Adult Mosquito Populations and Their Health Impact around and far from Dams in Tigray Region, Ethiopia

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ABSTRACT

Malaria control program in Ethiopia has a history of more than 40 years, but still now, malaria is a major cause of morbidity and mortality in Ethiopia. The objective of this study is to assess the impact of dam construction in the distribution of mosquito in intervention (dam nearby villages) and controlled (villages far from dam). Indoor adult mosquitoes were collected using 144 CDC light traps from 12 villages (6 from the intervention and 6 from the control villages) Community-based malaria parasitology was also done. Sampling was done in November 2005, December 2005, May 2006 and September 2006). A total of 1713 adult indoor mosquitoes were collected, of these, 1182 (69%) were *Anopheles* and 531 (31%) *Culex*. The prevalence of *Anopheles* was 45.77% in the intervention villages and 23.23% in the controlled villages (F p = 0.012) . The prevalence of *Anopheles* increased twice in the intervention compared to the controlled villages. A total of 1436 children, 888 from intervention and 548 from control villages were examined for malaria parasitology. Only 57 children were found infected by *Plasmodium* species. Malaria prevalence rate was 3.97% (4.17% and 3.65% in intervention and control village, respectively)($\chi 2$ = 0.11, p= 0.7399). Among the 57 malaria positive cases in 32 (56.14%) we found *P. vivax* and in the 25 (43.86%) *P.falciparum*. We can tentatively conclude that the dams situated at 2000m and above do resulted two fold adult indoor mosquito, but do not seem to have resulted in a markedly higher incidence of malaria in the region. The study concludes that concerned authorities should take appropriate measures to improve health-care facilities for local communities when planning new irrigation schemes wherever they occur.

Key words: *Anopheles, Culex*, Dam, Intervention, Malaria.

1. INTRODUCTION

The high growth rate of the Ethiopian population and the recurrent drought especially in Northern Ethiopia has led to an increased demand for food production. In order to meet this need, the government has sought ways of improving food production by initiating irrigation projects, involving reclamation of arid and semi-arid areas for the cultivation of crops. In semiarid areas, dams could contribute storing water during the dry season for irrigation, domestic use, drinking purpose, recharging ground water and down streams. There are more than 70 reservoirs in Tigray (Northern Ethiopia), ranging in reservoir water volume from 50,000 to

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4,500,000 m^3 (Tadesse et al., 2008; DeWit, 2003). The majority of the dams are situated near human settlements at an altitude range of 1700-2700m.

As a potential negative side-effect, dams may create conducive environment for breeding sites of malaria and schistosomiasis vectors. A study in Tigray showed that dams situated below 1900m increase the incidence of malaria by sevenfold (Ghebreyesuset al., 1999). In Ethiopia, it is estimated that about 75% of the country is malarious and about 65% of the residents live in malarious areas (Ministry of Health, 2002). Malaria control program in Ethiopia has a history of more than 40 years, but still now, malaria is a major cause of morbidity and mortality in Ethiopia. Current control strategies are institution-based diagnosis and treatment, presumptive treatment by community health workers (CHWs), selective indoor residual spraying, killing of larvae by pesticides in selected urban areas, and epidemic control. In spite of these control efforts, malaria remains a major public health problem in Ethiopia. It has long been argued that the best way to reduce malaria transmission is to target adult female mosquito with insecticides that can reduce vector density, longevity and human feeding frequency (Magesa et al, 1991; Robert et al., 1991; Quinones et al., 1998; Mabogo et al., 1996).Due to the existence of various environmental and physical factors the nature of malaria in Ethiopia is variable (Ministry of Health, 2002). Thus, we designed to study the environmental factors associated with the breeding sites of anopheline mosquito in six selected microdams in Tigray.

This paper tries a) to compare the density of adult mosquito in the intervention and controlled villages; b) to assess abundance of indoor resting adult anopheline mosquitoes in the study area; c) to assess the prevalence and incidence of malaria infections in children aged 6 months to 10 years old in the study communities, as to determine the impact of dams on human health.

