PMI | Africa IRS (AIRS) Project

Indoor Residual Spraying (IRS 2) Task Order Six

AIRS RWANDA 2015 ENTOMOLOGY REPORT

FINAL REPORT

NOVEMBER 2015

Recommended Citation: Africa Indoor Residual Spraying project. November 2015. Rwanda: *Entomological Monitoring of October 2014 – October 2015*. Final Report. Kigali, Rwanda. AIRS Project, Abt Associates Inc.

Contract: GHN-I-00-09-00013-00

Task Order: AID-OAA-TO-14-00035

Submitted to: United States Agency for International Development/PMI

Prepared by: Abt Associates, Inc.

RWANDA: ENTOMOLOGICAL MONITORING OF OCTOBER 2014 – OCTOBER 2015. FINAL REPORT

DECEMBER 2015

Abt Associates Inc. | 4550 Montgomery Avenue | Suite 800 North | Bethesda, Maryland 20814 | T. 301.347.5000 | F. 301.913.9061 | www.abtassociates.com

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF FIGURES

ACRONYMS

AIRS	Africa Indoor Residual Spraying
ELISA	Enzyme-linked Immunosorbent Assay
HLC	Human Landing Catch
IRS	Indoor Residual Spray
MOH	Ministry of Health
PMI	President Malaria Initiative
PSC	Pyrethrum Spray Catch
WHO	World Health Organization
WP	Wettable Powder

EXECUTIVE SUMMARY

During the reporting period (October 2014 to October 2015), entomological monthly data collection was conducted in the IRS districts: Bugesera, Gisagara, Nyagatare and Kirehe. Kirehe District had been a control district from January 2015 to August 2015 but was sprayed in September 2015. It was then replaced with Ngoma District in September which is currently the control district.

Adult mosquitoes were sampled using Pyrethrum Spray Catch (PSC) and Human Landing Catch (HLC) to assess vectors species composition, seasonality, and behavior. WHO cone bioassays were conducted to assess the quality of spraying as well as determine insecticide decay rates on sprayed surfaces. Tests were conducted on three wall surface types: mud, plastered not painted (PNP) and plastered and painted (PP).

A total of 14,917 adult female anophelines were collected using PSC and HLC; 14,563 (97.6%) were morphologically identified as *Anopheles gambiae* s.l.

The difference in vector abundance from the PSC collections between Nyagatare district and the control district was not statistically significant ($p > 0.05$). It was however significant in Gisagara and Bugesera districts ($p<0.05$). Vector density (average *An. gambiae* s.l./house/day) was highest in the control district through the reporting period. Nyagatare district showed the highest vector density relative to the IRS districts.

There was a statistically significant difference between the indoor and outdoor HLC collections in all the districts ($p<0.05$). A*n. gambiae* s.l. generally showed slightly more exophagic than endophagic tendency in the four districts, including the control district. Hourly biting rates per person varied across the districts. In Nyagatare, and Kirehe districts, biting was generally high at 1900h with a drop at 2000h. An increase in biting density was observed at around 2200h, peaked at 0001h and remained high until 0003h. In Bugesera, hourly biting rose at around 2100h and remained relatively constant through the rest of the night.
There was no clear trend observed in all the districts for parity through the reporting period.

Cone bioassays conducted within one week of spraying to assess the quality of spraying during the two spray rounds (February and September 2015) recorded 100% mortality of susceptible *An. gambiae* s.l., indicating quality spraying took place. Following the February 2015 spray campaign, monthly cone bioassay tests showed that mortality of over 80% was observed on all the three wall surface types in the two districts up to three months after spraying. The plastered and not painted (PNP) surfaces in Nyagatare district however recorded above 80% mortality up to the fifth month after IRS. One month post-September IRS, 100% mortality of *An. gambiae* s.l. was recorded in all sites on all the three wall surfaces on which the tests were conducted.

1. INTRODUCTION

Abt Associates is implementing the three-year Africa Indoor Residual Spraying (AIRS) project funded by USAID under the President's Malaria Initiative (PMI). Abt supports the implementation of the IRS project in 17 African Countries including Rwanda. The objective of the project is to limit exposure to malaria vectors and reduce the incidence and prevalence of malaria. Abt works closely with ministries of health (MOHs), and national malaria control programs (NMCPs), district health offices, local non-governmental organizations, and community and business leaders to ensure that government, the private sector, and communities are able to sustain and lead future indoor residual spraying (IRS) and malaria control programs.
Part of the support Abt Associates Inc. provides in IRS implementation is technical support for entomological monitoring. Entomological monitoring activities are essential for proper targeting and planning of indoor residual spraying (IRS). Further, they help to determine whether or not the insecticide is properly applied, if it remains effective against the vectors and for how long, and the effect of the insecticide on the vector. Since 2013, Rwanda has been implementing two spray rounds (February-March and September-October) with a carbamate in a year.

During the period October 2014 – October 2015, AIRS Rwanda conducted entomological monitoring activities whose objectives were to:

- Assess malaria vector density and species composition in intervention and selected control areas
- Understand vector feeding times and locations
- Ovary dissection for parity determination
- Monitor the quality of insecticide application and insecticide decay rates

2. DATA COLLECTION SITES AND METHODS

2.1 STUDY SITES

Data collection was conducted in the IRS districts: Bugesera, Gisagara, Nyagatare and Kirehe. Kirehe District was sprayed for the first time under the mandate of Abt Associates in

September 2015. Kirehe District was a control district during the period January-September 2015 but was sprayed in September 2015. It was then replaced with Ngoma District in September 2015 which is currently the control district (Figure1). In each IRS district 2 sectors were selected as data collection (sentinel) sites. Some of the sectors that had been sampled earlier as data collection (sentinel) sites in the intervention districts were not sprayed during the September spray campaign and were thus replaced starting September 2015. Table 1 below shows a summary of the data collection sites.

