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THE PMI VECTORLINK PROJECT
DEMOCRATIC REPUBLIC OF CONGO

ENTOMOLOGICAL SURVEILLANCE
FINAL REPORT
DECEMBER 1, 2017–DECEMBER 31, 2018

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TABLE OF CONTENTS

ACRONYMS

CDC	Centers for Disease Control and Prevention
DRC	Democratic Republic of Congo
ELISA	Enzyme-linked Immunosorbent Assay
HBR	human biting rate
HLC	human landing catch
INRB	Institut National de Recherche Biomédicale/National Institute of Bio-medical Research
LLIN	long-lasting insecticidal net
NMCP	National Malaria Control Program
PMI	President's Malaria Initiative
PSC	pyrethrum spray catch
WHO	World Health Organization

1. EXECUTIVE SUMMARY

The U.S. President's Malaria Initiative (PMI) VectorLink Project conducted entomological monitoring activities in the Democratic Republic of Congo (DRC) in 11 sentinel sites distributed nationwide. This report describes activities from December 2017 through December 2018. Pyrethrum spray catch (PSC) and human landing catch (HLC) activities were conducted monthly from January to December in two sites (Kabondo and Kalemie), and on three occasions from January to June 2018 in four sites (Karawa, Pawa, Inongo and Kimpese). *Anopheles gambiae* s.l. was the predominant malaria vector in all sites, followed by *An. funestus* s.l.

Particularly high biting rates were recorded in Kabondo from March to December, with a mean nightly *An. gambiae* s.l. biting rate of 18 and 23 bites per person, indoors and outdoors, respectively. The mean annual entomological inoculation rate (EIR) was extremely high, at 150 infectious bites per person per year in Kabondo. In Kalemie, mean human biting rates (HBRs) each month were much lower, between 0 and 6 *An. gambiae* s.l. bites per person per night.

In Kalemie, 63% of *Anopheles* captured were caught by PSC. The reasons for the relatively low HLC catch rate compared to PSC require further investigation. No sporozoite positive mosquitoes were collected from Kalemie.

Insecticide susceptibility and resistance intensity bioassays using *Anopheles gambiae* s.l. were conducted for permethrin, deltamethrin, and alpha-cypermethrin at 1, 5, and 10 times the diagnostic concentration, according to World Health Organization (WHO) protocols. Resistance to permethrin (percentage mortality < 90) was observed in all sites, except Katana; to deltamethrin in all sites except Lodja and Inongo; and to alpha-cypermethrin in all sites. There was resistance to pirimiphos-methyl in Lodja, but this needs confirmation due to possible issues with reliability of pirimiphos-methyl papers (as reported in other countries).

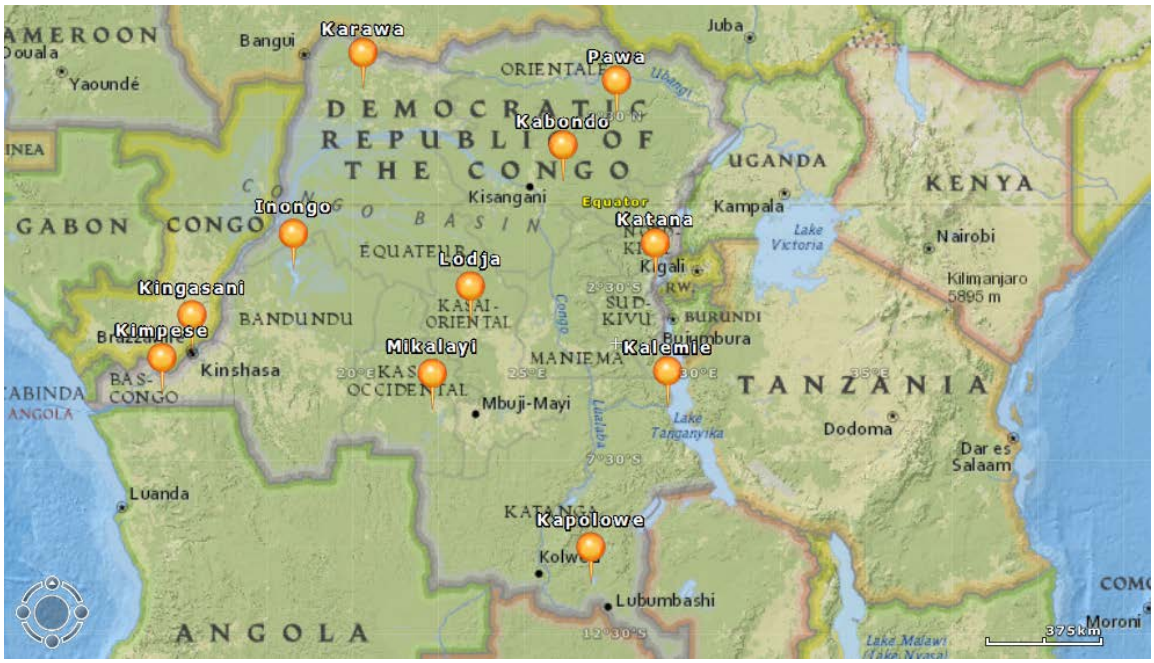
The intensity of resistance was moderate for almost all pyrethroids, although in some sites survivors were recorded at 10 times the diagnostic doses of permethrin and deltamethrin, indicating high intensity resistance. Nevertheless, this moderate intensity resistance level observed nationwide is extremely concerning, and has the potential to compromise the effectiveness of pyrethroid long-lasting insecticidal nets (LLINs). Bioassay testing of pyrethroids with the synergist piperonyl butoxide (PBO) will be conducted in 2019. Malaria vectors were susceptible to chlorfenapyr in four sites tested using doses of 100 and 200µg/bottle. This data will help to inform the National Malaria Control Program (NMCP) and donors regarding choice of LLINs for future distribution campaigns.

In an effort to build local capacity, Dr. Fiacre Agossa and three staff from the Institut National de Recherche Biomédicale (INRB) participated in a training course at Witwatersrand University, South Africa on *Anopheles* culturing techniques, morphological mosquito identification, sampling techniques, and insecticide resistance detection. Three junior staff (two NMCP staff from the Kabondo and Kalemie sites, and one from the INRB) attended an entomology training course in Benin to strengthen their basic skills and knowledge on mosquito ecology and behavior, mosquito rearing, susceptibility testing, sampling of larval and adult mosquitoes, and morphological identification.

2. Project Activities and Methodology

This final report details the results of entomological activities conducted in 11 sites from January to December 2018 (Figure 1).

Figure 1: 2018 Sentinel Sites for Entomological Monitoring



These activities were conducted according to the work plan developed by PMI VectorLink DRC (Table 1). We have opted to present data by site, per activity.

Table 1: Schedule for Entomological Activities*

Activity	Purpose	Sites	Timeline	Frequency / Participants	Status
Vector susceptibility and intensity of resistance	To determine vector susceptibility level to five insecticides	Kabondo, Kalemie, Mikalayi, Lodja, Kingasani, Kapolowe, Katana, Pawa, Kimpese, Karawa, and Inongo	February–December 2018	11 sites, 1 time per site	Completed
Seasonal vector dynamics, species composition, annual innoculation rate, biting times	To gather more-detailed annual information on malaria vector dynamics and behavior	Kabondo, Kalemie	January 2018–December 2018	2 sites, every month	Completed

Vector composition and behavior	To morphologically identify malaria vectors and determine vector biting times and indoor/outdoor resting/biting behavior	Pawa, Kimpese, Karawa, and Inongo	1- January 2018 2- March 2018 3- May 2018	4 sites, 3 times per site	Completed
Collection of *Anopheles coustani* group mosquitoes	To collect specific mosquito species for use as reference samples	Lodja and Kapolowe	June and August 2018	2 sites, 1 visit	Completed
Molecular assays	To identify mosquito species of the *An. gambiae* s.l. species complex, mechanisms of resistance (*kdr*), and sporozoite rates	Kabondo, Kalemie, Mikalayi, Lodja, Kingasani, Kapolowe, Katana, Pawa, Kimpese, Karawa, and Inongo	March–December 2018	11 sites	Completed for Enzyme-linked Immunosorbent Assay (ELISA); PCR will be completed by March and data will be reported in April 2019
Mapping of malaria vectors	Provide information on the distribution of *Anopheles* mosquitoes in Kwango province	Kwango Province	July–August 2018 (dry season)	10 sites, 2 visits	Completed for dry season
Morphological ID training at Witwatersrand University	At the end of training, three staff from the INRB should be competent in the use of a mosquito identification key, and be able to identify the major *Anopheles* mosquitoes in DRC using an identification key.	N/A	May 2018	Three INRB staff	Completed
Entomology training at the Entomological Research Center of Cotonou, Benin	This training will provide staff based at sentinel sites with a strong background for collections and analysis of mosquitoes, allowing improved work to be conducted in these sites.	N/A	2 months duration (July–August) 2018	Three sentinel site and/or INRB staff	Completed

*As the rainy seasons are not the same in all areas of the DRC, the seasonal effects will be taken into account when planning the activities.

2.1 HLCs

HLCs were performed indoors and outdoors to assess mosquito biting time, feeding behavior, and biting rates, and to monitor species composition and sporozoite rates. Trained residents collected adult mosquitoes during four consecutive nights in two different houses each night, with one person placed indoors and another placed outdoors in each selected house. HLCs were done from 6 p.m. to 6 a.m. Collectors were rotated indoors and outdoors every hour. In Kalemie and Kabondo, HLCs were conducted monthly, while in Pawa, Kimpese, Karawa, and Inongo, sampling was conducted three times per year. Houses were sampled in different villages each night in Kalemie and Kabondo to get a more representative sample of the area. The same houses were chosen for HLCs during each month. In the newer sentinel sites of Pawa, Kimpese, Karawa, and Inongo, sampling was conducted within a single village per site, with eight different houses chosen in the same village and used for sampling three times in the year.

All *Anopheles* mosquitoes collected in HLCs were identified to species morphologically in the field, and cross-checked by INRB entomologists either in the field or in Kinshasa (depending on the supervision schedule). All *Anopheles* were preserved in 1.5 ml Eppendorf tubes on silica gel for further molecular analysis in Kinshasa by the INRB.

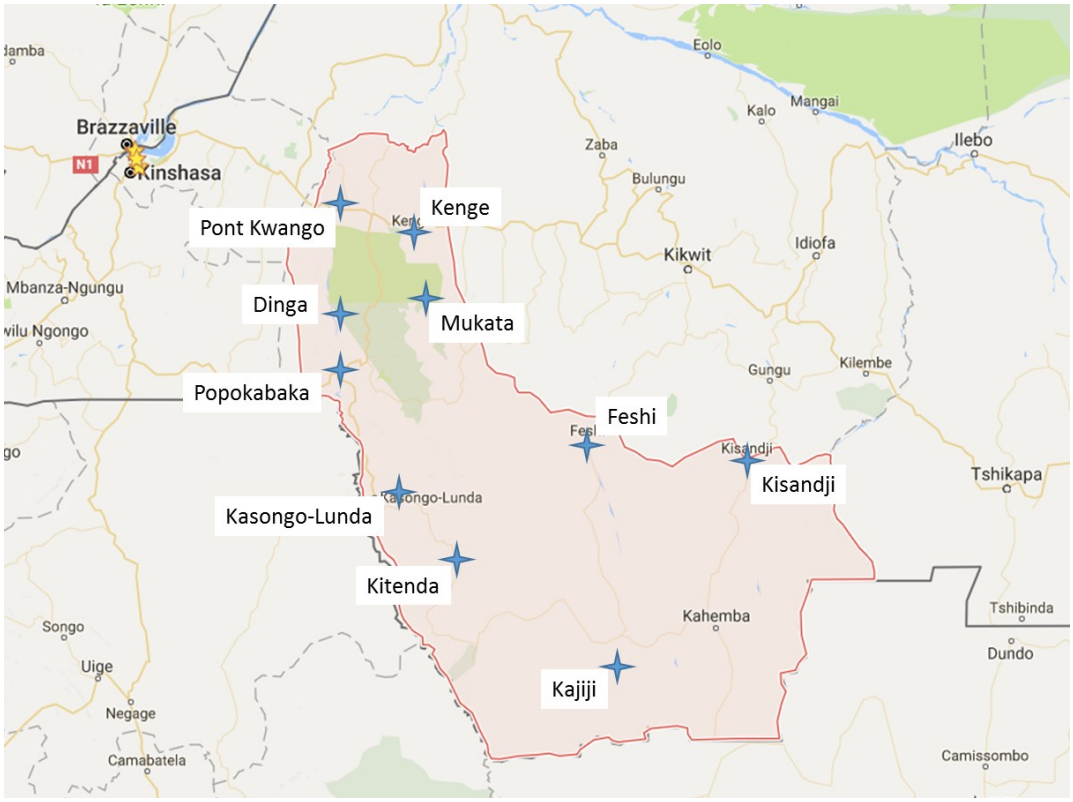
2.2 PSCs

PSCs were conducted to estimate the indoor resting density of mosquito species. In the same area used for HLCs, 10 houses were selected for indoor PSCs. PSCs were carried out between 6 and 9 a.m. for two days in five houses per day, for a total of 10 houses. Before the PSCs were performed, all occupants were asked to move out of the house. The rooms were sprayed with commercially available aerosol containing pyrethroid and piperonyl butoxide to knock down mosquitoes resting inside the house. Twenty minutes after spraying, all mosquitoes knocked down were collected from a white sheet lying on the flat surfaces. Female *Anopheles* were classified according to the four abdominal stages (unfed, fed, half-gravid, and gravid). Each mosquito collected was properly labeled, stored in an Eppendorf tube with silica gel, identified to species morphologically in the field, and cross-checked by an INRB entomologist once back at the central lab.

2.3 Vector Mapping In Kwango Province

One round of sampling was conducted in the dry season (July–August 2018) in 10 sites (Figure 2) in Kwango Province to better understand vector composition and behavior throughout the province. During the visit to each site, human landing catches were conducted for one night in two houses, and PSCs were made in 10 houses the following morning. The methodologies described above were used for HLCs and PSCs. In each village, *Anopheles* larvae were collected from larval sites and fourth stage larvae were conserved in 95% ethanol and kept at the INRB in the freezer at -20°C for molecular species identification. The GPS coordinates of the larvae collection points were collected.

FIGURE 2: SITES FOR VECTOR MAPPING IN KWANGO



2.4 Collection of *Anopheles coustani* Group Mosquitoes

HLCs were conducted in Lodja (June 2018) and Kapolowe (August 2018) to provide samples morphologically identified as *Anopheles paludis, Anopheles coustani,* and *Anopheles caliginosus* that can be used as archival voucher specimens. Ten nights of HLCs were conducted in Kapolowe, and in Lodja two nights of HLCs were conducted (four households each night in both locations). Prior to these collections, Dr. Seth Irish of the U.S. Centers for Disease Control and Prevention (CDC) conducted training in DRC on how to pin mosquitoes using card points for archiving. Pinned specimens from Lodja were taken to CDC in Atlanta, where a single leg was removed from each specimen for ITS-2 and CO-1 sequencing by the University of Notre Dame. Samples from Kapolowe will be sent to CDC in Atlanta in 2019. Specimens with accompanying sequencing data will then be sent to the Smithsonian Institution in Washington D.C. for archiving as reference samples.

2.5 Insecticide Susceptibility and Resistance Intensity Testing

Insecticide susceptibility and resistance intensity testing was conducted in 11 sentinel sites. INRB entomologists traveled to each site to collect larvae and pupae, which were reared to adulthood before the susceptibility and resistance intensity tests were conducted. In addition to testing at the diagnostic dose, WHO intensity bioassays were also conducted, by testing pyrethroid papers treated with 5 and 10 times the diagnostic dose.

The insecticides tested in 2018 were:

1. Deltamethrin ×1, ×5, ×10 (0.05%, 0.25%, 0.5%)
2. Permethrin ×1, ×5, ×10 (0.75%, 3.75%, 7.5%)
3. Alpha-cypermethrin ×1, ×5, ×10 (0.05%, 0.25%, 0.5%)
4. Pirimiphos-methyl ×1 (0.25%)
5. Chlorfenapyr 12.5, 25, 50, 100, 200µg/bottle (diagnostic dose not defined; chlorfenapyr was tested in CDC bottle bioassays)

In all sites, susceptibility testing was conducted with adult *An. gambiae* s.l., following the WHO method. During the susceptibility tests, female adult mosquitoes were exposed for one hour to insecticide-treated filter papers provided by WHO (USM-Malaysia). Exposure tests were accompanied by negative control tests where mosquitoes were exposed to filter papers impregnated with oil or solvent. Testing was done according to WHO protocols, with mortality being the primary outcome measure. Four replicates of 25 *An. gambiae* s.l. were exposed to each concentration.

Susceptibility testing of wild collected adult F_0 *An. funestus* was also done using the WHO susceptibility assay for three pyrethroids (alphacypermethrin 0.05%, permethrin 0.75%, and deltamethrin 0.05%), in Kimpese and Kapolowe. No testing on *An. funestus* s.l. was done in Mikalayi or Katana as the INRB could not travel to these locations for security concerns. A specialist is needed to assist in collection and the field supervisors are not trained to do it alone.