2. MATERIALS AND METHODS

2.1. Study Area

Mai Nigus, Mai Sessela and Mai Seye dams are located in the Central zone of Tigray. The other three study dams (Mai Dille, Adi Kenafiz and Gira Bered) are located in the Southern zone of the Regional State of Tigray (Fig 1). The 6 intervention villages located near the 6 dams and the 6 control villages at least 4km far from any villages are listed in table 1.

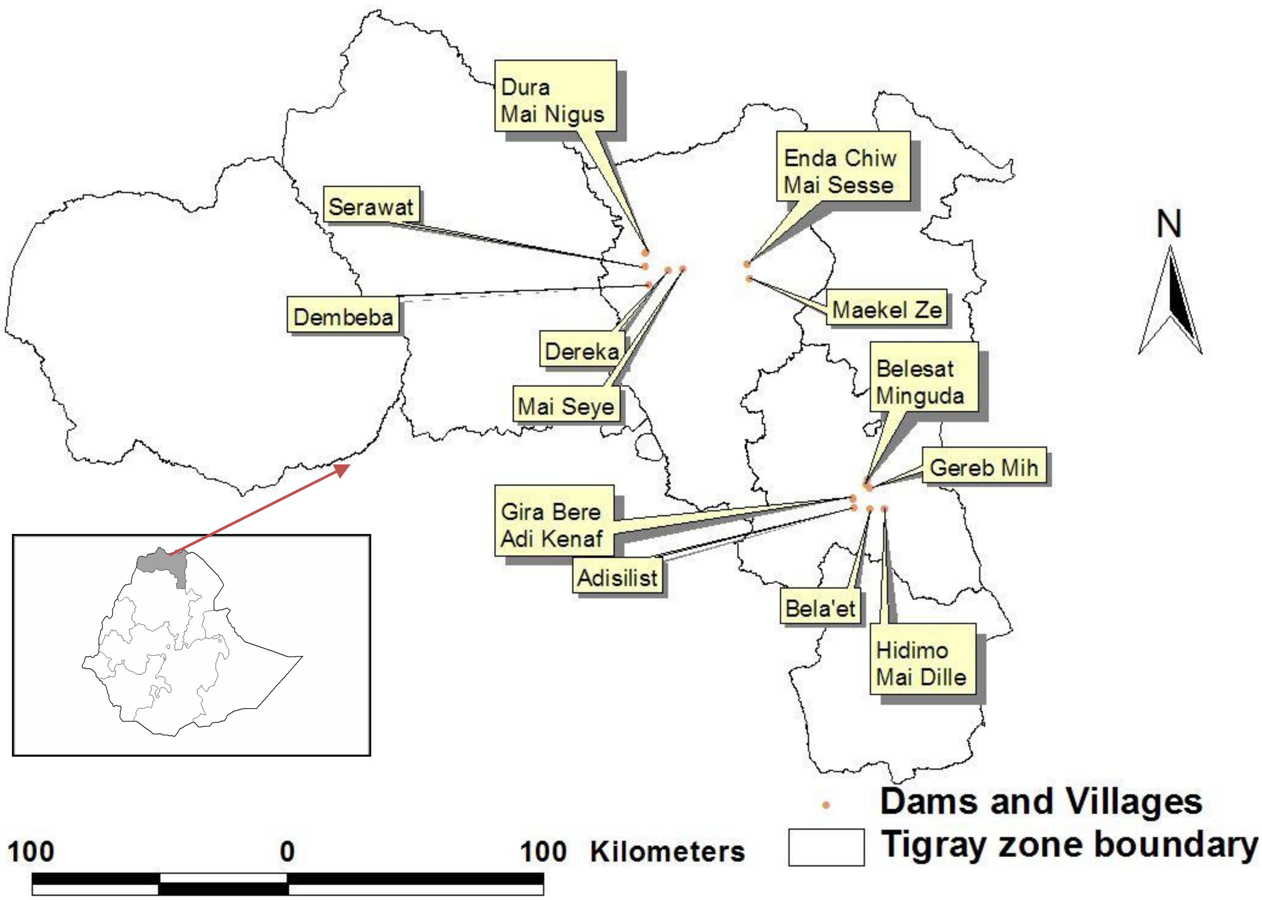

Figure 1. Map of study area.