Figure 1: Map of Rwanda Showing data Collection Districts

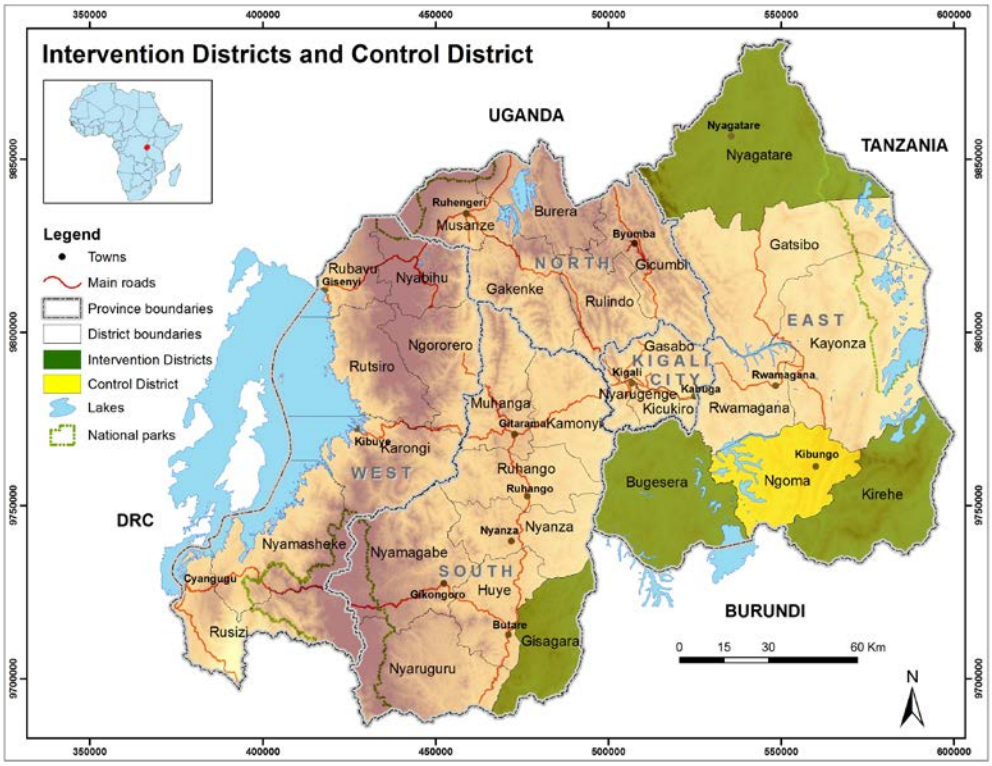


Table 1: Data Collection (sentinel) Sites

Period	District	Data collection sites (sectors)	Spray status
October 2014- August 2015	Bugesera	Nyarugenge & Musenyi	Sprayed
	Gisagara	Muganza and Gishubi	Sprayed
	Nyagatare	Nyagatare & Rukomo	Sprayed
	Kirehe(control)	Gatore	Not Sprayed
September 2015-to date	Bugesera	Nyarugenge & Musenyi	Sprayed
	Gisagara	Nyanza and Gikonko	Sprayed
	Nyagatare	Nyagatare & Karangazi	Sprayed

	Kirehe	Gatore & Nyamugali	Sprayed
	Ngoma (control)	Remera	Not Sprayed

The intervention sites were sprayed using a carbamate (Bendiocarb 80WP) and, entomological data collection was done monthly in both the intervention and control district(s).

2.2 OBJECTIVES OF AIRS RWANDA ENTOMOLOGICAL MONITORING

The objectives of the AIRS Rwanda entomological monitoring are to;

- Assess the malaria vector species composition present in the IRS intervention districts and one control district, their indoor resting density, and biting behavior.
- Determine the endophagic (indoor feeding) and exophagic (outdoor feeding) tendency of the malaria vectors.
- Determine parity (proportion of parous females) as an entomological indicator to ascertain if the age composition of the mosquito population has been reduced post IRS as compared to the control or pre-spraying, and consequently, if IRS interventions reduce the vector's ability to transmit malaria in the intervention areas.
- Provide quality assurance of the IRS program and assess the decay rate of the sprayed insecticide using the World Health Organization (WHO) cone/wall bioassay test

2.3 DATA COLLECTION METHODS

Blood seeking and resting adult mosquito collections were conducted in two sites in each IRS district and one site in the control district using HLC and PSC collection methods, respectively, on a monthly basis.

Spraying quality was assessed using World Health Organization (WHO) cone/wall bioassays which were conducted within one week of the start of the spray campaign. Further, cone/wall bioassay were conducted on monthly basis after the spray round to assess insecticide decay rate.

2.3.1 HUMAN LANDING CATCH

Human landing catch (HLC) was done in three households in each site for two consecutive nights per month; therefore, data was collected for four nights per district per month. A team of collectors composed of four people per night per house; two collectors per house collected from 6pm to 12mid-night and other two collected from 12am to 6am. Outdoor mosquito collection was carried out about six meters from the door of each of the three sampled houses. Collectors adjusted their clothing so that the legs were exposed up to the knees. At the end of the collection, mosquitoes were transported to the field lab and were identified using taxonomic keys (Gilles and Coetzee, 1987)[1].

[1] Gillies MT and Coetzee C. 1987. A Supplement to the Anopheline of Africa South of the Sahara. South African Institute for Medical Research. Johannesburg, SA

2.3.2 PYRETHRUM SPRAY CATCH

Pyrethrum Spray Catch (PSC) was used to sample indoor resting mosquitoes in 15 houses per day in each of the sites for two consecutive days every month. Collections were carried out in the morning between 6:00 a.m. to 9:00 a.m. Before the PSC was performed, all occupants were cordially asked to move out of the house. The floor was covered with white sheets. Windows, and other mosquito escape routes around the house were closed and the house was sprayed with BOP insecticide which contains Tetramethrin 0.30% w/w, Cypermethrin 0.07% w/w and D-Allethrin 0.12%w/w. Ten minutes after spraying, collectors collected all the mosquitoes that were knocked downed from the sheets and sorted them by species. The abdominal status of all female anophelines was determined, and individuals were categorized according to the blood digestion stage (unfed, freshly fed, half-gravid and gravid females).

2.4 IDENTIFICATION OF MALARIA VECTORS

Anopheles mosquitoes collected through HLC and PSC were identified to the species level morphologically. A sample of the *Anopheles gambiae* s.l. identified were labeled and preserved individually in eppendorf tubes over silica gel for molecular analysis.

2.5 DETERMINATION OF PARITY

Ovaries of unfed females belonging to *An. gambaie* s.l., from HLC were dissected under a dissecting microscope to determine the parity rate based on coiling of ovarian tracheoles (Detinova 1962)[2].

2.6 QUALITY OF SPRAY AND INSECTICIDE DECAY RATE

Quality of spraying and insecticide decay rates were assessed using the World Health Organization (WHO)[3] approved protocol. Test cones were placed at three different heights on sprayed wall surfaces while the control tests were fixed on surfaces known to be free of insecticide. Batches of 10 mosquitoes, two to five days-old non-blood-fed female *Anopheles gambiae* (Kisumu strain), were introduced into each of the cones. The mosquitoes were left in the cones exposed to the insecticide for 30 minutes, after which they were transferred to paper cups.

Knockdown and mortality were observed and recorded after 30 minutes exposure and after a 24-hour holding period, respectively. When mortality in the control cones was between 5% and 20%, the results of the treated samples were corrected using Abbot's formula.

