

Anopheles mosquito species composition, density, longevity and malaria prevalence around Gilgel-Gibe area, Southwest Ethiopia

Alemayehu Dagne¹, Behailu Taye¹, AbebeAsale² and Delenasaw Yewhalaw^{3,4}

¹Departement of Biology, Faculty of computational and Natural Sciences, Mettu University, Mettu, Ethiopia

²Departement of Biology, College of Natural Sciences, Jimma University, Jimma, Ethiopia

³Departement of Medical Laboratory Sciences and Pathology, College of Health Sciences, Jimma University, Jimma, Ethiopia.

⁴ Director of Tropical Infectious Diseases Research Center, Jimma University, Jimma, Ethiopia

Corresponding author: alemayehudagne@gmail.com

Abstract

Introduction: Change in temperature, humidity, altitude, population of humans, deforestation and construction of reservoir (dam) are ecological factors that play essential roles in changing the dynamics of malaria transmission.

Objective : This study was intended to assess the effect of dam on anopheles mosquito species composition, abundance, longevity, and density and malaria prevalence pattern at Gilgel-gibe hydro-electric dam I.

Methods: Monthly entomological study was conducted from June to December 2013 in two kebele (Koticha Gibe and Decha Nadi) of Tiro Afeta district, Jimma zone Southwest Ethiopia. Centers for Disease Control and Prevention (CDC) Light Trap (LT) and Pyrethrum Spray Collection (PSC) was employed for biting and resting *Anopheles* mosquitoes sampling respectively while retrospective parasitological records was taken from Logbook of health facilities. A total of 1521 adult anopheline mosquitoes were collected. Students t-test for mean density comparison, Chi-square for comparison of malaria prevalence and Pearson's correlation to test the association between means were used. P-values less than 0.05 were considered as statistically significant.

Result: Overall, 1521 adult anopheline mosquitoes belonging to two species were collected. *An. gambiae* sensu lato was the predominant species (72.9%) followed by *An. coustani* sensu lato (27.1%). The mean monthly *An. gambiae* sensu lato density, collected by LTCs and PSCs, was 5.6 per trap/night and 3.51 per house/day, respectively. The density of *An. gambiae* sensu lato in Koticha Gibe was higher (8.5 per trap/night and 5.6 per house/day) than that of Decha Nadi (2.71 per trap/night and 1.95 per house/day), respectively. There was a significant difference between mean indoor and outdoor *An. gambiae* sensu lato density ($P < 0.05$). There was no significant difference between mean indoor and outdoor density of *An. coustani* sensu lato in the two kebele ($P > 0.05$). Degree of exophily increased from 1.61 to 1.28 and 1.35 to 1.23 in Koticha Gibe and Decha Nadi kebele, respectively, post Indoor Residual Spray (IRS) operation and Long Lasting Insecticide Nets (LLITNs) distribution. Overall probability of daily survival of *An. gambiae* sensu lato decreased from 0.70 to 0.56 during post IRS operation and LLITNs distribution. The prevalence of malaria in the study setting was 2.2%.

Conclusion: Despite the two kebeles having identical ecotypes and weather conditions, the kebele located near to the dam had a relatively high mosquito density and malaria prevalence than the kebele located far away from the dam.

Key words: Anopheline, malaria, longevity, Gilgelgibe dam, Ethiopia.

Introduction

Despite remarkable achievements, the human toll of malaria and the global risk it still poses remains unacceptably high (WHO 2015; WHO 2017). In 2017, *P. falciparum* accounted for 99.7% of estimated malaria cases in the WHO African Region followed by WHO regions of South-East Asia (62.8%) (WHO 2017). In 2015, over two million malaria cases (confirmed plus clinical) were recorded, responsible for 662 deaths (MOHa 2015; MOHb 2015). Of these total cases, *P. falciparum* accounted for 63.7%, and the remaining were due to *P. vivax* (MOH 2015). Change in temperature, humidity, altitude, population of humans and deforestation are just a few ecological factors that play essential roles in changing the dynamics of malaria transmission (Shililu 2003). Among ecological changes occurring in Ethiopia one is construction of dams (Abbink 2012; Franco et al. 2013). It is obvious that the construction of water storage reservoirs is

critical for eradicating hunger, improving access to clean water (Millennium Development Goals 1 and 7, respectively), and generating electricity usually results in elevated malaria transmission in surrounding human communities and contributes to a disease burden that claims 1.5 and 2.5 million lives each year (Lautze 2007). The development, management and operation of water resources have a history of modifying the frequency and transmission dynamics of malaria (WHO 2005). According to Ledec and Quintero (2003), Ethiopia has been constructed a large number of dams to produce electricity, irrigate farmlands and control flood. However, these development projects could have impact on ecology of vectors and malaria transmission dynamics (Norris 2004; WHO 2014). Therefore this study was intended to assess the effect of Ethiopian dams and meteorological variables on anopheles mosquito species composition, abundance, longevity, and density and malaria prevalence pattern at Gilgel-gibe hydro-electric dam I.

Materials and Methods

Description of the Study area and period: The study was conducted in two kebeles (sub districts/peasant associations) in Tiro-Afeta district Jimma zone southwestern Ethiopia located 260km away from Addis Ababa with an latitude of 7°4'20''N and

longitude 37°18'00'' E. The two kebeles were Koticha Gibe (near to dam) and (Decha Nadi) away from the dam. Koticha Gibe is located <1km away from the reservoir of Gilgel Gibe Hydroelectric dam while Decha Nadi is relatively far (5km) from the dam. (Figure 1).

