Part I - Parasites, Human Hosts, and the Environment

1. An Introduction to Paleoparasitology

Luiz Fernando Ferreira

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part I

Parasites, Human Hosts, and the Environment

An Introduction to Paleoparasitology

Luiz Fernando Ferreira

Paleoparasitology is the study of parasites found in the remains of humans and other animal species recovered from archaeological or paleontological sites or any other source in which they have remained preserved. The word derives from the Greek *παλιος*, which means “ancient” or “archaic”, and *παρσιτος*, which can be divided into *παρα*, meaning “next to”, and *σιτος*, meaning “bread” or “food”. Finally, *λογος* can be translated as “to study”.

Paleoparasitology emerged as a field of knowledge, splitting off from paleopathology with the finding of parasite forms in archeological material. Sir Marc Armand Ruffer conducted the pioneering work in 1910 when he published his finding of *Schistosoma haematobium* eggs in the kidney tissue of Egyptian mummies from the 20th Dynasty, dated to circa 1250 to 1100 BC (Ruffer, 1910). Lothar Szidat (Szidat, 1944) later studied two well-preserved Prussian bog bodies and reported finding *Trichuris trichiura* and *Ascaris lumbricoides* eggs. These findings marked the beginning of the search for parasites in archaeological material.

PALEOPARASITOLOGY AND OTHER SCIENCES

Paleoparasitology is situated in an interdisciplinary enclave. Its body of practical and theoretical knowledge draws on several other sciences, including medicine, biology, archaeology, anthropology, geography, genetics, and molecular biology. The list should also include history, especially the history of medicine, and the more recently characterized field of the history of diseases (Nascimento, Carvalho & Marques, 2006). Two major syntheses of medicine and history, published in 1983 by Mirko Grmek (Grmek, 1983) and Jean Bernard (Bernard, 1983), laid the groundwork for this line of research. Both authors combined history and medicine in their studies, seeking the origins and history of the evolution of diseases. Aidan Cockburn (1963) also laid essential groundwork by launching possibilities for research in paleopathology and its various relations with the other sciences.

The study of diseases in the past can also use artistic depictions, skeletal remains, and literary works as sources of information (Wells, 1964). An example of the use of literary sources to diagnose a specific disease at a given time in the past comes from two interesting passages in the classic work by Gabriel Soares de Sousa, written in 1587 (Sousa,

1974). Soares de Sousa was a sugar cane plantation owner in Jaguaripe and Jiquiriçá, in the Province (now State) of Bahia, Brazil. He died in the hinterlands while prospecting for silver lodes. He was a *bandeirante* (bushwhacker), botanist, zoologist, geographer, tropicalist, anthropologist, and helminthologist. He recorded diseases and treatments from Brazil's colonial period, as in Chapter 41: "*Carimã* [manioc flower] is good for children with worms. Give it to them to drink, dissolved in water, and it kills all the worms" (Sousa, 1974: 91).

Chapter 46 goes on to talk about shamans and Indians that ate dirt to kill themselves:

"These savages have another barbaric habit. If they get upset or disillusioned and decide to die, they start eating dirt, a little bit every day, until they wither away and their face and eyes swell up, and they die from it. No one can do anything, or dissuade them from wanting to die. They claim the devil taught them, and that he appears to them and that is why they are determined to eat the dirt." (Sousa, 1974: 175)

The quote clearly refers to geophagy, common in individuals with hookworm infection, as commented by Pirajá da Silva on the work of Sousa (Sousa, 1974: 409): "Gabriel Soares is referring to the Indians that ate dirt and died. In the hookworm infection known as necatoriasis, oppilation, fatigue, or hypoemia, geophagy is the most striking symptom."

Dequeker (2006) cited works of art as sources of information. As an experienced rheumatologist, he quoted, among others, the diagnosis of rheumatoid arthritis in the painting *The Painter's Family*, by Jacob Jordaen (1593–1678).

The study of parasitic infections in isolated indigenous populations also provides important additional material for knowledge on diseases in the past. In addition to the work of Samuel Darling (Darling, 1921) and Fred Soper (Soper, 1927), there is an excellent book by Olympio da Fonseca Filho (Fonseca Filho, 1972) and studies by Francisco Salzano (Salzano, 1990). Carlos Coimbra Jr. and Ricardo Ventura Santos comment as follows:

"Despite inherent difficulties, there are various reasons for seeking to correlate the epidemiological data pertaining to contemporary indigenous populations with those available from prehistoric groups. First, even with the socioeconomic and biological break caused by the arrival and expansion of Europeans on the American continent, there may be similarities between epidemiological patterns in past and present populations. Second, it would be interesting if we could document spatial and temporal continuities or discontinuities in the epidemiological processes in native populations on the American continent. Third, paleoepidemiologists should take into account the complexity of the epidemiological situation of contemporary indigenous populations when constructing explanatory models for the health/disease process in the past. The reason is that an intrinsic limitation of paleopathological studies is that not all pathological processes leave specific records in the bony and dental remains, the biological materials most commonly analyzed in such studies" (Coimbra Jr. & Santos, 1992: 169-170).