CDC bottle bioassays were completed in Kalemie, Kinshasa, Kimpese, and Kapolowe to determine the susceptibility status of *An. gambiae* s.l. populations to chlorfenapyr. As no diagnostic dose had been determined at that time, we tested five doses ranging from 12.5 to 200µg/bottle. Recently, PMI VectorLink indicated that 100µg/bottle is considered the interim diagnostic concentration. Four replicates of at least 20 *An. gambiae* s.l. were exposed for 60 minutes to chlorfenapyr 12.5, 25, 50, 100, and 200 ug/bottle. The proportion of mosquitoes knocked down was recorded 60 minutes after the start of the test, while mosquitoes were still in the bottle. After 60 minutes of exposure, mosquitoes were removed from the bottle, transferred to paper cups, and supplied with a sugar solution. Mortality was recorded every 24 hours for three days following the 60-minute exposure.

2.6 Molecular Analysis

All molecular analyses were conducted in the molecular laboratory of the Parasitology Department at the INRB, Kinshasa. The mosquito samples collected from sentinel sites were transported to the INRB, where processing and analysis were carried out. Technicians conducted laboratory analyses under the supervision of the INRB focal point entomologist, Professor Francis Wat'senga, and PMI VectorLink Entomologist Dr. Rodrigue Fiacre Agossa, following the protocols described in Table 2.

TABLE 2: CURRENT PROTOCOLS FOR LABORATORY ANALYSES OF MOSQUITO VECTORS

Molecular Analysis	Protocol	Output
ELISA	Malaria Research and Reference Reagent Resource Centre document "*Anopheles* in Research" (based on Wirtz et al. 1987)	Sporozoite identification: Identified mosquito samples that were positive for *Plasmodium falciparum* sporozoites
PCR	Santolamazza et al. 2008	Species identification: Identified *Anopheles gambiae* complex sibling species including *Anopheles coluzzii*, *An. gambiae* and *An. arabiensis*.
	Martinez-Torres et al. (1998)	Voltage gated sodium channel mutation L1014F presence: Monitored pyrethroid target site resistance mechanism frequency

Only testing for sporozoite identification, using ELISA, was completed in 2018. The other laboratory tests are ongoing, and results will be shared in April 2019. ELISA tests were conducted on a subsample of *Anopheles* collected through HLCs in Kabondo and Kalemie (targeted at a sample of 200 per month, or 2,400 total). At least 25 *Anopheles funestus* s.l. collected in five of the six monitoring sites (Kabondo, Kalemie, Pawa, Kimpese, and Karawa) through HLCs or PSCs were tested to determine the species. Not enough *An. funestus* s.l. were collected in Inongo for testing. A subsample of up to 50 *An. gambiae* s.l. or *An. funestus* s.l. will be tested from each of the 10 sites in Kwango Province.

2.7 Data Analysis

The following formulas were used to calculate entomological indicators:

- The sporozoite rate = (total ELISA positive/total number tested) x 100
- HBR = total collected by HLCs during a specific period/total number of trap-nights
- Nightly EIR = Nightly HBR x sporozoite rate
- Monthly EIR = Nightly mean EIR x the number of nights in the month

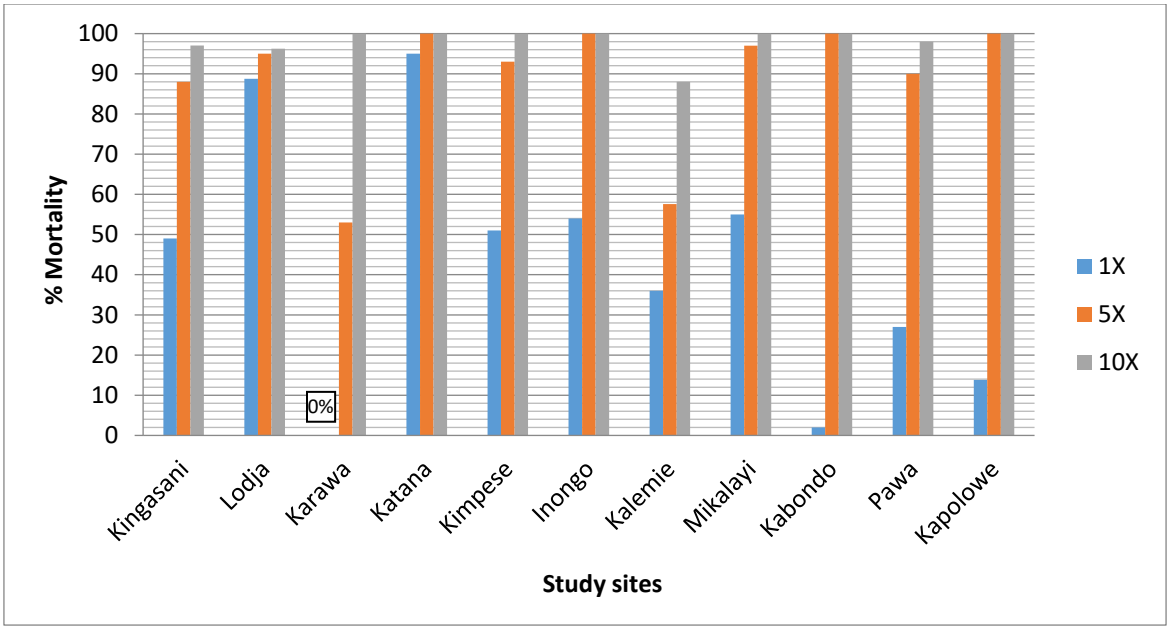
3. INSECTICIDE SUSCEPTIBILITY RESULTS

WHO insecticide susceptibility and resistance intensity tests were completed with *An. gambiae* s.l. populations in all 11 sites. The data is presented in Figures 3, 4, 5, and 6. In Kabondo, testing with alpha-cypermethrin 5X and 10X was not completedas mortality was >20% in the control and the field team was unable to find sufficient larvae for repeat tests. Resistance to permethrin (<90% mortality) was observed in all sites, except Katana, where there is possible resistance (90-98% mortality). Resistance intensity was low in Katana, Inongo, and Kapolowe; moderate (<98% mortality at ×5 dose) in Karawa, Kimpese, Mikalayi, and Pawa; and high (< 98% mortality at ×10 dose) in Kingasani, Lodja, and Kalemie (Figure 3).

Resistance to deltamethrin was recorded in all sites, except Lodja and Inongo. In Katana, there was possible resistance. The intensity of resistance was low in Kapolowe and Kabondo, moderate in Mikalayi, and high in Kingasani, Karawa, Kimpese, Kalemie, and Pawa (Figure 4).

Resistance to alpha-cypermethrin was also observed in all sites. The intensity was low in Kalemie and Kapolowe, high in Katana, Mikalayi, and Lodja, and moderate in the remaining five sites (Figure 5). There was susceptibility to pirimiphos-methyl in seven sites; possible resistance in Kapolowe, Kabondo, and Mikalayi; and resistance in Lodja (Figure 6). However, there have been issues with reliability of pirimiphos-methyl papers as reported in other countries, so these tests require repetition. Susceptibility tests in Kimpese and Kapolowe with *An. funestus* s.l. showed resistance to all tested pyrethroids except deltamethrin 0.05% in Kapolowe (Figure 7).

FIGURE 3: MORTALITY OF *AN. GAMBIAE* S.L. AFTER EXPOSURE TO PERMETHRIN AT ×1, ×5, AND ×10 TIMES THE DIAGNOSTIC CONCENTRATION,* DRC 2018



* In Karawa, 0% mortality was recorded with permethrin 1X.

FIGURE 4: MORTALITY OF *AN. GAMBIAE* S.L. AFTER EXPOSURE TO DELTAMETHRIN AT ×1, ×5, AND ×10 TIMES THE DIAGNOSTIC CONCENTRATION, DRC 2018

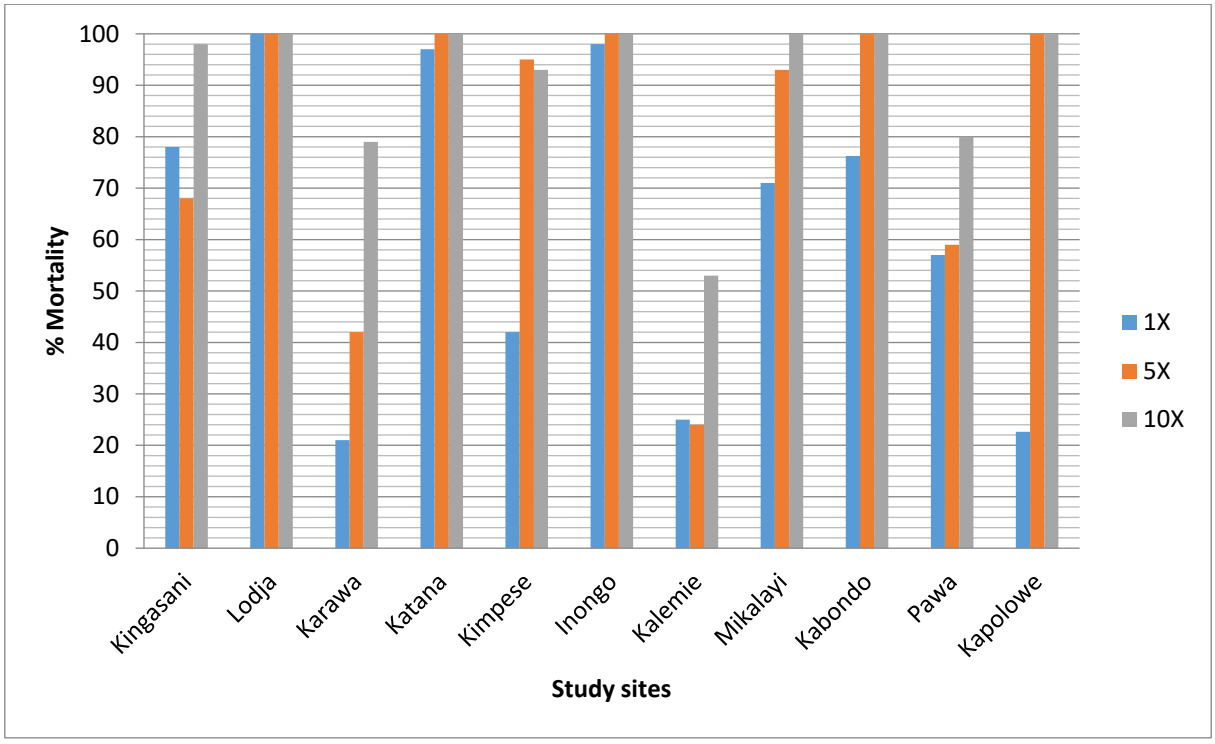
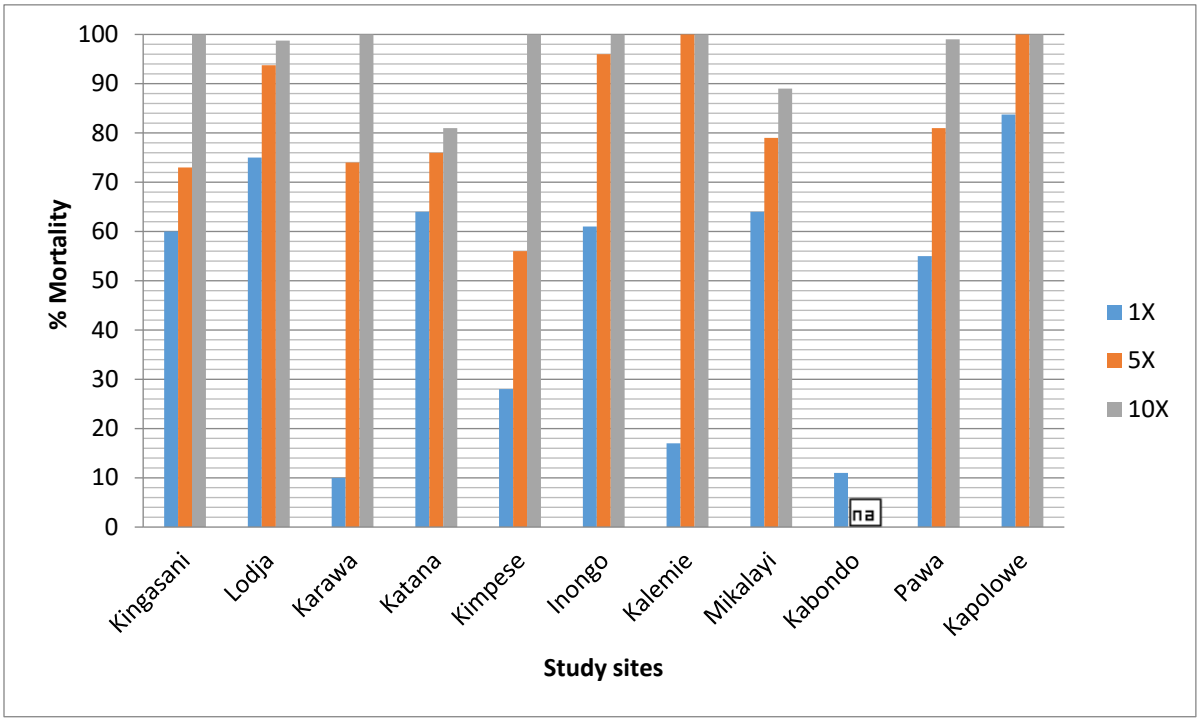


FIGURE 5: MORTALITY OF *AN. GAMBIAE* S.L. AFTER EXPOSURE TO ALPHA-CYPERMETHRIN AT ×1, ×5, AND ×10 TIMES THE DIAGNOSTIC CONCENTRATION*, DRC 2018



