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Weir, L.

1996 Recent Developments in the Government of Pregnancy. *Economy and Society* 25(3):372-392.

Wilson, P.

1982 *Black Death, White Hands*. Sydney: George Allen and Unwin.

Wolfe, P.

1998 *Settler Colonialism and the Transformation of Anthropology: The Politics and Poetics of an Ethnographic Event*. London: Cassell.

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Commentaries

Various Perspectives on the Origins of Pathogens: Questions of Evidence

In 1997, *Medical Anthropology* published an article by Kathleen Fuller entitled "Hookworm: Not a Pre-Columbian Pathogen" (Volume 17, Number 4). In it, Fuller enters a debate concerning whether or not hookworm was one of the many pathogens brought to the Americas in the process of European conquest and colonization. If hookworm was endemic in sub-tropical and tropical regions of the Americas prior to European contact and the slave trade, then questions immediately arise as to how this pathogen *did* arrive. And these are important questions, as the clearer our picture of pre-Columbian disease loads in the Americas, the clearer our picture of the impact of European conquest on Aboriginal populations. Furthermore, as the presence of hookworm is generally associated with iron deficiency, it is indicative of a population's overall health status.

In her article, Fuller dismisses the reported evidence of hookworm infection in the Americas and declares speculation about the pre-Columbian transoceanic origin and spread of hookworm to be unnecessary: "Based on an analysis of the life cycle and the morphology of hookworm, the paleopathological indications for the presence of hookworm infestation in the Americas prior to 1492 are suspect." Below, Faulkner and Patton, and Reinhard et al.—the two groups of scientists whose evidence for the Pre-Columbian existence of hookworm Fuller challenges—provide rebuttals to her article. At issue here is not only our understanding of the complex ecology of host-parasite-environment relations and how pathogens travel from place to place, but, more important, our understanding

- Barr, T. C. Jr.
1961 Caves of Tennessee. Bulletin 64, Tennessee Division of Geology.
Beaver, P. C., R. C. Jung and E. W. Cupp
1984 Clinical Parasitology, 9th edition. Philadelphia: Lea and Febiger.
Chandler, A. C.
1930 Introduction to Human Parasitology, 4th edition. New York: Wiley.
Faulkner, C. T.
1991 Prehistoric Diet and Parasitic Infection in Tennessee: Evidence from the Analysis of Desiccated Human Paleofeces. *American Antiquity* 56:687-700.
Faulkner, C. T., S. Patton and S. S. Johnson
1989 Prehistoric Parasitism in Tennessee: Evidence from the Analysis of Desiccated Fecal Material Collected from Big Bone Cave, Van Buren County, Tennessee. *Journal of Parasitology* 75:461-463.
Ferreira, L. F., A. J. G. de Araújo and U. E. C. Confalonieri
1983 Finding of Helminth Eggs in a Brazilian Mummy. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 77:65-67.
Fuller, K.
1997 Hookworm: Not a Pre-Columbian Pathogen. *Medical Anthropology* 17: 297-308.
Georgi, J. R. and C. L. Sprinkle
1974 A Case of Human Strongyloidosis Apparently Contracted from Asymptomatic Colony Dogs. *American Journal of Tropical Medicine and Hygiene* 23:899-901.
Hawdon, J. M. and S. A. Johnson
1996 Hookworms in the Americas: An Alternative to Trans-Pacific Contact. *Parasitology Today* 12:72-74.
Kliks, M. M.
1990 Helminths as Heirlooms and Souvenirs: a Review of New World Paleoparasitology. *Parasitology Today* 6:93-100.
Reinhard, K. J.
1992 Parasitology as an Interpretive Tool. *American Antiquity* 57:231-245.
Sloss, M. W., R. L. Kemp and A. M. Zajac
1994 *Veterinary Clinical Parasitology*, 6th edition. Ames: Iowa State University Press.

American Hookworm Antiquity

Karl Reinhard, Adauto Araújo, Luiz Fernando Ferreira and Carlos E. A. Coimbra

Fuller (1997) presents a refutation of the evidence of ancylostomids (hookworms) in the New World. She argues that the life cycle of hookworms limits them to warm, moist environments and, thus, confines their prehistoric distribution to the Old World. Smith (1990) emphasizes that very little is known about the ecological

parameters of egg and larval survival and that eggs and larvae can survive in cold environments. Fuller's hookworm life cycle is oversimplistic and does not address the diverse array of infection modes available to *Ancylostoma duodenale*. This species is capable of mucosal penetration and, therefore, can cause infection if its larvae are eaten. In other words, *A. duodenale* is a geohelminth, and the host can be an active player in the infection mode. Hypobiosis of *A. duodenale* diversifies infection modes (Schad 1990). The larvae have the capacity to infect through milk, and there is strong evidence that they can also migrate into the fetus. Experimental evidence indicates that the larvae can enter hypobiosis in the muscle of animals and can infect humans who eat the meat of such animals. Thus infection can occur without an extracorporeal phase.

