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Plasmodium falciparum and helminth coinfections among schoolchildren in relation to agro-ecosystems in Mvomero District, Tanzania

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ABSTRACT

Background: In Sub-Saharan Africa, some individuals infected with malaria are also infected with helminths. However, the magnitude and distribution of such coinfections in relation to eco-systems remains poorly defined. This study was undertaken to determine the prevalence of *Plasmodium falciparum* and helminth coinfections among schoolchildren in relation to agro-ecosystems in Mvomero District, Tanzania.
Methods: The agro-ecosystems were categorised as sugarcane, traditional flooding rice irrigation, improved non-flooding rice irrigation and savannah. Schoolchildren had their blood examined for *P. falciparum* and *Wuchereria bancrofti*; urine for *Schistosoma haematobium* and stool for intestinal helminths. Blood samples were also examined for haemoglobin concentration.
Results: A total of 578 schoolchildren (mean age = 7.96 years) were involved in the study. Overall, 60% of all schoolchildren had at least an infection of either *P. falciparum*, *W. bancrofti*, *S. haematobium* or hookworm. The highest prevalence of *P. falciparum* (75.3%), *W. bancrofti* (62.9%) and hookworm (24.7%) infections was observed among children in flooding rice irrigation ecosystem. *P. falciparum* + *S. haematobium* (10.9%) and *P. falciparum* + *W. bancrofti* (11.1%) were the most prevalent types of coinfection in the area. The highest prevalence of double parasitic infections was observed among children in the flooding rice irrigation ecosystems. The risk for acquiring coinfections of *P. falciparum* + *W. bancrofti* was significantly higher among children in the flooding rice irrigation ecosystem. Forty-five (7.8%) children were coinfected with three types of parasitic infections. The risk of acquiring triple infection among children from flooding rice irrigation was higher for *P. falciparum* + *S. haematobium* + *W. bancrofti* ($p < 0.001$). Seven schoolchildren (1.2%) were found infected with four parasites and all were from the flooding rice irrigation ecosystem. Significantly high *P. falciparum* geometric parasite density was observed among children coinfected with either hookworms or *W. bancrofti* ($p < 0.001$). On average, 17.8% (103/578) of the children had enlarged spleens. Over 3- and 4-folds increase in the risk of having an enlarged spleen were observed among children coinfected with *P. falciparum* + *S. haematobium* and *P. falciparum* + *W. bancrofti*, respectively. The overall prevalence of anaemia (<11.5 g/dl) was 61.9% (358/578).
Conclusion: Malaria–helminth coinfections are prevalent among schoolchildren in rural Tanzania and the pattern varies between agro-ecosystems. Results of this study suggest that integrated control of malaria and helminthes should be designed based on the local agro-ecosystems.

1. Introduction

Malaria and helminth infections are major public health problems in Sub-Saharan Africa. These two groups of parasitic diseases show a spatial congruence in their geographical distribution and coinfections have been reported in a number of countries in the region (Mwangi et al., 2006; Brooker et al., 2006, 2007). Of the most common helminths, hookworm is more geographically widespread, occurring throughout much of Sub-Saharan Africa (Brooker et al., 2006), and hence, a wider distribution of *Plasmodium falciparum* and helminth coinfections is the greatest for hookworm in the region.

High frequencies of multiple infections of *P. falciparum*, *Ascaris lumbricoides* and *Trichuris trichiura* have been reported among children populations in several West (Tshikuka et al., 1999; Sokhna

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et al., 2004; Achidi et al., 2008) and East African countries (Brooker et al., 2006; Bejon et al., 2008). However, coincidental malaria–helminth at-risk population in Sub-Saharan Africa is the greatest for hookworm than is for *A. lumbricoides* or *T. trichiura* (Brooker et al., 2007). Although coinfections of *P. falciparum* and schistosomes have been reported (Sokhna et al., 2004; Briand et al., 2005; Lyke et al., 2005), the later have a more focal distribution that make the prediction of co-distribution with malaria more difficult to assess. A few studies have also reported the occurrence of filarial infections among malaria infected individuals in East Africa (Muturi et al., 2006a,b; Hillier et al., 2008).

The implications of multiple infections of malaria and helminths on the health of the victim are controversial. Some studies have shown a protective role of helminths (Nacher et al., 2000; Briand et al., 2005), while others have implicated helminth infections with adverse clinical outcome of malaria infections, suggesting that the former influence the acquisition of immunity against *P. falciparum* (Druilhe et al., 2005). Thus, helminths could constitute a confounding factor in the assessment of efficacy of malaria control interventions.

Despite the potential public health importance of coinfections and synergistic opportunities for control, little is known about its magnitude and distribution in Tanzania. The objective of this study was therefore to determine the prevalence of malaria–helminth coinfections in apparently healthy schoolchildren in different agro-ecosystems in Mvomero District, Tanzania.