[2] Age-grouping methods in diptera of medical importance, with special reference to some vectors of malaria / T. S. Detinova ; [with] an Annex on the ovary and ovarioles of mosquitos (with glossary) by D. S. Bertram - See more at: http://apps.who.int/iris/handle/10665/41724#sthash.YVKq2sql.dpuf

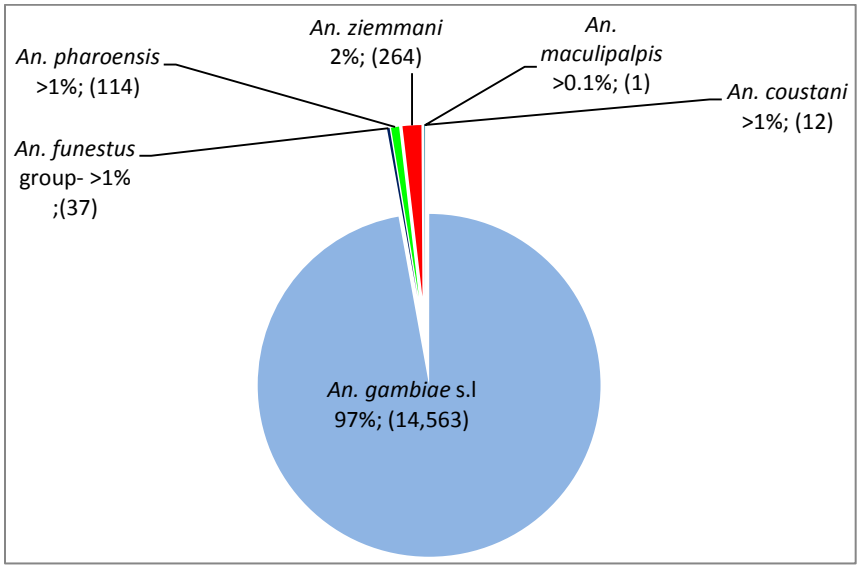
[3] WHO, 1998. Test procedures for insecticide resistance monitoring in malaria vectors, bio-efficacy and persistence of insecticides on treated surfaces. Document WHO/CDS/MAL/98.12, Geneva, Switzerland.

3. RESULTS, DISCUSSION AND CONCLUSIONS

3.1 SPECIES COMPOSITION AND VECTOR SEASONALITY

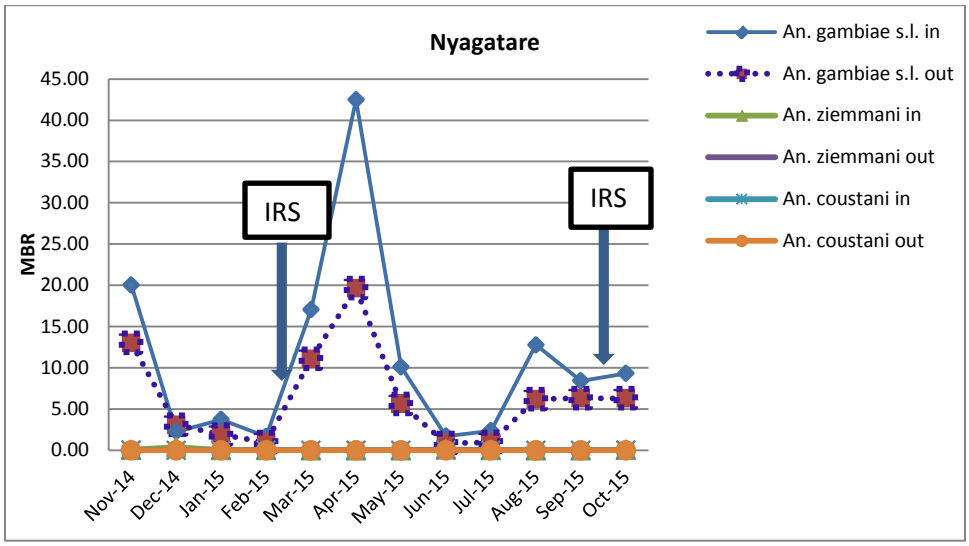
During the period October 2014 – October 2015, a total of 14,917 adult female *Anopheles* mosquitoes were collected using PSC and HLC. The species composition was 14,563 (97.6%) *Anopheles gambiae* s.l., 37 *Anopheles funestus group*, 114 *Anopheles pharoensis*, 264 *Anopheles ziemmani*, 12 *Anopheles coustani* and 1 *Anopheles maculpalpis*. Figure 2 below shows disaggregation of the anopheline species in the IRS and non-IRS districts. In addition to the *Anopheles*, 63,601 Culicinae were collected through the different collection techniques. Only *Anopheles gambiae* s.l. and *Anopheles funestus* group are known to transmit malaria (vectors of malaria) in Rwanda. Other mosquito species collected are non-vectors of malaria.

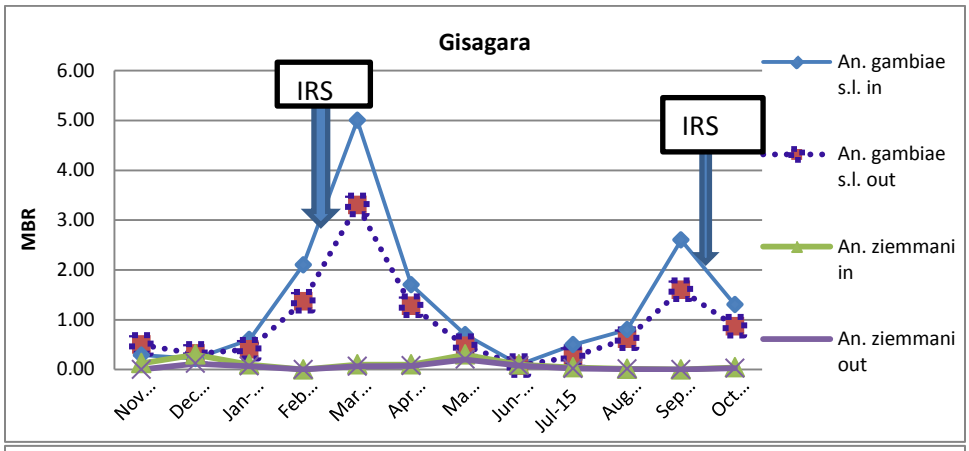
Figure 2: *Anopheles* Species Composition