2.2. Sampling design and procedures used

To measure the impact of the dams, we designed to compare areas around a dam (which we called intervention villages) and areas far from any dam with similar altitude (± 50 meters above sea level (masl)), which were our control villages. So, we pair sites from a village around a dam was compared to a village that is located further from the same dam (more than 4 km distance from the dam, which is greater than the flight range of mosquitoes) (Russell and Santiago, 1934). Our design involved largely a spatial approach; we also use added information on the temporal dynamics by collecting information from the local people on the history of mosquito and malaria in the study villages. Thus, 12 houses were selected from the intervention and 12 from the controlled villages. Successive sampling campaigns were done to obtain the necessary data.

Table 1.List of selected dams, district where they are located, altitude and corresponding intervention and control villages.

Dam	***Villages***	***District***	***Altitude***	***Remark***
Mai Nigus	Dura	Laelay Maichew	2050	Intervention
	Serawat	Laelay Maichew	2040	Control
Mai Seye	Dereka	Laelay Maichew	2000	Intervention
	Dembeba	Tahitay Maichew	1990	Control
Mai Sessela	Enda Chewa	Were Leke	2060	Intervention
	Maekel Zengui	Were Leke	2020	Control
Mai Dille	Hidimo	Hintalo Wejerat	2070	Intervention
	Bele'at	Hintalo Wejerat	2040	Control
Gereb Mihiz	Belesat	Hintalo Wejerat	2120	Intervention
	Minguda	Hintalo Wejerat	2170	Control
Adi Kenafiz	Gira Bered	Hintalo Wejerat	2020	Intervention
	Adi Silisto	Hintalo Wejerat	2070	Control

The first sampling campaign was done in November 2005, two months after the heavy and long rainy season. During this sampling, community based malaria parasitology and surveys of adult mosquito were done. During the second sampling, in February 2006, only adult mosquito survey was carried out. The third and fourth sampling were carried out in May and September 2006, respectively. In the September 2006 malaria parasitology and adult mosquito survey were done.

2.3. Entomology

2.3.1. Adult mosquito surveys

With an objective of establishing the level of indoor resting densities of adult anopheline mosquitoes in the study communities and houses were numbered. In both the control and intervention villages, 12 houses were randomly selected to assess adult mosquito density. Indoor adult mosquitoes were sampled using CDC light traps (Model 512; J.W. Hock Co., USA)and human-landing collections (WHO 1975).All adult anopheline mosquitoes were counted and identified based on morphological descriptions (Verrone, 1962; Gillies and Coetzee, 1987).

2.4. Epidemiology

To monitor the incidence and prevalence of malaria, we conducted longitudinal surveys of parasitemia and history of malaria-associated symptoms. Blood samples were taken from a total 1436 children, 548 from intervention villages and 888 children from control villages between 6 months and 10 years old, after informed consent by their parents or guardians. Blood films were prepared from all study children and their axillary temperature taken. A malaria episode is defined as a temperature of 37.5°C or higher in the presence of *Plasmodium falciparum* parasitaemia. Questions were also asked about fever in the past 24 hours, during the past 14 days, and about health care utilization and history of travel in the preceding 14 days. Those with a history of malaria (defined as 1 or more days of fever, chills, sweating, and headache) were treated immediately with sulfadoxine-pyrimethamine or co-arthem. All asymptomatic positive cases also received treatment after screening the slides.

2.5. Parasitology

Thick blood films were stained with 3% Giemsa and examined under 700-fold (i.e., 7 x 100 – oil immersion objective) magnification. Parasites were counted per high power field, and 100 fields were counted before a slide was declared negative. The same 2 experienced microscopists read each slide. Parasite counts were carried out against 300 white blood cells.