2. Materials and methodology

2.1. Study area

This study was carried out in Mvomero District (latitudes 6–7°S; longitudes 37–38°E) in Tanzania. The district has a total area of 7325 km^2 and lies within the Wami River basin, on the foothills of Nguru Mountains to the north-west and Uluguru Mountains to the south-east. Rainfall in the study area is high (1100 mm per annum) and bimodal (March–May and October–December) with a relatively short dry spell between June and September. The mean maximum temperature is 31 °C, and is experienced from October to March; whereas the mean minimum temperature is 19 °C between June and September. Mvomero district is endemic for malaria with a prevalence of 40.1–46.1% (Mboera et al., 2006).

The locations of the agro-ecosystems and villages were georeferrenced using a hand held Global Positioning System (GPS) receiver. The coordinates of the variables were imported into GIS databases in which they were converted into a point map by Arc GIS software. The study area was stratified into four agro-ecosystems namely sugarcane, traditional flooding rice irrigation, improved non-flooding rice irrigation, and savannah. The respective villages in agro-ecosystems were Mtibwa, Komtonga, Mkindo-Dihombo and Dakawa-Luhindo (Fig. 1).

The characteristics of the study area have been previously described in detail (Mboera et al., 2010). The sugarcane ecosystem is located at the furthest northern point of the study area. The area comprises the largest sugarcane estate in Tanzania. The sugarcane plantation is irrigated by the use of sprinklers (overhead) or by open earth-lined and gravity-fed irrigation canals. The inhabitants in this ecosystem were mainly permanent employees and labourers in the sugarcane plantation and sugar factory. The traditional flooding rice irrigation ecosystem is characterised by swampy flatland lying on the tributaries of Wami River. The area is inhabited by small-scale farmers of rice using the traditional ground flooding irrigation

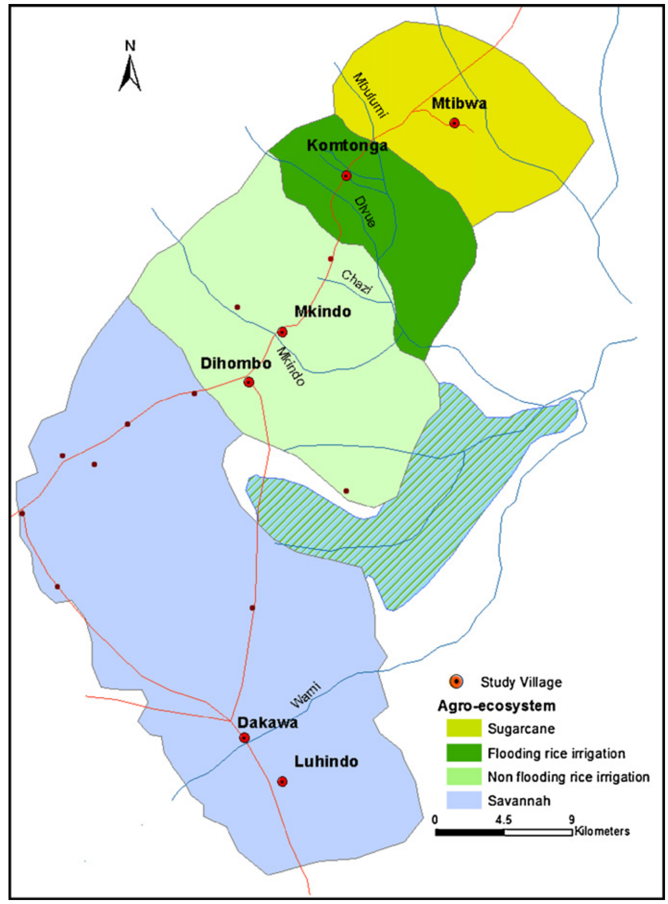

Fig. 1. Distribution of agro-ecosystems in Mvomero, Tanzania.

practice. Improved non-flooding rice irrigation ecosystem forms the central part of the study area. Communities in this area practice improved canal rice-irrigation employing gravitational water supply technique. The rice-field canals are open-earth-lined and distribute water from the main canal from the Mkindo River. The savannah ecosystem is located in the southern part of the study area and is characterised by short grass, trees and shrubs that provide a wide range of pasture for livestock grazing. The area is inhabited mainly by pastoralists and maize farming communities.

2.2. Study subjects and sample collection

This cross-sectional study was carried out during May 2005 at the end of the long rainy season and involved schoolchildren in six primary schools, one from each village. In each school, children in the lower classes (1–4) were enrolled and each had his/her sex, age and area of residence recorded. From each child, a blood sample (3–5 ml) was collected by venepuncture into a heparinised vacutainer. A drop of this blood was used to make thick and thin blood smears for malaria parasite examination and other sub-samples were used for detection of *Wuchereria bancrofti* antigens and quantification of haemoglobin concentrations. Malarial infection was determined by Giemsa-stained blood smears examined under light microscope at 100× magnification. Parasitaemia was measured by counting the number of asexual parasites against 200 leukocytes on the thick blood smear and species identification was done through microscopic examination of the thin blood smear. Circulating filarial antigens were assayed using NOW® Filariasis test cards (Binax Inc., Portland, ME, USA) (Weils et al., 1997). Haemoglobin