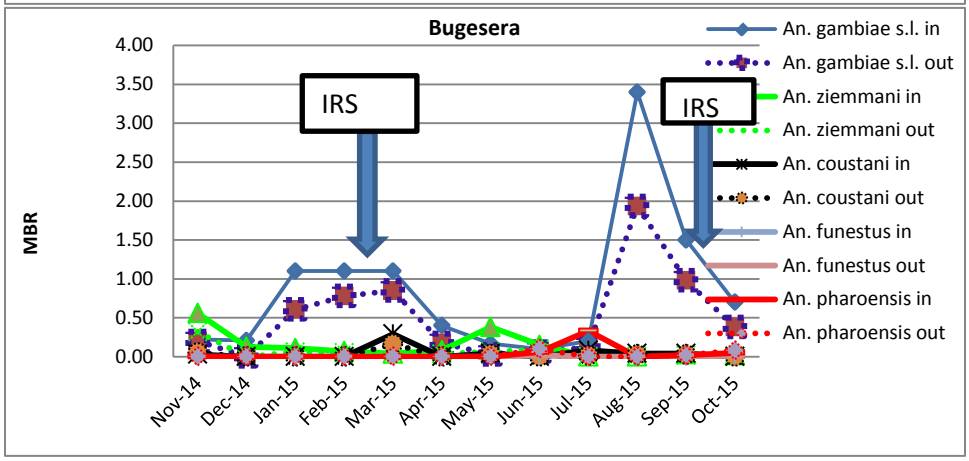


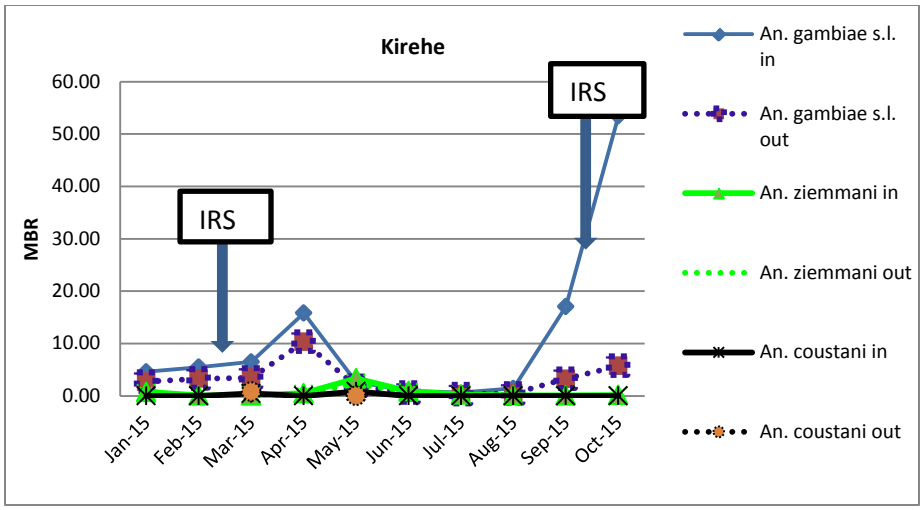
An. gambiae s.l. was the most prevalent malaria vector throughout the data collection period (see Figure 3).

Figure 3: Vector Seasonality









3.2 VECTOR DENSITY

A total of 1186 female indoor resting *An. gambiae* s.l. were collected using PSC in the IRS districts and the control districts. Table 2 below shows the disaggregation of the collections and density in the districts.

Table 2: PSC collections and Vector density

District	Nyagatare		Gisagara		Bugesera		Kirehe*		Ngoma**	
	Total Collected	Vector Density	Total Collected	Vector Density	Total Collected	Vector Density	Total Collected	Vector Density	Total Collected	Vector Density
Oct-14	27	0.45	3	0.05	0	0				
Nov-14	17	0.3	0	0	0	0				
Dec-14	19	0.32	1	0.016	2	0.033				
Jan-15	15	0.25	4	0.067	13	0.216	15	0.5		
Feb-15	8	0.13	23	0.38	10	0.166	27	0.9		
Mar-15	39	0.65	8	0.133	32	0.533	48	1.6		
Apr-15	56	0.93	2	0.033	0	0	35	1.167		
May-15	14	0.23	1	0.017	0	0	21	0.7		
Jun-15	1	0.0167	1	0.017	4	0.067	4	0.133		
Jul-15	2	0.03	2	0.033	1	0.016	5	0.167		
Aug-15	13	0.21	13	0.22	24	0.4	10	0.333		
Sep-15	20	0.333	21	0.35	68	1.13	126	2.1	232	7.73
Oct-15	22	0.367	18	0.3	10	0.166	42	0.7	107	3.57
Total	253		97		164		333		339	
P-value***	0.098		0.0156		0.0272					

*Kirehe District was the control (non-IRS) district between January and August 2015. IRS was conducted in Kirehe in September 2015

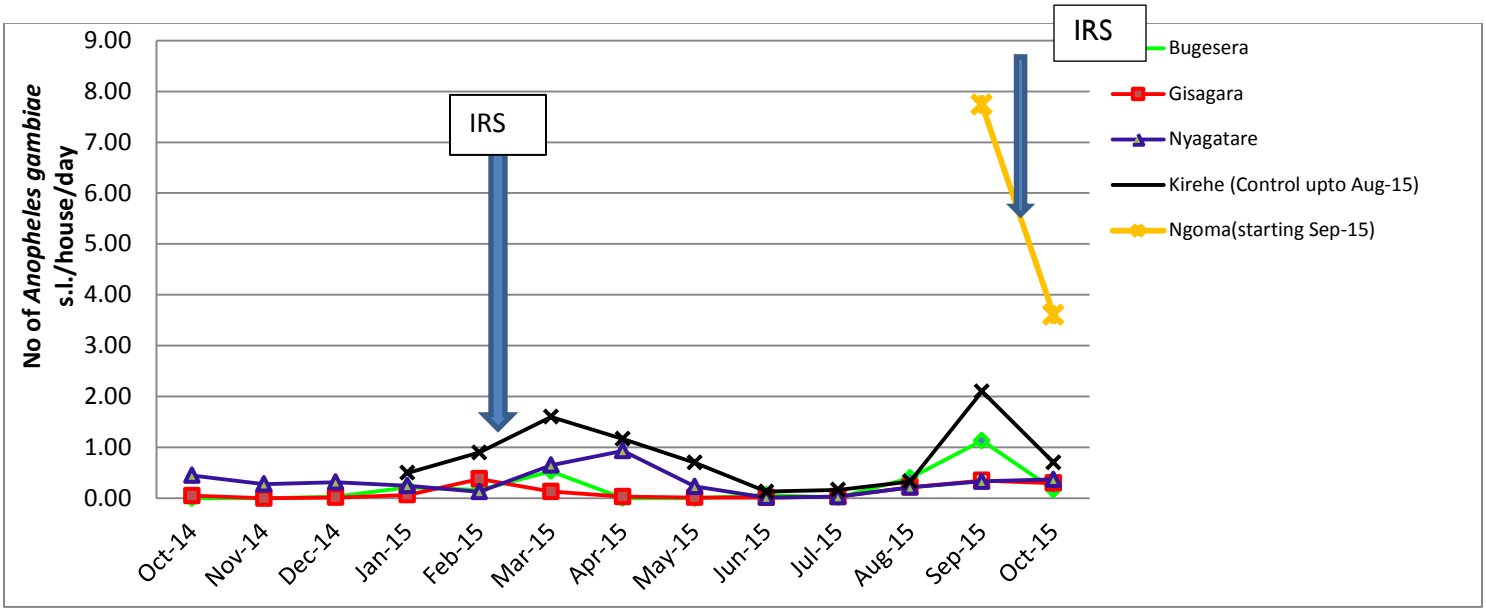
**Ngoma District is currently the control district (non-IRS); it replaced Kirehe District starting September 2015

***P-value was calculated for the period between January –August 2015 when Kirehe was the control district.

The difference in vector abundance from the PSC collections between Nyagatare district and the control district was not statistically significant ($p > 0.05$). Vector density was however significantly lower in Gisagara and Bugesera districts ($p<0.05$) relative to the control district.