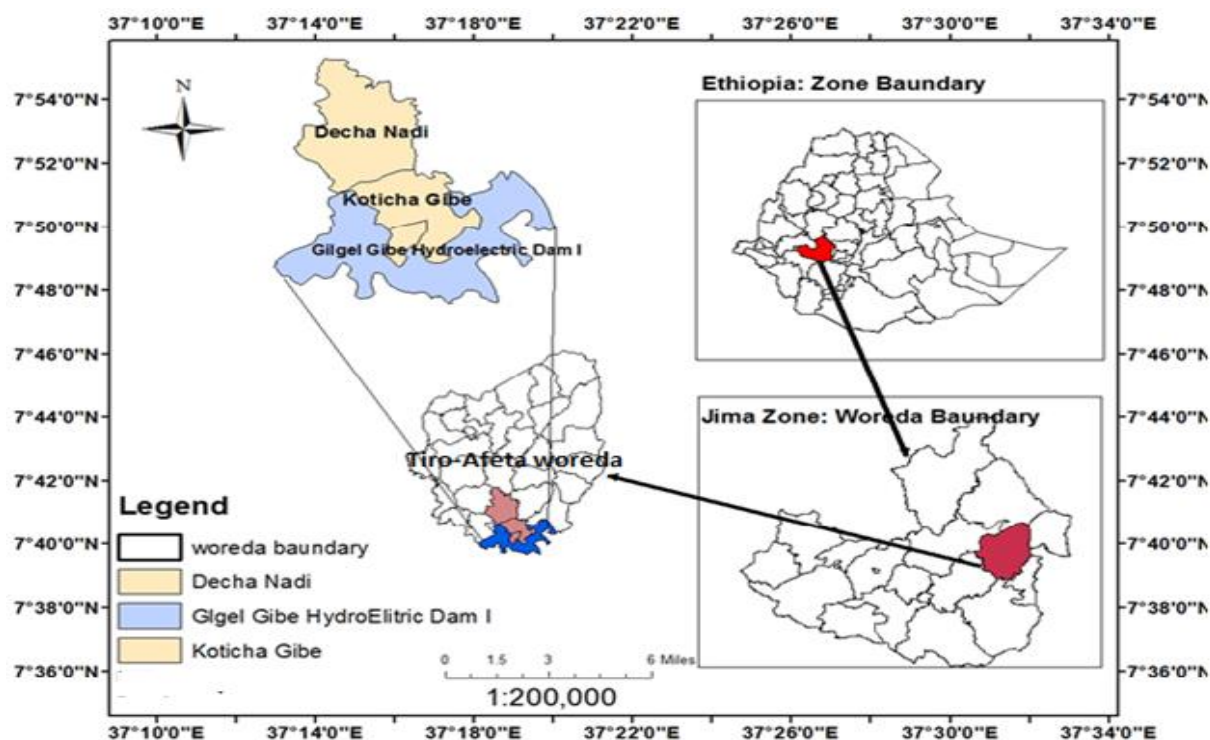


Figure 1: Map of the study area (modified from Tiro Afeta District Communication Office, 2013; Yewhalaw et al. 2013).

The study area district lies between at an altitude of 1,734–1,864 m a.s.l. The kebeles has a sub-humid, warm to hot climate, both cultivated and uncultivated land, is characterized by two rainy seasons, (June to September-the main rainy season and March to May-the short rainy season and receives annual minimum and maximum rain fall ranges from 1,300-1,800mm and has mean minimum and maximum annual temperatures of 16°C and 30°C respectively).The estimated total populations of the two kebeles (Koticha Gibe and Decha Nadi) were 3493 and 3240, respectively (Tiro Afeta District Communication Office 2013).

Study area sampling method: From 190 woreda located in Oromia regional state 172 of them were malarious which is, 65% of the total population of the Region residing in malarious areas (Deressa 2004). Among 13 woreda located in Jimma zone 10 of them were malarious of them three woreda (Omo Nada, Sokoru and Tiro-Afeta) share boundaries with Gilgel-Gibe hydro-electric dam 1 among them Tiro-afeta woreda was randomly selected. Among four kebele Koticha Gibe which is <1km from dam and whereas from those kebeles located away (>5km) from the reservoir of

Gilgel Gibe, Decha Nadi kebele was randomly selected. The census from the district administrative office 2006 showed that the population of Koticha Gibe and Decha Nedhi has 3493 and 3240, respectively (Tiro Afeta District Communication Office 2013).

Mosquito sampling and identification: Adult mosquitoes were collected from the two kebeles (four villages) using pyrethrum spray catches (PSCs) and Center for disease control and prevention (CDC) light trap catches (LTCs) (Model 512; John W. Hock Co., Gainesville, FL). Two villages were selected from each kebele for mosquito sampling. From the two kebele total of 16 houses for CDC LTCs (eight from Koticha Gibe and Eight from Decha Nadi) and twenty houses for PSCs (ten from Koticha Gibe and Decha Nadi kebele respectively) were randomly selected and mosquito collection was conducted monthly on each of the selected houses. LTCs were placed indoor near the bed at 1.5 meters above the ground whereas outdoor mosquito collection was set in the radius of 8m surrounding the house selected for outdoor collection from 6:00 PM in the evening to 6:00AM in the morning.

For PSCs each selected house was sprayed between 6:00-7:00AM following the standard procedure (WHO 1975). The residents were informed to leave the houses, remove food items and animals from each selected house, white cloth sheets were spread to cover the entire floor surface. Windows and doors were closed and other openings were covered to prevent the exit of mosquitoes. A commercially available insecticide (Byogon) containing pyrethroids (Tetramethrin 0.3%, Permethrin 0.25%, Perfume 0.25%, Kerosine and propellant 99.2%; manufactured by Changzhou Zhongtian Aerosol product co.ltd) was used. The room was kept closed for 15 minutes after the spray to ensure maximum knock-down of mosquitoes (WHO 1975). All mosquitoes were collected from sheets with a hand-held battery-powered with forceps. Specimens were killed with chloroform and placed in paper cup. The collected mosquito specimens were morphologically identified at Asendabo Field Vector Biology Laboratory of Jimma University; following standard key (Gillies and Coetzee, 1987; Verrone 1962 b). Gravid and half gravid mosquito were labeled according to site, species, date and sampling techniques and preserved individually in eppendorf tubes over silica gel.

Parity rate determination: The freshly killed mosquito with chloroform was placed on a microscope slide with a drop of Phosphate Buffered Saline (PBS) solution. On the sixth or seventh abdominal segment, the contents were pulled out gently. The ovaries were then left to dry. The ovaries were then observed under the stereo dissecting microscope to determine parity based on ovariolar tracheoles skeins. (Detinova 1962; WHO 1975).

Parasite prevalence survey: A record and chart review of malaria cases were conducted in Dimtu Health Center, Koticha Gibe and Decha Nedi health post of Tiro Afeta district from June to December, 2013. The prevalence of clinical malaria in the total population was calculated as the number of malaria cases diagnosed in the health facilities during study period divided by the total population of the communities (Koticha and Decha Nadi Kebele) that the individual health facilities serves. Where k is constant indicating the size of the populations to which the rate is applied (usually 100, 1000 or 10 000 but more generally 10^n). (WHO 1986; Falgunee et al. 2007)

$$P = \frac{\text{malaria cases}}{\text{Total number of population at risk}} * K$$

Meteorological data: Relative humidity (%), monthly rainfall (mm), maximum and minimum temperature (°C) of the study area were obtained from the south-

western branch regional office of the Ethiopian Meteorological Agency from June-December, 2013.