Another important issue is the study of parasites in the great apes and their relations to humans (Hoeppli, 1959; Dunn, 1970; Hugot, Reinhard & Gardner, 1999), as we shall see in Chapter 7, on the origin of parasites in the human species.

We have written the following on the relevance of paleoparasitology for medicine and public health:

"Paleoparasitology provides direct evidence of infections in past populations, introducing the time factor into the analysis without the need for the extrapolations required in data from contemporary populations. In addition, depending on the distribution of these findings in time and space, theoretically they allow reconstituting sequences for the progression of a parasitic disease in a region previously unaffected by it.

Finding parasites in archaeological material, besides fostering better knowledge of the evolution of infections, provides support for researching prehistory by constituting a more sensitive indicator of population contacts from the past rather than the comparison of individuals' cultural traits or physical characteristics. Various researchers have contended that knowledge of diseases in past populations, by providing a historical perspective on the development of current endemics, explains certain obscure aspects of the latter, pointing to new directions for studying their dynamics, with implications for disease control strategies" (Ferreira, Araújo & Confalonieri, 1988:16).

Paleoparasitology is also the point of departure for studies of parasites preserved in amber, with particular emphasis on findings of parasite vectors (Andrade Filho & Brazil, 2003) and even the parasites themselves (Poinar, 2005), as well as for studies in coprolites of extinct reptiles (Poinar & Boucot, 2006). Comparative linguistics can also be used to identify parasites cited in ancient languages (Rodrigues, 2005).

THE FIRST PARASITE FINDINGS IN ARCHAEOLOGICAL MATERIAL

Paleoparasitology began with the description by Ruffer (1910), and various paths led to the development of a series of pioneering studies (Darling, 1921; Soper, 1927; Taylor, 1955; Callen & Cameron, 1960; Samuels, 1965; Pike, 1967; Allison et al., 1974; Fry, 1977; Ferreira, Araújo & Confalonieri, 1979; Jones, 1982; Reinhard, 1985; Ferreira, Araújo & Confalonieri, 1988).

In particular, the development of studies in coprolites unearthed from archaeological layers during excavations raised a series of pressing methodological questions to ensure robust results. The development of molecular biology thus poses fascinating challenges, especially for diagnosis.

Paleoparasitology data are obviously provisional, since new studies are always on the verge of happening. One can even contend that such studies correspond more to the distribution of the paleoparasitologists (and especially to that of the archaeologists that conduct the excavations) than to the real distribution of parasitic infections in the past. Archaeologists that send material to the laboratory for tests follow their own logic, the objective of which is certainly not to obtain data to paint a paleoepidemiological picture. Diagnoses could not be performed accurately until the advent of relatively recent molecular biology techniques, adapted to ancient material, besides various techniques originally developed in clinical medicine, especially advanced imaging. However, the positive paleoparasitology data are real and allow some considerations.

HUMANS AND THEIR PARASITES

Having originated in Africa, the human species migrated early, carrying with it the parasites inherited from its pre-human ancestors. In newly occupied regions, the environmental conditions, social organization, sedentary habits, local fauna, eating habits, and other factors led to the persistence or loss of original parasites and to the acquisition of others.

Numerous authors have attempted to associate the current distribution of parasites to late 10th and early 11th-century Portuguese and Spanish seafaring voyages, overlooking that humans have been on the move virtually since the species first emerged. The most common parasites in *Homo sapiens* were already present in New World human populations when the Europeans first arrived, followed soon after by Africans (Araújo, Ferreira & Confalonieri, 1981; Horne, 1985).

A certain degree of racism attributed the majority of parasites in America to the African slaves (Freitas, 1935). This may have been the result (although somewhat delayed) of the letters by Pero Vaz de Caminha and Américo Vespúcio, who described America as a paradise free of diseases, and who were certainly fascinated by the indigenous women: "Among them were three or four young and lovely girls with long black hair flowing down their backs, and their private parts were so high and tight and void of hair that no matter how long we stared at them, they were not ashamed" (Caminha, 2002).

Various research groups dedicated to paleoparasitology have emerged, presenting interesting results. Such collaborative efforts have considerably expanded the knowledge on infections in the past, since an important stage is to collect increasing amounts of data in order to steadily build the field of paleoepidemiology on solid foundations (Souza, De Carvalho & Lessa, 2003). Such is the task of future generations.

As a brief overview of the principal articles that gave rise to (or rather, encouraged and provided the basis for) studies in paleoparasitology, we will now present an annotated bibliography and some milestones in chronological order, starting with the first studies of coprolites and other ancient remains, in order for readers to be able to retrace the paths that led us into these fascinating studies. This review is not intended to be exhaustive, but will touch on the classic studies. We read some of these articles at the beginning of our research, others have become part of our references, and still others (modesty aside) include our own work.

1678 – LISTER, M. *Historia animalium Angliae tres tractatus*.

This was the first known reference to coprolites. Martin Lister, court physician and English naturalist, Vice-President of the Royal Society, graduated from Cambridge. He established the relationship between the feces' shape and the animal's intestinal tract. In the official language of science of the time, he described mollusk excrement as follows: "*Praeterea, ex excrementarum differentia, certum est intestinorum figuram aliam atque aliam esse in diversis speciebus.*"

1829 – BUCKLAND, W. On the discovery of a new species of pterodactyl; and also of the faeces of the *Ichthyosaurus*; and of a black substance resembling sepia, or Indian ink, in the Lias at Lyme Regis. *Proceedings of the Geological Society of London*, 1: 96-98, 1829.