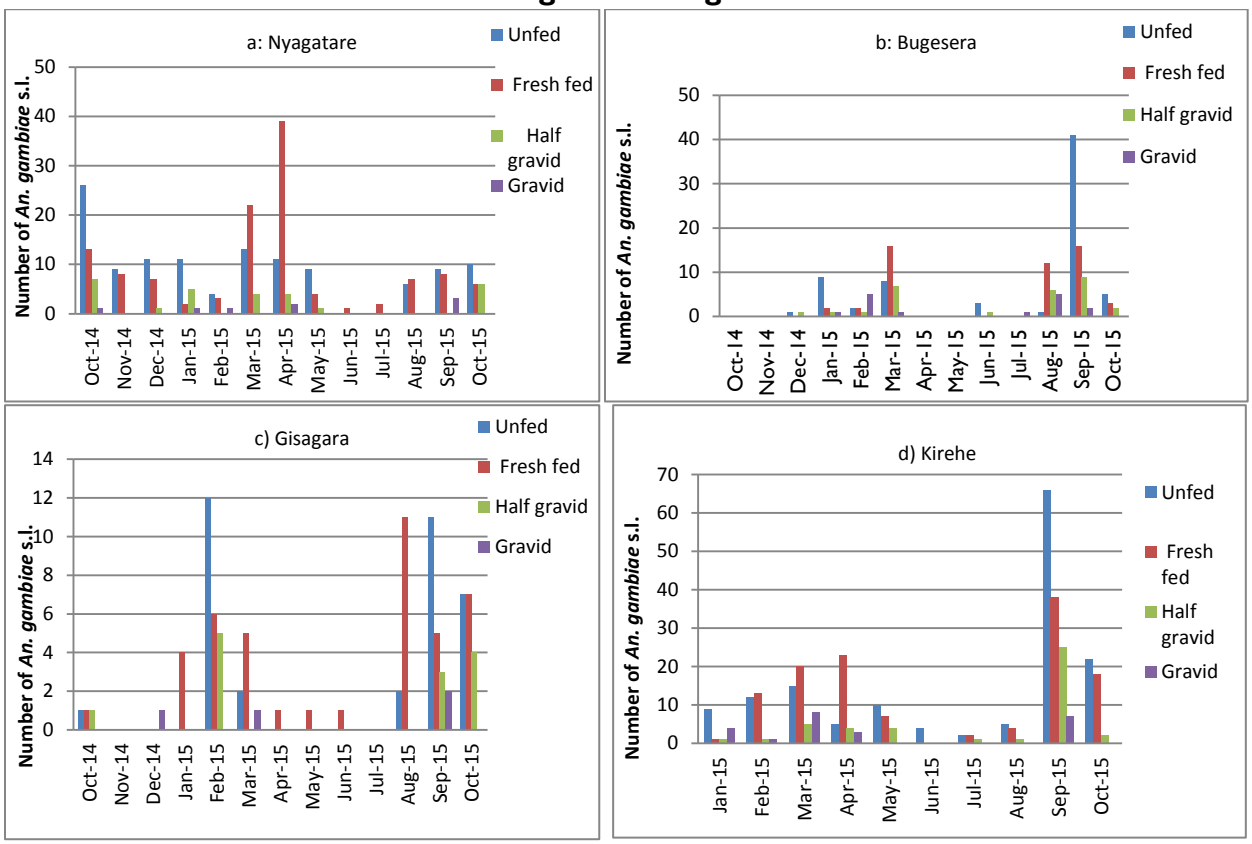
Vector density (average *An. gambiae* s.l./house/day) was highest in the control district through the reporting period including time before spraying. Nyagatare district showed the highest vector density relative to the other two IRS districts. Vector density in the four districts (including the control district) rose in February and March but tended to drop in April and remained low until September when an increase was observed. In Nyagatare however, the density peaked in March after which there was a drop. The highest density was recorded in Bugesera in September as 1.13 *An. gambiae* s.l./house/day; in Gisagara it was 0.38 *An. gambiae* s.l./house/day in February; in Nyagatare it was 0.93 *An. gambiae* s.l./house/day in April and in Kirehe (the control district) it was 2.10 *An. gambiae* s.l./house/day in September. Even though spraying was done in September in Kirehe, the sample sites specifically had not been sprayed since spraying was still in progress but also it might have been too soon to experience effects from IRS. A drop in vector abundance was observed in all sites in October which could partly be attributed to IRS although a drop was also observed in Ngoma, the control (non-IRS) district during the same period, (see Figure 4 below).

Figure 4: Anopheles gambiae s.l. Densities



All the 1206 *Anopheles gambiae* s.l. collected using PSC were classified according to their blood digestion stages, 493 (40.9%) were unfed 480 (39.8%) were freshly fed, 141 (11.7%) were half gravid and 92 (7.6%) were gravid, (see Figure 5 below)

Figure 5: Number of *An. gambiae* s.l. collected using PSC according to Blood Digestion Stages



3.3 VECTOR FEEDING TIME AND LOCATION

A total of 13,711 adult female *Anopheles* mosquitoes were collected using HLC. The species composition was; 13,311 *Anopheles gambiae* s.l, 14 *Anopheles funestus,* 112 *Anopheles pharoensis*, 261 *Anopheles ziemmani*, 12 *Anopheles coustani* and 1 *Anopheles* maculpalpis. There was a statistically significant difference between the indoor and outdoor collections in all the districts ($p<0.05$) (Table 3). A*n. gambiae* s.l. generally showed slightly more exophagic than endophagic tendency in the four districts, including the control district.

Table 3: Indoor and Outdoor Biting Rates

	Nyagatare			Gisagara			Bugesera			Kirehe					
	Indoor	Outdoor	In: Out ratio	Indoor	Outdoor	In: Out ratio	Indoor	Outdoor	In: Out ratio	Indoor	Outdoor	In: Out ratio	Indoor	Outdoor	In: Out Ratio
Oct-14	0.29^{S}	0.5^{S}	0.44:0.56	1.05^{NS}	2.25^{NS}	0.27:0.73	18.8^{NS}	23.25^{NS}	0.35:0.65						
Nov-14	0.4^{S}	0.4^{S}	0.4:0.6	0.58^{S}	1^{S}	0.19:0.81	31.16^{S}	47.74^{S}	0.5:0.5						
Dec-14	0.12^{S}	0.18^{S}	0.44:0.56	0.31^{NS}	0.69^{NS}	0.15:0.85	9.32^{NS}	11.38^{NS}	0.42:0.58						