Data analysis: Data were entered and analyzed using SPSS version 16.0 statistical package. The abundances and percentage composition of anopheles mosquitoes were computed. Data was log transformed, Student t-test was used for mean density comparison of anopheles mosquitoes between Kebelle located near dam and far from the dam. Chi-square was used for comparison of malaria prevalence between Kebelle located near and away from the dam. An association between mean Anopheles mosquitoes density, monthly malaria prevalence and meteorological variables was assessed and further checked by Pearson's correlation at zero, one, two months and three months lag periods. P-value less than 0.05 were considered statistically significant during the analysis. Mean Anopheles mosquitoes Density (D) = (number of females ÷ number of houses) ÷ number of nights. P = duration of indoor resting after blood feeding. This parameter is obtained from the analysis of the abdominal condition of resting females. P = 1 + (number of half-gravid and gravid females ÷ number of freshly fed females (WHO 2003). Parity rate (S) was obtained by

$$S = \frac{\text{No. parous mosquitoes}}{\text{Total number of dissected Anopheles mosquitoes}} * K \quad (\text{Olayemi and Ande, 2008})$$

The probability of surviving one day (denoted as p) can be estimated as: $p = \frac{1}{L^{gc}}$ Proportion parous and three day interval were assumed for *An. gambiae* s.l. gonotrophic cycle (gc). Life expectancy was estimated using the formula $L = 1 / -\log_e p$ (Davidson 1954; WHO 2003).

Where L = life expectancy p = probability of daily survival.

Ethical consideration: Ethical approval for the study was obtained from Jimma University, College of Natural Science. Written informed consent was also sought from head of the selected house hold.

Results

Entomological survey

Composition and abundance of anopheles mosquitoes: A total of 1521 adult anopheles mosquitoes belonging two species were collected during longitudinal entomological survey. *An. gambiae* s.l. was the predominant species in the study areas which accounted for 72.9%, followed by *An. coustani* s.l. (27.1%). The majority (70.41%) of anopheline mosquitoes was collected from Koticha Gibe (Table 1).

Table 1: Species composition and abundance of anopheles mosquitoes in Tiro Afeta District, Jimma zone, Southwest Ethiopia.

Kebele	Anopheles species	Collection method			PSC	Total
		LTC (Indoor)	LTC (Outdoor)	LTC (Total)		
Dacha Nadi	<i>An. coustani</i> s.l.	54 (38.8)	63 (45.3)	117	22 (15.8)	139 (100.0)
	<i>An. gambiae</i> s.l.	116(37.3)	36 (11.6)	152	159(51.1)	311(100.0)
Koticha Gibe	<i>An. coustani</i> s.l.	93(34.1)	118(43.2)	211	62(22.7)	273(100.0)
	<i>An. gambiae</i> s.l.	305(38.2)	152(19.0)	457	341(42.7)	798(100.0)
	<i>An. coustani</i> s.l.	147 (35.7)	181 (43.9)	328	84 (20.4)	412 (100.0)
	<i>An. gambiae</i> s.l.	421 (38.0)	188 (17.0)	609	500 (45.0)	1109 (100.0)
Overall	Total	568 (37.3)	369 (24.3)	937	584 (38.4)	1521(100.0)

Key: LTC = Light trap catches, PSC= Pyrethrum spray catches, Number in parenthesis indicate percentage.

Anopheles mosquito density: Mean monthly *An. gambiae* s.l. density was 8.5 and 2.70 per trap/night with statistically significant difference ($P=0.04$) from near dam and far away from dam whereas 5.07 and

1.95 per/house/day using PSC with statistically significant difference ($P=0.048$) was recorded kebele located near to dam and far away from dam respectively (Figure 2).

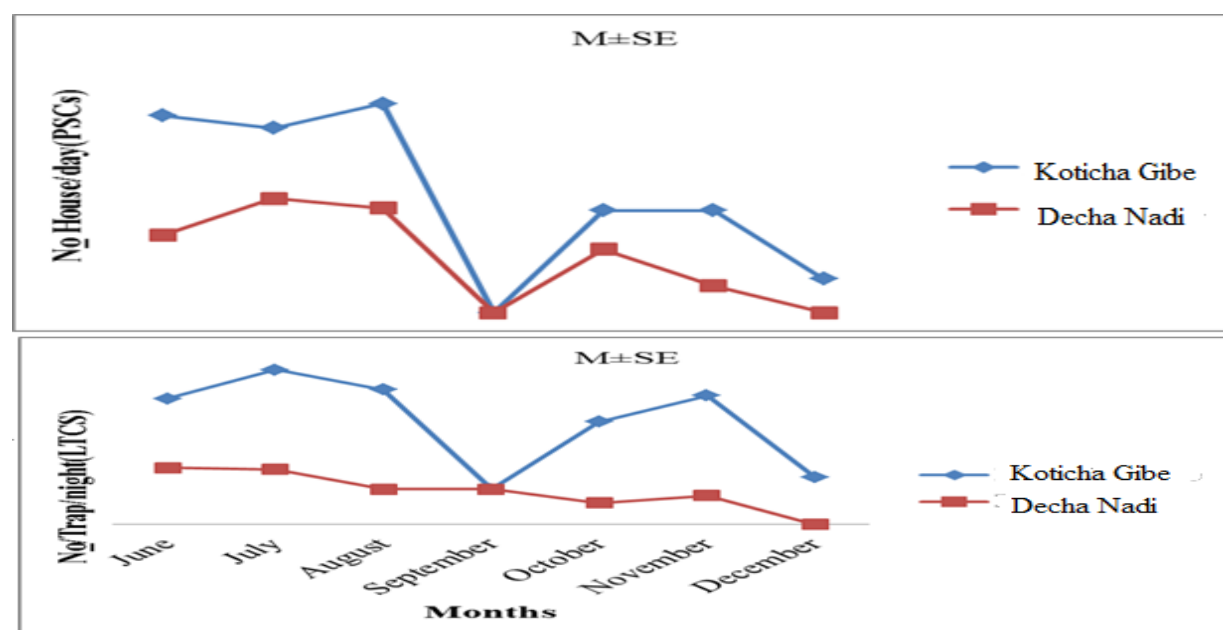


Figure 2: Mean *An. gambiae* s.l. density in villages near dam (Koticha Gibe) and away from dam (Decha Nadi), Tiro Afeta district, Jimma zone Southwest Ethiopia (June-December 2013).

Table 2 presents indoor and outdoor *An.gambiae* s.l. and *An. coustani* s.l.density in the near dam and far away from dam kebelles.The result shows that in both kebelles, mean indoor density of *An.gambiae* s.l. was significantly higher than the outdoor density ($P=0.04$; 0.03). On the other hand, *An.coustani* s.l. indoor/ outdoor density didn't show significant difference

($P=0.49/0.79$). Moreover, there was a significant difference in mean indoor density of *An. gambiae* s.l. ($p=0.038$) before (June-August 2013) and after IRS operation (September-December 2013) while there was no significant difference ($P=0.81$) in mean indoor density of *An.coustani* s.l.in both kebelles (Table 2).