An English geologist, William Buckland, was the first to describe a dinosaur, even before the name was coined. He coined the term "coprolite" for fossilized feces of saurians. Various authors adopted the term for feces of extinct animals.

1866 – WUCHERER, O. E. H. A molestia como parte do plano da criação. *Gazeta Medica da Bahia*, 1:129, 1866.

Otto Edward Henry Wucherer was born in the city of Oporto, Portugal, on July 7, 1820. Son of a German father and Brazilian mother, between six and seven years of age he lived in Salvador, Bahia, where his father was the manager of a trading company. The family then moved to Germany, where he graduated in medicine from the University of Tübingen. He returned to Brazil in 1843, settling in Salvador. Considered the founder of Brazilian helminthology, he was the first to use the microscope in Brazil for the diagnosis and scientific study of diseases coming from Africa (www.museudavida.fiocruz.br). Concerning the speech by Benjamin E. Colting, Secretary of Foreign Affairs of the Massachusetts Medical Society and former member of the Agassiz Expedition in Brazil, he commented: "Coprolites, or petrified feces found inside and outside fossil animals, often reveal to us not only the nature of the ingested matter, displaying parts of other animals consumed, but even the nature of the mucosal surface of the gut, and prove that ingestion occurred in ancient times more or less as in our time" (Wucherer, 1866: 129).

1896 – HARSHBERGER, J. W. The purposes of ethno-botany. *Botanical Gazette*, 21: 146-154, 1896.

In this work, John W. Harshberger indicated the possibilities for reconstructing the diets of prehistoric populations by studying their coprolites.

1910 – RUFFER, M. A. Note on the presence of *Bilharzia haematobia* in Egyptian mummies of the twentieth dynasty (1250–1000). *British Medical Journal*, part 1: 16, 1910.

Sir Marc Armand Ruffer was definitely the leading pioneer of paleopathology. Born in Lyon, France, in 1859, he graduated in medicine in London in 1887 and received his PhD in 1889. He focused initially on the study of phagocytosis, and in 1891 he was named the first director of the British Institute of Preventive Medicine. He later moved to Egypt, where he taught for years at the Cairo Medical School. He introduced techniques for rehydration of mummified tissues, allowing their histological study. The same techniques are used to this day, with minor modifications. He died in 1917, leaving several unpublished works. *Studies in the Paleopathology of Egypt* was edited by his wife, Lady Alice Mary Ruffer, and published in the United States by Roy Moodie in 1921. Ruffer coined the definition of paleopathology: “The science of the diseases which can be demonstrated in human and animal remains of ancient times.”

1921 – DARLING, S. T. Observations on the geographical and ethnological distribution of hookworms. *Parasitology*, 12: 217-233, 1921.

Samuel T. Darling discussed the origin of ancylostomiasis in South American indigenous tribes based on the geographic distribution of human Ancylostomidae, making assumptions on prehistoric migrations to America. His work, together with that of Soper (1927) and later Manter (1967) and Fonseca (1970), opened the way for research on prehistoric intestinal parasitic infections in the Americas (Ferreira, Araújo & Confalonieri, 1988).

1925 – SETON, E. T. On the study of scatology. *Journal of Mammalogy*, 6: 47-49, 1925.

Ernest Thompson Seton was born in England and migrated with his family to Canada, where he became a naturalist and nature illustrator. He observed that the shape and content of feces are excellent clues for diagnosing the animal's order. Feces from species of the same order display characteristics that group them and reflect a particular anatomy. Feces show little value for diagnosis of the family and none at the genus level. However, Seton highlighted the curious and apparently contradictory fact that the shape of feces is a valuable aid in species diagnosis, as well as in meal size and content, which sometimes separates proximate species. He also conducted important studies on the feeding habits of wild animals. His studies were fundamental for establishing morphological patterns in coprolites diagnosis.

1927 – SOPER, F. L. The report of a nearly pure *Ancylostoma duodenale* infestation in Native South American Indians and a discussion of its ethnological significance. *American Journal of Hygiene*, 7: 174-184, 1927.

Fred Soper studied a tribe in the Paraguayan Chaco, the Lengua Indians, far from contact with the colonizers, and found a high prevalence of *Ancylostoma duodenale* as compared to *Necator americanus*, with a ratio of 13:1 of adult worms expelled after treatment. He thus concluded that *Ancylostoma duodenale* infection was already present before the arrival of the Europeans and Africans, while *Necator americanus* was introduced by the conquerors and slaves. These conclusions were later used in interpretations of prehistoric migrations, together with data from paleoparasitology (Araújo, Ferreira & Confalonieri, 1981).

1930 – EAMES, A. J. Report on ground sloth coprolites from Dona Ana County New Mexico. *American Journal of Science*, 20: 353-356, 1930.

Arthur Eames studied coprolites from extinct ground sloths in New Mexico and was one of the first to differentiate microscopic food remains in coprolites.