2.6. Data analysis

Univariate analyses were performed with the statistical program STATISTICA 9.0. Indoor adult *A. arabiensis* abundance was compared within and among the villages of the intervention and control sites by using ANOVA. Chi-square (χ^2) was performed using SPSS version 12 to test if there is malaria prevalence difference between the intervention and control villages. All statistical analyses were performed at the 5 % significance level.

3. RESULTS

3.1. Adult mosquito survey

Indoor adult mosquitoes were collected using 144 CDC light traps from 12 villages (6 from the intervention and 6 from the control villages). The sampling was done four times and a total of 1713 adult mosquitoes were collected. Of these, 1182 (69%) were *Anopheles* and 531 (31%) *Culex*. In general, adult night indoor mosquito catches showed a significant difference between intervention and control villages. The prevalence of *Anopheles* was 45.77% (784 / 1713) in the intervention village and 23.23% (398 / 1713) in the controlled villages ($F = 6.52$, $p = 0.012$) (Fig 2). The prevalence of *Anopheles* increases twice in the intervention compared to the controlled village.

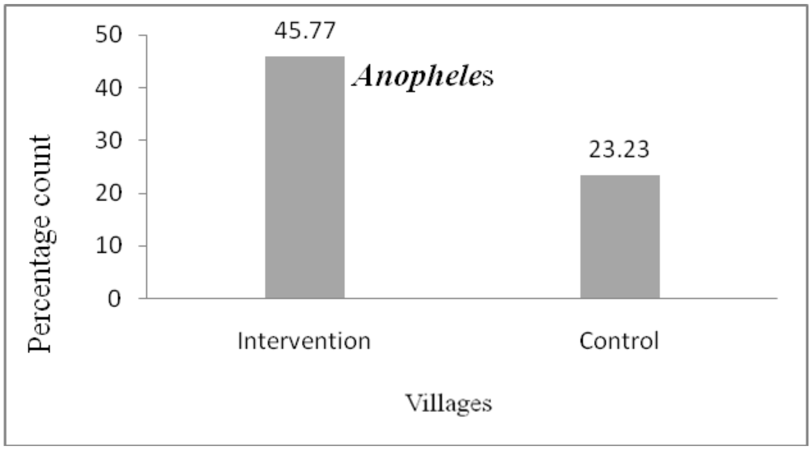

Figure 2. Prevalence of indoor *Anopheles* in intervention and control villages.

Generally adult mosquito catches was significantly vary between months (F = 4.715, P = 0.003). This temporal variation was significant for *Culex* (F= 4.54, P = 0.034), but not for *Anopheles* ((F = 2.403, P = 0.067)) (see Figure 3).