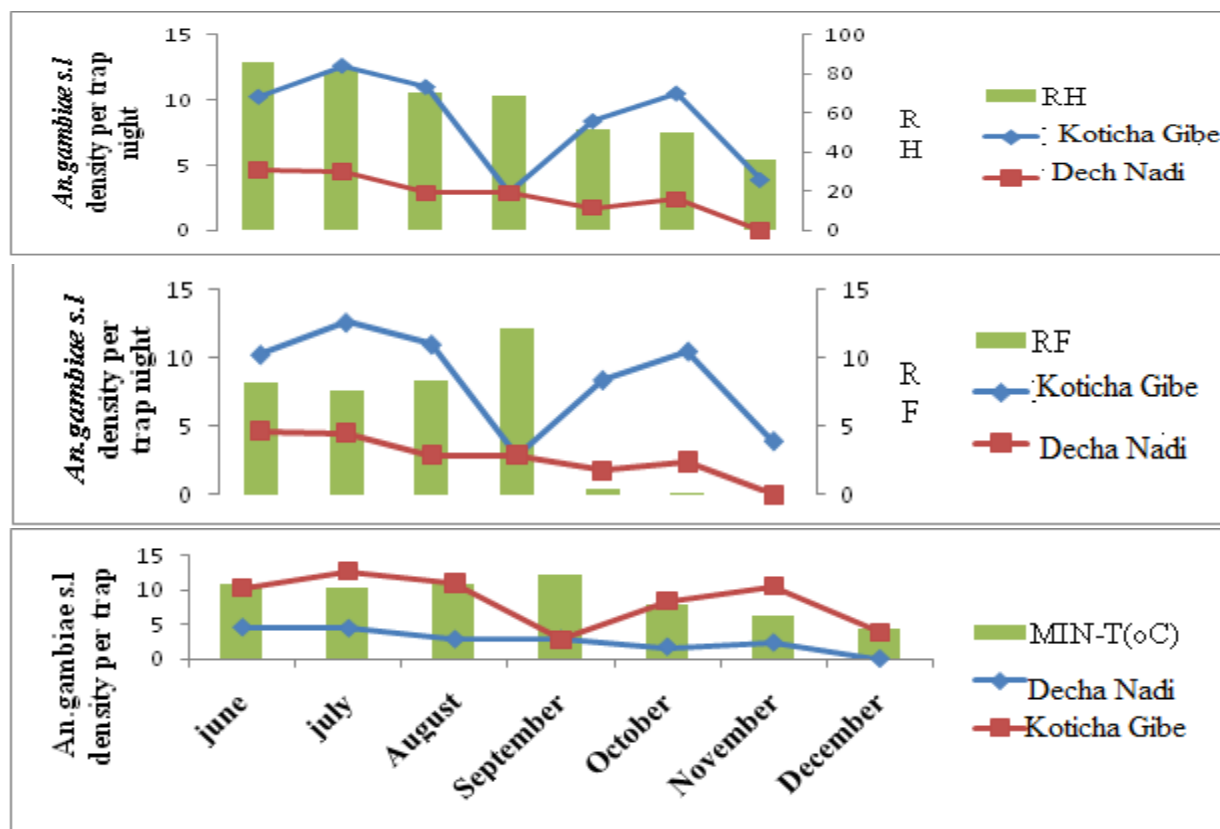
Table 2: Mean Indoor and outdoor Anopheline mosquitoes density per trap night in Tiro Afeta District, Jimma zone Southwest Ethiopia (June-December 2013).

Kebele	Speceis	Density	M±SE	p-value
Decha Nadi	<i>An. gambiae</i> s.l.	In	2.21±0.48	0.04*
		Out	0.50±0.44	
	<i>An. coustani</i> s.l.	In	0.96±0.38	0.49
		Out	0.98±0.26	
Koticha Gibe	<i>An. gambiae</i> s.l.	In	5.45±1.03	0.03*
		Out	2.70±0.46	
	<i>An. coustani</i> s.l.	In	1.66±0.29	0.79
		Out	2.11±0.29	

*Significant at $p < 0.05$

The mean monthly *An. gambiae* s.l. density per trap night and its association with meteorological variables in the two kebelles is shown in figure 3. In both kebelles the mean monthly density of *An. gambiae* s.l. was strongly correlated with two month lag of minimum temperature ($r=0.74$, $p=0.058$)

and ($r=0.92$, $p=0.004$) whereas weak correlation was observed for RH ($r = 0.034$, $p = 0.94$ and ($r = 0.0026$, $p = 0.95$) and RF ($r = 0.39$, $p = 0.37$ and $r = 0.24$, $p = 0.61$) in kebele near to dam and far away from the dam respectively (Figure 3).



Key:-RH=Relative Humidity, RF=Rain fall, Min-T=Minimum Temperature. RH in % RF in mm Min-T in °C.

Figure 3: Correlation of mean *An. gambiae* s.l. density with meteorological variables in Tiro Afeta district, Jimma zone, Southwest Ethiopia (June-December 2013).

Duration of resting indoor after blood feeding

Overall 500 *An. gambiae* s.l. were collected from the two kebelles by PSCs during the seven consecutive months (June-December 2013). Of these, 365 *An. gambiae* s.l. was collected during pre IRS operations (June - August 2013). Of these, 241 were fed mosquito specimens while 124 were half gravid and gravid. After IRS operation (September - December 2013) of the total 135 *An. gambiae* s.l.

collected, 107 of them were fed and the rest 28 were half gravid and gravid (Table 3). In Koticha-Gibe duration of resting indoor after blood feeding decreases from 1.61 to 1.28 during Pre and post IRS operation respectively. Also in Decha-Nadi kebele duration of resting indoor after blood feeding decreases from 1.35 to 1.23 during Pre and post IRS operation and LLINs distributions respectively.

Table 2: Fed to gravid ratio and degree of exophily of *An. gambiae* s.l. pre and post IRS operations and LLINs distributions in Tiro Afeta district, Jimma zone Southwest Ethiopia.

Intervention (IRS & LLINs)	Kebele	F	HGG	F:G	P
Pre	Decha Nadi	90	32	2.80:1	1.35
	Koticha Gibe	151	92	1.64:1	1.61
Post	Decha Nadi	30	7	4.29:1	1.23
	Koticha Gibe	77	21	3.66:1	1.28
Total		348	152	2.29:1	1.44

Key: F= fed, HGG=half-gravid to gravid, DE= Degree of Exophily, IRS= Indoor Residual Spraying, LLINs= long- lasting insecticidal nets.