1944 – SZIDAT, L. Über die Erhaltungsfähigkeit von Helmintheneiern in vor- und Fühgeschichtlichen Moorleichen. *Zeitschrift für Parasitenkunde*, 13: 265-274, 1944.

Lothar Szidat studied two bog bodies discovered in Prussia, a man and a woman, dated to 500 AD (Anno Domini) and 600 BP (Before Present). Parasitological examination of the intestinal contents showed *Ascaris lumbricoides* and *Trichuris trichiura* eggs in both. In one body he found mite eggs, a plant nematode, and possibly eggs from *Diphyllobothrium latum*.

1947 – VAN CLEAVE, H. J. & ROSS, J. A. A method for reclaiming dried zoological specimens. *Science*, 105:318, 1947.

This method was a milestone in the study of coprolites by allowing the rehydration of helminths kept in museum collections, using trisodium phosphate aqueous solution. The method was later adapted by Callen & Cameron (1960) – with huge success – for recovering the original consistency of coprolites and facilitating tests for parasites and food remains.

1954 – PIZZI, T. & SCHENONE, H. Hallazgo de huevos de *Trichuris* en contenido de un cuerpo arqueológico incaico. *Boletín Chileno de Parasitología*, 9: 73-75, 1954.

The authors studied the intestinal contents of an Inca child 8 to 9 years old, dated to the period immediately prior to the Spanish Conquest. The body was found frozen in the Andes, close to Santiago, Chile. They found numerous *Trichuris trichiura* eggs and possible *Entamoeba coli* cysts.

1955 – TAYLOR, E. L. Parasitic helminths in mediaeval remains. *Veterinary Record*, 67: 216-218, 1955.

Taylor examined material from the medieval period in Winchester, England, dated to approximately 1100 AD. In the fecal matter from cesspits, he found helminth eggs diagnosed as *Trichuris trichiura*, *Ascaris lumbricoides*, and *Dicrocoelium dendriticum*. He was one of the first to examine the contents of medieval cesspits.

1955 – CALLEN, E. O. & CAMERON, T. W. M. The diet and parasites of pre-historic Huaca Prieta Indians as determined by dried coprolites. Ottawa, Royal Society of Canada, *Proceedings*, June 7: 51-52, 1955.

Thomas Cameron and Eric Callen presented a study to the Royal Society of Canada that served as a definitive watershed in studies of coprolites, introducing trisodium phosphate in 0.5% aqueous solution for rehydration, based on the work of Van Cleave & Ross (1947). They described the presence of helminth eggs, probably *Diphyllobothrium* sp., and were the first to identify this parasite in prehistoric Peruvian populations.

1958 – HELBAECK, H. Grauballemandens sidste måltid. *Kuml*: 83-116, 1958.

In this fascinating article, Helbaeck described what would have been the last meal of the Grauballe Man, distinguishing between the remains of cultivated and uncultivated plants. He also identified numerous *Trichuris trichiura* eggs.

1960 – CALLEN, E. O. & CAMERON, T. W. M. A pre-historic diet revealed in coprolites. *The New Scientist*, 8: 35-37; 39-40, 1960.

Callen and Cameron published the data from a paper presented in a congress in 1955. This is one of the most widely cited articles in the field of paleoparasitology, reporting on the introduction of rehydration in 0.5% aqueous solution of trisodium phosphate (Na_3PO_4) for an average of 72 hours. This excellent technique recovers not only the original consistency of fecal matter but also the morphometry of the organic residues. The latter include parasite structures, whose natural dimensions remain unaltered according to experiments with this technique in our laboratory and those of other paleoparasitologists.

1964 – MARTIN P. S. & SHARROCK, F. W. Pollen analysis of pre-historic human feces: a new approach to ethnobotany. *American Antiquity*, 30: 168-180, 1964.

Martin and Sharrock launched a series of publications on food remains and parasites found in coprolites in North American sites. By observing different pollen species found in prehistoric feces in Utah, they sought to determine the importance of certain plants in the diet of these populations.

1965 – SAMUELS, R. Parasitological study of long dried fecal samples. In: OSBORNE, D. & KATZ, B. S. (Eds.). *Contributions of the Wetherill Mesa Archaeological Project, Society for American Archaeology*, 1965 (Memoirs, 19).

The author found *Enterobius vermicularis* eggs, mites, and free-living nematodes. These were the first eggs from a parasite species found in human coprolites in North America.

1966 – JANSEN, Jr. I. & OVER, H. J. Observations on helminth infections in a Roman army camp. Rome: International Congress for Parasitology I, *Proceedings*, II: 791, 1966.

Jansen and Over presented the results of tests in material collected from a Roman fort in Valkenbur-on-Rhine, dated to the first century AD. They found eggs from *Trichuris trichiura*, *Ascaris lumbricoides*, and *Oxyuris equi*, the latter an equine parasite, thereby demonstrating the mixture of archaeological remains from humans and domestic animals.

1967 – BROTHWELL, D. & SANDISON, A. T. (Eds.). *Diseases in Antiquity*. Springfield: Charles & Thomas, 1967.