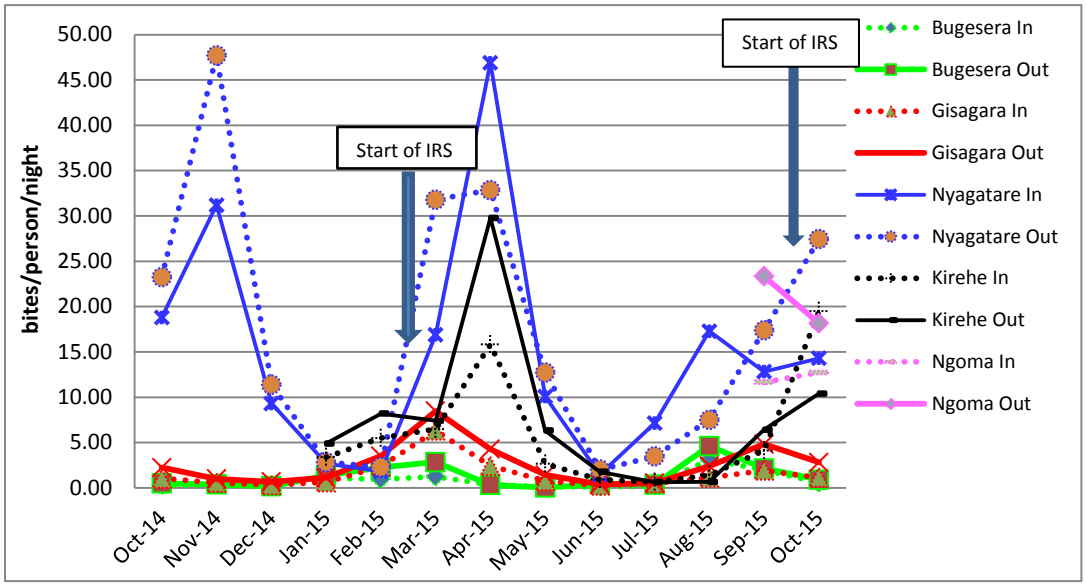
Jan-15	1.08^{S}	1.37^{S}	0.49:0.51	0.62^{NS}	1.13^{NS}	0.32:0.68	2.69^{NS}	2.86^{NS}	0.45:0.55	3.40^{S}	4.90^{S}	0.41:0.59			
Feb-15	0.96^{S}	2.24^{S}	0.41:0.59	2.38^{NS}	3.52^{NS}	0.35:0.65	1.83^{NS}	2.27^{NS}	0.29:0.71	5.51^{S}	8.19^{S}	0.40:0.60			
IRS															
Mar-15	1.25^{S}	2.85^{S}	0.35:0.65	6.32^{S}	8.48^{S}	0.34:0.66	16.91^{S}	31.79^{S}	0.23:0.77	6.49^{NS}	7.41^{NS}	0.47:0.53			
Apr-15	0.37^{NS}	0.33^{NS}	0.54:0.46	2.43^{NS}	4.28^{NS}	0.25:0.75	46.90^{NS}	32.85^{NS}	0.56:0.44	15.82^{NS}	29.78^{NS}	0.35:0.65			
May-15	0.15^{S}	0.05^{S}	0.44:0.56	0.76^{S}	1.44^{S}	0.32:0.68	10.09^{NS}	12.71^{NS}	0.83:0.17	2.66^{S}	6.34^{S}	0.3:0.7			
Jun-15	0.11^{S}	0.44^{S}	0.49:0.51	0.26^{S}	0.39^{S}	0.22:0.78	1.47^{S}	2.03^{S}	0.38:0.62	0.93^{NS}	1.77^{NS}	0.34:0.66			
Jul-15	0.26^{S}	0.39^{S}	0.59:0.41	0.50^{NS}	0.55^{NS}	0.49:0.51	7.14^{NS}	3.46^{NS}	0.39:0.61	0.65^{NS}	0.65^{NS}	0.5:0.50			
Aug-15	3.13^{S}	4.62^{S}	0.52:0.48	1.14^{NS}	2.41^{NS}	0.23:0.77	17.29^{NS}	7.51^{NS}	0.43:0.57	1.43^{S}	0.67^{S}	0.68:32			
Sep-15	2.00^{S}	2.15^{S}	0.25:0.75	1.91^{NS}	4.84^{NS}	0.39:0.61	12.82^{NS}	17.38^{NS}	0.35:0.65	4.13^{S}	6.42^{S}	0.41:0.59	11.66	23.35	0.33:0.67
IRS															
Oct-15	0.59^{S}	0.91^{S}	0.33:0.67	1.14^{NS}	2.81^{NS}	0.33:0.67	14.31^{NS}	27.44^{NS}	0.46:0.54	19.49^{S}	10.41^{S}	0.45:0.55	12.73	18.17	0.41:0.59

*Kirehe District was the control (non-IRS) district between January and August 2015. IRS was conducted in Kirehe in September 2015

**Ngoma District is currently the control district (non-IRS); it replaced Kirehe District starting September 2015

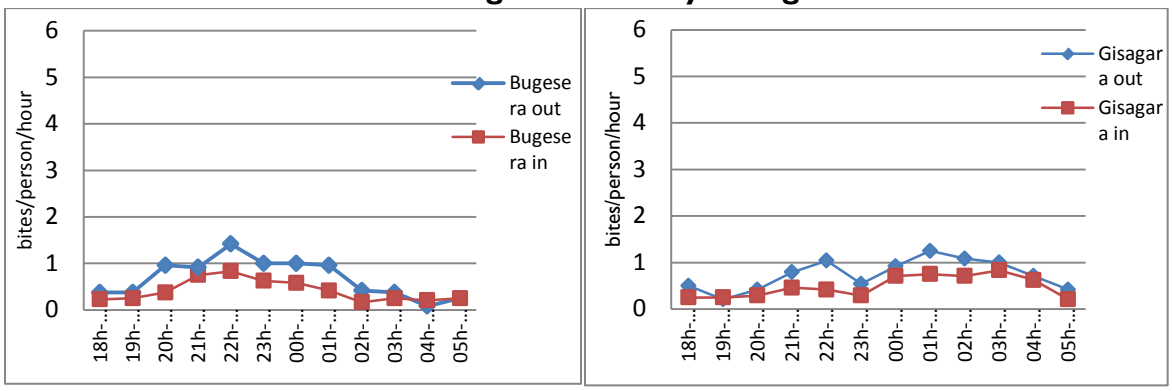
While biting was generally low in both Gisagara and Bugesera in October 2014 to January 2015, it was comparatively high in Nyagatare District during the same period. A rise in vector biting was observed in the month of March (both indoor and outdoor) in all districts. It peaked in April and gradually fell in May and June to comparatively low levels. Even though this could be as a result of the IRS application in February it is not clear what the contribution of IRS was since the trend between the intervention and control districts is similar and biting rates in Nyagatare (IRS district) were more than in Kirehe, the control district. The drier weather conditions might have partly contributed to lower vector density and consequently lower biting rates. Biting rates slightly rose in August. This coincided with the period around which the residual efficacy of the insecticide dropped to levels below 80% mortality of susceptible *An. gambiae* s.l. In Nyagatare district both indoor and outdoor biting was generally higher than in the other districts and the trend was similar to that of the control district (Kirehe). Apart from Kirehe and Nyagatare outdoor biting dropped in all other sites in October. Indoor biting dropped in Bugesera and Gisagara in October. (Figure 6)

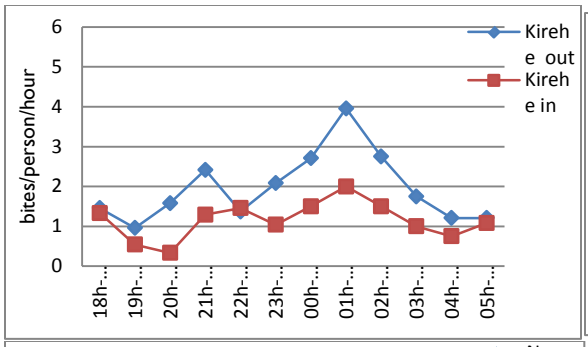
Figure 6: *An. gambiae* s.l. Average Monthly Biting Trends