Fuller also refutes the diagnoses of ancylostomids from archaeological sites. The first diagnosis of ancylostomids in the New World was based on the recovery of adult worms from the intestine of a mummified body dated to pre-Columbian times (Allison et al. 1974). Allison et al.'s documentation consists of light microscopy, scanning electron microscopy (SEM), and histology, and they present a diagnosis of *Ancylostoma duodenale*. Fuller's attempt to refute Allison et al.'s diagnosis is based on the following points: (1) "The southern coast of Peru is totally free of hookworm infection" (Fuller 1997:301, citing Chandler 1929); (2) the mummified adult worms are smaller than worms found in clinical settings (Fuller 1997:302); and

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(3) the eggs found in the intestinal contents of the mummified body are more advanced in embryogenesis than is typically the case for eggs studied in a clinical setting. From these three points Fuller concludes that what Allison et al. diagnosed as hookworm (*Ancylostoma duodenale*) was actually pinworm (*Enterobius vermicularis*).

Fuller's assertion that the southern coast of Peru is totally free of hookworm infection is simply incorrect. More recent studies than Chandler (1929) show that hookworm infection is endemic in the area (Faust and Russell 1964; Camillo-Coura 1970; Náquira, 1990). As of 1994, there was a documented 1.6% prevalence of ancylostomid infection among the people living in the Andes and a 0.33% prevalence among coastal Peruvians (Elliot and Caceres 1994:36). *Ancylostoma duodenale* is even more common on the Pacific coast. Therefore, Fuller's first point is invalid.

Fuller's second point is also invalid. Her use of worm size as a diagnostic criterion reflects her lack of familiarity with parasite taphonomy. Size should never be used as a diagnostic criterion for desiccated adult nematodes (Reinhard et al. 1986). Nematodes have neither an endoskeleton nor an exoskeleton, so the worms shrink as they desiccate. In our experience, only egg size can be used as a diagnostic criterion.

Fuller's third point relates to the state of larval maturation found by Allison et al. She notes that "fecal hookworm eggs are at the four-cell or eight-cell stage of embryonation when they are expelled from the host.... Therefore, it would not be possible for these presumed egg casings to contain larvae." She fails to recognize that hookworm eggs embryonate in a variety of environments, including distilled water, saline solution, the interior of refrigerators, and even dead hosts. It follows that the state of embryonation of nematode eggs in fresh feces cannot be applied as a diagnostic criterion for determining the nature of paleoparasitological remains.

Fuller's alternative diagnosis—that is, what Allison et al. actually found was *E. vermicularis*—cannot be accepted. According to Fuller: "Given the size and morphology of the 'worms' in Allison et al. (1974) photos, it is probable that they are the larval stage of *E. vermicularis*." It is impossible to confuse an adult hookworm with a larval pinworm. The animals are in two separate nematode orders (Strongyloidea and Oxyuroidea, respectively). The *A. duodenale* adult possesses a muscular esophagus and four teeth. It feeds by engulfing a section of intestinal epithelium, using its teeth as an anchor and cutting mechanisms, and it attaches itself to the wall of the small

intestine. This is precisely what Allison et al.'s photos demonstrate; thus there can be no doubt that they were dealing with adult *Ancylostoma* worms.

Fuller then turns her attention to Ferreira et al.'s identification of ancylostomid eggs, as reviewed by Horne (1985) and Araújo (1987). Ancylostomid work in Brazil is complicated by the fact that only eggs and larvae have been found. Experimental analysis of artificially desiccated eggs indicates that the egg morphology of some species can be used as a diagnostic criterion (for a review, see Reinhard et al. 1986). Brazilian researchers turned to the SEM study of larvae (Araújo 1987; Reinhard et al. 1987), which indicated that the microstructure of ancylostomids preserves and can be used for diagnosis. Again citing Chandler (1929), Fuller suggests that at least some of these finds were misdiagnosed because the remains from one of the sites come from northeastern Brazil, an area in which hookworm is absent. However, later researchers, whom she does not cite, did encounter hookworms in that area. Camillo-Coura (1970) found an 18% prevalence of ancylostomid infection among the population in northeastern Brazil. As with the eggs found in Allison et al.'s Peruvian mummy, so with the Brazilian eggs: Fuller argues that the fact that they are embryonated negates the possibility that they come from hookworms. She is apparently under the mistaken belief that "hookworm larvae do not develop until the feces come in contact with warm, moist soil" (Reinhard et al. 1986:303). She also believes that moisture level within the cave was insufficient for hookworm embryonation. These opinions reflect a lack of knowledge of both fecal ecology and the variability in hookworm embryonation. Fecal pellets in dry environments undergo surface desiccation, which protects the inside of the feces from drying. Thus, for a period of time, embryonation occurs inside feces that look dry. It follows that it is possible to find unembryonated eggs, embryonated eggs, and free larvae in the same feces. Also, hookworm egg embryonation is not dependent upon coming into contact with warm, moist soil, as Fuller asserts. She presents an alternative diagnosis of *Strongyloides stercoralis* for the Brazilian ancylostomids. This diagnosis is not consistent with the *Strongyloides* life cycle, as *S. stercoralis* lay eggs that hatch in the intestine and are rarely seen in stool.