This book was published in England and is now difficult to find in bookshops, since there was no second edition. It was a milestone for the various studies on infectious diseases in the past. Various pioneering authors contributed to the different chapters, some discussing the presence of helminths in organic material preserved in archaeological sites, highlighting the difficulty in recognizing the human or animal origin of the feces (Pike, 1967). This is one of the main problems faced by paleoparasitologists when they receive material for examination in the laboratory. Field studies are indispensable for the correct diagnosis and differentiation between human coprolites and those of other animals.

1967 – MANTER, H. W. Some aspects of the geographical distribution of parasites. *The Journal of Parasitology*, 53: 2-9, 1967.

Harold Manter, an American researcher, published this article which became another key reference for paleoparasitology. Parasite findings in coprolites were still just beginning at the time, and his article does not specifically use the term “paleoparasitology”. However, his review of Ancylostomidae provided the basis for the study

of prehistoric human migrations and parasitism, highlighting the importance of paleoparasitology for archaeologists and anthropologists. The University of Nebraska at Lincoln named the Harold W. Manter Laboratory of Parasitology in his honor. The curator is Scott L. Gardner, co-author of Chapter 8 in this book.

1969 – HEIZER, R. F. & NAPTON, L. K. Biological and cultural evidence from prehistoric human coprolites. *Science*, 165: 563-568, 1969.

This article by Heizer and Napton systematized the study of coprolites and defined the methodology and applications to archaeology. Studying material from Lovelock Cave, Nevada, the authors reconstructed subsistence patterns from the area.

1969 – HALL, H. J. Rehydration and concentration of parasite ova in human coprolites from the Great Basin, 1969 (Mimeo).

Unpublished manuscript from the archives of the Department of Anthropology, University of Utah, Salt Lake City (abstract in Wilke & Hall, 1975). The author studied techniques for the parasitological examination of coprolites. He performed rehydration using trisodium phosphate and the Ritchie concentration technique, modified for parasite eggs. He reported finding eggs from acanthocephalans and *Enterobius vermicularis*.

1969 – DE LUMLEY, H. A Paleolithic camp at Nice. *Scientific American*, 220: 42-50, 1969.

Henry de Lumley studied the pollen in coprolites from 400,000 year ago, collected at Terra Amata on the Mediterranean coast of France, one of the most important sites in Europe occupied by *Homo erectus*.

1970 – FRY, G. F. Preliminary analysis of the Hogup Cave coprolites. In: AÏKENS M. (Ed.). *Hogup Cave, Appendix III*. Salt Lake City: University of Utah, 1970. (Anthropological Papers)

In the Hogup Cave coprolites, Fry found *Moniliformis clarki* eggs in human material dated 6400 to 2000 BC. He discussed false parasitism, but also found *Enterobius vermicularis* eggs in samples from 2000 to 4500 years BP.

1970 – FONSECA FILHO, O. *Parasitismo e Migrações Humanas Pré-históricas*. Rio de Janeiro: Mauro Familiar Editor, 1970/1972.

In this comparative study of New World and Old World parasitic infections, Olympio da Fonseca Filho laid the basis for a new line of parasitological research which he called ethnic, geographic, and comparative parasitology. This approach, in addition to providing elements for studying the origin of parasitic associations, is particularly important as an ancillary method in ethnological and anthropological research, to the extent that it helps elucidate the origin of certain indigenous populations in America and their migration routes in the remote past. This was a pioneering work of inestimable value.

1973 – The Paleopathology Association was founded and the *Paleopathology Newsletter* was launched under the leadership of Aidan Cockburn.

Aidan Cockburn had published two essential books: COCKBURN, A. *The Evolution and Eradication of Infectious Diseases*. Baltimore: The Johns Hopkins Press, 1963, and COCKBURN, A. *Infectious Diseases: their evolution and eradication*. Springfield: Charles C. Thomas, 1967. The books highlighted the importance of studying parasites in

archaeological material. The Association was created during a seminar as a group dedicated to the study of diseases in past times. Participants in the meeting included Aidan Cockburn, Eve Cockburn, Robin Barraco, William Peck, and Theodore Reyman, among others. In 1980 Cockburn, his wife Eve Cockburn, and Theodore Reyman published *Mummies, Disease and Ancient Cultures*, indispensable reading for researchers in paleopathology. His visit to Brazil in 1981, when we were beginning our own research work, was a priceless source of support for our group. He told stories, visited archaeological sites in the State of Minas Gerais with archaeologist André Prous of the Federal University of Minas Gerais, and participated in the 6th Congress of the Brazilian Society of Parasitology in Belo Horizonte, where he gave a memorable lecture to a full auditorium, thoroughly captivating the audience.

1974 – ALLISON, M J.; PEZZIA, A.; HASEGAWA, I. & GERSZTEN, AND. A case of hookworm infestation in pre-Columbian America. *American Journal of Physical Anthropology*, 41: 103-106, 1974.

Marvin Allison, Enrique Gerszten, and colleagues described the presence of adult hookworms in the gut of a Peruvian mummy from 890-950 AD. They founded the Paleopathology Club, using regular mail to send clinical cases from the past (always accompanied by photographs) for discussion by specialists. The journal is now published online.

