On Hookworms in the Americas and Trans-Pacific Contact

Since Darling[1] and Soper[2] first suggested a trans-Pacific origin for human hookworm parasitism in South America, a number of authors have advanced different arguments.

New paleoparasitological findings[3–7] have added further information, bringing the discussion about the hypothesis of ancient trans-Pacific human migration to the American continent again into focus[8,9].

In a recent paper, Hawdon and Johnston[10] suggested an alternative migratory route, via Beringia, for the introduction of hookworms to the New World. The authors based their arguments on the possibility of arrested development of *Ancylostoma duodenale* larvae. This could possibly explain the survival of *Ancylostoma* larvae in a host living in such an inhospitable environment[11]. However, it is unlikely that, even considering the possibility of such a biological peculiarity, hookworm transmission could be maintained at endemic levels under below-zero temperatures for any long period of time. Although a number of authors appropriately cited by Hawdon and Johnston[10] refer to vertical transmission, its epidemiologic significance remains to be established in *A. duodenale*.

It should be noted, however, that Hawdon and Johnston[10] overlooked the important paleoparasitological finding of *Trichuris trichiura* in coprolites from Brazil dated 3490 ± 120 to 430 ± 70 years BP (before present)[4,5]. Neither hypobiosis nor vertical transmission has been reported in this species. In addition, *T. trichiura* eggs also require a passage in soil to attain full embryological development. Since warm soil temperatures necessary for the development of *T. trichiura* eggs are not found in the Bering region, the case of this helminth, in addition to what is already known about the paleoparasitology of other worms, supports the hypothesis of trans-Pacific human contacts with the New World[9,12].

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Reply

The question of how hookworms arrived in the New World has long engendered heated discussion. The apparently tropical nature of hookworms has led many authors, including Ferreira and Araújo[1], to suggest that they were introduced by a trans-Pacific human migration to the New World, despite the absence of convincing archaeological evidence for even an isolated contact by this route. Recently, we proposed an alternative mechanism by which hookworms might have arrived as arrested stages in human populations that migrated across the Bering land bridge from northern Asia[2], a hypothesis consistent with the abundant archaeological evidence for a Beringial crossing. Once again, this alternative to the trans-Pacific theory has sparked a controversy.

Ferreira and Araújo point out several legitimate concerns regarding our hypothesis. However, the suggestion that arrested development in the human host is a 'biological peculiarity' is interesting, considering the extensive amount of data indicating that hypobiosis among the *Ancylostoma* species, including *A. duodenale*, has been shown to be an extremely important mechanism for protecting infective stages from harsh environmental conditions[3–6]. It is reasonable to suggest that this mechanism provided a major means of transmission in parasite populations at the edges of their distributions (ie. northern Asia). In addition, there is mounting epidemiological evidence from China suggesting vertical transmission of *A. duodenale* as an important human hookworm transmission strategy[6–8].

The presence of *Trichuris trichiura* in pre-European New World contexts does at first glance support a trans-Pacific contact. However, it should be pointed out that *T. trichiura* is much more tolerant of cold climates even than hookworm is, as evidenced by its discovery in Iron Age remains of the Grauballe and Tollund bog mummies of Denmark, the Lindow bog mummy from England, and the Neolithic 'Glacier man' from the Alps[9–11]. These findings indicate transmission at high latitudes and altitudes not generally associated with 'tropical' parasites such as *Trichuris*. The highly resistant eggs undoubtedly afford a great deal of cold tolerance, and probably also allowed their introduction via the Bering land bridge.

Many aspects of the peopling of the New World may never be known, including the size of the migrating populations, whether a coastal route was used, the actual climatic conditions, or the rate of the migrations. Each of these parameters could have influenced the success of a Beringial route for hookworm colonization of the New World. The archaeological and genetic evidence indicates that the continent was peopled by several distinct, independent migrations of humans originating in northern Asia, and that these people spread rapidly throughout the Western hemisphere. However, there is no convincing evidence of any kind for trans-oceanic contacts with the New World prior to the appearance of Europeans in the late 15th century. As we stated in the original article, our hypothesis of a Beringial route for the introduction of hookworm is meant as a feasible alternative to the trans-Pacific route, a hypothesis unsupported by any other evidence.

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