**In Kabondo, alpha-cypermethrin 0.25% and 0.5% were not tested.*

FIGURE 6: MORTALITY OF *AN. GAMBIAE* S.L. AFTER EXPOSURE TO PIRIMIPHOS METHYL, DRC 2018

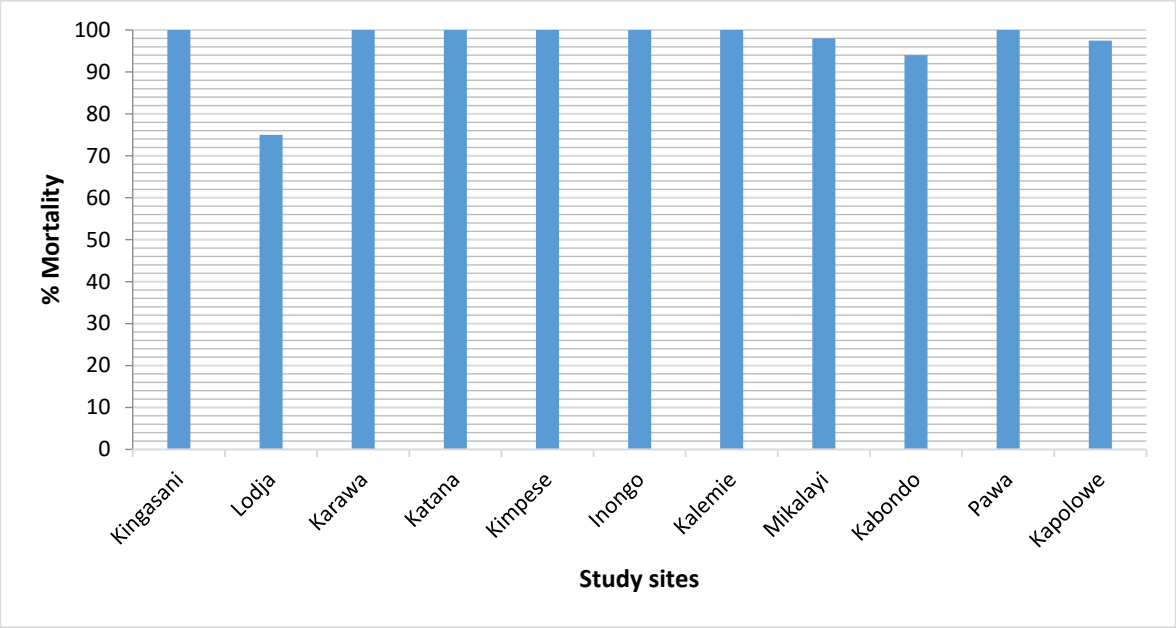
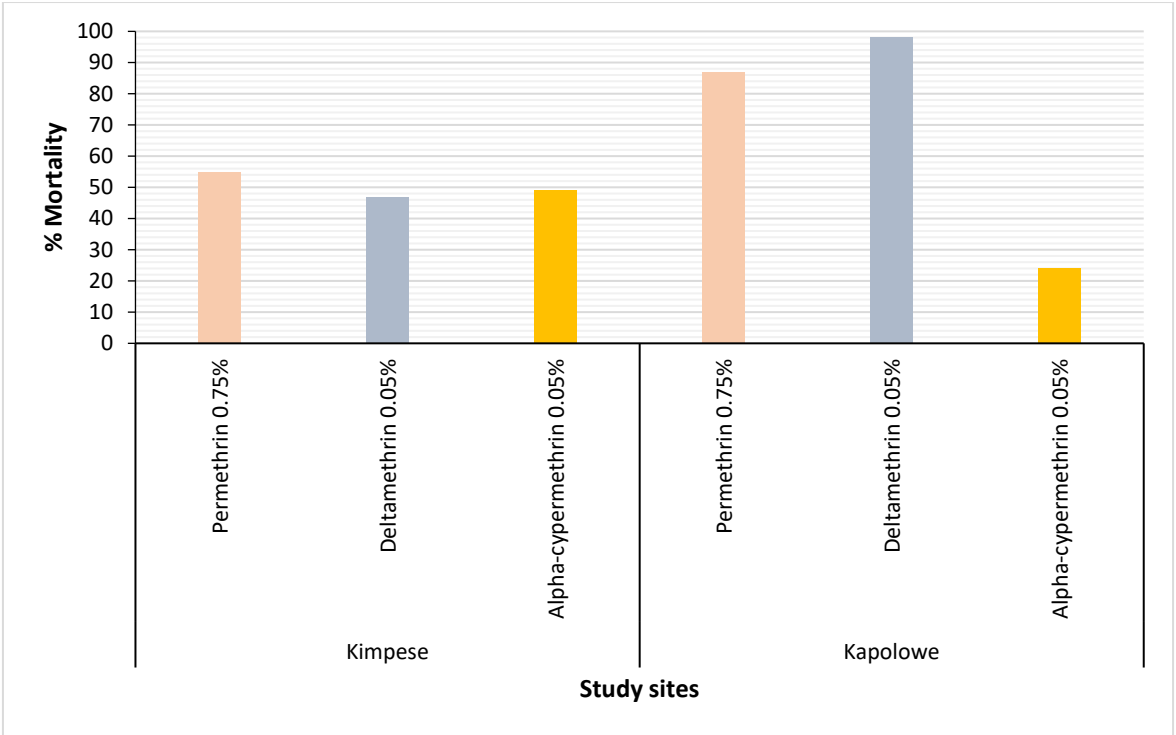
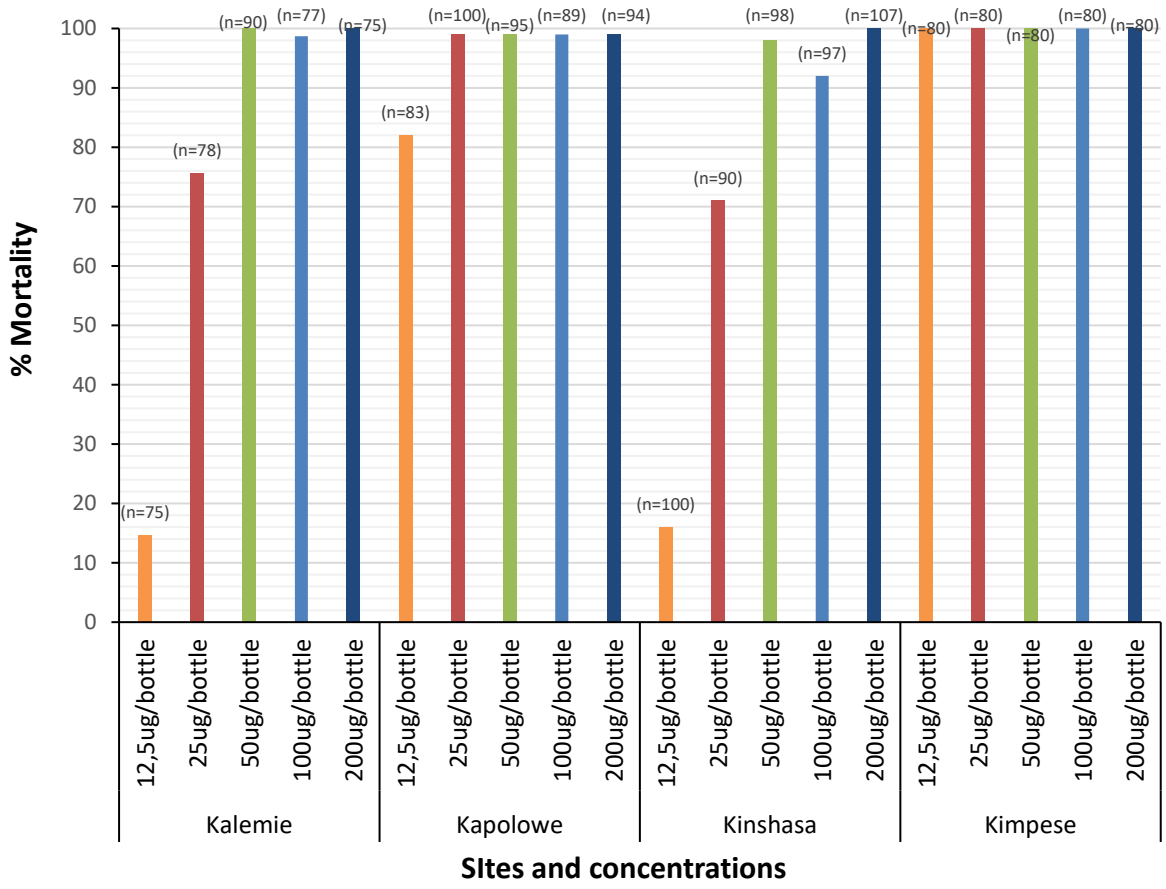


FIGURE 7: MORTALITY OF *AN. FUNESTUS* S.L. AFTER EXPOSURE TO PERMETHRIN, DELTAMETHRIN, AND ALPHA-CYPERMETHRIN IN KIMPESE AND KAPOLOWE, 2018



Five concentrations of chlorfenapyr were tested in four sites to help determine a suitable diagnostic concentration and to test for susceptibility (Figure 8). The lower concentration of 12.5µg provided <90% mortality after 72 hours in three of the four sites. The 25µg/bottle dose also produced <90% mortality in two sites (annex Table A1-A4). PMI VectorLink has since recommended use of 100µg/bottle as the diagnostic dose for chlorfenapyr (until WHO release further guidance), and additional tests should be conducted with 200µg/bottle if any suspected resistance is detected. Based on the 100µg/bottle dose, susceptibility was recorded in Kalemie, Kapolowe, and Kimpese, but possible resistance was detected in Kinshasa. However, tests with the 200µg/bottle produced 100% mortality at the same sites. These results indicate that Interceptor G2 LLINs (chlorfenapyr plus alpha-cypermethrin) should be effective against wild *An. gambiae* s.l. in the sites tested.

FIGURE 8: 72H MORTALITY RATES INDUCED BY CHLORFENAPYR 12.5, 25, 50,100, AND 200 µG/ML IN BOTTLE BIOASSAYS AGAINST WILD *AN. GAMBIAE* S.L. IN FOUR SITES, 2018



4. *ANOPHELES* SPECIES COMPOSITION AND ABUNDANCE RESULTS

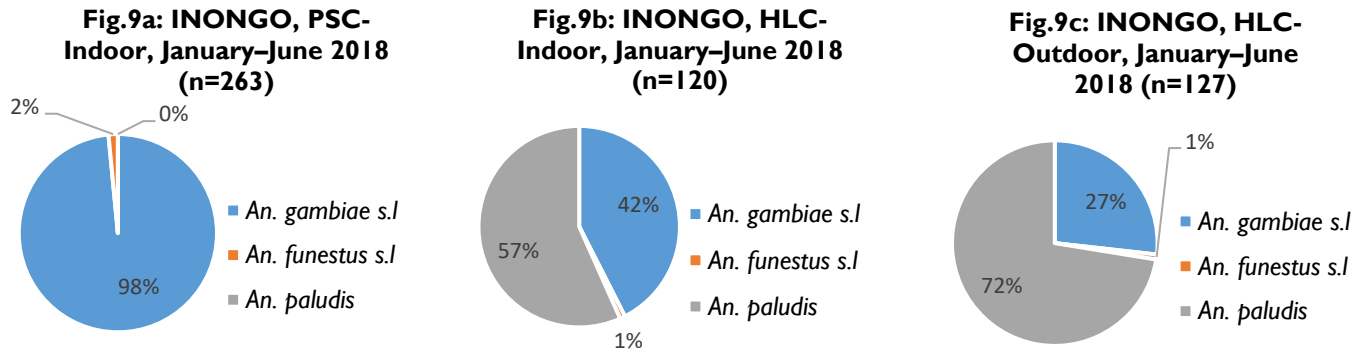
4.1. Vector Species Composition in Sites with Triannual Collection

Species composition found at the four sites in which collection was conducted three times in 2018 is described below. The total numbers of mosquitoes collected in each site from HLCs and PSCs are annexed in the tables A.5-8.

4.1.1. Mai-Ndombe Province, Inongo Site (January–June 2018)

Three species, *An. gambiae* s.l., *An. funestus* s.l., and *An. paludis,* were collected in Inongo (Figure 9). Overall, *An. gambiae* s.l. were most abundant, followed by *An. paludis*. Twenty-five percent (85/344) of *An. gambiae* s.l. were captured by HLC and 75% (259/344) by PSC (See Annex Table A.5). The mean number of *An. gambiae* s.l. per trap-night was greater by PSC, at 8.6 (259/30) per trap-night, than by HLC indoors, with 2.1 (51/24) per trap-night. The collections were done in Maman Yaka (S01°55'140" and E018°17'042"), which is in a different health zone than the site for 2017 collections. The village used for trapping is in a gallery forest and, according to personal observation of INRB staff, use of LLINs is not common. Therefore, *An. gambiae* s.l. may rest longer indoors than at other sites due to a lack of insecticide-induced repellency.

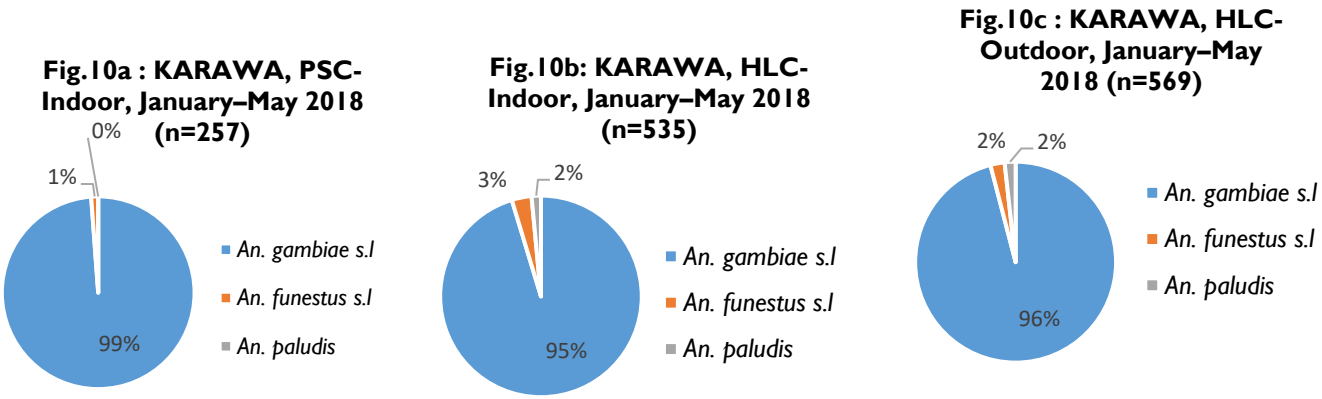
FIGURE 9: SPECIES COMPOSITION OF *ANOPHELES* CAPTURED BY PSC AND HLC IN INONGO



4.1.2. Nord Ubangi Province, Karawa Site (January–May 2018)

Figure 10 summarize the species composition captured across the two methods of collection. Further details are annexed in Table A6. In Karawa 81% (1,104/1,361) of *Anopheles* species were captured by HLC and 19% (257/1,361) by PSC. *An. gambiae* s.l. was the most abundant species (95%; 596/1,310). The collections were done in City Mbaya (S03°20'067" and E020°18'824"), which is in a different health zone than the site for 2017 collections. At this site, community members make fish ponds, which serve as larval sites for mosquitoes.

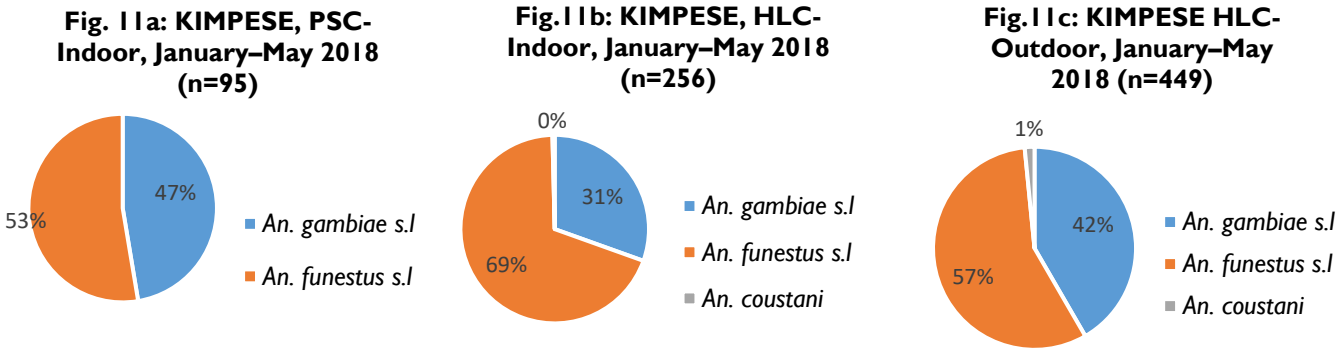
FIGURE 10: SPECIES COMPOSITION OF *ANOPHELES* CAPTURED BY PSC AND HLC IN KARAWA, 2018



4.1.3. Kongo Central Province, Kimpese Site (January–May 2018)

Figure 11 summarize the species found during the reporting period. Details by collection method are in the annexed in Table A7. These show that 88% (705/800) of *Anopheles* species were captured by HLC and 12% (95/800) by PSC. Overall, *An. funestus* s.l. were the most abundant species (60%; 482/800). The same observations were made in 2017, when *An. funestus* s.l. was the predominant species throughout the year. However, in 2018 *An. gambiae* s.l. were more abundant (66%; 160/241) in the rainy season (January to April), and *An. funestus* s.l. (72%; 401/559) in the dry season (May to June). 2017 collections were done in the grounds of the National Episcopal Conference of Congo, which were atypical of the wider Kimpese area and characterized by a small gallery forest alongside a river. 2018 collections were conducted in the village of Yanga-Diasonga: S 05°34'4.95", E 014°25'7.10". This is a more typical suburban area with no forest and more-abundant *An. gambiae* s.l. larval sites in the rainy seasons.

FIGURE 11: DISTRIBUTION OF *ANOPHELES* CAPTURED BY PSC AND HLC INDOORS AND OUTDOORS IN KIMPESE

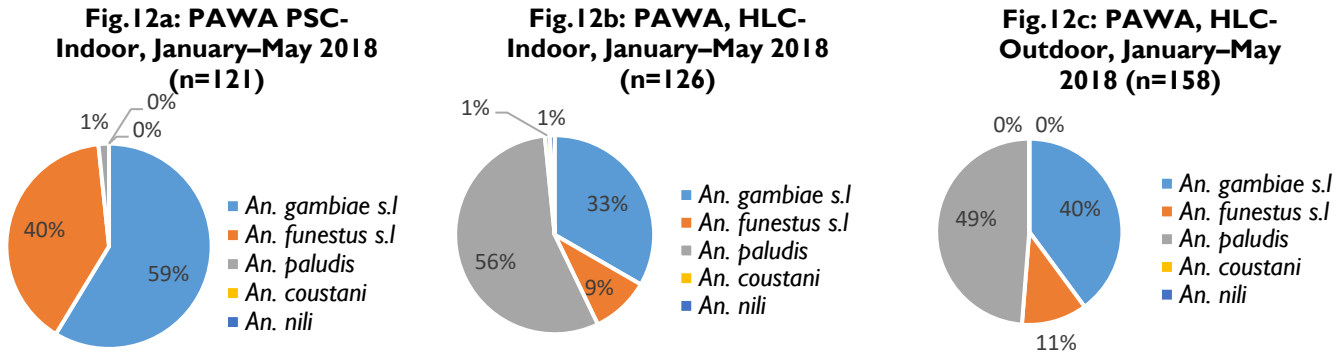


4.1.4. Haut-Uele Province, Pawa Site (January–May 2018)

Figure 12 summarize the species found during the collection period. Details on species broken down by collection method is annexed in Table A8. In Pawa, 70% (284/405) of *Anopheles* species were captured by HLC and 30% (121/405) by PSC. *An. gambiae* s.l. were the most abundant (43%; 176/405), followed by *An.*

paludis (37%; 149/405). In 2017, *An. gambiae* s.l. was more dominant, comprising 83–92% of *Anopheles* captured by PSC and HLC.