1975 – WILKE, J. P & HALL, H. G. *Analysis of ancient feces: a discussion and annotated bibliography*. Archaeological Research Facility, Department of Anthropology, University of California, Berkeley, 1975.

This was an annotated bibliography of studies on ancient fecal matter in which the authors analyzed the possibilities for studies based on coprolite contents, such as diet, the population's technology, the local climate during occupation, nature and extent of parasitic infections, and other paleoecological aspects.

1977 – COCKBURN, A. Where did our infectious diseases come from? The evolution of infectious disease. *Ciba Foundation Symposium*, 49: 103-112, 1977.

The author highlighted the importance of studies on parasites in archaeological material. Cockburn discussed parasitic infections and diseases, their origins, and their evolution over time.

1979 – FERREIRA, L. F.; ARAÚJO, A & CONFALONIERI, U. Subsídios para a paleoparasitologia do Brasil I – Parasitos encontrados em coprólitos no município de Unaí, MG. CONGRESSO BRASILEIRO DE PARASITOLOGIA, 4, Campinas, 1979. *Anais...* 1979, p. 56.

The authors described eggs from Ancylostomidae and *Trichuris trichiura* in pre-Columbian human coprolites from the Gentio II cave in the county of Unaí, Minas Gerais State, from the collection of the Institute of Brazilian Archaeology, headed at the time by Dr. Ondemar Dias Júnior. This was the first such study presented in Brazil and the first to use the term paleoparasitology, marking the beginning of a series of scientific articles, Master's theses, and PhD dissertations.

1980 – ARAÚJO, A. *Contribuição ao Estudo dos Helminthos Encontrados em Material Arqueológico no Brasil*, 1980. Master's thesis, Rio de Janeiro: Instituto Oswaldo Cruz, 1980.

Supervised by Luiz Fernando Ferreira, this was the first thesis on paleoparasitology in Brazil and the first in the graduate studies program in Parasite Biology at the Oswaldo Cruz Institute. The author studied helminth infections in pre-Columbian America in human coprolites from the Gentio II cave in Unaí, Minas Gerais, and the results in animal coprolites (in this case lacertid lizards) found by Dr. André Prous of the Museum of Natural History at the Federal University of Minas Gerais at the Santana do Riacho archaeological site in Minas Gerais.

1982 – JONES, A. K. J. Recent finds of intestinal parasite ova at York, England. Presented at the annual meeting of the European Chapter of the Paleopathology Association, 1982 (Mimeo).

The author updated the data on England with his findings from York. He studied quasi- mineralized conserved coprolites and used 10% hydrochloric acid solution to dissociate them for microscopic examination. His subsequent studies introduced techniques for egg counts in coprolites.

1983 – BERNARD, J. *Le Sang et l'Histoire*. Paris: Buchet-Chastel, 1983.

Jean Bernard, drawing on his profound knowledge of hematology and history, wrote this fascinating book on various questions in population migrations and culture. He concluded with the chapter entitled “Blood and the Fall of Empires”.

1983 – GRMEK, M. D. *Les Maladies à l'Aube de la Civilisation Occidentale*. Paris: Payot, 1983.

Mirko Grmek used his profound medical and literary erudition and a command of Greek to elaborate on historical sources and data from paleopathology. He established the concept of pathocenosis and sought to define the reality of diseases in the prehistoric, archaic, and classical Greek world. Grmek visited the Oswaldo Cruz Foundation at the invitation of Paulo Gadelha, then director of Casa de Oswaldo Cruz, providing Brazilian researchers with excellent moments of discussion on the origin and evolution of infectious diseases.

1983 – CONFALONIERI, U. *Paleoparasitologia do Gênero Trichuris Roederer, 1768 com um Estudo Paleoepidemiológico sobre a Origem do Trichuris trichiura (Linn) na América (Nematoda: Trichuridae)*, 1983. PhD dissertation, Seropédica: Universidade Federal Rural do Rio de Janeiro.

The dissertation by Ulisses Confalonieri analyzes the origin of parasitism by species from genus *Trichuris* in humans and animals and the dispersal of the species that infests humans in the Americas. He discusses its introduction by sea in prehistoric times, since the parasite's eggs would not have survived in soil during migration of the hosts from Siberia to Alaska.

1985 – REINHARD, K. J. *Recovery of Helminths from Prehistoric Feces: the cultural ecology of ancient parasitism*, 1985. Unpublished Master's thesis, Flagstaff, Arizona: Department of Biological Sciences, Northern Arizona University.

Karl Reinhard presents his Master's thesis, one of the first to discuss parasites found in coprolites from North American archeological sites.

1985 – HORNE, P. D. A review of the evidence of human endoparasitism in the pre-Columbian New World through the study of coprolites. *Journal of Archaeological Science*, 12: 299-310, 1985.

Patrick Horne conducts a review of studies in paleoparasitology in the Americas, using paleoparasitology as the key word in the text. He discusses the question raised in our articles on the introduction of human parasites into the New World by routes other than the Bering Land Bridge. In addition to studying human coprolites, he participated in various necropsies of mummified bodies, including the Cerro El Plomo Boy, one of the most famous mummies in Chile, always studying parasites. After exchanging extensive correspondence, we finally met in person at the Turin congress in 2004. Horne passed away in 2008, leaving a legacy of fundamental contributions on the distribution of parasites in ancient peoples in both the New and Old Worlds (Castro, 2008).