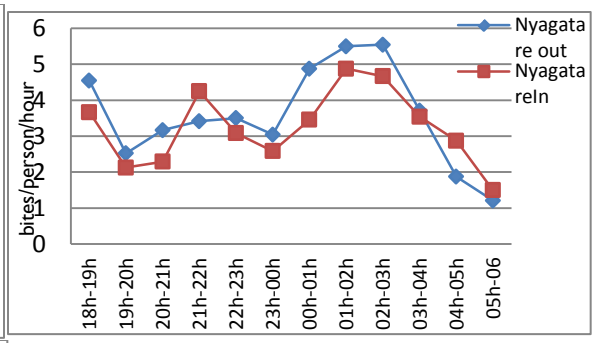


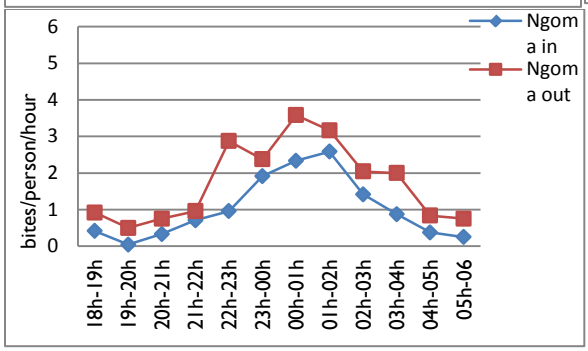
Hourly biting rates per person varied across the five districts; they were highest in Nyagatare, followed by Kirehe (former control district) and Ngoma (current control district), then Gisagara and Bugesera showed the least bites/person/hour. The relatively higher biting in Nyagatare and Kirehe could be due to the fact that apart from the rains there is considerably more rice farming in the districts relative to the other districts. Hourly biting was slightly higher outdoors than indoors. In Nyagatare, and Kirehe districts, biting was generally high at 1900h dropped at 2000h. An increase in biting density was observed at around 2200h, peaked at 0001h and remained high until 0003h. In Bugesera, hourly biting rose at around 2100h and remained relatively constant through the rest of the night. Figure 7 below shows average *An. gambiae* s.l. bites per person per hour through the night across the three districts.

Figure 7: Hourly Biting









3.4 DETERMINATION OF PARITY

Ovary dissection of the *An. gambiae* s.l. collected by HLC was performed to determine parity rates. Table 4 below shows the results. The p-values varied through the months across the districts. In Bugesera District there was no statistically significant difference in the monthly collection compared with the control district (Kirehe) except in August 2015. A significant difference between the parous rates of the vector populations in Gisagara District versus the control district was observed in September and October. In January, February, March, September and October statistically significant difference in parity between vector population in Nyagatare and the control district was observed. This could be an indication that even though the vector population is high in Nyagatare, the mosquitoes are relatively young and therefore IRS is having an effect. Further analysis of the mosquito samples to determine the sporozoite rates which is planned to be done in March/April should shed more light in this area. This difference could be attributed to the fact that unlike the other two districts (Bugesera and Gisagara) Nyagatare has not been excluded in any of the seven past spray campaigns in a row. Parity in the IRS districts tended to be higher during the months of March, May, September and October (Figure 8).

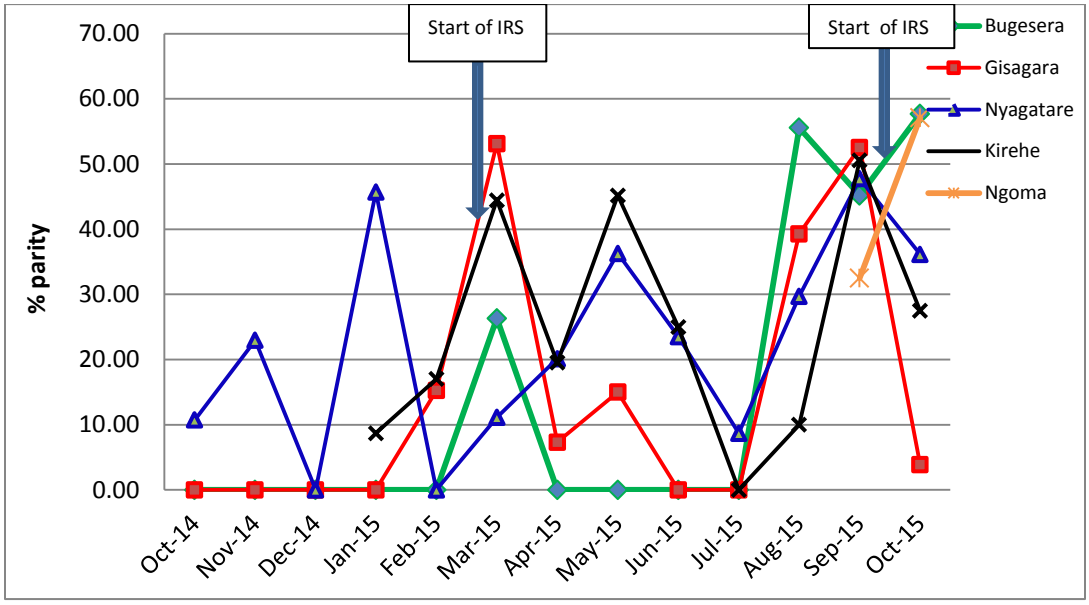
Table 4: Parity

	Bugesera					Gisagara					Nyagatare					Kirehe								
	Total An. gambiae s.l. Dissected	# parous	% parity	P-value	Result	Total An. gambiae s.l. Dissected	# parous	% parity	p-value	Result	Total An. gambiae s.l. Dissected	# parous	% parity	p-value	result	Total An. gambiae s.l. Dissected	# parous	% parity	p-value	result	Total An. gambiae s.l. Dissected	# parous	parity	p-value
Oct-14	0	0	0.0	-	-	0	0	0.0	-	-	149	16	10.7											
Nov-14	0	0	0.0	-	-	0	0	0.0	-	-	61	14	23.0											
Dec-14	0	0	0.0	-	-	0	0	0.0	-	-	74	0	0.0											
Jan-15	0	0	0.0	-	-	0	0	0.0	-	-	35	16	45.7	0.003	S	23	2	8.7						
Feb-15	17	0	0.0	0.068	NS	59	9	15.3	0.805	NS	27	0	0.0	0.023	S	47	8	17.0						
Mar-15	19	5	26.3	0.164	NS	64	34	53.1	0.347	NS	153	17	11.1	0.000	S	54	24	44.4						
IRS																								
Apr-15	0	0	0.0	-	-	41	3	7.3	0.778	NS	144	29	20.1	0.909	NS	82	16	19.5						
May-15	0	0	0.0	-	-	20	3	15.0	0.026	NS	124	45	36.3	0.362	NS	31	14	45.2						
Jun-15	0	0	0.0	-	-	0	0	0.0			17	4	23.5	0.927	NS	12	3	25.0						
Jul-15	0	0	0.0	-	-	5	0	0.0			23	2	8.7	0.493	NS	5	0	0.0						

Aug-15	54	30	55.6	0.008	S	28	11	39.3	0.087	NS	101	30	29.7	0.185	NS	10	1	10.0						
Sep-15	31	14	45.2	0.212	NS	59	31	52.5	0.017	S	111	53	47.7	0.034	S	89	45	50.6	0.017	S	80	26	32.5	0.017
IRS																								
Oct-15	26	15	57.7	0.959	NS	52	2	3.8	0.000	S	155	56	36.1	0.001	S	131	36	27.5	0.000	S	98	56	57.1	