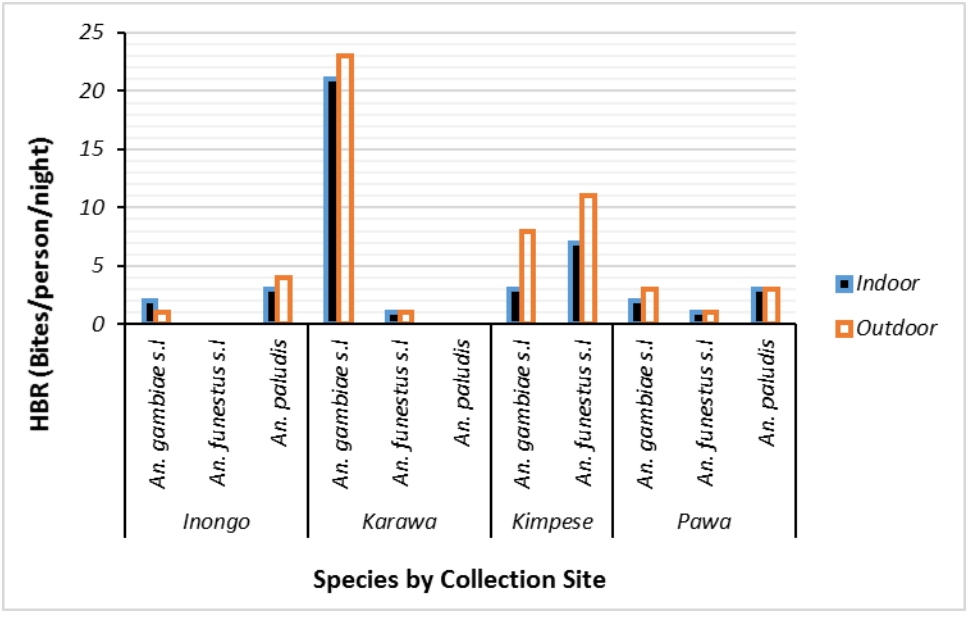
FIGURE 12: DISTRIBUTION OF *ANOPHELES* CAPTURED BY PSC AND HLC INDOORS AND OUTDOORS IN PAWA



4.2. HBR of Malaria Vectors Indoors and Outdoors Collected by HLC

Figure 13 shows the overall mean biting rate per person per night for Inongo, Karawa, Kimpese, and Pawa. The details of HBR per time period are presented in the Annex, Tables A9–A14. The highest biting rate was in Karawa, where *An. gambiae* s.l. was the predominant species, with 21 bites per person per night indoors and 23 outdoors. In general, the *An. gambiae* s.l. biting rates were low in Inongo and moderate in Kimpese and Pawa. In Kimpese the biting rate appeared to be higher outdoors than indoors. *An. funestus* s.l. were collected in all four sites, with a moderate biting rate of 7 and 11 bites per person per night respectively indoors and outdoors in Kimpese, and low biting rates in the other three sites.

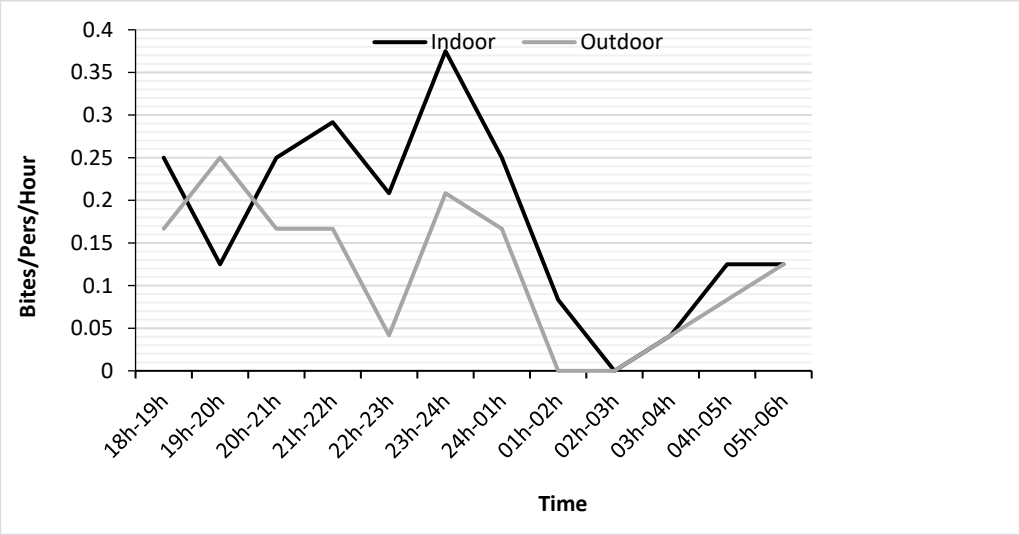
FIGURE 13: HBRS OF MALARIA VECTORS INDOORS AND OUTDOORS IN INONGO, KARAWA, KIMPESE, AND PAWA SITES (JANUARY–JUNE 2018)



4.3. Biting Times of Malaria Vectors Indoors and Outdoors

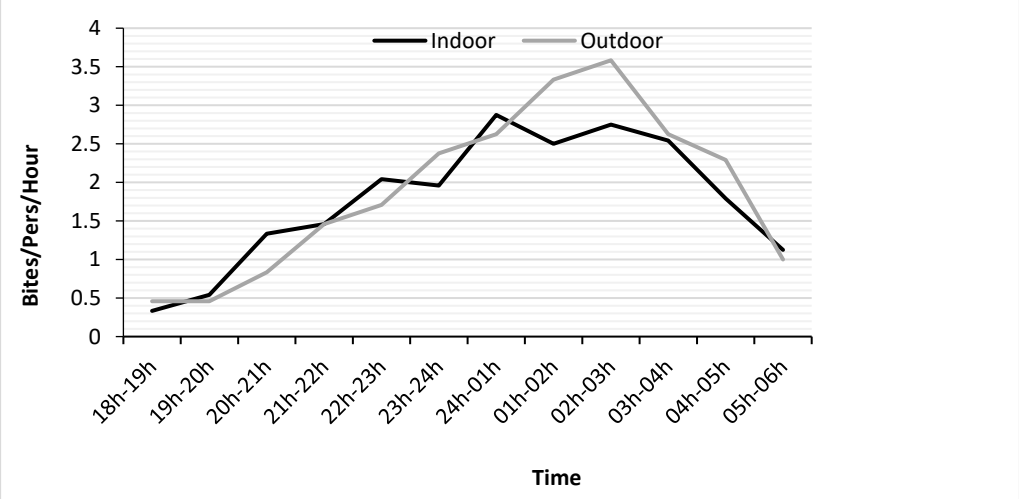
Biting trends are presented only for locations where the total number caught per species by HLC was >50 between January and June 2018. In general, indoor biting by *An. gambiae* s.l. and *An. funestus* s.l. was primarily late at night, between 10 p.m. and 5 a.m., and was similar to outdoor biting trends (Figures 14-18). In Kimpese and Pawa, there was some biting occurring between 4 a.m. and 6 a.m.; thus, longer monitoring may be useful to determine whether morning biting occurs.

FIGURE 14: MEAN BITING ACTIVITY OF *AN. GAMBIAE* S.L. AT INONGO SITE (JANUARY–JUNE 2018) N=51 INDOORS, N=34 OUTDOORS*



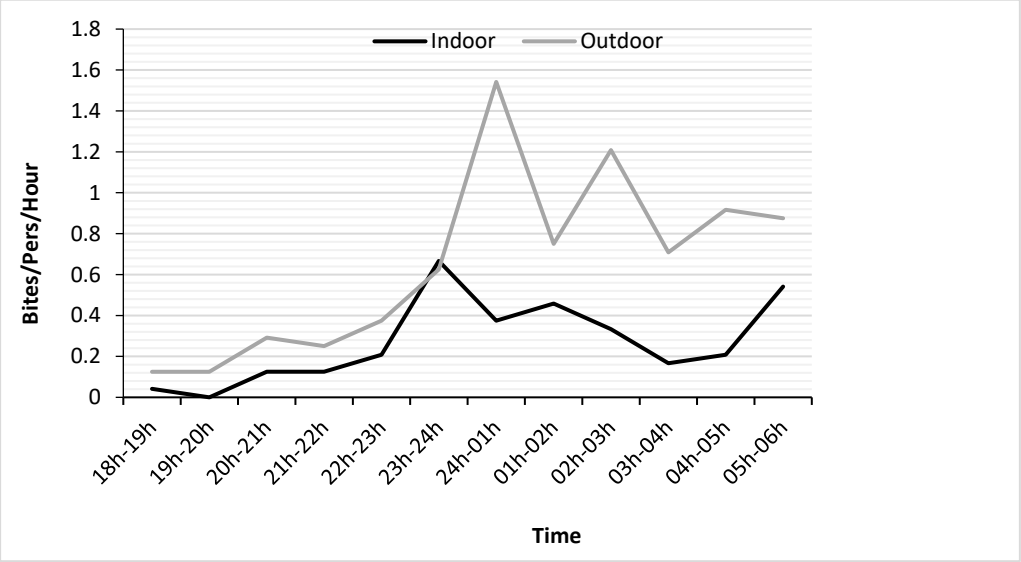
*n refers to total *An. gambiae* s.l. collected over the trapping period.

FIGURE 15: MEAN BITING ACTIVITY OF *AN. GAMBIAE* S.L. AT KARAWA SITE (JANUARY–MAY 2018), N=510 INDOORS, N=546 OUTDOORS*



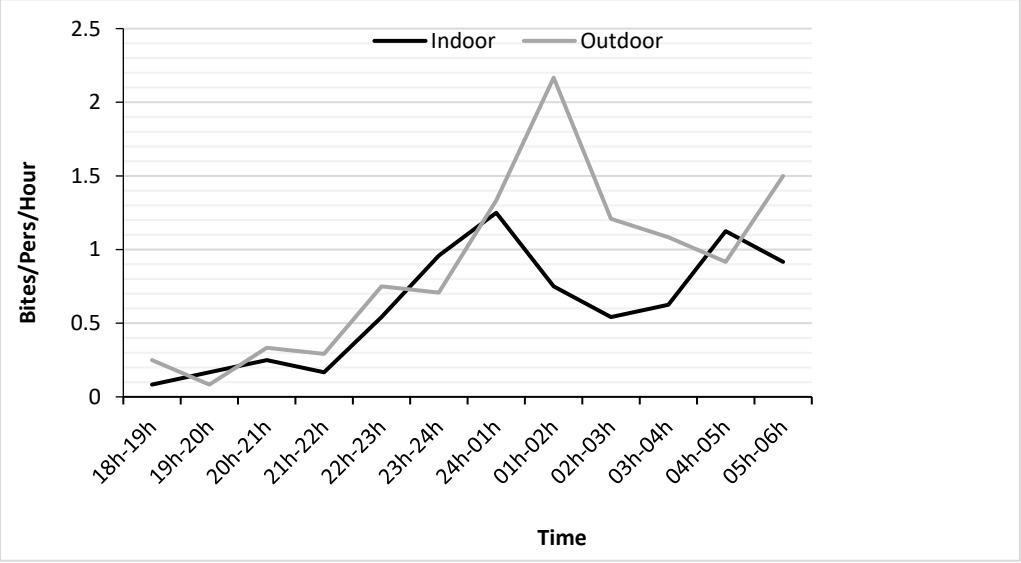
*n refers to total *An. gambiae* s.l. collected over the trapping period.

FIGURE 16: MEAN BITING ACTIVITY OF *AN. GAMBIAE* S.L. AT KIMPESE SITE (JANUARY–MAY 2018), N=78 INDOORS, N=187 OUTDOORS*



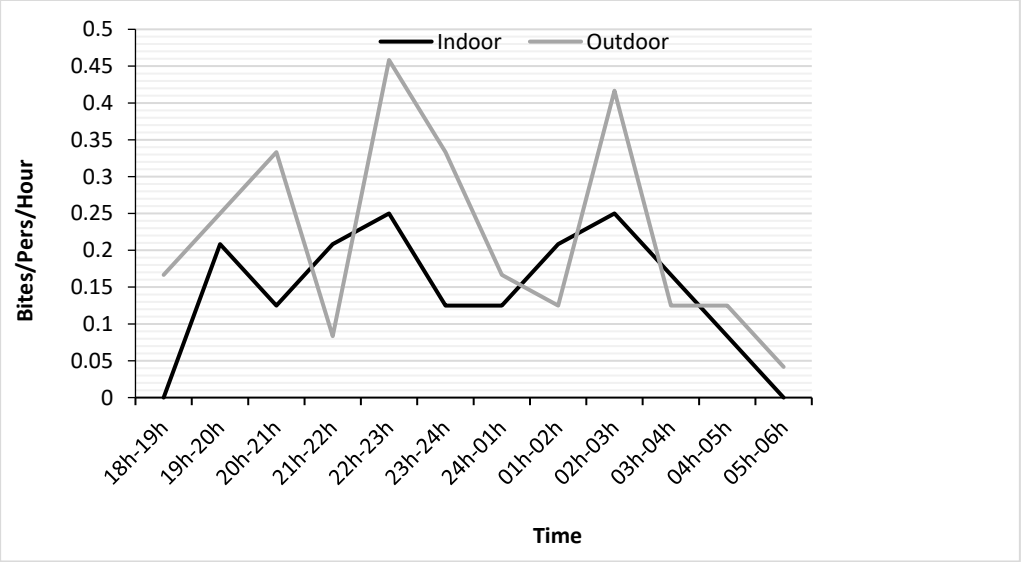
*n refers to total *An. gambiae* s.l. collected over the trapping period.

FIGURE 17: MEAN BITING ACTIVITY OF *AN. FUNESTUS* AT KIMPESE SITE (JANUARY–MAY 2018), N=177 INDOORS, N=255 OUTDOORS*



*n refers to total *An. gambiae* s.l. collected over the trapping period.

FIGURE 18: MEAN BITING ACTIVITY OF *AN. GAMBIAE* S.L. AT PAWA SITE (JANUARY–MAY 2018), N=42 INDOORS, N=63 OUTDOORS*



*n refers to total *An. gambiae* s.l. collected over the trapping period.

4.4. Abdominal Status of Malaria Vectors Collected Using PSC

The abdominal status of malaria vectors collected indoors by PSC between January and June 2018 is presented in Table 3. In all sites, the majority of *An. gambiae* s.l. and *An. funestus* s.l. collected by PSC were blood-fed (70%, 516/736), with <25% being either half-gravid or gravid.

TABLE 3: ABDOMINAL STATUS OF MALARIA VECTORS COLLECTED RESTING INDOORS THROUGH PSC, INONGO, KARAWA, KIMPESE, AND PAWA (JANUARY–JUNE 2018)

Abdominal Status					
Method	**PSC**				
Sentinel site and species	**Unfed**	**Blood-fed**	**Half-gravid**	**Gravid**	**Total**
Inongo					
***An. gambiae* s.l.**	30 (12%)	177 (68%)	19 (7%)	33 (13%)	259 (100%)
***An. funestus* s.l.**	1 (25%)	2 (50%)	1 (25%)	0 (0%)	4 (100%)
Total Inongo	**31 (12%)**	**179 (68%)**	**20 (8%)**	**33 (13%)**	**263 (100%)**
Karawa					
***An. gambiae* s.l.**	43 (17%)	169 (67%)	40 (16%)	2 (1%)	254 (100%)
***An. funestus* s.l.**	1 (33%)	1 (33%)	0 (0%)	1 (33%)	3 (100%)
Total Karawa	**44 (17%)**	**170 (66%)**	**40 (16%)**	**3 (1%)**	**257 (100%)**
Kimpese					
***An. gambiae* s.l.**	2 (4%)	43 (96%)	0 (0%)	0 (0%)	45 (100%)
***An. funestus* s.l.**	9 (18%)	41 (82%)	0 (0%)	0 (0%)	50 (100%)
Total Kimpese	**11 (12%)**	**84 (88%)**	**0 (0%)**	**0 (0%)**	**95 (100%)**
Pawa					
***An. gambiae* s.l.**	18 (25%)	52 (73%)	1 (1%)	0 (0%)	71 (100%)
***An. funestus* s.l.**	15 (31%)	31 (65%)	0 (0%)	2 (4%)	48 (100%)

An. paludis	2 (100%)	0 (0%)	0 (0%)	0 (0%)	2 (100%)
Total Pawa	**35 (29%)**	**83 (69%)**	**1 (1%)**	**2 (2%)**	**121 (100%)**

4.5. Monthly Monitoring of Malaria Vectors in Kalemie and Kabondo (January–December 2018)

Species composition and abdominal status of mosquitoes found at the two sites where collections were conducted monthly in 2018 is described below.

4.5.1. Vector Species Composition and Abdominal Status

The main malaria vectors *An. gambiae* s.l. and *An. funestus* s.l. were sampled each month in both sites (Figure 19 and 20). In Kabondo the abundance of *Anopheles* species was greater (88%:4,097/4,631) with HLC than with PSC (12%:534/4,631). In Kalemie, more *Anopheles* were sampled by PSC, at 63% (902/1,442), than by HLC at 37% (540/1,442). *An. gambiae* s.l. were abundant (>80%) in both sites (Table A16 and A17 in annex).

The abdominal status of malaria vectors collected indoors by PSC between January and June 2018 is presented in annex Table A18 & 19. The majority of mosquitos collected across both sites were fed.

