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Review

Food, parasites, and epidemiological transitions: A broad perspective

K.J. Reinhard[a], L.F. Ferreira[b], F. Bouchet[c], L. Sianto[b], J.M.F. Dutra[b], A. Iniguez[b], D. Leles[d], M. Le Bailly[e], M. Fugassa[f], E. Pucu[b], A. Araújo[b,*]

[a] University of Nebraska-Lincoln, 719 Hardin Hall, 3100 Holdrege Street, Lincoln, NE 68583-0987, USA
[b] Fundação Oswaldo Cruz, Avenida Brasil 4365, Manguinhos, CEP 21040-900 Rio de Janeiro, RJ, Brazil
[c] Université de Reims, 51 rue Cognacq-Jay, 51096 Reims Cedex, France
[d] Universidade Federal Fluminense, Rua Professor Hernani Melo 101, São Domingos, CEP 24210-130 Niterói, RJ, Brazil
[e] Faculté des Sciences et Techniques de l'Université de Franche-Comté, France
[f] Universidad Nacional de Mar del Plata, Diag. Alberdi Juan Bautista 2695, 7600 Mar Del Plata, Buenos Aires, Argentina

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ABSTRACT

Pathoecology provides unique frameworks for understanding disease transmission in ancient populations. Analyses of Old and New World archaeological samples contribute empirically to our understanding of parasite infections. Combining archaeological and anthropological data, we gain insights about health, disease, and the way ancient people lived and interacted with each other and with their environments. Here we present Old and New World parasite evidence, emphasizing how such information reflects the different ways ancient populations exploited diverse environments and became infected with zoonotic parasites. It is clear that the most common intestinal helminths (worm endoparasites) were already infecting ancient inhabitants of the New World prior to the European conquest, although not so intensely as in ancient Europe. The first paleoepidemiological transition from hunting–gathering to agriculture did not change the zoonotic infection pattern of people in the Americas. However, the same transition in Europe resulted in increased zoonotic parasitism with parasites from domestic animals. Therefore, there is a demonstrable difference in the impact of the first paleoepidemiologic transition in the Americas compared to Europe.

Contents

1. Introduction

Pathoecology, as defined by Martinson et al. (2003), is the study of parasitism in context of culture and environment. In a paleopathological sense, the evolution of *Homo* was an entirely new adaptive process. Typically, parasitism is derived from the coevolution of vertebrate hosts with parasites in a specific environment (Gandon et al., 2008). With humans, however, adaptive behavior strategies could be developed to accommodate this interaction. With the genus *Homo*, there evolved a capacity for symbolic thought that resulted in an enormous diversity of cultural

* Corresponding author. Tel.: +55 21 25982566; fax: +55 21 25982610.
E-mail addresses: kreinhard1@mac.com (K.J. Reinhard), ludovico@ensp.fiocruz.br (L.F. Ferreira), francoise.bouchet@univ-reims.fr (F. Bouchet), lsianto@ensp.fiocruz.br (L. Sianto), alena@ioc.fiocruz.br (A. Iniguez), dleles03@yahoo.com.br (D. Leles), matthieu.lebailly@univ-fcomte.fr (M. Le Bailly), mfugassa@mdp.edu.ar (M. Fugassa), adauto49@gmail.com, adauto@ensp.fiocruz.br (A. Araújo).

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adaptation to an equally diverse array of environments on a global scale. Thus, cultural evolution produced a variety of behaviors that enabled humans to adapt all environments and to spread the planet in hundreds of ecological niches, each with its own array of parasites. Therefore, throughout the early radiation of *Homo*, symbolic thought and flexible cultural evolution had adaptive value in coping with the endemic parasites encountered in diverse environments (Donald, 1993). This is especially true of food-borne parasites which were encountered as people adapted gastronomically to new and different fauna. In the New World archaeological record, we can see these processes at play.

The paleopathology of infections disease has been viewed as passing through distinct "paleoepidemiologic" transitions. Barrett et al. (1998) asserted that there are three pathoecologic phases and two major paleopaleoepidemiologic transitions. They proposed a "Paleolithic Age Baseline" of human infection and stated that during the Paleolithic times, human populations existed as small bands of nomadic foragers. The small and diffuse human groups could not support many infectious agents. This is the original state of human parasitism. With regard to pathoecology, this has been supported by analyses of coprolites (Reinhard, 1988, 1990; Reinhard et al., 1985). From this Paleolithic baseline, human populations experienced new infectious disease challenges with the Neolithic revolution. Therefore, the first epidemiologic transition was that between the Paleolithic and Neolithic. For Europe, the first epidemiologic transition established a pattern of high prevalence of disease that lasted in all regions for centuries. Barrett et al. (1998) asserted that permanent settlements, accumulation of human waste, animal domestication, and agricultural practices increased contact with a variety of parasites. The Industrial Revolution, according to Barrett and colleagues, saw the control of infectious diseases and the emergence of chronic, noninfectious challenges. This is the second epidemiologic transition. In the archaeoparasitological record, this is seen in a reduction of contexts that contain parasite remains and a reduction of the diversity of parasite species. For the Americas, the "Paleolithic Age Baseline" is represented analogously by Paleo-Indian and Archaic periods. The Neolithic revolution is represented by Formative cultures and their subsequent periods. We are comparing the evidence of food-borne parasites between the Americas and the Old World of Europe with some reference to the Old World of Asia. We are presenting our review following the transition sequence established by Barrett et al. (1998).