NS-Not Significant; S-Significant

Figure 8: Parity



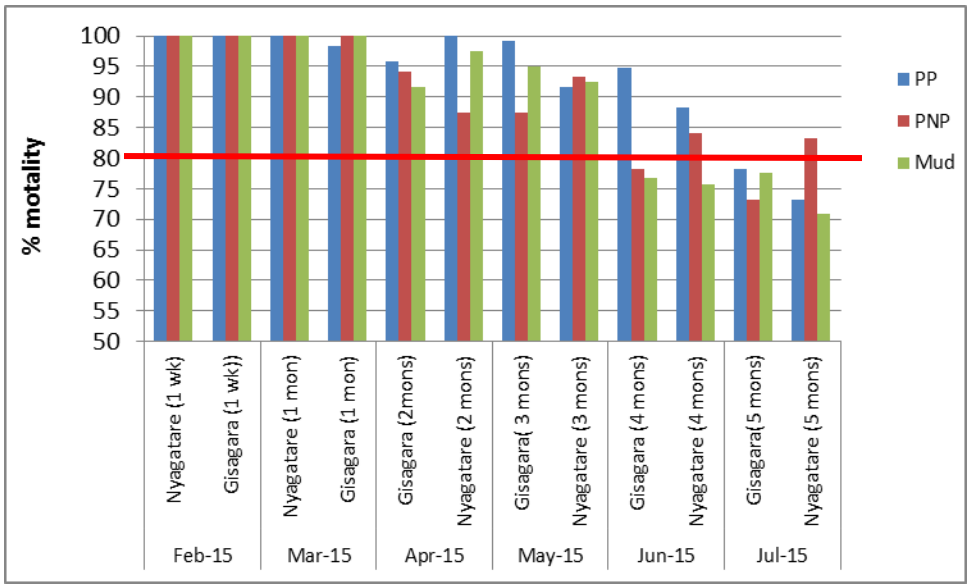
3.5 QUALITY OF SPRAY INSECTICIDE DECAY RATE

In February 2015 WHO cone bioassays were conducted in 24 sprayed structures in the two IRS districts. The tests were conducted on three different wall surfaces (mud, plastered not painted (PNP) and plastered and painted (PP)) in each of the two IRS districts. In each district, two different sectors were sampled, and in each sector six structures were sampled. Out of the six structures in each sector, two were of each wall surface type (mud, PNP PP). Control tests were conducted alongside on surfaces that were known to have no insecticide. The cone bioassays were conducted using susceptible *An. gambiae* s.l. (Kisumu colony).

Cone bioassays conducted within one week of spraying to assess the quality of spraying in February 2015 showed 100% mortality of susceptible *An. gambiae* s.l. indicating quality spraying took place.

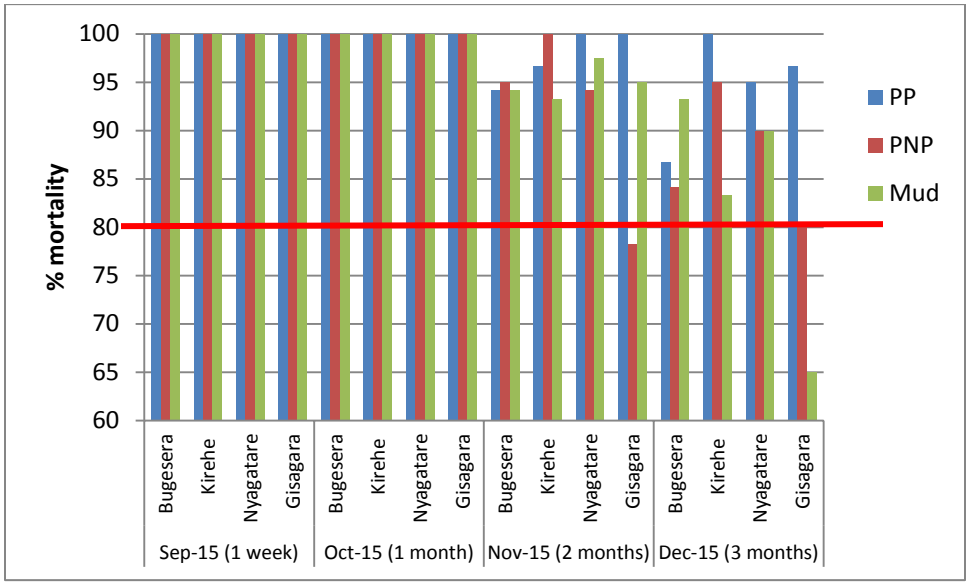
Monthly WHO cone bioassay tests conducted following the February 2015 IRS campaign showed the following results; mortality of over 80% was observed in all the three surface types in the two districts up to three months after spraying. At four months post spraying the plastered and painted surfaces recorded over 80% mortality rates in both districts. The plastered and not painted surfaces in Nyagatare district recorded above 80% mortality up to the fifth month after IRS, (Figure 9).

Figure 9: Wall Bioassay Test Results (February-July 2015)



During the September 2015 spray campaign quality control wall bioassay tests were conducted in 48 structures in the four districts (Bugesera, Kirehe, Nyagatare and Gisagara) within week one of spraying. In all test cones 100% mortality of susceptible *An. gambiae* s.s. was recorded. Percentage mortalities were observed to drop below the 100% mark at two months post IRS but were above the 80% threshold in all districts for all three different wall surfaces except Gisagara 'plastered not painted' (PNP) wall surface which recorded 78.3% mortality two months post IRS. It is not clear what led to a possible increase in the insecticide efficacy on the Gisagara PNP wall surface as a higher mortality rate (80%) was observed the following month (3 months post IRS). During the third month tests, efficacy on the mud surface in Gisagara District had deteriorated to mortality level of 65% but was above 80% in the other districts on all the three wall surfaces. As was observed in the earlier bioassay tests, the plastered wall surfaces seem to have a better retention of the insecticide over time.(Figure 10).

Figure 10: Wall Bioassay Test Results (September-December, 2015)



3.6 CONCLUSIONS

- *An. gambiae* s.l. is the major malaria vector in Nyagatare, Bugesera, Gisagara and Kirehe Districts.
- *An. gambiae* s.l tends to be more exophagic than endophagic in the four data collection districts.
- *An. gambiae* s.l. was the most prevalent malaria vector throughout the data collection period
- Hourly biting rates per person varied across the five districts. In Nyagatare, and Kirehe districts, biting was generally high at 1900h dropped at 2000h. An increase in biting density was observed at around 2200h, peaked at 0001h and remained high until 0003h. In Bugesera, hourly biting rose at around 2100h and remained relatively constant through the rest of the night.
- Biting rates were higher in Nyagatare relative to the other districts (including the control district) but parity rates were observed to be lower in Nyagatare. There was no clear trend observed for parity even with the IRS intervention.
- Bendiocarb 80WP has a three months efficacy period (80% mortality) on the three wall surface types tested; it can however last longer on plastered wall surfaces.

4. CHALLENGES AND RECOMMENDATIONS

4.1 CHALLENGES

- Molecular analysis of preserved mosquito samples was not conducted in time to be reported in this report; the analysis will be conducted in 2016 and the results reported then.

4.2 RECOMMENDATIONS

Molecular analysis of preserved vector samples will be done in 2016 moving forward.