FIGURE 19: SPECIES COMPOSITION OF *ANOPHELES* CAPTURED BY PSC AND HLC IN KABONDO, JANUARY TO DECEMBER 2018

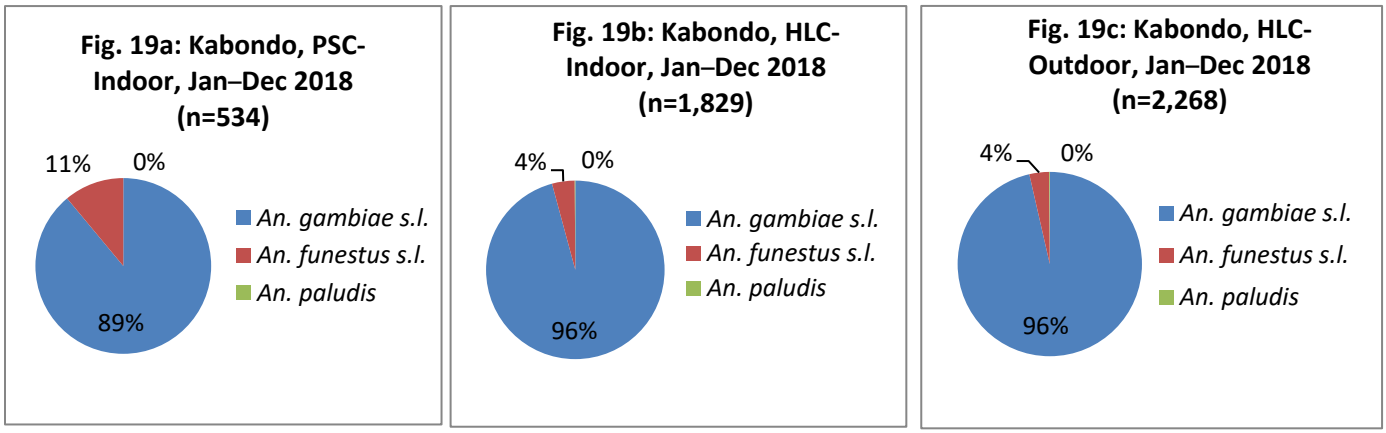
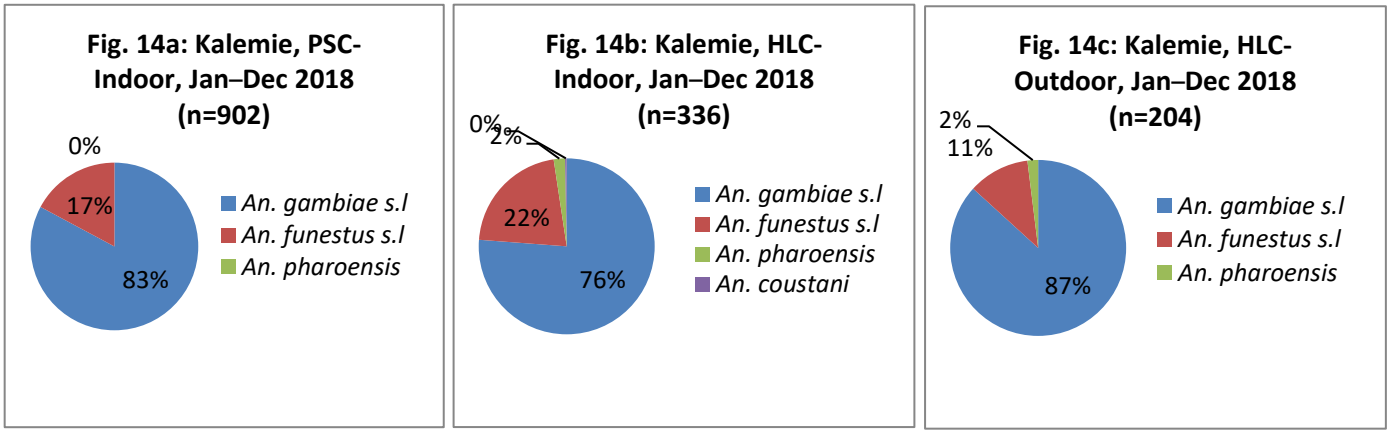


FIGURE 20: SPECIES COMPOSITION OF *ANOPHELES* CAPTURED BY PSC AND HLC IN KALEMIE, JANUARY TO DECEMBER 2018



4.5.2. HBR and Biting Times of Malaria Vectors Collected Indoors and Outdoors by HLC

Figures 21 – 24 show the biting rate per person per night in Kabondo and Kalemie, by species (further details annexed in Table A14 and 15. *An. gambiae* s.l. biting rates were particularly high in Kabondo, with a mean of 18 and 23 bites per person per night respectively indoors and outdoors. *An. gambiae* s.l. biting rates in Kabondo were >10 bites per person per night for 11 months of the year, with the peak recorded in August. *An. funestus* s.l. was also present, albeit at very low densities year-round in Kabondo. In Kalemie, the biting rates were generally much lower than in Kabondo, with a mean *An. gambiae* s.l. biting rate of three indoor and two outdoor per person per night.

FIGURE 21: MEAN HBRS OF *AN. GAMBIAE* S.L. INDOORS AND OUTDOORS IN KABONDO (JANUARY–DECEMBER 2018)

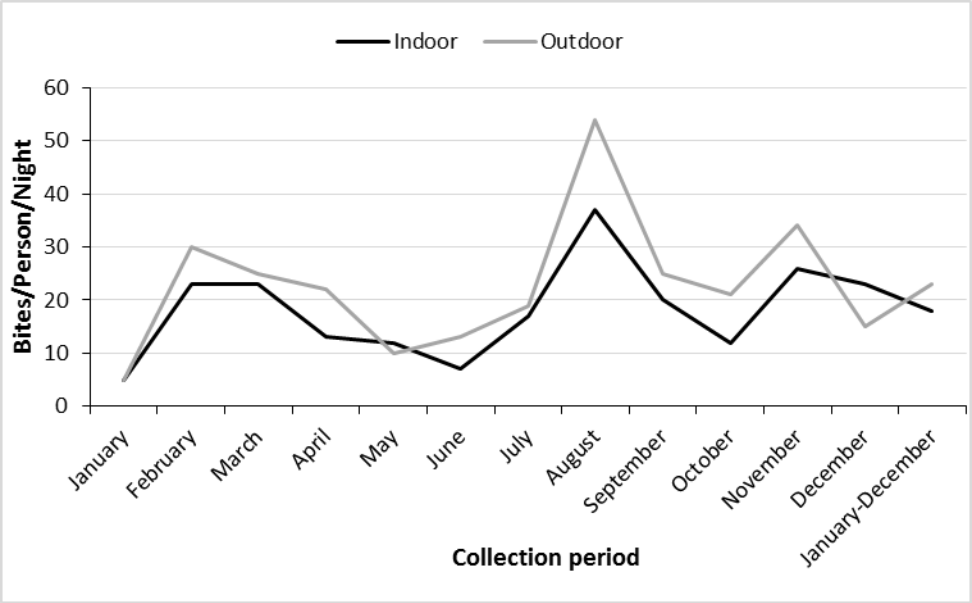


FIGURE 22: MEAN HBRS OF *AN. FUNESTUS* S.L. INDOORS AND OUTDOORS IN KABONDO (JANUARY–DECEMBER 2018)

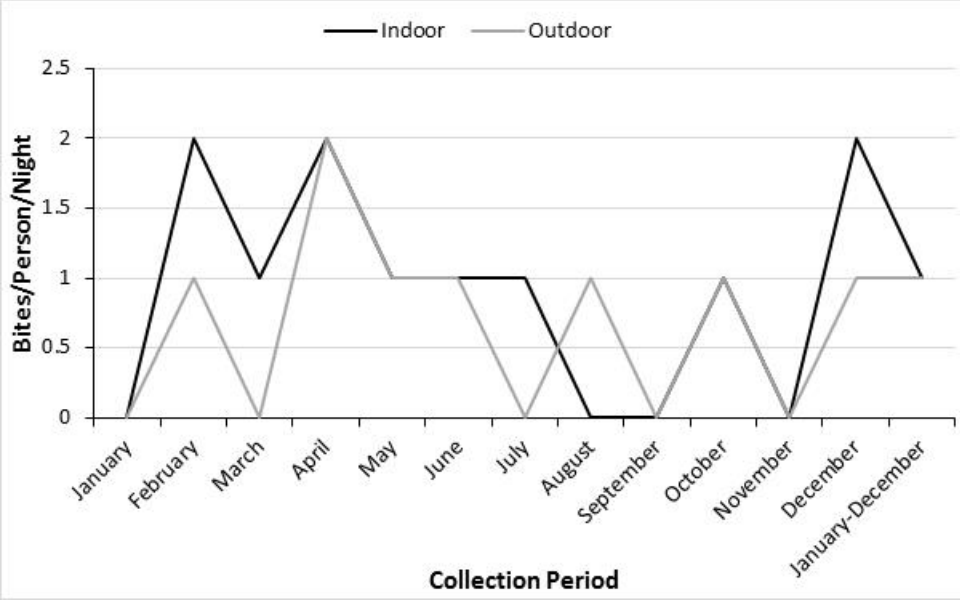


FIGURE 23: MEAN HBRS OF *AN. GAMBIAE* S.L. INDOORS AND OUTDOORS IN KALEMIE (JANUARY–DECEMBER 2018)

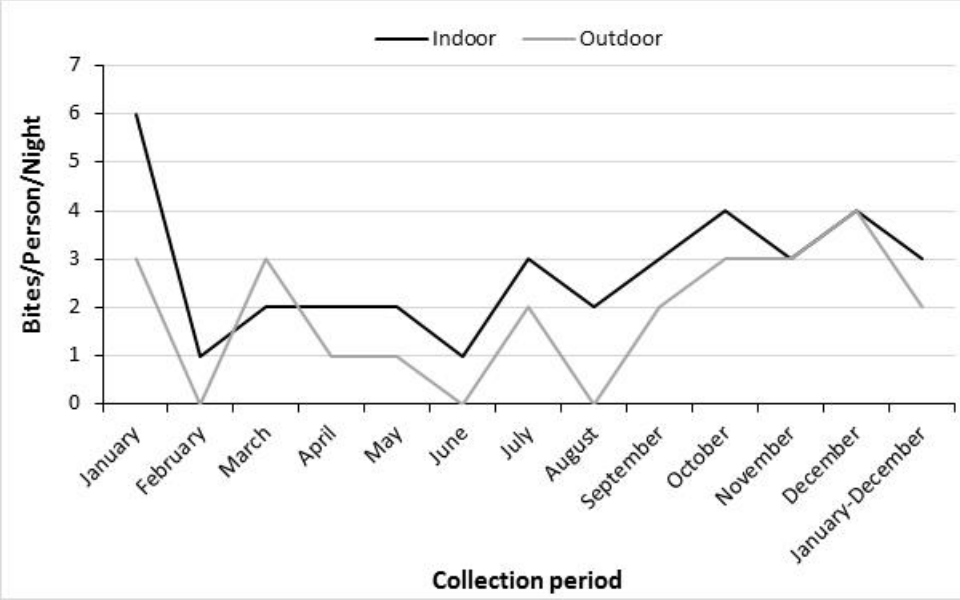
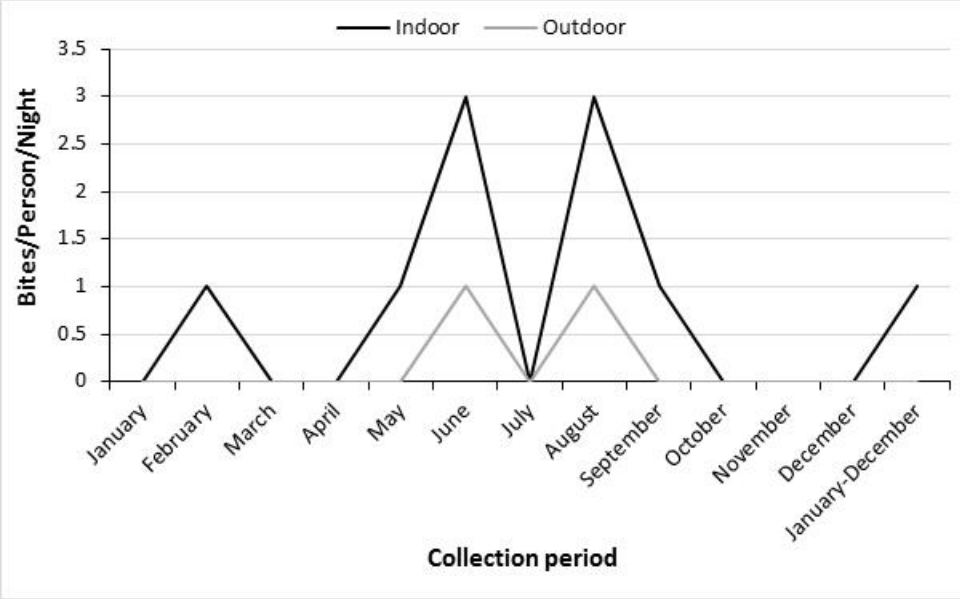


FIGURE 24: MEAN HBRS OF *AN. FUNESTUS* S.L. INDOORS AND OUTDOORS IN KALEMIE (JANUARY–DECEMBER 2018)



In general, indoor biting by *An. gambiae* s.l. was primarily late at night, between 10 p.m. and 5 a.m., and mirrored outdoor biting trends in both sites (Figure 24 and 25). Biting activity was low in Kalemie, so further investigation is needed to explain the high burden of malaria found here.

FIGURE 25: BITING ACTIVITY OF *AN. GAMBIAE* S.L. AT KABONDO (JANUARY–DECEMBER 2018), N=1,752 INDOORS, N=2,187 OUTDOORS

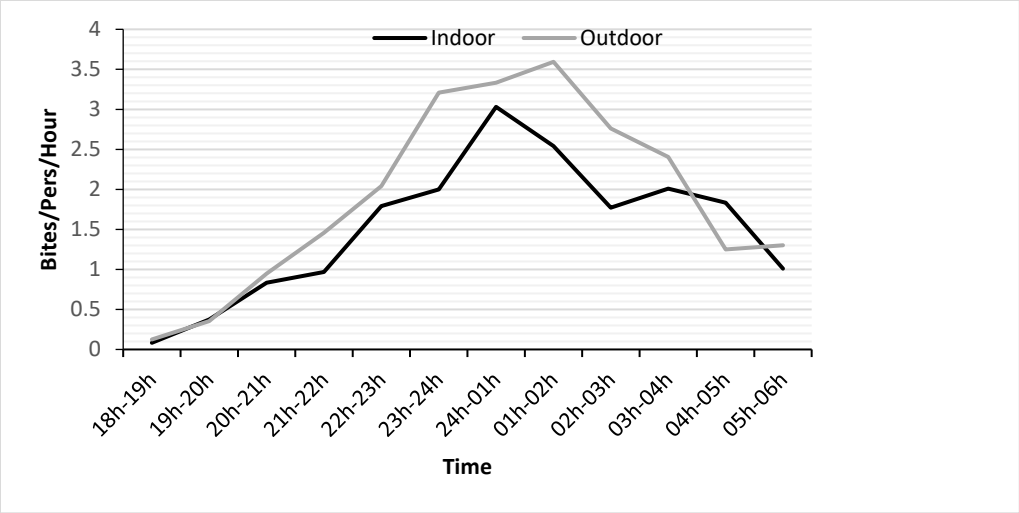
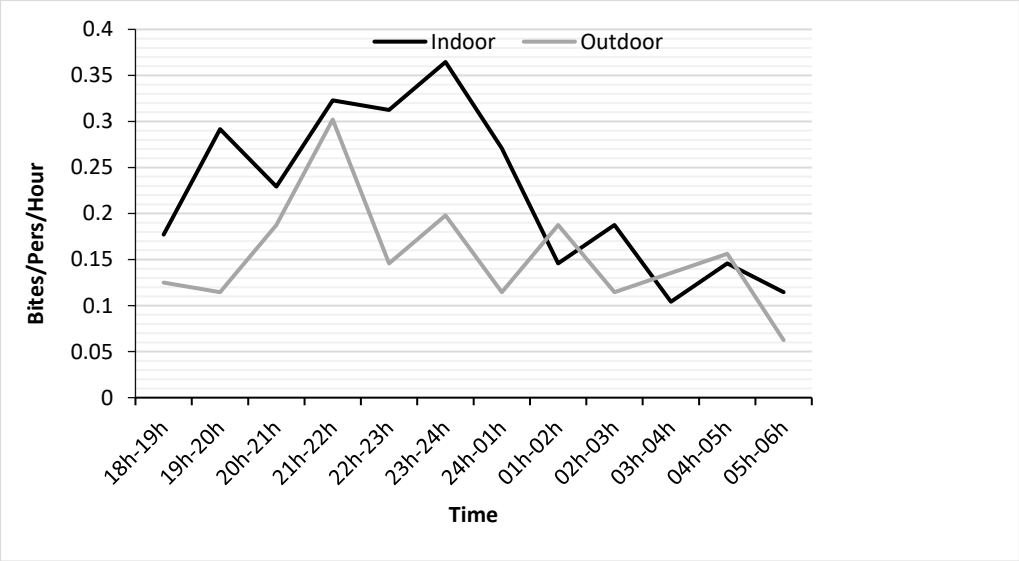


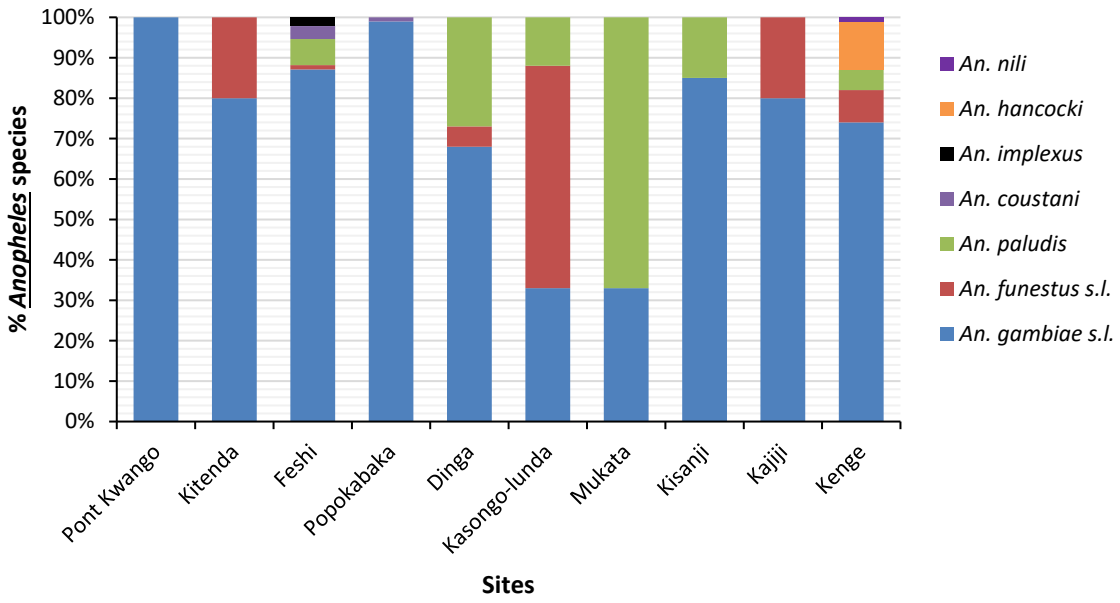
FIGURE 26: BITING ACTIVITY OF *AN. GAMBIAE* S.L. AT KALEMIE (JANUARY–DECEMBER 2018), N=256 INDOORS, N=177 OUTDOORS



4.6 Vector Mapping in Kwango Province

The species composition per site is summarized in Figure 25. *An. gambiae* s.l. was the predominant species in 8 of the 10 sites. *An. funestus* s.l. was captured in 7 of the 10 sites and was the predominant species in Kasongo-Lunda. As for other *Anopheles* species, *An. paludis* was captured in 6 of the 10 sites and was the predominant species in Mukata; *An. hancocki* and *An. nili* were caught only in Kenge. The greatest diversity of *Anopheles* species was found in Kenge. *Anopheles* collected with PSC were mostly blood-fed.