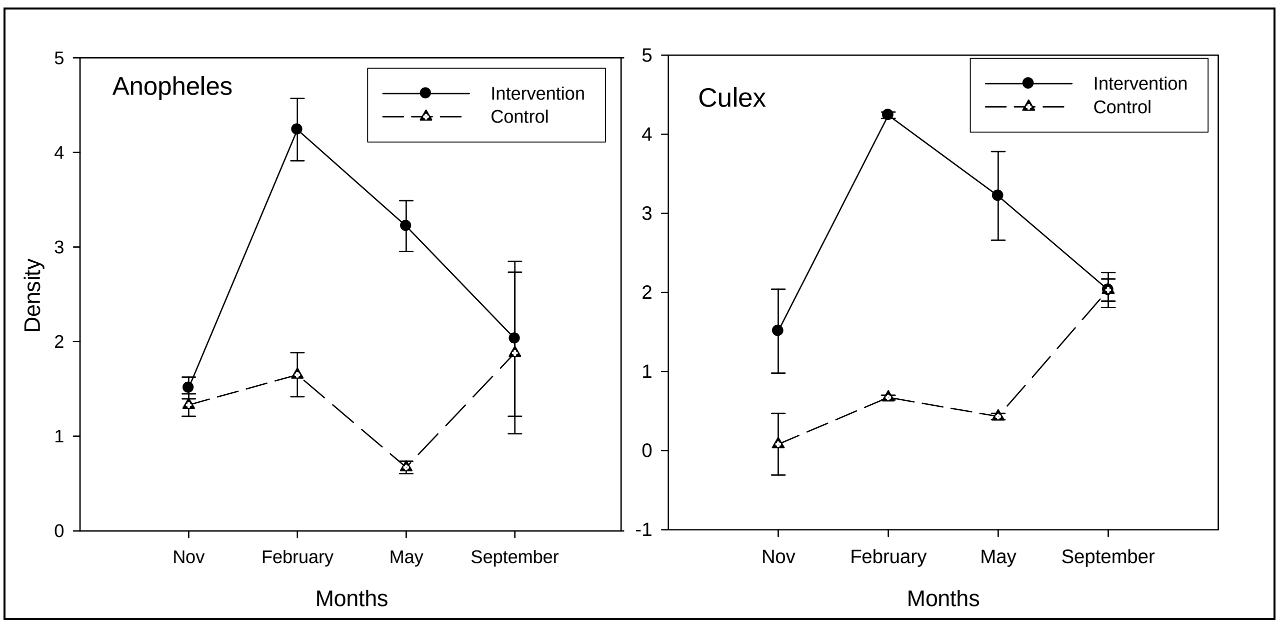

Figure 3. Adult indoor mosquito night catches in intervention and control villages in different months in Tigray (November 2005 – September 2006) density per house control village.

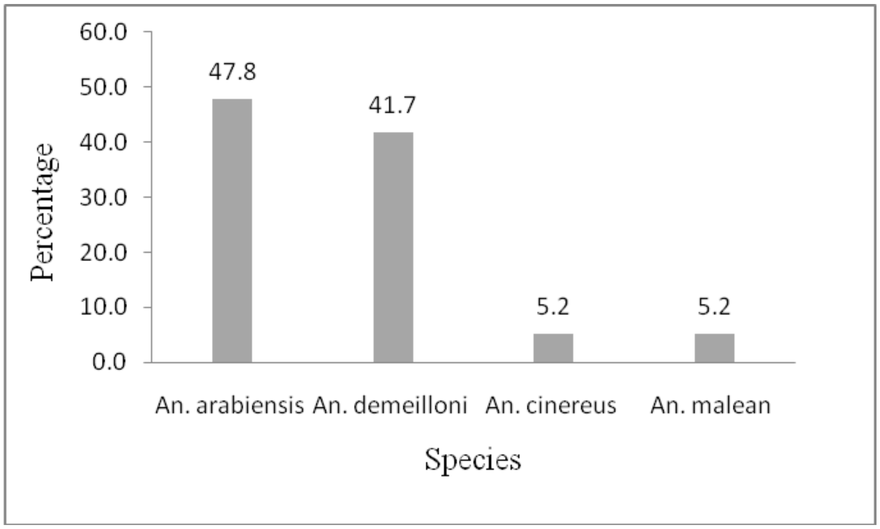

Figure 4. The identified species of the genus *Anopheles.*

Identification of the mosquitoes of the genus *Anopheles* revealed that there are four species in the study area: *An. Arabiensis* (47.8%*), An. Demeilloni* (41.7%), *An. Cinereus* (5.2%) and *An. Malean* (5.2%)(males) (Fig 4).

3.2. Malaria survey

A community based blood sample survey of 1436 children was done. Eight hundred eighty eight children were from intervention villages and 548 from control villages (Figure 5). From both sets of villages together, 57 children were infected by *Plasmodium* species.