1986 – The Paleopathology Association, in its 13th Annual Meeting in Albuquerque, New Mexico, devoted a session specifically to paleoparasitology.

Coordinated by Karl Reinhard, the session convened experts on this subject for the first time. Ulisses Confalonieri represented the Brazilian group and presented two papers: “Paleoparasitological research in Brazil: present status and perspectives” and “The origin and pre-historic dispersion of human trichuriasis in the New World”.

1987 – REINHARD, K. J.; CONFALONIERI, U. E. C.; FERREIRA, L. F.; HERMANN, B. & ARAÚJO, A. Aspects of paleoparasitological technique: recovery of parasite eggs from coprolites and latrines. *Homo*, 37: 217-238, 1987.

This article provides a review of the techniques used in paleoparasitology. The authors discuss the methods used, with a conclusion on the need for more in-depth studies, especially with a better morphological and morphometric description of the eggs.

1988 – FERREIRA, L. F.; ARAÚJO, A. & CONFALONIERI, U. Paleoparasitologia no Brasil. Rio de Janeiro: PEC/Ensp/Fundação Oswaldo Cruz, 1988.

This book, in Portuguese, presents the studies published as of that year by the authors, with the first chapter entitled “The Aim of Paleoparasitology”, reporting on the motivations and difficulties in conducting studies, formation of the research group, and the working conditions. The subsequent chapters are: “Findings in Coprolites”, “Autopsies in Mummies”, “Scientific Disputes”, “Technical and Methodological Issues”, “Interpreting Results”, and “Teaching Paleoparasitology”.

1988 – CHAME, M. *Estudo Comparativo de Fezes e Coprólitos Não Humanos da Região Arqueológica de São Raimundo Nonato, Sudeste do Piauí, Brasil*, 1988. Master's thesis, Rio de Janeiro: Museu Nacional, Universidade Federal do Rio de Janeiro.

Marcia Chame established a solid basis for the methodology to correlate coprolites with the animals from which they originated. Her Master's thesis aimed to open paths for morphological and morphometric diagnosis of animal feces and macroscopic and microscopic analysis of their content for comparison with coprolites.

1989 – BOUCHET, F. Étude parasitologique des coprolithes et des sédiments de trois ensembles clos médiévaux de la rue de Lutèce (Île de France) à Paris. *Revue d'Archéométrie*, 13: 13-21, 1989.

In France, Françoise Bouchet published her studies on parasites in ancient latrines and sediments. She founded the Paleoparasitology Laboratory at the University of Reims and established a team of young researchers, including Odile Loreille, Stéphanie Harter, and Matthieu Le Bailly. Françoise Bouchet received the Brazilian doctoral students Gino Chaves da Rocha and Marcelo Luiz Carvalho Gonçalves at her laboratory.

1991 – Founding of the Brazilian Society of Paleopathology.

This was a meeting of Brazilian experts to exchange ideas and conduct collaborative research work, with particular stimulus for training young researchers. Sheila Mendonça de Souza joined the research group on paleoparasitology and paleopathology. The Brazilian Society of Paleopathology was created as a chapter of the Paleopathology Association, and its first meeting took place during the congress of the Brazilian Society of Archaeology in Rio de Janeiro. The first scientific event took place at the National School of Public Health (ENSP/Fiocruz) in 1992, chaired by Marília Alvim

and then-president Luiz Fernando Ferreira. A memorable discussion on the meaning of “paleo” and “archaeo” took place among participants in the opening round table, including Marília de Melo Alvim, Sheila Mendonça de Souza, and Luiz Fernando Ferreira.

1993 – CAMPILLO, D. *Paleopatología: los primeros vestigios de la enfermedad*. 2 vols. Fundación Ulrico 1838, Barcelona, Spain, 1993/1994. (Colección Historia de la Salud, 4, 5).

Domingo Campillo published an edition on paleopathology in which he translated the methods and techniques for studies in the past into a language accessible to interested members of diverse fields. He mentioned coprolites as an important source for studies in infectious diseases and showed the results from different continents.

1998 – AUFDERHEIDE, A. & RODRÍGUEZ-MARTÍN, C. *The Cambridge Encyclopedia of Human Paleopathology*. Cambridge: Cambridge University Press, 1998.

Arthur C. Aufderheide and Conrado Rodríguez-Martín published this mandatory reference for experts and students in the field. This encyclopedia includes the state of the art and all aspects involved in research on diseases in the past.

1997-1998 – DESOWITZ, R. *Who Gave Pinta to the Santa Maria? Tracking the devastating spread of the lethal tropical diseases into America*. Harvest Books, 1997/1998.

Robert S. Desowitz proceeded with a series of books publicizing science, drawing on data from paleoparasitology to explain the origins and evolution of infectious diseases. In one chapter he comments on the issue of the introduction of hookworm infection into the Americas and discusses our articles. The book has an excellent theoretical basis and provides an easy and enjoyable read, recommended for whoever is interested in the origins and spread of infectious diseases.