FIGURE 27: OVERALL *ANOPHELES* SPECIES COMPOSITION IN THE DRY SEASON



4.7 Collection of *Anopheles coustani* Group Mosquitoes

Ten nights of HLC in Kapolowe in August resulted in the collection of 602 *Anopheles*; of which 8 were morphologically identified as *An. caliginosus* and 6 as *An. coustani*. Of the remaining samples, 30 were *An. gambiae* s.l. and 558 were *An. funestus* s.l. In Lodja, two nights of HLC in June 2018 resulted in the collection of 138 mosquitoes (*An. paludis/coustani*), which were pinned for further analysis and taken to CDC in Atlanta. Sequencing of samples, collected in Lodja, at the University of Notre Dame did not reveal a match with known species for the ITS-2 sequence (the closest match was *An. yatsushiroensis*), and the closest related species using the CO-1 sequence was *An. coustani* or *An. hyrcanus*. Therefore, these specimens may constitute new species of the *An. coustani* group. The remaining specimens from Kapolowe will also be sent for ITS-2 and CO-1 sequencing. We plan to subsequently send voucher specimens to the Smithsonian Institution in Washington, D.C., for reference archiving.

5. LABORATORY ANALYSES RESULTS

The number of *An. gambiae* s.l. and *An. funestus* s.l. analyzed for presence of sporozoites from each site is shown in Table 4. In some cases, the numbers of mosquitos analyzed were less than indicated in the work plan. This is due to an insufficient number of specimens for those tests from HLC collection samples.

TABLE 4: NUMBER OF *AN. GAMBIAE* S.L. AND *AN. FUNESTUS* S.L. SAMPLES COLLECTED BY HLC IN 2018 TESTED FOR PRESENCE OF SPOROZOITES BY ELISA

Sentinel Site	Total *An. gambiae* s.l. Collected by HLC in 2018	Total *An. gambiae* s.l. Tested by Sporozoite ELISA (tested/planned)	Total *An. funestus* s.l. Collected by HLC in 2018	Total *An. funestus* s.l. Tested by Sporozoite ELISA (tested)
Kabondo	3,939	2,216/2,400 (200 per month)	153	152
Kalemie	433	433/2,400 (all collected)	95	95
Kimpese	265	0/0	432	25
Pawa	105	0/0	30	25
Karawa	1,056	0/0	30	25
Inongo	344	0/0	6	N/A*
Kwango	508	276/500 (all collected)	39	37
Total	6,735	2,925	779	359

*Not enough *An. funestus* s.l. captured in Inongo for testing.

The monthly *An. gambiae* s.l. sporozoite rate for Kabondo from HLCs is presented in Figure 26. In Kabondo the mean *An. gambiae* s.l. infection rate was 2.21% (95% confidence interval; 0.8-3.7) over 12 months. In Kalemie far fewer *An. gambiae* s.l. were collected and none (0/433) tested positive for sporozoites. In 2018, the mean *An. funestus* s.l. sporozoite rate was 1.97% (95% confidence interval; 0.1-4.2) in Kabondo and 2.11% (95% confidence interval; 0.1-5.0) in Kalemie (Table 5). No *An. funestus* s.l. were sporozoite positive in 2018 from Kimpese, Pawa, and Karawa (only 25 mosquitoes tested per site). The sporozoite rates of *Anopheles* species collected by HLC and PSC from 10 sites in Kwango are summarized in Table 6. Among the species tested, only *An. gambiae* s.l. and *An. funestus* s.l. were found to be sporozoite positive.

FIGURE 28: MONTHLY *P. FALCIPARUM* SPOROZOITE RATES OF *AN. GAMBIAE* S.L. COLLECTED BY HLC IN KABONDO, 2018

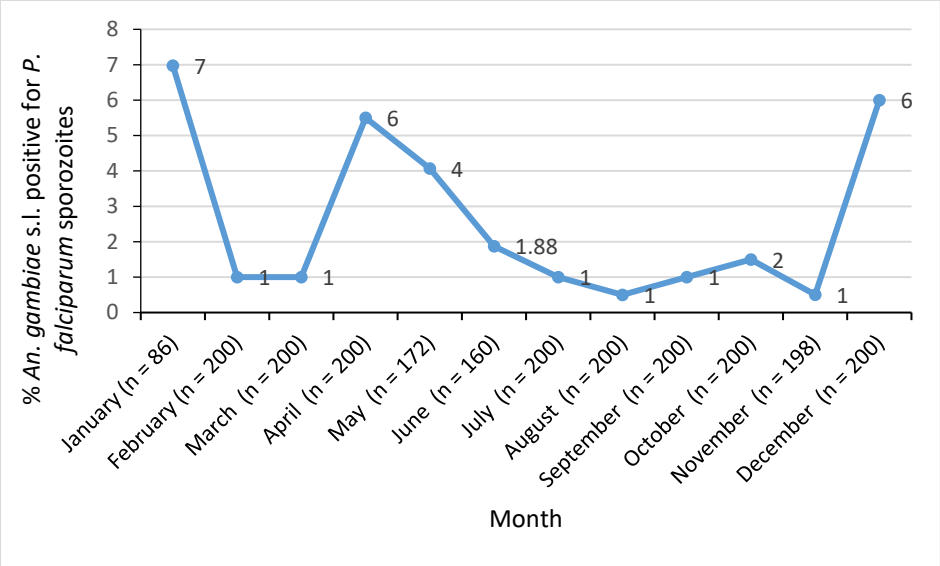


TABLE 5: MONTHLY *P. FALCIPARUM* SPOROZOITE RATES OF *AN. FUNESTUS* S.L. COLLECTED BY HLC FROM FIVE SITES, DRC 2018

Site	Month	Number Tested	Number +	% Positive
Kabondo	January	3	1	**33**
	February	20	0	**0**
	March	9	0	**0**
	April	30	0	**0**
	May	17	0	**0**
	June	15	1	**7**
	July	8	0	**0**
	August	11	0	**0**
	September	0	0	**0**
	October	14	0	**0**
	November	4	0	**0**
	December	21	1	**5**
Kalemie	January	3	0	**0**
	February	11	0	**0**
	March	1	0	**0**
	April	0	0	**0**
	May	12	0	**0**
	June	31	0	**0**
	July	0	0	**0**
	August	27	1	**4**
	September	10	0	**0**
	October	0	0	**0**
	November	0	0	**0**

	December	0	0	**0**
Kimpese		25	0	**0**
Karawa		25	0	**0**
Pawa		25	0	**0**

TABLE 6: *P. FALCIPARUM* SPOROZOITE RATES OF *ANOPHELES* SPECIES COLLECTED BY HLC FROM 10 SITES IN KWANGO, 2018

Collection Method: HLC & PSC				
Site	**Species**	**Number Tested**	**Number +**	**% Positive**
Pont Kwango	*An. gambiae* s.l.	70	2	**2.86**
Kitenda	*An. gambiae* s.l.	81	2	**2.47**
	An. funestus s.l.	33	1	**3.03**
Feshi	*An. gambiae* s.l.	45	1	**2.22**
	An. coustani	3	0	**0**
	An. paludis	5	0	**0**
	An. implexus	2	0	**0**
Popokabaka	*An. gambiae* s.l.	71	5	**7.04**
	An. coustani	1	0	**0**
Dinga	*An. gambiae* s.l.	57	2	**3.51**
	An. paludis	26	0	**0**
	An. funestus s.l.	4	0	**0**
Kasongolunda	*An. gambiae* s.l.	22	1	**4.55**
	An. funestus s.l.	33	4	**12.12**
	An. paludis	8	0	**0**
Mukata	*An. gambiae* s.l.	2	0	**0**
	An. paludis	4	0	**0**
Kisanji	*An. gambiae* s.l.	41	0	**0**
	An. paludis	12	0	**0**
Kajiji	*An. gambiae* s.l.	12	1	**8.33**
	An. funestus s.l.	3	0	**0**
Kenge	*An. gambiae* s.l.	38	3	**7.89**
	An. funestus s.l.	5	0	**0**
	An. hancocki	9	0	**0**
	An. paludis	4	0	**0**
	An. nili	1	0	**0**

4.9 EIR for *An. gambiae* s.l.

The combined indoor and outdoor EIR for *An. gambiae* s.l. in Kabondo for 2018 is summarized in Table 7. The mean monthly EIR was 12.6 infectious bites per person in Kabondo, giving an annual EIR of 150 infectious bites per person per year. The mean monthly EIR was 16.2 indoor and 13.8 outdoor (Table A 21 – A 22). The peak transmission season in Kabondo was April and December, but there was a high monthly EIR year-round. As no sporozoite positive *An. gambiae* s.l. were detected from Kalemie, the EIR was zero. The combined indoor and outdoor EIR for *An. funestus* s.l. in Kabondo and Kalemie in 2018 is summarized in annex Table A20 for the few months when sporozoite positive samples were detected.

TABLE 7: MONTHLY *AN. GAMBIAE* S.L. EIR IN KABONDO, 2018

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2018 Total
Total *An. gambiae* s.l. (HLC) collected	86	428	383	281	172	160	292	728	366	258	482	303	3,939
HLC trap-nights (indoors + outdoors)	16	16	16	16	16	16	16	16	16	16	16	16	192
HBR per night	5	27	24	18	11	10	18	46	23	16	30	19	21 (mean)
Total *An. gambiae* s.l. tested by ELISA	86	200	200	200	172	160	200	200	200	200	198	200	2,216
Sporozoite Rate	0.07	0.01	0.01	0.06	0.04	0	0.01	0.01	0.01	0.02	0.01	0.06	0.02
EIR p/night	0.35	0.27	0.24	1.08	0.44	0	0.18	0.46	0.23	0.32	0.3	1.14	0.42 (mean)
EIR p/month*	10.5	8.1	7.2	32.4	13.2	0	5.4	13.8	6.9	9.6	9	34.2	12.6 (mean)

*****Nightly EIR is multiplied by number of nights in that month.

6. TRAINING

Two staff from the INRB and one from the NMCP participated from May 6 to 19, 2018 in a morphological identification training at Witwatersrand University, South Africa. The objective was to reinforce INRB capacity to use a mosquito identification key to identify major *Anopheles* mosquitoes in the DRC. The training also covered mosquito sampling methods, rearing and management of mosquitoes in the insectary, labeling and storage of mosquito samples, susceptibility tests, and WHO cone bio-efficacy testing.

Two field supervisors, NMCP staff from Kabondo and Kalemie, and one INRB staff member participated from July 2 to August 30, 2018 in a basic entomological course at CREC, in Benin, for capacity development.

A practical follow-up molecular training was conducted by the University of Notre Dame at the INRB from May 22 to June 1, 2018. Two INRB staff attended. Emphasis was placed on specific protocols for species identification, sporozoite ELISA, and troubleshooting using these methods.

PMI VectorLink Entomologist Dr. Rodrigue Fiacre Agossa worked closely with the INRB team throughout the year. He focused his efforts on local capacity building through developing a culture of following standard operating procedures for all activities, improving supervisors' skills in mosquito identification, improving productivity of the insectary, and troubleshooting collection of field data.

7. CONCLUSION

Overall, eight *Anopheles* species were collected from January to December 2018 in Inongo, Pawa, Karawa, Kimpese, Kabondo, Kalemie, and Kwango. The main malaria vectors, *An. gambiae* s.l. and *An. funestus* s.l., were collected in all sites, while *An. paludis* was present in Inongo, Karawa, Pawa, Kabondo, and Kwango. The composition of vector species is similar to that of 2017 in five of the six main sites. In Kimpese, *An. gambiae* s.l. were more abundant in the rainy season (January to April) in 2018 than in 2017; but this is due to sampling in a different, more representative location. In general, indoor biting by *An. gambiae* s.l. and *An. funestus* s.l. was primarily late at night, between 10 p.m. and 5 a.m., and mirrored outdoor biting trends. The biting and resting behaviors observed are similar to 2017 trends. The EIR was particularly high year-round in Kabondo. This highlights the huge challenge faced in controlling malaria in parts of the DRC where significant rainfall provides larval habitats most of the year.

In nearly all sites, *An. gambiae* s.l. were resistant to diagnostic concentrations of three pyrethroids (permethrin, deltamethrin, and alpha-cypermethrin). The intensity of resistance was moderate for almost all pyrethroids (with survivors at the ×5 concentration). However, few survivors were recorded at 10 times the diagnostic doses of permethrin and deltamethrin. Nevertheless, this moderate intensity resistance level observed nationwide is extremely concerning and has the potential to compromise the effectiveness of pyrethroid LLINs. Bioassay testing of pyrethroids with the synergist piperonyl butoxide is being conducted in 2019. Malaria vectors were susceptible to chlorfenapyr in four sites tested. This data will help to inform the NMCP and donors regarding choice of LLINs for future distribution campaigns.

