into the 1900s. One concludes that the lack of sanitation resulted in the maintenance of fecal-borne disease in Harpers Ferry.

Harpers Ferry is not an isolated case of resistance to improved sanitation as indicated by archaeoparasitology. The continuity of fecal-borne parasitism from the late 1700s to the early 1900s is also demonstrated by the study by Fries, Beidleman, and Custer (1990) of privy deposits from Wilmington, Delaware. Deposits from four privies were studied. These deposits were dated as follows: 1790–1820, 1790–1830, and two to 1880–1920. Again, the most common parasite eggs found were those of *A. lumbricoides* and *T. trichiura.* Egg concentrations were low, ranging from 20 to 1,658 eggs per gram (g). Importantly, the presence of the eggs in all privies from all time periods demonstrates a continuity in fecal-borne parasitism throughout the occupation. Thus, Harpers Ferry was not unique in having a fecal-borne parasite problem that persisted into the 1900s.

The health threat of fecal-borne disease is profound. Helminth parasite eggs in latrines and possible wells from historic sites indicates Euroamerican susceptibility to fecal-borne helminth parasites, protozoa parasites, and bacteria as well. Both protozoa and bacteria result in diarrhea. A review of health in the Connecticut River valley by Goodman et al. (1988) indicates that increasing population density was related to water contamination with resulting increasing rates of childhood diarrhea through the 19th century. The parasite evidence from several historic settlements suggests that this problem was probably widespread in historic North America. Although only parasitic worms are represented in the record, fecal-borne protozoa and bacteria have similar life cycles as the worms, and therefore the presence of the worms suggests that bacterial and protozoal disease were also prevalent. Specifically, the protozoa species *Giardia lamblia* and *Entamoeba hystolitica* and bacteria genera such as *Salmonella* and *Shigella* could have been health threats in this community. Thus, pathogen-induced diarrhea was probably a health problem at Harpers Ferry.

As stated above, fecal contamination of water, food, and objects can result in fecal-borne disease. Fly pupa cases found in Feature 21 suggest another route of disease, since fecal pathogens can be transferred by flies, which can carry the pathogens directly into domiciles and onto food. The evidence of flies in Feature 21 raises the possibility of fly-borne disease to a probability. Therefore, fecal-borne bacteria had an alternate infection cycle at Harpers Ferry and were likely transferred directly from feces into households by flies.

The parasitological record recovered from the privies is affected by several depositional and post-depositional factors (Herrmann and Schultz 1987).

Depositional factors include cultural aspects such as the number of individuals using each privy, the socioeconomic status of the group, the age-sex composition of the group using the privy, and idiosyncratic household behavior that increases or decreases exposure to infective parasites. Biological factors such as worm burden of the individuals using the privy and worm fecundity also affect the parasitological record. Post-depositional factors include the extent of biological decomposition of the remains and cultural factors such as the frequency of privy cleanings and reuse of privies as trash pits.

Age-sex composition of the group using the privy can have a pronounced effect on the egg content of a privy. Children tend to be most heavily infected with intestinal parasites. Because of more intense child–mother interactions, adult females tend to be more heavily infected with certain species, such as pinworm, than adult males. In addition, the number of people using a privy may impact the diversity and concentration of parasites found in fecal deposits. As more people use the privy, fecal deposits in the privies will be more concentrated, and in the archaeological record, greater egg concentrations may be evident. In addition, with more people using the privy, there is a greater chance of finding a greater diversity of parasite species. Socioeconomic status may play a more profound role in shaping the parasite record of a privy. People of lower socioeconomic status tend to be more heavily parasitized than people of higher status.

Post-depositional cultural factors seem to have had a minimal effect on the Harpers Ferry parasite record. The boardinghouse privy exhibits a bimodal distribution of parasite remains. Parasite eggs and *Rubus* seeds are much more common in samples 20 and 22 than in sample 21. This may reflect a temporary use of the privy as a trash pit. In sample 21, increased deposition of trash diluted the concentration of fecal remains and, therefore, parasite eggs. In contrast, post-depositional biological factors had a pronounced impact on the parasite record of Feature 21. As noted above, more extreme decomposition reduced the recovery of biological remains.

Idiosyncratic household or personal behavior is difficult to identify either through documentation or archaeology. Certain behaviors such as washing hands, washing vegetables, drinking spring water, and other aspects of personal and household hygiene will limit parasitism. Other behaviors such as the use of night soil in household gardens, carrying out activities in parasite contaminated areas, or simply poor personal hygiene will increase exposure to infection. These aspects of personal and household behavior can rarely be traced through the archaeological record and therefore add variation to the parasite evidence that cannot easily be explained.

There is a marked difference in the parasite records of the Hurst and boardinghouse privies. Although the seed data indicate that fecal deposits were more concentrated in the boardinghouse privy, a pronounced increase in parasite concentration exists in the Hurst privy. This begs for explanation. Since the condition of preservation for both macroscopic and microscopic remains was similar between the two privies, post-depositional processes probably did not affect the parasite record differentially between these two features. Therefore, a cultural, depositional factor is implicated.

The Hurst privy was used by one of Harpers Ferry's leading families, while the boardinghouse privy was used mainly by boarders. Intuitively, one would expect a higher prevalence of parasitism among the transient boarders, but this does not appear to be the case. Low socioeconomic status cannot be implicated as a factor in producing the high egg concentration in the Hurst privy, since the Hursts were well off and well established in the community. Since the privy was primarily for family use, it is unlikely that very many individuals used the privy. Children are more frequently parasitized than adults, and the presence of children at the household could explain the increased egg concentration. However, children were not consistently present in the household at the time of deposition. Therefore, it is impossible at this point to relate age composition to the heightened parasite concentration. Unsanitary living conditions, such as yards contaminated with feces, can result in high parasite burdens. However, the Hurst yard is recorded as being well kept and orderly. Therefore, it

is unlikely that poor household sanitation resulted in increased parasitism.

One must ask if aspects of life among the boarders lowered the level of parasitism there. Since there is little information about the boarders, one cannot relate the socioeconomic status of the boarders to the parasite record. Boardinghouse owner James McGraw was one of the townspeople to enhance the sanitation of the town by establishing a piped water system that brought spring water into the town. Certainly the use of piped drinking water would reduce the potential of parasitism. However, this piped water was used primarily by McGraw's brewery and may not have extended to the boardinghouse. Since sanitation appears to have been similar between the boardinghouse and Hurst households, the existence of differences in household hygiene is not a testable explanation.

It could well be that the higher level of parasitism at the Hurst household could be a result of untraceable, idiosyncratic behavior. An approach to identifying this behavior is to examine the record of variances of the Hurst household from standard dietary and sanitation behavior for the town as a whole.

This research answers the basic question as to whether or not the lack of sanitation resulted in the continuation of the threat of fecal-borne disease. The parasite record indicates that fecal-borne disease at Harpers Ferry continued to be a problem into the 1900s.

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