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Review

Reestablishing rigor in archaeological parasitology

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ABSTRACT

Archaeological parasitology originated in the mid-twentieth century with interdisciplinary teams of specialists directed by archaeologists. The goals of such studies were detailed analyses of dietary, medicinal, and environmental factors that shaped the patterns of infection. By the 1970s, a cadre of unique coprolite analysts was trained to analyze macroscopic and microscopic remains for integrated reconstructions of the cultural determinants of parasitism. During these first phases of research, diagnostic rigor was maintained by direct training of specialists in parasitology and archaeology sub-disciplines including archaeobotany and archaeopalynology. Near the end of the twentieth century, however, "paleoparasitology" was defined as a separate field focusing on defining parasite distribution through time and space. Ironically, this focus resulted in an increase in misdiagnosis, especially prominent after 2000. Paleoparasitology does not explicitly include other specialized studies in it research design. Thus, dietary, environmental and medicinal inferences have been neglected or lost as samples were destroyed solely for the purpose of parasitological analysis. Without ancillary archaeological studies, paleoparasitology runs the risk of separation from archaeological context, thereby reducing its value to the archaeologists who recover samples for analysis.

1. Introduction

Dittmar (2009, 2013) defines goals for future study of parasites from archaeological sites. She states that the origins of the field began "at the onset of modern archaeology", but emphasized that the field is still based in parasitology. She argues that to extract the maximum information from studies, archaeologists and parasitologists must work together. This cooperation must include studies of flora, fauna and climate. I would add that cultural reconstructions are an essential aspect as well. Dittmar emphasizes systematic sampling of archaeological sites. She also asserts that predictive modeling of parasitological and epidemiological scenarios should be based on cooperation between archaeologists and parasitologists. Finally, she stresses that students need to be trained in diverse fields and integrate these fields into interdisciplinary approaches to reconstructing parasitism in the past.

These goals had been achieved in the past through rigorous application of interdisciplinary analyses of samples recovered through systematic archaeological field methods. This rigor was established early on in the late period of Processual Archaeology, also called New Archaeology (Willey and Phillips, 1958). Here I present a review of my personal experience in the field, based upon the important perspectives I received from my professors who pioneered the interdisciplinary archaeological parasitology.

2. Finding a perspective and getting trained

Rigor in archaeological parasitology can be traced to its historical roots. Archaeological parasitology is based upon a core interdisciplinarity that includes parasitology and archaeology. It began with interdisciplinary partnerships, which naturally evolved from students trained in both areas to address hypotheses relevant to both fields. This was a pattern that was repeated between archaeology and diverse fields including geology, botany, palynology and faunal analysis. In the earliest studies, archaeologists directed the research of interdisciplinary teams. For example, Callen and Cameron (1960) are frequently cited as the field's founders (Bryant 1994; Bryant and Dean, 2006). They were a botanist (Callen) and a parasitologist (Cameron) from McGill University who were directed by an archaeologist, Junius Bird of the American Museum of Natural History (Bird et al., 1985). Together, they reconstructed the parasitology of coastal Peru in context of dietary habits (Bryant 1994; Bryant and Dean, 2006).

During the peak of Processual Archaeology, the University of Utah saw an archaeologist, Jesse Jennings, and medical parasitologist, John G. Moore, form the core of a cooperative team of archaeobotanists and medical parasitologists who defined parasite distribution for the Great Basin of Utah and Oregon (Reinhard and Bryant 2008). Jennings championed the scientific method in archaeology, beginning with his first paper "The importance of scientific method in excavation" in 1934. His subsequent excavations in Utah were the first to focus on coprolite and parasite recovery. Therefore, Jennings began an archaeology of parasitism. As reviewed by Reinhard and Bryant, this approach spread to other researchers in California, Colorado, Arizona, New Mexico and the USA National Park Service (Bryant and Reinhard 2012; Reinhard and Bryant 2008).

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Two of Jennings and Moore's protégés, Gary Fry and Jay Hall, were the first hybrid archaeologists/parasitologists who completed their graduate degrees on coprolite studies. Their work was fundamentally significant in establishing rigorous methods of coprolite analysis, integrating dietary and parasitological study from the same collections, and applying a broad-based space/time approach to defining the distribution of parasites in the Great Basin and Colorado Plateau (Fry 1977; Fry and Hall 1969, 1975; Fry and Moore 1969; Hall, 1977; Moore et al., 1969, 1974; Wilke and Hall 1975). They laid the foundations for archaeological parasitology and established a high level of rigor. In this essay, I will be returning to these fundamentally significant, historical contributions.

I was trained as an evolutionary biologist (M.S.) and an environmental archaeologist (Ph.D.) during the 1980′s when the interdisciplinary teamwork established by Callen and Cameron, and Fry and Hall had reached its peak. The intellectual milieu of that period was receptive to their discoveries. This was arguably the apogee of interdisciplinary investigations of the past. Because coprolites contain so much environmental, parasitological and cultural data, it was a propitious time for the their study, both among paleontologists and archaeologists. Therefore, in the 1970s and 1980s, coprolite analysis was a key part of this intellectual milieu. Like many others, I was trained in palynology, zooarchaeology, archaeobotany and mycology, a constellation that encouraged full exploration of all data that could be recovered from coprolites and subsequent interpretations. The environmental, dietary and medicinal reconstructions had direct relevance to the interpretation of parasite remains. This broad training was the norm at Washington State University, University of Colorado, Texas A & M University, University of Arizona, Northern Arizona University and other institutions. The relevance was multidimensional. Fungal spores and sand grains can be confused with parasite eggs. Pollen evidence provides evidence for pharmacological treatment of infection. Analysis of animal bones and mollusk remains reveals the definitive and intermediate hosts. Archaeobotany is essential in inferring subsistence practices that are foundational for understanding paleoepidemiological transitions. This cross-disciplinary approach continues more recently in Hawdon (parasitologist) and Johnston's (archaeologist) 1996 perspective of hookworm-human migrations.