ANNEXES

TABLE A1: MORTALITY RATES INDUCED BY CHLORFENAPYR 12.5, 25, 50, 100, AND 200 UG/ML AGAINST WILD *AN. GAMBIAE* S.L. POPULATION FROM KALEMIE, 2018

Concentration	Total Tested	Nb Dead (percentage mortality 60 min)	Nb Dead (percentage mortality 24 H)	Nb Dead (percentage mortality 48 H)	Nb Dead (percentage mortality 72 H)
Solution E					
Control	**21**	0 **(0)**	1 **(4.7)**	1 **(4.7)**	1 **(4.7)**
12.5 µg/bottle	**75**	2 **(2.7)**	11 **(14.7)**	11 **(14.7)**	11 **(14.7)**
Solution D					
Control	**22**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
25 µg/bottle	**78**	21 **(26.9)**	36 **(46.2)**	52 **(66.7)**	59 **(75.6)**
Solution C					
Control	**25**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
50 µg/bottle	**90**	52 **(57.8)**	90 **(100)**	90 **(100)**	90 **(100)**
Solution B					
Control	**24**	1 **(4.2)**	1 **(4.2)**	1 **(4.2)**	1 **(4.2)**
100 µg/bottle	**77**	53 **(68.8)**	75 **(97.4)**	75 **(97.4)**	76 **(98.7)**
Solution A					
Control	**24**	1 **(4.2)**	1 **(4.2)**	1 **(4.2)**	1 **(4.2)**
200 µg/bottle	**75**	66 **(88)**	75 **(100)**	75 **(100)**	75 **(100)**

TABLE A2: MORTALITY RATES INDUCED BY CHLORFENAPYR 12.5, 25, 50, 100 AND 200 UG/ML AGAINST WILD AN. GAMBIAE S.L. POPULATION FROM KAPOLOWE, 2018

Concentration	Total Tested	Nb dead (percentage mortality 60 min)	Nb Dead (percentage mortality 24 H)	Nb Dead (percentage mortality 48 H)	Nb Dead (percentage mortality 72 H)
Solution E					
Control	**25**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
12.5 µg/bottle	**83**	2 **(2.4)**	66 **(80)**	68 **(82)**	68 **(82)**
Solution D					
Control	**25**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
25 µg/bottle	**100**	37 **(37)**	97 **(97)**	98 **(98)**	99 **(99)**
Solution C					
Control	**25**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**

50 µg/bottle	**95**	15 **(16)**	94 **(99)**	94 **(99)**	94 **(99)**
			Solution B		
Control	**24**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
100 ug/bottle	**89**	33 **(37)**	86 **(97)**	88 **(99)**	88 **(99)**
			Solution A		
Control	**25**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
200 µg/bottle	**94**	44 **(47)**	93 **(99)**	93 **(99)**	93 **(99)**

TABLE A3: **MORTALITY RATES INDUCED BY CHLORFENAPYR 12.5, 25, 50, 100 AND 200 UG/ML AGAINST WILD AN. GAMBIAE S.L. POPULATION FROM KINSHASA, 2018**

Concentration	Total Tested	Nb Dead (percentage mortality 60 min)	Nb Dead (percentage mortality 24 H)	Nb Dead (percentage mortality 48 H)	Nb Dead (percentage mortality 72 H)
			Solution E		
Control	**25**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
12.5 µg/bottle	**100**	2 **(2)**	8 **(8)**	12 **(12)**	16 **(16)**
			Solution D		
Control	**25**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
25 µg/bottle	**90**	14 **(16)**	41 **(46)**	55 **(61)**	64 **(71)**
			Solution C		
Control	**25**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
50 µg/bottle	**98**	4 **(4)**	61 **(62.2)**	67 **(68.4)**	96 **(98)**
			Solution B		
Control	**25**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
100 µg/bottle	**97**	26 **(27)**	79 **(81.4)**	87 **(90)**	89 **(92)**
			Solution A		
Control	**25**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
200 µg/bottle	**107**	58 **(54.2)**	105 **(98.1)**	107 **(100)**	107 **(100)**

TABLE A4: MORTALITY RATES INDUCED BY CHLORFENAPYR 12.5, 25, 50, 100, AND 200 UG/ML AGAINST WILD *AN. GAMBIAE* S.L. POPULATION FROM KIMPESE, 2018

Concentration	Total Tested	Nb Dead (percentage mortality 60 min)	Nb Dead (percentage mortality 24 H)	Nb Dead (percentage mortality 48 H)	Nb Dead (percentage mortality 72 H)
			Solution E		
Control	**20**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
12.5 µg/bottle	**80**	12 **(15)**	80 **(100)**	80 **(100)**	80 **(100)**
			Solution D		
Control	**20**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**

25 µg/bottle	**80**	15 **(19)**	80 **(100)**	80 **(100)**	80 **(100)**
Solution C					
Control	**20**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
50 µg/bottle	**80**	17 **(21.3)**	80 **(100)**	80 **(100)**	80 **(100)**
Solution B					
Control	**20**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
100 µg/bottle	**80**	18 **(23)**	80 **(100)**	80 **(100)**	80 **(100)**
Solution A					
Control	**20**	0 **(0)**	0 **(0)**	0 **(0)**	0 **(0)**
200 µg/bottle	**80**	28 **(35)**	80 **(100)**	80 **(100)**	80 **(100)**

TABLE A5: ABUNDANCE OF *ANOPHELES* COLLECTED IN INONGO BY SPECIES AND METHOD (PSC AND HLC) OF COLLECTION

Site	**Inongo**			
Period	**January–June 2018**			
Species/Method	**PSC (10 per period)**	**HLC Indoor (8 per period)**	**HLC Outdoor (8 per period)**	**Total**
January 2018				
An. gambiae s.l.	183 (100%)	10 (36%)	12 (39%)	205 (85%)
An. funestus s.l.	0 (0%)	1 (4%)	1 (3%)	2 (1%)
An. paludis	0 (0%)	17 (61%)	18 (58%)	35 (14%)
Total 1	**183 (100%)**	**28 (100%)**	**31 (100%)**	**242 (100%)**
March 2018				
An. gambiae s.l.	33 (100%)	21 (46%)	10 (16%)	64 (46%)
An. paludis	0 (0%)	25 (54%)	51 (84%)	76 (54%)
Total 2	**33 (100%)**	**46 (100%)**	**61 (100%)**	**140 (100%)**
June 2018				
An. gambiae s.l.	43 (91%)	20 (43%)	12 (34%)	75 (59%)
An. funestus s.l.	4 (9%)	0 (0%)	0 (0%)	4 (3%)
An. paludis	0 (0%)	26 (57%)	23 (66%)	49 (38%)
Total 3	**47 (100%)**	**46 (100%)**	**35 (100%)**	**128 (100%)**

TABLE A6: ABUNDANCE OF *ANOPHELES* COLLECTED IN KARAWA BY SPECIES AND METHOD (PSC AND HLC) OF COLLECTION

Site	**Karawa**			
Period	**January–May 2018**			
Species/Method	**PSC (10 per period)**	**HLC Indoor (8 per period)**	**HLC Outdoor (8 per period)**	**Total**
January 2018				
An. gambiae s.l.	46 (100%)	70 (83%)	93 (88%)	209 (89%)
An. funestus s.l.	0 (0%)	6 (7%)	4 (4%)	10 (4%)

An. paludis	0 (0%)	8 (10%)	9 (8%)	17 (7%)
Total 1	**46 (100%)**	**84 (100%)**	**106 (100%)**	**236 (100%)**
March 2018				
An. gambiae s.l.	125 (99%)	137 (99%)	125 (98%)	387 (99%)
An. funestus s.l.	1 (1%)	1 (1%)	2 (2%)	4 (1%)
An. paludis	0 (0%)	0 (0%)	1 (1%)	1 (0%)
Total 2	**126 (100%)**	**138 (100%)**	**128 (100%)**	**392 (100%)**
May 2018				
An. gambiae s.l.	83 (98%)	303 (97%)	328 (98%)	714 (97%)
An. funestus s.l.	2 (2%)	10 (3%)	7 (2%)	19 (3%)
Total 3	**85 (100%)**	**313 (100%)**	**335 (100%)**	**733 (100%)**

TABLE A7: ABUNDANCE OF *ANOPHELES* COLLECTED IN KIMPESE BY SPECIES AND METHOD (PSC AND HLC) OF COLLECTION, 2018

Site	**Kimpese**			
Period	**January–May 2018**			
Species/Method	**PSC (10 per period)**	**HLC Indoor (8 per period)**	**HLC Outdoor (8 per period)**	**Total**
January 2018				
An. gambiae s.l.	10 (77%)	20 (65%)	74 (70%)	104 (69%)
An. funestus s.l.	3 (23%)	11 (35%)	32 (30%)	46 (31%)
Total 1	**13 (100%)**	**31 (100%)**	**106 (100%)**	**150 (100%)**
March 2018				
An. gambiae s.l.	1 (6%)	10 (77%)	45 (74%)	56 (62%)
An. funestus s.l.	16 (94%)	3 (23%)	16 (26%)	35 (38%)
Total 2	**17 (100%)**	**13 (100%)**	**61 (100%)**	**91 (100%)**
May 2018				
An. gambiae s.l.	34 (52%)	48 (23%)	68 (24%)	150 (27%)
An. funestus s.l.	31 (48%)	163 (77%)	207 (73%)	401 (72%)
An. coustani	0	1(0%)	7 (2%)	8 (1%)
Total 3	**65 (100%)**	**212 (100%)**	**282 (100%)**	**559 (100%)**

TABLE A8: ABUNDANCE OF *ANOPHELES* COLLECTED IN PAWA BY SPECIES AND METHOD (PSC AND HLC) OF COLLECTION

Site	**Pawa**			
Period	**January–May 2018**			
Species/Method	**PSC (10 per period)**	**HLC Indoor (8 per period)**	**HLC Outdoor (8 per period)**	**Total**
January 2018				
An. gambiae s.l.	1 (13%)	7 (9%)	6 (8%)	14 (9%)
An. funestus s.l.	7 (88%)	4 (5%)	3 (4%)	14 (9%)

An. paludis	0 (0%)	63 (83%)	62 (87%)	125 (81%)
An. coustani	0 (0%)	1 (1%)	0	1 (1%)
An. nili	0 (0%)	1 (1%)	0	1 (1%)
Total 1	**8 (100%)**	**76 (100%)**	**71 (100%)**	**155 (100%)**
March 2018				
An. gambiae s.l.	68 (67%)	27 (75%)	49 (74%)	144 (71%)
An. funestus s.l.	32 (31%)	6 (17%)	7 (11%)	45 (22%)
An. paludis	2 (2%)	3 (8%)	10 (15%)	15 (7%)
Total 2	**102 (100%)**	**36 (100%)**	**66 (100%)**	**204 (100%)**
May 2018				
An. gambiae s.l.	2 (18%)	8 (57%)	8 (38%)	18 (39%)
An. funestus s.l.	9 (82%)	2 (14%)	8 (38%)	19 (41%)
An. paludis	0 (0%)	4 (29%)	5 (26%)	9 (20%)
Total 3	**11 (100%)**	**14 (100%)**	**21 (100%)**	**46 (100%)**

TABLE A10: HBR OF MALARIA VECTORS INDOORS AND OUTDOORS AT INONGO SITE, 2018

Please note: In these tables, "Nbr person-night" = Number of people that conducted a full night of HLC from 6 p.m. to 6 a.m.

Site	Inongo					
Period	January–June 2018					
Method	HLC					
Species	Location	Variables	Jan–Feb	Mar–Apr	May–Jun	Jan–Jun
An. gambiae s.l.	Indoor	Total mosquitoes	10	21	20	51
		Nbr person-night	8	8	8	24
		HBR/night	**1**	**3**	**3**	**2**
	Outdoor	Total mosquitoes	12	10	12	34
		Nbr person-night	8	8	8	24
		HBR/night	**2**	**1**	**2**	**1**
An. funestus s.l.	Indoor	Total mosquitoes	1	0	0	1
		Nbr person-night	8	8	8	24
		HBR/night	**0**	**0**	**0**	**0**
	Outdoor	Total mosquitoes	1	0	0	1
		Nbr person-night	8	8	8	24
		HBR/night	**0**	**0**	**0**	**0**
An. paludis	Indoor	Total mosquitoes	17	25	26	68
		Nbr person-night	8	8	8	24
		HBR/night	**2**	**3**	**3**	**3**
	Outdoor	Total mosquitoes	18	51	23	92
		Nbr person-night	8	8	8	24

		HBR/night	**2**	**6**	**3**	**4**

TABLE A11: HBR OF MALARIA VECTORS INDOORS AND OUTDOORS AT KARAWA SITE

Site	**Karawa**					
Period	**January–June 2018**					
Method	**HLC**					
Species	**Location**	**Variables**	**Jan–Feb**	**Mar–Apr**	**May–Jun**	**Jan–Jun**
An. gambiae s.l.	Indoor	Total mosquitoes	70	137	303	510
		Nbr person-night	8	8	8	24
		HBR/night	**9**	**17**	**38**	**21**
	Outdoor	Total mosquitoes	93	125	328	546
		Nbr person-night	8	8	8	24
		HBR/night	**12**	**16**	**41**	**23**
An. funestus s.l.	Indoor	Total mosquitoes	6	1	10	17
		Nbr person-night	8	8	8	24
		HBR/night	**1**	**0**	**1**	**1**
	Outdoor	Total mosquitoes	4	2	7	13
		Nbr person-night	8	8	8	24
		HBR/night	**1**	**0**	**1**	**1**
An. paludis	Indoor	Total mosquitoes	8	0	0	8
		Nbr person-night	8	8	8	24
		HBR/night	**1**	**0**	**0**	**0**
	Outdoor	Total mosquitoes	9	1	0	10
		Nbr person-night	8	8	8	24
		HBR/night	**1**	**0**	**0**	**0**

TABLE A12: HBR OF MALARIA VECTORS INDOORS AND OUTDOORS AT KIMPESE SITE

Site	**Kimpese**					
Period	**January–June 2018**					
Method	**HLC**					
Species	**Location**	**Variables**	**Jan–Feb**	**Mar–Apr**	**May–Jun**	**Jan–Jun**
An. gambiae s.l.	Indoor	Total mosquitoes	20	10	48	78
		Nbr person-night	8	8	8	24
		HBR/night	**3**	**1**	**6**	**3**
	Outdoor	Total mosquitoes	74	45	68	187
		Nbr person-night	8	8	8	24
		HBR/night	**9**	**6**	**9**	**8**
An. funestus s.l.	Indoor	Total mosquitoes	11	3	163	177
		Nbr person-night	8	8	8	24

		HBR/night	**1**	**0**	**20**	**7**
	Outdoor	Total mosquitoes	32	16	207	255
		Nbr person-night	8	8	8	24
		HBR/night	**4**	**2**	**26**	**11**
An. coustani	Indoor	Total mosquitoes	0	0	1	1
		Nbr person-night	8	8	8	24
		HBR/night	**0**	**0**	**0**	**0**
	Outdoor	Total mosquitoes	0	0	7	7
		Nbr person-night	8	8	8	24
		HBR/night	**0**	**0**	**1**	**0**

TABLE A13: HBR OF MALARIA VECTORS INDOORS AND OUTDOORS AT PAWA SITE

Site	**Pawa**					
Period	**January–June 2018**					
Method	**HLC**					
Species	**Location**	**Variables**	**Jan–Feb**	**Mar–Apr**	**May–Jun**	**Jan–Jun**
An. gambiae s.l.	Indoor	Total mosquitoes	7	27	8	42
		Nbr person-night	8	8	8	24
		HBR/night	**1**	**3**	**1**	**2**
	Outdoor	Total mosquitoes	6	49	8	63
		Nbr person-night	8	8	8	24
		HBR/night	**1**	**6**	**1**	**3**
An. funestus s.l.	Indoor	Total mosquitoes	4	6	2	12
		Nbr person-night	8	8	8	24
		HBR/night	**1**	**1**	**0**	**1**
	Outdoor	Total mosquitoes	3	7	8	18
		Nbr person-night	8	8	8	24
		HBR/night	**0**	**1**	**1**	**1**
An. paludis	Indoor	Total mosquitoes	63	3	4	70
		Nbr person-night	8	8	8	24
		HBR/night	**8**	**0**	**1**	**3**
	Outdoor	Total mosquitoes	62	10	5	77
		Nbr person-night	8	8	8	24
		HBR/night	**8**	**1**	**1**	**3**
An. coustani	Indoor	Total mosquitoes	**1**	**0**	**0**	**1**
		Nbr person-night	8	8	8	24
		HBR/night	**0**	**0**	**0**	**0**
	Outdoor	Total mosquitoes	0	0	0	0
		Nbr person-night	8	8	8	24
		HBR/night	**0**	**0**	**0**	**0**

An. nili	Indoor	Total mosquitoes	I	0	0	I
		Nbr person-night	8	8	8	24
		HBR/night	**0**	**0**	**0**	**0**
	Outdoor	Total mosquitoes	0	0	0	0
		Nbr person-night	8	8	8	24
		HBR/night	**0**	**0**	**0**	**0**

TABLE A14: HBR OF MALARIA VECTORS INDOORS AND OUTDOORS AT KABONDO SITE, 2018

Site		Kabondo												
Period		January–December 2018												
Method		HLC												
Species	Location	Variables	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
An. gambiae s.l.	Indoor	Total mosquitoes	43	186	181	107	95	59	137	295	163	94	207	185	1,752
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**5**	**23**	**23**	**13**	**12**	**7**	**17**	**37**	**20**	**12**	**26**	**23**	**18**
	Outdoor	Total mosquitoes	43	242	202	174	77	101	155	433	203	164	275	118	2,187
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**5**	**30**	**25**	**22**	**10**	**13**	**19**	**54**	**25**	**21**	**34**	**15**	**23**
An. funestus s.l.	Indoor	Total mosquitoes	1	12	7	13	8	6	6	2	0	5	1	14	75
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**0**	**2**	**1**	**2**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**2**	**1**
	Outdoor	Total mosquitoes	2	9	2	17	9	9	2	9	0	9	3	7	78
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**0**	**1**	**0**	**2**	**1**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**1**
An. paludis	Indoor	Total mosquitoes	0	0	0	0	0	0	0	1	0	1	0	0	2
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Outdoor	Total mosquitoes	1	1	0	0	0	0	0	0	0	1	0	0	3
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

TABLE A15: HBR OF MALARIA VECTORS INDOORS AND OUTDOORS AT KALEMIE SITE, 2018

Site		Kalemie												
Period		January–December 2018												
Method		HLC												
Species	Location	Variables	January	February	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Total
An. gambiae s.l.	Indoor	Total mosquitoes	44	7	12	18	14	4	27	12	27	32	24	35	256
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**6**	**1**	**2**	**2**	**2**	**1**	**3**	**2**	**3**	**4**	**3**	**4**	**3**
	Outdoor	Total mosquitoes	22	2	25	6	5	2	14	3	18	25	27	28	177
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**3**	**0**	**3**	**1**	**1**	**0**	**2**	**0**	**2**	**3**	**3**	**4**	**2**
An. funestus s.l.	Indoor	Total mosquitoes	2	8	1	0	10	22	0	20	9	0	0	0	72
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**0**	**1**	**0**	**0**	**1**	**3**	**0**	**3**	**1**	**0**	**0**	**0**	**1**
	Outdoor	Total mosquitoes	1	3	0	0	2	9	0	7	1	0	0	0	23
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
An. pharaonsis	Indoor	Total mosquitoes	0	5	0	2	0	0	0	0	0	0	0	0	7
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Outdoor	Total mosquitoes	0	3	1	0	0	0	0	0	0	0	0	0	4
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
An. coustani	Indoor	Total mosquitoes	0	0	0	1	0	0	0	0	0	0	0	0	1
		Nbr person-night	8	8	8	8	8	8	8	8	8	8	8	8	96
		HBR/night	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