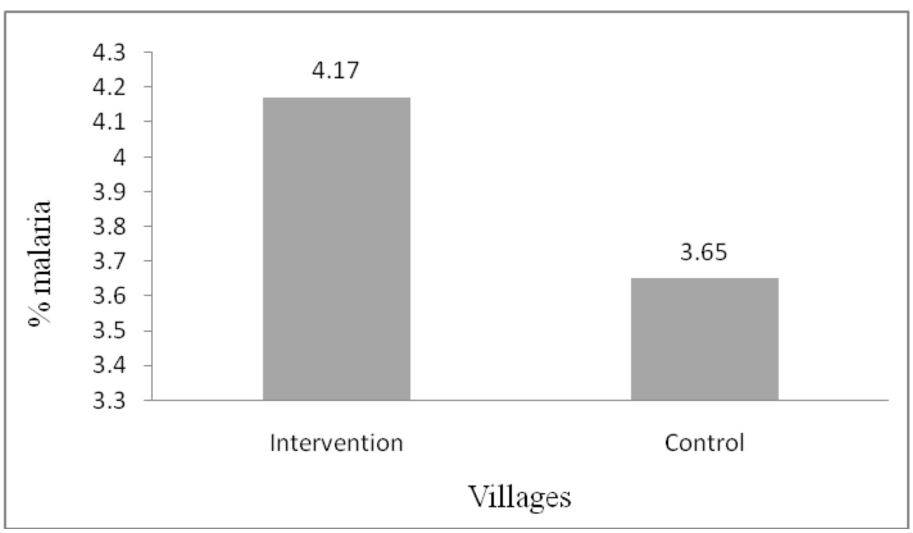

Figure 5. Percentage of children positives for *Plasmodium spp* in intervention and control villages (November, 2005)

In this survey, malaria prevalence rate was 3.97%. We found 4.17% and 3.65% in intervention and control village, respectively. In general the prevalence of malaria was very low and there was no significance difference between intervention and control villages ($\chi2 = 0.11$, P = 0.7399) (Fig 5). But prevalence of adult mosquito showed trend of twice increases in the intervention compared to the controlled villages (Fig. 2). A total of 57 (3.97%) children were positive for malaria, of which, 32 (56.14%) for *P. vivax*, 25 (43.86%) for *P. falciparum*. Children residing in the intervention villages were more likely to have *P. vivax*than being infected by *P. falciparum* when compared with that of children from the controlled village and vice versa, but this was not significant ($\chi2$ =1.785, P= 0.403) (Figure 6).

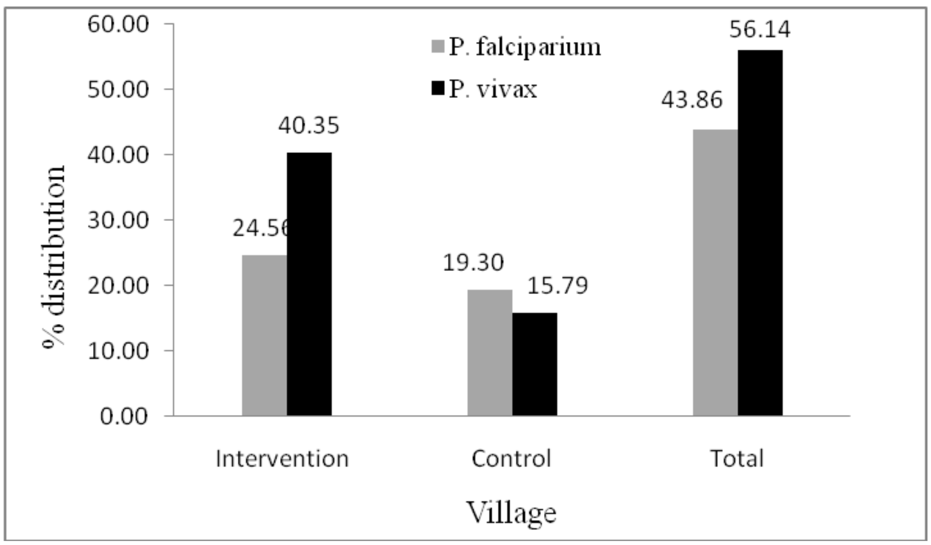

Figure 6. The proportion of *Plasmodium* infection in residents of intervention village and control village.