Parity rate and longevity of *An. gambiae* s.l.: The parous rate of *An. gambiae* s.l. was higher (34.69%) pre IRS operation than post operation (17.64%)

(Table 4). Moreover, *An. gambiae* s.l. showed longer survival rate before control intervention as compared to post control operation.

Table 3: Parity rate, daily survival and longevity of *An. gambiae* s.l. before and after control intervention in Tiro Afeta District, Southwest Ethiopia (June-December 2013).

Intervention (IRS & LLINs)	Dissected	Nulliparous	Parous	Parity rate (%)	P(days)	LE(days)
Pre	98	20	34	55.1	0.75	2.80
Post	68	35	12	0.21	0.56	1.72

Key: P=Probability of Daily Survival, LE= Life Expectancy.

Malaria prevalence: During the study period, 112 febrile patients visited the three health facilities from the two kebeles. Overall, 15 (13.14%) of the febrile cases were positive for malaria parasites. *P. falciparum* accounted for 73.3% of the positive cases and the remaining 26.7% cases was due to *P. vivax*. More than half (53.3%) of the positives cases were

recorded from kebele near to dam with prevalence of 0.31 while prevalence of 0.12 were recorded from kebele away from dam with over all prevalence of 2.22. There was no significance difference in malaria cases between the two *kebeles* ($\chi^2 = 9.386$, $P = 0.052$). (Table 5).

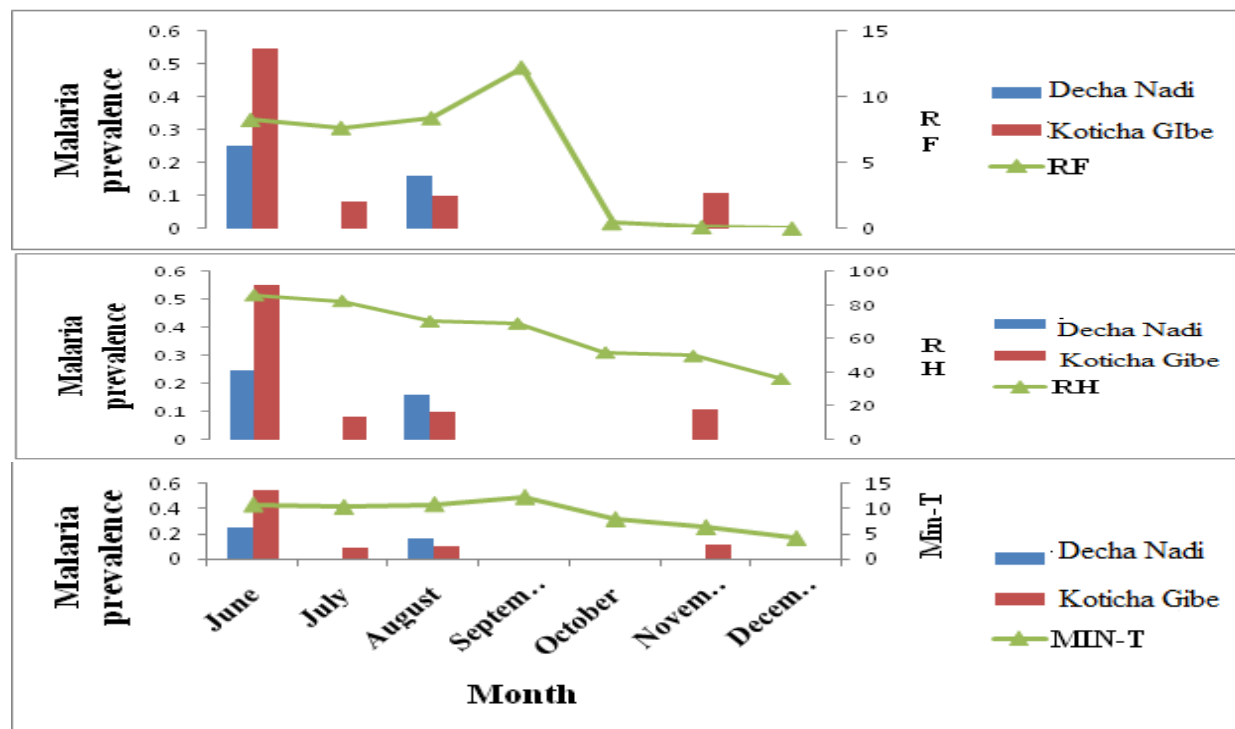
Table 4: Malaria prevalence in Tiro Afeta district, Jimma zone southwest Ethiopia

Kebeles	Number of cases	Species Pf	Pv	Total	X ²	P- value
Dacha Nadi	43(87.8)	5(8.2)	2(4.1)	50(100.0)	9.386	0.05
Koticha Gibe	54(87.1)	6(9.7)	2(3.2)	62(100.0)		
Total	97(86.6)	11(9.8)	4(3.6)	112(100.0)		

Key: Pf: *Plasmodium falciparum*, Pv: *Plasmodium vivax*, Number in parenthesis indicate percentage.

In kebele near to dam monthly malaria cases was positively correlated with zero month lag of relative humidity, rain fall and minimum temperature and statistically there was no significant correlation with RH($r=0.62$, $P=0.13$), Min-T($r=0.30$, $P=0.51$) and RF($r=0.26$, $P=0.56$). Similar trend was observed in kebele away from dam. Malaria cases was positively correlated with zero month lag of relative humidity,

rain fall and minimum temperature and there was no significant correlation between malaria cases and RH ($r=0.6$, $P=0.15$), between malaria cases and Min-T ($r=0.43$, $P=0.43$) and malaria cases and RF ($r=0.40$, $P=0.38$) and there was weak correlation between malaria cases and meteorological variables at one month, two month and three month lag time in both kebelles (Figure 4).



Key: RH; Relative Humidity, RF; Rain fall, Min-T; Minimum Temperature.
NB: RH in % RF in mm Min-T in °C

Figure 4: Correlation between malaria prevalence and meteorological variables in Tiro Afeta district South west Ethiopia (June-December 2013).

Discussion

Malaria is a serious threat to human life in sub-Saharan Africa, claiming many lives and causing the greatest morbidity as compared to other infectious diseases (Obion et al. 2014). Ethiopia is one of the sub-Saharan countries which are suffering from this threat. Malaria control program in Ethiopia has a history of more than 40 years. There were a lot of obstacles which could hamper the successful malaria control program in Africa particularly in Ethiopia. Of these problems, occurrence of malaria parasite resistance to drugs (Ketema et al. 2009) insecticide resistance species of major malaria vectors (Asale et al. 2014; Yewhalaw et al. 2011 and 2010), climate change (Avanade et al. 2008; Hay et al. 2005) and man-made ecological transformation such as construction of dams for controlling flood, producing electricity and irrigated farm land (Guerra et al. 2008; WHO 2005). The development, management and operation of water resources have a history of modifying the frequency and transmission dynamics of malaria in Ethiopia (Kibret et al. 2009; Yewhalaw et al. 2009; Lautze et al. 2007) and malaria vector density most importantly *An. gambiae* s.l. (Afrane et al. 2006; Tunon et al. 2005).

