A DETERMINISTIC MODEL OF SCHISTOSOMIASIS WITH SPATIAL STRUCTURE

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Abstract. It has been observed in several settings that schistosomiasis is less prevalent in segments of river with fast current than in those with slow current. Some believe that this can be attributed to flush-away of intermediate host snails. However, free-swimming parasite larvae are very active in searching for suitable hosts, which indicates that the flush-away of larvae may also be very important. In this paper, the authors establish a model with spatial structure that characterizes the density change of parasites following the flush-away of larvae. It is shown that the reproductive number, which is an indicator of prevalence of parasitism, is a decreasing function of the river current velocity. Moreover, numerical simulations suggest that the mean parasite load is low when the velocity of river current flow is sufficiently high.

1. Introduction. Schistosomiasis, a parasite (schistosome)-induced disease, is also known as bilharzia after Theodor Bilharz, who first identified the parasite in Egypt in 1851. Infection is widespread with a relatively low mortality rate but a high morbidity rate, causing severe debilitating illness. The disease is generally associated with rural poverty. An estimated 170 million people suffered it in sub-Saharan Africa in 2004, and so did a further 30 million in North Africa, Asia, and South America [26].

Schistosomes have to go through an intermediate host (snails in most cases) to complete their life cycle: from eggs, to miracidia, to cercariae, finally to adult flukes. Unlike direct parasites, schistosomes have two stages of reproduction - sexual production in humans and asexual amplification in snails. Mathematical modeling and analysis of schistosomiasis has drawn the attention of many researchers since the first paper by MacDonald in 1965 [15]. Thereafter, Anderson and May [2, 3], Cohen [6], Nåsell [16], Dobson [7], Adler and Kretzschmar [1], Pugliese [17], and many other researchers built excellent unstructured models and developed a decent understanding of transmission mechanism of schistosomiasis. However, many important biological facts (e.g., age/size- or spatial factors) are overlooked in these models. For example, snails tend to cease production eventually, and they quickly...