4. DISCUSSION

A survey of the impact of dams on the prevalence of malaria was carried out by comparing villages in the immediate neighborhood of dams (intervention villages) with villages at least 4 km distant from any dam (control villages). Both *Anopheles* and *Culex* adult indoor were collected during all sampling months (November, February, May and September) in both intervention and control villages. There was significant difference between intervention and control villages, and variation among months was also observed in mosquito indoor catches in all villages. Similar findings were reported in Tigray (Ghebreeysus et al. 1999; Ghebreyesus et al 2000; Mekonnen et al. 2005). Most of the adult mosquitoes collected were *Anopheles*: among these almost half of them were *Anopheles arabiensis*, which is responsible for transmitting *P.falciparum* and *P. vivax*in Ethiopia (Ghebreyesus et al. 2006). The prevalence of *Anopheles* increases by two fold in the intervention compared to the controlled village.

Adult indoor *Anopheles*and *Culex* showed similar trend of temporal variation. Both genera of adult indoor mosquito were collected in all sampling campaigns (during wet and dry seasons)in both intervention and control villages. In our survey, we were able to observe higher density variation between the intervention and control villages in the months where there was no rain (February) and heavy short period rain with floods (May). But similar pattern and no difference were observed in the months after the long and heavy rainy season where water and crops were available in the study area (September and November).Thus, the presence of dams may have contributed to the presence of adult mosquitoes in the villages throughout the year. The pattern of indoor mosquito catches is, however, contrary to the expectations based on our observations of larvae, which showed a decrease in density from November 2005 to May 2006 (no larvae found in May)(Tadesse et al., 2011).

The prevalence of malaria was very low. Similar finding was also reported from Tigray (Mekonnen et al., 2005) and from Gilgel-Gibe hydroelectric dam (Delenasaw et al., 2009). We found no significant difference in the prevalence rate of malaria between the intervention and control villages, but a trend of two fold increase in the intervention compared to that of controlled village. A study done in Koka Reservoir, Central Ethiopia, reported similar findings; in villages around the dam, malaria prevalence increases by about 1.5 times increase in the prevalence of malaria compared to villages that are located 3 to 6km from the dam mainly during seasons of greater transmission intensity (Lautze et al., 2007). Unlike the seven fold increase in malaria prevalence in the near dam villages than far dam reported by Ghebreyesuset al. (1999) in Tigray might be due to the fact that the difference in the altitude of the study sites. The previous studies were done in altitudes below 1900masl, but ours are 2000m and above. Thus, it might be very important to mention the altitude when comparing health impact of dams.

*P. vivax*was most prevalent in the intervention villages and *P. falciparum* in control villages. Similar finding were also reported by Delenasaw et al., (2009) and opposite result by Lautze et al. (2007).

5. CONCLUSION

Our observations suggest a clear impact of dams on the prevalence of adult mosquitoes. There was, however, no significant difference in the prevalence of *Plasmodium* infections (malaria) between the intervention and control villages.

Combined, our data on malaria and mosquito vector densities revealed a complex interaction:

a) Indoor adult mosquito night catches showed monthly variation in both intervention and controlled.
b) We observed two fold increase of adult *Anopheles*in intervention compared to control villages
c) In contrast, there was no significant difference in malaria prevalence between intervention and control villages.

Summarizing, our data suggest that there seems to be two fold increase in the occurrence of adult *Anopheles* in the neighborhood of dams than controlled villages (distant villages), but not a significantly higher the incidence of malaria. We can tentatively conclude that the dams situated 2000m and above do not seem to have resulted in a markedly higher incidence of malaria in the region. A remark should be made here. Even our “lowland” dams still are situated at a relatively high altitude (2000m and above). This should be taken into account when interpreting our data. For instance, Ghebreyesuset al.(1999), reported seven foldincrease in malaria incidence upon dam construction in Tigray region at lower altitude (less than 1900m).

Our findings on densities of indoor adult mosquitoes and malaria parasitology were not consistent. It is therefore recommended that more research should be carried out to unravel why we obtained these conflicting results. Based on the observation of a higher number of malaria vectors in villages near to the dams, and especially based on our observation that malaria does occur at low prevalence in villages >2000 masl,

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