The species compositions of Anopheline mosquitoes in the two kebeles showed that *An. gambiae* s.l. and *An. coustani* s.l. were found in sympatry. *An. gambiae* s.l. was predominant malaria vectors in the study sites which is similar with other parts of Ethiopia (Coetzee et al. 2000). Likewise, this study also found *An. coustani* s.l. where some of its sibling which was believed to be less anthropophilic with no epidemiological importance in malaria transmission (Adugna et al. 1996) was abundant next to *An. gambiae* s.l. in the study sites.

Significant differences in mean monthly *An. gambiae* s.l. density between the two kebele were observed. In our surveys, higher density of *An. gambiae* s.l. were collected from kebele which was found near to the dam than kebele which was found far from the dam during the period of long rainy seasons and after long rainy seasons. Thus, the presence of dam together with seasons may have contributed to the presence of higher adult mosquito density in the kebele near to the dam. This finding corroborate with Yewhalaw et al. (2013), higher densities of the major local malaria vector, *An. arabiensis*, which were recorded during the wet season in villages nearer to the dam reservoir.

An. gambiae s.l. showed significant difference in indoor over the outdoor density, this suggested that the species has higher tendency to bite indoor than outdoor. Gillies and Coetzee (1987) and White (1974)

reported that *An. gambiae* s.l. and *An. funestus*, primarily feed and rest indoors where they can be efficiently targeted with intra-domiciliary residual insecticides. The other study which complemented this observation was that *An. gambiae* s.l. showed endophagic behavior in Gambella region, Ethiopia (Krafsur 1977). In contrast to this, other studies reported that *An. gambiae* s.l. had predominantly exophagic behavior than endophagic behavior in central highlands of Ethiopia (Taye et al. 2017; Woyesa et al. 2004). While, there was no significant difference in indoor and outdoor density of *An. coustani* s.l., this may be due to the inhabitant partially dwell with Cattles (domestic animals) mixed home. However studies conducted in this area showed this species more of exophagic and exophilic (Taye et al. 2016; Lelisa et al. 2017). In this study there was no significant difference in mean indoor and outdoor *An. coustani* s.l. density. Other studies also indicated that *An. coustani* s.l. is well known exophagic species in Ethiopia (Abose et al. 1998) and in Kenya (Mwangangi et al. 2013). Moreover there was no significant difference in mean indoor density of *An. coustani* s.l. before (June-August 2013) and after (September-December 2013) IRS operation and LLINs delivery while there was significant difference in mean indoor density of *An. gambiae* s.l. in both kebelles. This finding was in line with Woyesa et al. (2004).

The finding of the study further showed that the density of *An. gambiae* s.l. was more affected by metrological variables as mean monthly density of *An. gambiae* s.l. was influenced by Rain fall, Relative humidity and Temperatures. Other previous studies had also indicated the effect of metrological variables on mosquito density (Yewhalaw et al. 2013; Woyesa et al. 2004). Mean monthly *An. gambiae* s.l. density and monthly malaria prevalence was positively correlated with two month lag and zero month lag (a month where *An. gambiae* s.l. proliferate) respectively. This finding suggested that malaria prevalence in June was transmitted by presence of *An. gambiae* s.l. in previous two months. Previous studies had indicated the biology of the *Anopheles* mosquitoes and of the *Plasmodium* parasite, the effect of metrological variables on malaria transmission is expected to be lagged in time. Other previous empirical studies suggested that the effect of rainfall on malaria transmission is lagged by approximately 8 weeks (Krefis. 2013; Deresa et al. 2003; Tull 1993).

Lower vector density was observed after IRS operation (September-2013). The results indicated that IRS operation that sprayed (propoxur) had an effect on the vector population which decreased vector density and longevity. This finding is consistent with Obion et

al. (2014) and Patrica et al. (2014). *Anopheles* mosquito density began to buildup after IRS. This may be due insecticide resistance (Asale et al. 2014; Yewhalaw et al. 2011) insecticide decay rate or operational problems.

Post IRS operation decrease in density of resting indoor after blood feeding was observed in both kebelles. This could be explained by behavioral resistance or a strong decrease in the proportion of gravid and half gravid mosquitoes. This finding was consistent with Padonou et al. (2012) and Mutuku et al. (2011) where strong decrease in proportion of gravid and half gravid mosquito was observed after IRS operation.

Before IRS operations June-August 2013 the observed parity rates were high. This indicates that older populations of mosquitoes tend to accumulate with time (Service 1976). This could be due to availability of potential breeding sites. This allows for increased feeding frequencies and thus, increased chances of the vectors becoming infected or even re-infected during subsequent feeding (Olayemi and Ande 2008; WHO 1975). Decrease in parity rate after interventions could be due to wide spread IRS in the locality. The current vector control strategies of IRS with primarily affect the daily probability of mosquito survivorship and/or reduce vector-host contact (Taye et al. 2016; Enayati et al. 2010; Curtis et al. 2003).

The prevalence rate of malaria observed in this study was 0.22%, which is less compared with prevalence rate of 10.5% from similar studies around Gilgel Gibe area (Yewhalaw et al. 2009). This may be due to the intervention programs that have been took place in the locality during the study period. Similar finding in India and Thailand revealed that no increase of malaria incidence was observed near the in Uttaranchal dam India and Nong Wai dam and Ubol Ratana dam in Thailand because of IRS of all houses with DDT (Shukla et al. 2001; Bunnag et al. 1979). The study documented that relatively highest malaria prevalence with 0.31% were recorded from Koticha-Gibe (Near dam) while 0.12% prevalence of malaria were recorded from Decha-Nadi Kebelle. Chi square test confirmed that there was no significant difference in malaria prevalence between the two kebelles. Whereas in Ethiopia; small dams constructed for irrigation (Ghebreyesus 1999), Koka dam (Kibret et al. 2009), and Gilgel-Gibe hydro-electric dam (Yewhalaw et al. 2009) indicated that dams are associated with an increased malaria risk where malaria control program were not under taken.