Fuller's literature review misses some important points. First, the diagnosis of the Brazilian ancylostomids was long ago debated in the literature (see Horne [1985] for a review). The result of that debate was the acceptance of the ancylostomid diagnosis (Horne 1985;

Kliks 1990; Reinhard 1990; Náquira 1990; Merbs 1992). Her discussion of the Brazilian finds, based as it is on a 1929 reference, is hopelessly dated; she simply does not seem to realize that the parasitological community at large accepts our diagnosis. Fuller presents no actual diagnostic basis for altering previous conclusions, and she neglects a number of ancylostomid-egg finds in North America that have been discussed fully by Reinhard (1990).

REFERENCES

- Allison, M. J., J. Pezzia, A. Hasegawa and E. Gerszten
1974 A Case of Hookworm Infection in a Pre-Columbian American. *American Journal of Physical Anthropology* 41:103-106.
- Araújo, A.
1987 Paleoepidemiologia da Ancilostomose. Ph.D. Dissertation, Escola Nacional de Saúde Pública/FIOCRUZ, Rio de Janeiro, Brazil.
- Araújo, A., L. F. Ferreira and U. Confalonieri
1981 A Contribution to the Study of Helminth findings in Archaeological Material in Brazil. *Revista Brasileira de Biologia* 41:873-881.
- Camillo-Coura, L.
1974 Contribuição à profilaxia das geohelmintíases. *Revista da Sociedade Brasileira de Medicina Tropical* 8:341-356.
- Camillo-Coura, L.
1970 Contribuição ao Estudo das Geohelmintíases. M.S. Thesis in Livre-Docência, Universidade de Rio de Janeiro, Brazil.
- Chandler, A. C.
1929 Hookworm Disease. New York: Macmillan.
- Elliot, A. and I. Caceres
1994 Parasitologia Médica del Peru. Instituto de Medicina Tropical "Daniel A. Carrion", Universidad Nacional Mayer San Marcos, Lima.
- Faust, E. C., P. F. Russell and R. C. Jung
1964 Craig and Faust's Clinical Parasitology. Philadelphia: Lea and Febinger.
- Ferreira, M. R., W. Souza, E. P. Perez, T. Lapa, A. B. Carvalho, A. Furtado, H. B. Coutinho and D. Wakelin
1998 Intestinal Helminthiasis and Anemia in Youngsters from Matriz da Luz, district of São Lourenço da Mata, state of Pernambuco, Brazil. *Memórias do Instituto OSWLADO Cruz* 93:289-293.
- Fuller, K.
1997 Hookworm: Nota Pre-Columbian Pathogen. *Medical Anthropology* 17:297-308.
- Home, P. D.
1985 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.
- Kliks, M. M.
1982 Parasites in Archaeological Material from Brazil. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 7:701.
- Kliks, M. M.
1990 Helminths as Heirlooms and Souvenirs: A Review of New World Paleoparasitology. *Parasitology Today* 6:93-100.
- Merbs, C. F.
1992 A New World of Infectious Disease. *Yearbook of Physical Anthropology* 53:1-9.
- Náquira, C.
1990 Hookworm Infection in Latin America and the Caribbean. In *Hookworm Disease: Current Status and New Directions*. G. A. Schad and K. S. Warren, eds. Pp. 55-68. London: Taylor and Francis.
- Perez, E., P. Gazin, A. Furtado, P. Miranda, N. M. Marques, M. R. Silva and R. Valera
2000 Parasitoses intestinales et schistomose en milieu urbain, en region littorale et en region semi-aride du Nord-Est du Brésil. *Cahiers Santé* 10:127-129.
- Reinhard, K. J.
1990 Archaeoparasitology in North America. *American Journal of Physical Anthropology* 82:145-162.
- Reinhard, K. J., U. E. C. Confalonieri, B. Herrmann, L. F. Ferreira and A. Araújo
1986 Recovery of Parasite Remains from Coprolites and Latrines: Aspects of Paleoparasitological Technique. *Homo* 37:217-239.
- Schad, G. A.
1990 Hypobiosis and Related Phenomena in Hookworm Infection. In *Hookworm Disease: Current Status and New Directions*. G. A. Schad and K. S. Warren, eds. Pp. 71-88. London: Taylor and Francis.
- Smith, G.
1990 The Ecology of the Free-Living Stages: A Reappraisal. In *Hookworm Disease: Current Status and New Directions*. G. A. Schad and K. S. Warren, eds. Pp. 89-104. London: Taylor and Francis.
- Vinha, C.
1969 Incidência de Ancylostoma, Ascaris e Trichuris no Brasil. *Revista Brasileira de Malariologia e Doenças Tropicais* 21:549-557.

Response

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Based on the analyses presented in the preceding two rebuttals of my 1997 article, it would appear that these researchers have proven

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