Wildlife parasitology, medical parasitology, and veterinary parasitology all contribute to archaeology and paleopathology, especially regarding diagnosis. The wildlife parasitology world provides insights into some of the more bizarre parasites of past peoples, acanthocephalans being the most notable, but also including flukes and other zoonotic parasites (Sianto et al., 2005; Leles et al., 2014). Some of us enter archaeological parasitology from the world of medical or veterinary parasitology (Faulkner 1992; Faulkner et al., 1989; Faulkner and Patton 2001; Faulkner and Reinhard 1914; Reinhard 1985a,b; Reinhard et al., 1987, 2013). Veterinary parasitology is especially useful in providing a lesson in humility regarding the wide range of parasites that can be associated with human-animal communities, many species of which produce eggs that appear similar. Medical parasitology is also beneficial in providing basic data regarding pathology caused by infections and mechanisms for estimating pathology by egg per gram (epg) counts from feces.

Different theoretical perspectives permit hypothesis generation to test a variety of models. Parasitology is a rich source of ecological theory and diverse, almost innumerable, examples of host-parasite interactions. The theories of Price (1981) and Brooks and McLennan (1993) provide a background to the long-term and broad-scale evolution of hosts and their parasites. More specific to archaeology, the model for parasite infection proposed by Pavlovsky (1966) and adapted to archaeology by Reinhard and Bryant (2008) is useful for fine-grained interpretation in archaeological context. This is the pathoecology approach of Martinson et al. (2003). All these perspectives offer something beneficial to archaeological parasitology. Importantly, the insights gained from these fields are directly related to rigorous analysis and well-documented quantification and diagnosis of prehistoric parasites.

Dutour (2013) reviewed the concept of pathocenosis, defined by Grmek (1969) as " the qualitatively and quantitatively defined group of pathological states present in a given population at a given time. The frequency and the distribution of each disease depend not only on endogenous—infectivity, virulence, route of infection, vector—and ecological factors—climate, urbanization, promiscuity—but also on frequency and distribution of all the other diseases within the same population". If applied by archaeological parasitology, this concept could be of great value in developing a big picture approach to evaluating multiple infectious agents over broad areas and time ranges.

Today, students are entering the field from physical anthropology combined with clinical or molecular biology experience. Obtaining archaeological training is necessary for these new experts in archaeological parasitology. Courses in archaeological method and theory, field archaeology, and paleopathology are essential. Archaeobotany and paleonutrition training is important, if only to prevent confusing botanical or fungal structures with parasite eggs. If a student is especially interested in an archaeological region, specialized courses should be taken related to that region.

Broad parasitological training is currently hampered by the limited number of specialized parasitology courses available today compared to 40 years ago. The decline of the "ologies" limits broad training. For example, I completed my parasitology training in the Veterinary Medicine Department and the School of Biological Sciences at Texas A & M. In the 1980s I enrolled in parasite ecology, parasitic protozoa, helminthology, nematode biology, acanthocephalan biology and mollusk biology. In addition, I did a practicum in veterinary/wildlife parasitology. In checking course offerings at the time of this writing, basic parasitology and parasite ecology are still offered, but the specialized courses are gone. Therefore, students today may not be able to obtain broad formal training. Students should minimally have courses in general parasitology and parasite ecology. Molecular biology and immunology are excellent choices for researchers who intend to go into DNA and ELISA testing for ancient remains.

In retrospect, the veterinary/wildlife practicum was very valuable in showing the pathology caused by parasites in various organs. I have vivid memories of recovering living hookworms attached to fresh intestinal mucosa, ascarids wriggling free from the lumen, and recovering living flukes from their migration tracts as I sectioned livers. When working with ancient remains today, I can visualize the parasites in ancient hosts due to this practical experience in recovering parasites in necropsy. I would encourage young people entering the field to gain some practical experience through necropsy or autopsy participation.

Importantly, never limit your training to you graduate degrees. From my personal experience, I suggest every student to continue gaining experience through conferences, workshops and fieldwork to expand your knowledge base.

Whatever one's perspective, basic data collection must be rigorous regarding diagnosis and quantification. Main issues with archaeological parasitology are false negatives and false positives. False positives are samples from parasite-free people that become contaminated at some point between antiquity and lab analysis. False negative samples are samples from infected people that lose evidence of parasites over time. False negatives are generally due to the decomposition of remains. Protozoa cysts, roundworm larvae some delicate eggs such as the human pinworm are ephemeral and preserve poorly. I often assume I have minimal values for these species when analyzing samples with low preservation potential. False positives can be due to false parasitism, including pseudoparasitism caused by an object or organism that resembles or is mistaken for a parasite. False parasitism can include eggs ingested by unsuitable host or non-infective eggs eaten and passed. Most false positives in the archaeological parasitology literature are plant, fungal, non-parasitic animal and mineral objects that were confused with real parasite eggs. Finally, false positives may be due to