Generally it has been reported elsewhere that the decline in malaria prevalence in Ethiopia (PMI 2014; Ketema and Bacha 2013), in general, and in the study

area, in particular, has been attributed to a combination of factors including improved access to effective malaria treatment with artemisinin combination therapy, interventions using IRS and LLINs decreases mosquitoes bite and decreasing daily porbability of survivorship which decreases the completion of parasite development into infectious sporozoites stages (Taye et al. 2016; Enayit et al. 2010). It may also be due to the sudden heavy rain fall recorded in September in the middle of the study which washed larval breeding sites.

Conclusion

In this study, the dam was found to be an important factor in variation in the density of *Anopheles* mosquitoes. That means higher density of anopheline mosquitoes and high prevalence of malaria parasites was observed in the villages nearby dam. *An. gambiae* s.l. was predominant malaria vector with significantly higher indoor biting behavior in the study area. Therefore this information lets every developmental activity such as dam and reservoir should consider the environmental impact analysis in relation to malaria and other infection and special emphasize must be given particularly for those community that dwell nearby water reserves or dam.

References

- Abbink J (2012). Dam controversies: contested governance and developmental discourse on the Ethiopian Omo River dam. *Social Anthropology*, 20(2):125-144.
- AboseT, Yeebiyo Y, Olana D, Alamirew D, Beyene YA, Regassa L, et al. (1998). Re-orientation and Definition of the Role of Malaria Vector Control in Ethiopia: The Epidemiology and Control of Malaria with Special Emphasis on the Distribution, Behaviour and Susceptibility of Insecticides of Anopheline Vectors and Chloroquine Resistance in Zwai, Central Ethiopia and Other Areas. World Health Organization WHO/Mal/1998.1085.
- Adugna N & Petros B (1996). Detrmination of the human blood index of some Anophelinemosquitoes by using ELISA. *Ethiopian Medical Journal*, 34:1-10.
- Afrane YA, Zhou G, Lawson BW, Githeko GK & Yan G (2006). Effect of micro climate changes caused by deforestation on the survivorship and reproductive fitness of *An. gambiae* in Western Kenya high lands. *American Journal of Tropical Medicine and Hygiene*, 74:772-778.
- Asale A, Getachew Y, Hailesilassie W, Speybroeck N, Duchateau L & Yewhalaw D (2014). Evaluation of the efficacy of DDT indoor residual spraying and long-lasting insecticidal nets against insecticide resistant populations of *Anopheles*

- arabiensis* Patton (Diptera: Culicidae) from Ethiopia using experimental huts. *Parasite Vectors*, 7:131-138.
- Avanade A, Adeoye NO & Babatimehin O (2010). "Climate Change/Variability and Malaria Transmission in Sub-Saharan Africa: A Case of Nigeria," *An International Conference on the Occasion of the 250th Anniversary of the Royal Norwegian Society of Sciences and Letters*, Trondheim.
- Coetzee M, Craig M & Le SD (2000). Distribution of African malaria mosquitoes belonging to the *Anopheles gambiae* complex. *Parasitology Today*, 16 (2):74-77.
- Curtis CF, Jana-Kara B & Maxwell CA (2003). Insecticide treated nets: impact on vector populations and relevance of initial intensity of transmission and pyrethroid resistance. *Journal of Vector Borne Diseases*, 40:1-8.
- Deressa W, Chibsa SH & Olana D (2004). The distribution and magnitude of malaria in Oromia, Ethiopia. *Ethiopian Journal of Health Development*, 18:3-7.
- Detinova S (1962). Age grading methods in Diptera of medical importance with special reference to some vectors of malaria. Monograph series. *Bulletin of World Health Organization*, 47:1-216.
- Enayati A & Hemingway J (2010). Malaria management: Past, present, and future. *Annual Review of Entomology*, 55:569-591.
- Franco J, Mehta L & Veldwisch GJ (2013). The global politics of water grabbing. *Third World Quarterly*, 34(9):1651-1675.
- Ghebreyesus TA, Haile M, Witten KH, Getachew A, Yohannes AM, Yohannes M, et al. (1999). Incidence of malaria among children living near dams in northern Ethiopia: Community based incidence survey. *British Medical Journal*, 319: 663-666.
- Guerra CA, Gikandi PW, Tatem AJ, Noor AM, Smith DL, Hay SI, et al. (2008). The limits and Intensity of *Plasmodium falciparum* transmission: Implications for Malaria Control and Elimination Worldwide. *PLoS Medicine*, 5(2):1-38.
- Hay S, Shanks G, Stern D, Snow R, Randolph S & Rogers D (2005). Climate variability and malaria epidemics in the highlands of East Africa. *Trends Parasitology*, 21:52 - 53.
- Ketema T & Bacha K (2013). *Plasmodium vivax* associated severe malaria complications among children in some malaria endemic areas of Ethiopia. *BMC Public Health*, 13:637.
- Ketema T, Bacha K, Birhan T & Petros B (2009). Chloroquine-resistant *Plasmodium vivax* malaria in Serbo town, Jimma zone, south-west Ethiopia. *Malaria Journal*, 8:177.
- Kibret S, McCartney M, Lautze J & Jayasinghe G (2009). Malaria transmission in the vicinity of impounded water: Evidence from the Koka Reservoir, Ethiopia. Colombo, Sri Lanka: International Water Management Institute. P 31-32 (IWMI Research Report 132).
- Krasfur E (1977). The Bionomics and Relative prevalence of *Anopheles species* with respect to the transmission of plasmodium to man in Western Ethiopia. *Journal of Medical Entomology*, 14(2):180-194.
- Krefis AC, Schwarz NG, Kru"ger A, Fobil, J & Nkrumah B (2011). Modeling the relationship between precipitation and malaria incidence in children from a holoendemic area in Ghana. *American Journal of Tropical Medicine and Hygiene*, 84:285-291.
- Lautze J, McCartney M, Kirshen P, Olana D, Jayasinghe G & Spielman A (2007). Effect of a large dam on malaria risk: the Koka reservoir in Ethiopia. *Tropical Medicine International Health*, 12(8):982-989.
- Ledec G & Quintero J (2003). Good dams and bad dams: Environmental criteria for site selection of hydroelectric projects. Latin American Caribbean Region Sustainable Development Working Paper 16. In Yewalaw D, Yehenew G, Kora T, Kifle WM, Wondwossen K, Luc D, et al. (2013). The effect of dams and seasons on malaria incidence and anopheles abundance in Ethiopia. *BMC Infectious Diseases*, 13:161.
- Lelisa K, Asale A, Taye B, Emanu D & Yewhalaw D (2017). Anophelinemosquito's behavior and entomological monitoring in southwestern Ethiopia, *Journal of Vector Borne Disease*, 54:240-248
- MOHa (2015). Annual health performance report. Addis Ababa: Ministry of Health [Ethiopia]; 2014/2015. <http://www.moh.gov.et/documents/26765/0/Annual+Perfomance+Report+2006+EFY/4f5a6b33-3ef1-4430-a0a0-21fa13221343?Version=1.0> Accessed 22 December 2018.
- MOHb (2015). Health and Health related indicators (2014/2015): version 1. Addis Ababa: Ministry of Health [Ethiopia] http://www.moh.gov.et/ngos/_asset_publisher/7V6nCILKVGUQ/document/id/6062592. Accessed in December 2018.
- Mukutu FM, King CH, Mungai P, Mbogo CH, Mwangangi J, Muchiri EM, et al (2011). Impact of insecticide-treated bed nets on malaria transmission indices on the south coast of Kenya. *Journal the American Mosquito Control Association*, 10:356.
- Mwangangi J, Shililu J, Muturi EJ, Muriu S, Jacob B & Kabiru EW. (2013). *Anopheles* larval abundance and diversity in three riceagro-village complexes

