Water, dams, and prawns: novel ecological solutions for the control and elimination of schistosomiasis

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Abstract

Background Dams have long been associated with increased burdens of human schistosomiasis, but how dams increase disease is not always clear, in part because dams have many ecological and socioeconomic effects. A recent hypothesis argues that dams block the reproduction of the migratory river prawns that eat the snail hosts of schistosomiasis. In the lower basin of the Senegal River, there is evidence that prawn populations decreased and schistosomiasis increased after completion of the Diama Dam in Senegal. Restoring prawns to a water-access site upstream of the dam has been shown to reduce snail density and reinfection rates in people. However, whether a similar cascade of effects (from dams to prawns to snails to human schistosomiasis) occurs elsewhere is unknown. The aim of this work was to assess whether the dam-associated prawn declines coincident with schistosomiasis increases observed in the Diama Dam watershed in Senegal might be generalisable across a broad geographic area.

Methods We delineated prawn habitat boundaries for 24 large, marketable, migratory *Macrobrachium* spp prawns, based on the United Nations Food and Agriculture Organization species catalogue of shrimps and prawns. Using a published repository of schistosomiasis studies in sub-Saharan Africa, we compared infection before and after the construction of 14 large dams for people living in: (1) upstream catchments within historical habitats of native prawns, (2) comparable undammed watersheds, and (3) dammed catchments beyond the historical reach of migratory prawns. For each of these three scenarios, we calculated odds ratios (ORs) of schistosomiasis disease before:after dams using the number of people infected out of the total number examined, reported in the freely available GNTD database by using a generalised linear mixed model with binomial errors and a "logit" link function. Finally, by using published Gridded Population of the World estimates for 2015, version 3 (GPWv3) available from NASA's SEDAC data portal, we calculated the current human population living within areas around the world that are both endemic for schistosomiasis and occur within native prawn ranges.

Findings Catchments located within prawn habitat had overall ORs after:before of 2·8 (95% CI 2·7–2·9) for *Schistosoma haematobium* and 4·4 (3·6–5·3) for *Schistosoma mansoni*, showing a strong overall increase in schistosomiasis. By contrast, undammed watersheds in nearby prawn habitat experienced overall schistosomiasis declines across the same time periods; ORs after:before 0·90 (95% CI 0·88–0·91) for *S haematobium* and 0·75 (0·73–0·78) for *S mansoni*. The dammed catchments outside of prawn habitats also experienced schistosomiasis increases, but to a lesser degree than did dammed catchments within prawn ranges; ORs after:before 1·15 (95% CI 1·1–1·2) for *S haematobium* and 1·5 (1·3–1·8) for *S mansoni*. Finally, we estimated that a third to a half of the global population-at-risk of schistosomiasis could benefit from restoring native prawns.

Interpretation Because dams block prawn migrations, our results suggest that prawn extirpation contributes to the sharp increase of schistosomiasis after damming, and points to prawn restoration as an ecological solution to reduce human disease.

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Contributors
SHS conceived, designed, and coordinated the study, collected the data, did the statistical analysis, and wrote the Abstract. IJJ, DL, OC, JF, and AK collected the data, assisted with ArcGIS, and helped draft the Abstract. MJ, AL, CLW, KDL, AMK, CMH, JR, PAC, DLC, and GADL helped draft the Abstract. All authors gave final approval for publication.