2001 – DITTMAR, K. *Untersuchungen zum Vorkommen von Ektoparasiten bei Domestizierten und wild Leben den Meerschweinchen (Cavia spp.) sowie an Präinkaischen Meerschweinchenmumien in Peru, Südamerika*, 2001. PhD dissertation, Leipzig: Universität Leipzig.

Katharina Dittmar presented this PhD dissertation at the School of Veterinary Medicine, University of Leipzig, Germany. She studied ectoparasites found on the mummified bodies of animals that were buried as funeral companions of humans during the pre-Columbian period. During her post-doctoral studies, Katharina Dittmar visited our laboratories at the Oswaldo Cruz Foundation and University of Nebraska, worked for several years at the University of Utah, Provo. She currently teaches at the State University of New York in Buffalo.

2002 – IÑIGUEZ, A. M. *Diagnóstico Molecular de Enterobius vermicularis (Linnaeus 1758) em Populações Pré-históricas: análise da região intergênica dos genes ribossomal 5S RNA e do gene SL1RNA*, 2002. PhD dissertation, Rio de Janeiro: Instituto Oswaldo Cruz.

Through her PhD dissertation, Alena Mayo Iñiguez consolidated the area of molecular paleoparasitology at the Oswaldo Cruz Institute, as one of the key references on this topic. This research continues the work she developed during her Master's thesis, *Análise de DNA Ancestral para o Estudo de Infecções Parasitárias em Populações Pré-históricas*.

2003 – Special issue of *Memórias do Instituto Oswaldo Cruz*, 98, suppl. 1, 2003. Available at <<http://memorias.ioc.fiocruz.br/98sup/98sup.html>>. This was the first special issue of a scientific journal dedicated entirely to paleoparasitology. Organized by Ferreira, Reinhard, Bouchet, and Araújo, it contains articles by various paleoparasitologists, with an introduction by Claude Combes and Arthur Aufderheide.

2003 – AUFDERHEIDE, A. *The Scientific Study of Mummies*. Cambridge University Press, United Kingdom, 2003.
Art Aufderheide published another fundamental book for paleopathology and paleoparasitology.

2004 – First International Course on Paleoparasitology organized and coordinated by Ricardo Guichón and Martín Fugassa, taught by Adauto Araújo, at the Unidad de Enseñanza Universitaria Quequén, Universidad Nacional del Centro (Unicen), Province of Buenos Aires, Argentina.

2005 – First meeting of the Paleopathology Association held in Brazil (and in South America), chaired by Sheila Mendonça de Souza, who also edited the papers published in *Memórias do Instituto Oswaldo Cruz*, special issue 101, supplement 2, in 2006. Available at <[http://memorias.ioc.fiocruz.br/101\(supII\).html](http://memorias.ioc.fiocruz.br/101(supII).html)>.

2007 – AVANTIN, F. *Paleoparasitologie: contribution à l'étude des paléoenvironnements de sites pleistocenes et holocenes du littoral méditerranéen français*. Oxford: David Brow Book Company, 2007.

Françoise Avantin turned her PhD dissertation into the first book published in Europe on findings of parasites in archaeological material. The author discusses specific sites, but the book became mandatory reading for archaeologists and paleoparasitologists, based on her recommendations for specific care in collecting material and on the techniques employed in her study.

2008 – FERREIRA, L. F.; REINHARD, K., & ARAÚJO, A. *Paleoparasitologia*. Rio de Janeiro: Editora Fiocruz, 2008.
(Temas em Saúde)

This edition of public science communication aimed to awaken interest in paleoparasitology among young researchers.

2008 – UJVARI, S. C. *A História da Humanidade Contada pelos Vírus, Bactérias, Parasitas e Outros Organismos*. São Paulo: Editora Contexto, 2008.

Stefan Ujvari had already published a highly interesting book in 2003, called *A História e suas Epidemias: a convivência do homem com os microrganismos* (Senac Rio), in which he discussed infectious diseases and host-parasite adaptations. In this more recent publication, Ujvari uses data from paleoparasitology to back some of his theses. An infectious diseases expert at the Oswaldo Cruz German Hospital in the city of São Paulo, he was one of the pioneers in opening the field of studies on the origins and evolution of parasitic infections in Brazil.

2009 – SORENSON, J. L. & JOHANNESSEN, C. L. *World Trade and Biological Exchanges before 1492*. New York: iUniverse, 2009.

John Sorenson and Carl Johannessen continued the line of arguments and data they had been collecting since their last publication in 2004, in online format, with evidence of overseas migrations or contacts between Asian and American peoples before the arrival of Europeans and Africans. They drew extensively on the data from paleoparasitology,

described by our group, concerning the evidence of ancylostomiasis and trichuriasis in pre-Columbian America, as well as on prior data and arguments by earlier parasitologists such as Fred Soper, Samuel Darling, Harold Manter, and Olympio da Fonseca Filho. Sorenson and Johannessen also used data on cultivated plants such as sweet potato and maize, taken from the Americas to Asia prior to the great European seafaring voyages.

2011 – The original Portuguese-language of the current book, with new paleoparasitologists and new ideas. We will stop the reminiscing here. No one is better than students to motivate and encourage their professors, so this book is a tribute to the students.

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