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

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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 Anophelines mosquitoes sampling respectively while retrospective parasitological records was taken from Logbook of health facilities. A total of 1521 adult anopheles mosquitoes were collected. Students t–test for mean density comparison, Chi-square for cmparison of malaria prevalence and Pearson’s correlation to test the association between means were used. P-values less than 0.05 were considersed as stastically significant.

Result: Overall, 1521 adult anopheles mosquitoes belonging to two species were collected. An. gambiae senso lato. was the predominant species (72.9%) followed by An. coustani senso lato (27.1%). The mean monthly An. gambiae senso lato density, collected by LTs and PSCs, was 5.6 per trap/night and 3.51 per house/day, respectively. The density of An. gambiae senso 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 senso lato density (P < 0.05). There was no significant difference between mean indoor and outdoor density of An. coustani senso 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 senso 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 (Abbinck 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 metrological 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 $7^\circ 4'20''$N and longitude $37^\circ 18'00''$ 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 $16^\circ$C and $30^\circ$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 I 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 leaves 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 (Byogan) containing pyrethroids (Tetramethrin 0.3%, Permethrin 0.25%, Perfurme 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 chlorofrom 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 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 applies (usually 100, 1000 or 10 000 but more generally 10^9). (WHO 1986; Falgunee et al. 2007)

\[ P = \frac{\text{malarial cases}}{\text{Total number of population at risk}} \]

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

\[ S = \frac{\text{No parous mosquitoes}}{\text{Total number of dissected Anopheles mosquitoes}} \]

The probability of surviving one day (denoted as p) can be estimated as: \( p = e^{-\lambda} \) Proportion parous and three day interval were assessed for An. gambiae.s.l. gonotrophiccycle (gc). Life expectancy was estimated using the formula \( L = 1/\log p \) (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.

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

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 kebelle located near to dam and far away from dam respectively (Figure 2).

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

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

*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 kebelle near to dam and far away from the dam respectively (Figure 3).

**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 kebelle 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.**

<table>
<thead>
<tr>
<th>Intervention (IRS &amp; LLINs)</th>
<th>Kebele</th>
<th>F</th>
<th>HGG</th>
<th>F:G</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>Decha Nadi</td>
<td>90</td>
<td>32</td>
<td>2.80:1</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>Koticha Gibe</td>
<td>151</td>
<td>92</td>
<td>1.64:1</td>
<td>1.61</td>
</tr>
<tr>
<td>Post</td>
<td>Decha Nadi</td>
<td>30</td>
<td>7</td>
<td>4.29:1</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td>Koticha Gibe</td>
<td>77</td>
<td>21</td>
<td>3.66:1</td>
<td>1.28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>348</td>
<td>152</td>
<td>2.29:1</td>
<td>1.44</td>
</tr>
</tbody>
</table>

**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.

*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.
Ethiop. j. public health nutr.

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).

<table>
<thead>
<tr>
<th>Intervention (IRS &amp; LLINs)</th>
<th>Dissected</th>
<th>Nulliparous</th>
<th>Parous</th>
<th>Parity rate (%)</th>
<th>P(days)</th>
<th>LE(days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>98</td>
<td>20</td>
<td>34</td>
<td>55.1</td>
<td>0.75</td>
<td>2.80</td>
</tr>
<tr>
<td>Post</td>
<td>68</td>
<td>35</td>
<td>12</td>
<td>0.21</td>
<td>0.56</td>
<td>1.72</td>
</tr>
</tbody>
</table>


**Malaria prevalence:** During the study period, 112 febrile patients visited the three health facilities from the two kebelles. 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 kebelle near to dam with prevalence of 0.31 while prevalence of 0.12 were recorded from kebelle away from dam with over all prevalence of 2.22. There was no significance difference in malaria cases between the two kebelles ($x^2 = 9.386, P = 0.052$).

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

<table>
<thead>
<tr>
<th>Kebeles</th>
<th>Number of cases</th>
<th>Species</th>
<th>P</th>
<th>Total</th>
<th>X²</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dacha Nadi</td>
<td>43(87.8)</td>
<td>5(8.2)</td>
<td>2(4.1)</td>
<td>50(100.0)</td>
<td>9.386</td>
<td>0.05</td>
</tr>
<tr>
<td>Koticha Gibe</td>
<td>54(87.1)</td>
<td>6(9.7)</td>
<td>2(3.2)</td>
<td>62(100.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>97(86.6)</td>
<td>11(9.8)</td>
<td>4(3.6)</td>
<td>112(100.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

In kebelle 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 kebelle 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.

Figure 4: Correlation between malaria prevalence and metrological 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 farmland (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. (Afane et al. 2006; Tunon et al. 2005). The species compositions of Anopheles 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 kebeles 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 (Krafur 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 cattle (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 kebeles. 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 rainfall, 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 (Kefris. 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
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; Enayatiet 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 Kebele. 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**


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