- Mwea irrigation scheme, central Kenya. *Malaria Journal*, 9:228.
- Norris E & Douglas E (2004). Mosquito-borne diseases as a consequence of land use change. *EcoHealth*, 1(1):19-24.
- Obion OV, Lucy K & Michael G (2014). Infections of *Anopheles gambiae* Mosquitoes with *Plasmodium* Oocysts and its Effects on Highland Malaria in Kisii Town and its Surroundings." *American Journal of Epidemiology and Infectious Diseases*, 21:13-18.
- Olayemi K & Ande T (2008). Survivorship of *Anopheles gambiae* in relation to malaria transmission in Ilorin, Nigeria. *International journal of Health and Allied Science*, 7:1-5.
- Padonou GG, Sèzonlin M, Ossè R, Aizoun N, Oké-Agbo F, Oussou O, et al (2012). Impact of three years of large scale Indoor Residual Spraying and Insecticide Treated Nets interventions on insecticide resistance in *Anopheles gambiae* in Benin. *Parasite Vectors*, 10:72.
- Patricia N, Okorie KOK, Popool A, Olayemi M, Kolade T & George OA (2014). Species composition and temporal distribution of mosquito populations in Ibadan, Southwest Nigeria. *Journal of Entomology and Zoology studies*, 2:164-169.
- PMI (2014). President's malaria initiative Ethiopia malaria operational plan fy 2014. USAID from the American people. www.pmi.gov/.../malaria-operational-plans/.../ethiopia_mop_fy14.pdf? Last accessed on July 2014.
- Service MW (1976). Studies on sampling larval populations of the *Anopheles gambiae* complex. *Bulletin of World Health Organization*, 45(2):169-80.
- Shukla RP, Sharma SN, Kohli VK, Nanda N, Sharma VP & Subbarao SK (2001). Dynamics of malaria transmission under changing ecological scenario in and around Nanak Matta Dam, Uttaranchal, India. *Indian Journal Malariol*, 38:91-98.
- Tarleton RL & Kissinger J (2001). Parasite genomics: Current status and future prospects. *Current Opinion in Immunology*, 13(4):395-402.
- Taye B, Kidane L, Emanu D, Asale A & Yewhalaw D (2016). Seasonal Dynamics, Longevity, and Biting Activity of Anopheline Mosquitoes in Southwestern Ethiopia, *Journal of Insect Science*, 16(1):6-13.
- Tulu NA (1993). The ecology of health and disease in Ethiopia. In *Malaria* Edited by: Kloos H & Zein AZ. Boulder M. West view Press, 1:341-352.
- Tunon N, Okeka W, Minakawa N, Takagi M & Yan G (2005). Survivorship of *Anopheles gambiae sensu stricto* (Diptera; Clucidea) Larvae in Western Kenya high land forest. *Journal of Medical Entomology*, 42:270-277.
- Verrone 1962 b (1962). Outline for the determination of malaria mosquitoes in Ethiopia. Part I. Adult female *Anopheles* -mosquitoes in Ethiopia. *Mosquito News*, 2:38-39.
- White GB (1974). *Anopheles gambiae* complex and disease transmission in Africa. *Royal society of Tropical Medicine and Hygiene*, 68(4):278-301.
- WHO (1975). Manual on practical entomology in malaria. Part II: Methods and Techniques. Geneva, Switzerland. pp 157-186.
- WHO (2003). World Health Organization, HIV/AIDS, Tuberculosis, and Malaria. Roll Back Malaria. Trial Edition. Last Accessed January 2018.
- WHO (2005). Section I: World Malaria Report Global malaria situation. pp 1-17.
- WHO (2013). www.who.int/entity/gho/governance_aid_effectiveness/countries/eth.pdf. Last Accessed in January 2018
- WHO (2013). Malaria entomology and vector control. Learner guide trial addition. WHO/CDS/CPE/ 2002.18 Rev.1 Part 1.
- WHO (2014). Fact Sheet Vector-Borne Diseases. Retrieved from: http://www.who.int/kobe_centre/mediacentre/vbdfactsheet.pdf. Accessed in December 2018.
- WHO (2015). World Malaria Report. Geneva: <http://www.who.int/malaria/publications/world-malaria-report-2015/report/en/>. Accessed in December 2018.
- WHO (2017). World Malaria Report. <https://malaria.world.org/blog/who-world-malaria-report-2017-out>. Accessed in December 2018.
- Woyessa A, Gebre-Michael T & Ali A (2004). An indigenous malaria transmission in the outskirts of Addis Ababa, Akaki town and its environs. *Ethiopian Journal of Health Development*, 18(1):1-17.
- Yewhalaw D, Legesse W, Bortel WV, Gebre-Selassie S, Helmut K, Duchateau L, et al (2009). Malaria and water resource development: the case of Gilgel-Gibe hydroelectric dam in Ethiopia. *Malaria Journal*, 8:21-31.
- Yewhalaw D, Bortel WV, Denis L, Coosemans M, Duchateau L, & Speybroeck N (2010). First Evidence of High Knockdown Resistance Frequency in *Anopheles arabiensis* (Diptera: Culicidae) from Ethiopia. *American Journal of Tropical Medicine and Hygiene*, 83(1):122-125.
- Yewhalaw D, Wassie F, Steubaut W, Spanoghe P, Van Bortel W, Denis L, et al. (2011). Multiple Insecticide Resistance: An Impediment to Insecticide-Based Malaria Vector Control Program. *PLOS ONE*, 6(1):1-7.
- Yewhalaw D, Getachew Y, Tushune K, W/Michael K, Kassahun W, Duchateau L & Speybroeck N (2013). The effect of dams and seasons on malaria incidence and anopheles abundance in Ethiopia. *BMC Infectious Diseases*, 13(61):7-9.