For this paper, we are focusing on cultural dietary adaptations, or gastronomy in the broadest definition of the word. Therefore, we review the literature for Europe and the Americas with specific interest in parasitic evidence that is directly related to food choice and preparation. The data set comes from a variety of sources including mummies, coprolites, burial sediments, and latrines. Taphonomically, these data sources are not equal. Methods have been refined over several decades to recover parasite remains efficiently from these sources (Reinhard et al., 1986). However, the best methods cannot recover ephemeral remains from contexts, such as open middens, that are prone to decomposition. Ephemeral remains include larvae and delicate eggs. In our combined experience, there is significant decomposition of remains from latrines by fungi and arthropods as described by Reinhard et al. (1986). In contrast, coprolites exhibit the best preservation. Mummies (Reinhard and Urban, 2003) and sediments from sacra (Fugassa et al., 2008a) also show excellent preservation of delicate eggs. Of the range of nematode, cestode, and trematode eggs recovered from archaeological sites from these sources, pinworm eggs, hookworm eggs and larvae and threadworm larvae are differentially susceptible to decomposition in latrines. However, they preserve well in mummies and coprolites. In coprolites found in archaeological layers larvae may have abandoned feces before desiccation be completed. Those nematodes that have infective larvae, such as hookworms and threadworms, are rare in latrines and this may be due to poor preservation conditions. The delicate eggs of pinworm have been rarely found in latrines, partly because of decomposition and partly because few pinworm eggs are passed in feces relative to geohelminths. As of this writing, thousands of parasite samples from hundreds of sites have been analyzed from Europe, Asia, North America and South America. This provides a data base that can show the general relation between diet and parasitism for these areas. Archaeoparasitology and paleoparasitology are terms used hereafter interchangeably. The first term is mainly used in association with human remains while the other has a broader spectrum, also referring to animal parasites. Both refer to parasite infections, not necessarily to diseases.

2. Parasite migration to the New World

Ancient populations arrived in the New World with an array of tightly coevolved human-specific parasites that adapted to *Homo* early in that genus's evolutionary history (Araújo et al., 2008). Thus, over ten thousand years ago human groups in South and North America hosted the intestinal helminths pinworm (*Enterobius vermicularis*), hookworm (*Ancylostoma duodenale*/*Necator americanus*), whipworm (*Trichuris trichiura*), and rarely roundworm (*Ascaris lumbricoides*). The head louse (*Pediculus humanus*) is also a human parasite found in South and North American archaeological sites. Intestinal worm and louse eggs have been found associated with humans in archaeological sites dated as early as 10,000 years ago. Therefore, some common human parasites already infected prehistoric human populations in the Americas long before historic immigrants from Europe and Africa. However, all the parasites cited above (head lice, whipworm, hookworm, and roundworm) ultimately have an African origin, probably coevolving with remote *Homo* ancestors. Based on mitochondrial DNA (mtDNA) data, human head lice (*P. humanus*) separated from Chimpanzee head lice (*Pediculus schaeffi*) about 5.6 million years ago (Reed et al., 2004). The world's oldest known direct head louse association – nits on human hair – was found at a 10,000 year old archaeological site in northeast Brazil (Araújo et al., 2000). The intestinal helminths mentioned above and head lice were dispersed by human migrations to other parts of the world whenever and wherever climatic conditions allowed maintenance of the parasites' life cycles. Parasitological data showed that some of these parasites, especially hookworm, roundworm, and whipworm were introduced before 10,000 years ago by routes other than the Bering Land Bridge between Siberia and Alaska (Araújo et al., 2008). Pinworm and head lice, by contrast, were able to complete their life cycles in cold conditions of Arctic and may therefore have been introduced by groups migrating across the Bering Land Bridge (Araújo and Ferreira, 1995).

3. Diet and parasitism in the New World

In the New World, dietary patterns played a key role in defining parasitology in ancient people from the Paleolithic onward through the Formative and until Columbian contact (Reinhard, 1990, 1992a). Zoonotic parasites normally exist in animals but can be transmitted to humans. New studies that compare parasite diversity show that zoonotic parasites were taxonomically more diverse and with highly varied life cycles compared to human specific parasites in New World prehistoric agriculturalists (Jiménez et al., 2012; Cleeland et al., 2013). In other words, Native Americans exposed themselves to a greater variety of zoonotic parasites with a greater variety of life cycles than human-specific parasites. This was demonstrated by studies of a single site in northern Mexico. There, four zoonotic species were present, transferred by consumption