TABLE A16: DISTRIBUTION AND ABUNDANCE OF MOSQUITOES COLLECTED IN KABONDO BY SPECIES AND METHOD (PSC AND HLC) OF COLLECTION, 2018

Site	Kabondo	January–December 2018			
		PSC	HLC		Total
Periods	Species	Indoor	Indoor	Outdoor	
January	*An. gambiae* s.l.	27 (90%)	43 (98%)	43 (93%)	113 (94%)
	An. funestus s.l.	3 (10%)	1 (2%)	2 (4%)	6 (5%)
	An. paludis	0 (0%)	0 (0%)	1 (2%)	1 (1%)
Total January		**30 (100%)**	**44 (100%)**	**46 (100%)**	**120 (100%)**
February	*An. gambiae* s.l.	75 (93%)	186 (94%)	242 (96%)	503 (95%)
	An. funestus s.l.	6 (7%)	12 (6%)	9 (4%)	27 (5%)
	An. paludis	0 (0%)	0 (0%)	1 (0%)	1 (0%)
Total February		**81 (100%)**	**198 (100%)**	**252 (100%)**	**531 (100%)**
March	*An. gambiae* s.l.	62 (86%)	181 (96%)	202 (99%)	445 (96%)
	An. funestus s.l.	10 (14%)	7 (4%)	2 (1%)	19 (4%)
Total March		**72 (100%)**	**188 (100%)**	**204 (100%)**	**464 (100%)**
April	*An. gambiae* s.l.	37 (79%)	107 (89%)	174 (91%)	318 (89%)
	An. funestus s.l.	10 (21%)	13 (11%)	17 (9%)	40 (11%)
Total April		**47 (100%)**	**120 (100%)**	**191 (100%)**	**358 (100%)**
May	*An. gambiae* s.l.	22 (85%)	95 (92%)	77 (90%)	194 (90%)
	An. funestus s.l.	4 (15%)	8 (8%)	9 (10%)	21 (10%)
Total May		**26 (100%)**	**103 (100%)**	**86 (100%)**	**215 (100%)**
June	*An. gambiae* s.l.	67 (83%)	59 (91%)	101 (92%)	227 (89%)
	An. funestus s.l.	14 (17%)	6 (9%)	9 (8%)	29 (11%)
Total June		**81 (100%)**	**65 (100%)**	**110 (100%)**	**256 (100%)**
July	*An. gambiae* s.l.	35 (81%)	137 (96%)	155 (99%)	327 (95%)
	An. funestus s.l.	8 (19%)	6 (4%)	2 (1%)	16 (5%)

Total July		**43 (100%)**	**143 (100%)**	**157 (100%)**	**343 (100%)**
August	*An. gambiae* s.l.	43 (98%)	295 (99%)	433 (98%)	771 (98%)
	An. funestus s.l.	1 (2%)	2 (1%)	9 (2%)	12 (2%)
	An. paludis	0 (0%)	1 (0%)	0 (0%)	1 (0%)
Total August		**44 (100%)**	**298 (100%)**	**442 (100%)**	**784 (100%)**
September	*An. gambiae* s.l.	20 (95%)	163 (100%)	203 (100%)	386 (100%)
	An. funestus s.l.	1 (5%)	0 (0%)	0 (0%)	1 (0%)
Total September		**21 (100%)**	**163 (100%)**	**203 (100%)**	**387 (100%)**
October	*An. gambiae* s.l.	11 (92%)	94 (94%)	164 (94%)	269 (94%)
	An. funestus s.l.	1 (8%)	5 (5%)	9 (5%)	15 (5%)
	An. paludis	0 (0%)	1 (1%)	1 (1%)	2 (1%)
Total October		**12 (100%)**	**100 (100%)**	**174 (100%)**	**286 (100%)**
November	*An. gambiae* s.l.	23 (100%)	207 (100%)	275 (99%)	505 (99%)
	An. funestus s.l.	0 (0%)	1 (0%)	3 (1%)	4 (1%)
Total November		**23 (100%)**	**208 (100%)**	**278 (100%)**	**509 (100%)**
December	*An. gambiae* s.l.	53 (98%)	185 (93%)	118 (94%)	356 (94%)
	An. funestus s.l.	1 (2%)	14 (7%)	7 (6%)	22 (6%)
Total December		**54 (100%)**	**199 (100%)**	**125 (100%)**	**378 (100%)**
Overall Total		**534 (100%)**	**1829 (100%)**	**2268 (100%)**	**4631 (100%)**

January–December 2018					
	PSC	**HLC**			
Species	**Indoor**	**Indoor**	**Outdoor**	**Total HLC**	**Total**
An. gambiae s.l.	475 (89%)	1,752 (96%)	2,187 (96%)	3,939 (96%)	4,414 (95%)
An. funestus s.l.	59 (11%)	75 (4%)	78 (3%)	153 (4%)	212 (5%)
An. paludis	0 (0%)	2 (0%)	3 (0%)	5(0%)	5 (0%)
Overall Total	**534 (100%)**	**1,829 (100%)**	**2,268 (100%)**	**4,097 (100%)**	**4,631 (100%)**

TABLE A17: DISTRIBUTION AND ABUNDANCE OF MOSQUITOES COLLECTED IN KALEMIE BY SPECIES AND METHOD (PSC AND HLC) OF COLLECTION, 2018

Site	Kalemie	January–December 2018			
		PSC	HLC		Total
Periods	Species	Indoor	Indoor	Outdoor	
January	*An. gambiae* s.l.	79 (81%)	44 (96%)	22 (96%)	145 (87%)
	An. funestus s.l.	18 (19%)	2 (4%)	1 (4%)	21 (13%)
Total January		**97 (100%)**	**46 (100%)**	**23 (100%)**	**166 (100%)**
February	*An. gambiae* s.l.	79 (74%)	7 (35%)	2 (25%)	88 (32%)
	An. funestus s.l.	28 (26%)	8 (40%)	3 (38%)	39 (39%)
	An. pharaonsis	0 (0%)	5 (25%)	3 (38%)	8 (29%)
Total February		**107 (100%)**	**20 (100%)**	**8 (100%)**	**135 (100%)**
March	*An. gambiae s.l.*	117 (91%)	12 (92%)	25 (96%)	154 (92%)
	An. funestus s.l.	11 (9%)	1 (8%)	0 (0%)	12 (7%)
	An. pharaonsis	0 (0%)	0 (0%)	1 (4%)	1 (1%)
Total March		**128 (100%)**	**13 (100%)**	**26 (100%)**	**167 (100%)**
April	*An. gambiae* s.l.	62 (95%)	18 (86%)	6 (100%)	86 (93%)
	An. funestus s.l.	3 (5%)	0 (0%)	0 (0%)	3 (3%)
	An. pharaonsis	0 (0%)	2 (10%)	0 (0%)	2 (2%)
	An. coustani	0 (0%)	1 (5%)	0 (0%)	1 (1%)
Total April		**65 (100%)**	**21 (100%)**	**6 (100%)**	**92 (100%)**
May	*An. gambiae* s.l.	42 (86%)	14 (58%)	5 (71%)	61 (76%)
	An. funestus s.l.	7 (14%)	10 (42%)	2 (29%)	19 (24%)
Total May		**49 (100%)**	**24 (100%)**	**7 (100%)**	**80 (100%)**
June	*An. gambiae* s.l.	53 (79%)	4 (15%)	2 (18%)	59 (57%)
	An. funestus s.l.	14 (21%)	22 (85%)	9 (82%)	45 (43%)
Total June		**67 (100%)**	**26 (100%)**	**11 (100%)**	**104 (100%)**
July	*An. gambiae* s.l.	50 (78%)	27 (100%)	14 (100%)	91 (87%)
	An. funestus s.l.	14 (22%)	0 (0%)	0 (0%)	14 (13%)
Total July		**64 (100%)**	**27 (100%)**	**14 (100%)**	**105 (100%)**
August	*An. gambiae* s.l.	52 (78%)	12 (38%)	3 (30%)	67 (61%)
	An. funestus s.l.	15 (22%)	20 (63%)	7 (70%)	42 (39%)

Total August		**67 (100%)**	**32 (100%)**	**10 (100%)**	**109 (100%)**
September	*An. gambiae* s.l.	73 (96%)	27 (75%)	18 (95%)	118 (90%)
	An. funestus s.l.	3 (4%)	9 (25%)	1 (5%)	13 (10%)
Total September		**76 (100%)**	**36 (100%)**	**19 (100%)**	**131 (100%)**
October	*An. gambiae* s.l.	48 (75%)	32 (100%)	25 (100%)	105 (87%)
	An. funestus s.l.	16 (25%)	0 (0%)	0 (0%)	16 (13%)
Total October		**64 (100%)**	**32 (100%)**	**25 (100%)**	**121 (100%)**
November	*An. gambiae* s.l.	47 (80%)	24 (100%)	27 (100%)	98 (89%)
	An. funestus s.l.	12 (20%)	0 (0%)	0 (0%)	12 (11%)
Total November		**59 (100%)**	**24 (100%)**	**27 (100%)**	**110 (100%)**
December	*An. gambiae* s.l.	45 (76%)	35 (100%)	28 (100%)	108 (89%)
	An. funestus s.l.	14 (24%)	0 (0%)	0 (0%)	14 (11%)
Total December		**59 (100%)**	**35 (100%)**	**28 (100%)**	**122 (100%)**
Overall Total		**902**	**336**	**204**	**1,442**

January–December 2017					
	PSC	**HLC**			
Species	**Indoor**	**Indoor**	**Outdoor**	**Total HLC**	**Total**
An. gambiae s.l.	747 (83%)	256 (76%)	177 (87%)	433 (80%)	1,180 (82%)
An. funestus s.l.	155 (17%)	72 (21%)	23 (11%)	95 (18%)	250 (17%)
An. pharaonsis	0 (0%)	7 (2%)	4 (2%)	11 (2%)	11 (1%)
An. coustani	0 (0%)	1 (0%)	0 (0%)	1 (0%)	1 (0%)
Overall Total	**902 (100%)**	**336 (100%)**	**204 (100%)**	**540 (100%)**	**1,442 (100%)**

TABLE A18: ABDOMINAL STATUS OF MALARIA VECTORS COLLECTED RESTING INDOORS THROUGH PSC FROM KALEMIE (JANUARY–DECEMBER 2018)

Site	**KALEMIE**		**January – December 2018**		
Method			**PSC**		
Periods/Species	**Unfed**	**Fed**	**Half-gravid**	**Gravid**	**Total**
January	**13(13%)**	**84(87%)**	**0**	**0**	**97(100%)**

An. gambiae s.l	11(14%)	68(86%)	0	0	79(100%)
An. funestus s.l	2(11%)	16(89%)	0	0	18(100%)
February	**7(7%)**	**100(93%)**	**0**	**0**	**107(100%)**
An. gambiae s.l	7(9%)	72(91%)	0	0	79(100%)
An. funestus s.l	0	28(100%)	0	0	28(100%)
March	**6(5%)**	**91(71%)**	**31(24%)**	**0**	**128(100%)**
An. gambiae s.l	6(5%)	83(71%)	28(25%)	0	117(100%)
An. funestus s.l	0	8(73%)	3(27%)	0	11(100%)
April	**6(9%)**	**56(86%)**	**3(5%)**	**0**	**65(100%)**
An. gambiae s.l	6(10%)	53(85%)	3(5%)	0	62(100%)
An. funestus s.l	0	3(100%)	0	0	3(100%)
May	**6(12%)**	**30(61%)**	**7(14%)**	**6(12%)**	**49(100%)**
An. gambiae s.l	4(10%)	26(62%)	7(17%)	5(12%)	42(100%)
An. funestus s.l	2(29%)	4(57%)	0	1(14%)	7(100%)
June	**6(9%)**	**57(85%)**	**2(3%)**	**2(3%)**	**67(100%)**
An. gambiae s.l	5(9%)	44(83%)	2(4%)	2(4%)	53(100%)
An. funestus s.l	1(7%)	13(93%)	0	0	14(100%)
July	**29(45%)**	**34(53%)**	**1(2%)**	**0**	**64(100%)**
An. gambiae s.l	29(58%)	20(40%)	1(2%)	0	50(100%)
An. funestus s.l	0	14(100%)	0	0	14(100%)
August	**7(10%)**	**57(85%)**	**3(4%)**	**0**	**67(100%)**
An. gambiae s.l	7(13%)	42(81%)	3(6%)	0	52(100%)
An. funestus s.l	0	15(100%)	0	0	15(100%)
September	**5(7%)**	**71(93%)**	**0**	**0**	**76(100%)**
An. gambiae s.l	5(7%)	68(93%)	0	0	73(100%)
An. funestus s.l	0	3(100%)	0	0	3(100%)
October	**0**	**64(100%)**	**0**	**0**	**64(100%)**
An. gambiae s.l	0	48(100%)	0	0	48(100%)
An. funestus s.l	0	16(100%)	0	0	16(100%)

November	**19(32%)**	**40(68%)**	**0**	**0**	**59(100%)**
An. gambiae s.l	18(38%)	29(62%)	0	0	47(100%)
An. funestus s.l	1(8%)	11(92%)	0	0	12(100%)
December	**7(12%)**	**52(88%)**	**0**	**0**	**59(100%)**
An. gambiae s.l	4(9%)	41(91%)	0	0	45(100%)
An. funestus s.l	3(21%)	11(79%)	0	0	14(100%)
Overall Total	**111(12%)**	**736(82%)**	**47(5%)**	**8(1%)**	**902(100%)**

TABLE A19: ABDOMINAL STATUS OF MALARIA VECTORS COLLECTED RESTING INDOORS THROUGH PSC FROM KABONDO (JANUARY–DECEMBER 2018)

Site	**KABONDO**	**January – December 2018**			
Method			**PSC**		
Periods/Species	**Unfed**	**Fed**	**Half-gravid**	**Gravid**	**Total**
January	**12(40%)**	**18(60%)**	**0**	**0**	**30(100%)**
An. gambiae s.l	12(44%)	15(56%)	0	0	27(100%)
An. funestus s.l	0	3(100%)	0	0	3(100%)
February	**21**	**47**	**0**	**13**	**81(100%)**
An. gambiae s.l	17(23%)	45(60%)	0	13(17%)	75(100%)
An. funestus s.l	4(67%)	2(33%)	0	0	6(100%)
March	**13(18%)**	**48(67%)**	**5(7%)**	**6(8%)**	**72(100%)**
An. gambiae s.l	10(16%)	41(66%)	5(8%)	6(10%)	62(100%)
An. funestus s.l	3(30%)	7(70%)	0	0	10(100%)
April	**11(23%)**	**35(74%)**	**1(2%)**	**0**	**47(100%)**
An. gambiae s.l	10(27%)	26(70%)	1(3%)	0	37(100%)
An. funestus s.l	1(10%)	9(90%)	0	0	10(100%)
May	**2(8%)**	**23(88%)**	**1(4%)**	**0**	**26(100%)**
An. gambiae s.l	2(9%)	19(86%)	1(5%)	0	22(100%)
An. funestus s.l	0	4(100%)	0	0	4(100%)
June	**6(7%)**	**68(84%)**	**2(2%)**	**5(6%)**	**81(100%)**

An. gambiae s.l	4(6%)	56(84%)	2(33%)	5(7%)	67(100%)
An. funestus s.l	2(14%)	12(86%)	0	0	14(100%)
July	**9(21%)**	**34(79%)**	**0**	**0**	**43(100%)**
An. gambiae s.l	7(20%)	28(80%)	0	0	35(100%)
An. funestus s.l	2(25%)	6(75%)	0	0	8(100%)
August	**19(43%)**	**25(57%)**	**0**	**0**	**44(100%)**
An. gambiae s.l	18(42%)	25(58%)	0	0	43(100%)
An. funestus s.l	1(100%)	0	0	0	1(100%)
September	**9(43%)**	**12(57%)**	**0**	**0**	**21(100%)**
An. gambiae s.l	8(40%)	12(60%)	0	0	20(100%)
An. funestus s.l	1(100%)	0	0	0	1(100%)
October	**11(92%)**	**1(8%)**	**0**	**0**	**12(100%)**
An. gambiae s.l	10(91%)	1(9%)	0	0	11(100%)
An. funestus s.l	1(100%)	0	0	0	1(100%)
November	**15(65%)**	**8(35%)**	**0**	**0**	**23(100%)**
An. gambiae s.l	15(65%)	8(35%)	0	0	23(100%)
December	**19(35%)**	**35(65%)**	**0**	**0**	**54(100%)**
An. gambiae s.l	19(36%)	34(64%)	0	0	53(100%)
An. funestus s.l	0	1(100%)	0	0	1(100%)
Overall Total	**147(28%)**	**354(66%)**	**9(2%)**	**24(4%)**	**534(100%)**

TABLE A20: MONTHLY *AN. FUNESTUS* S.L. EIR IN KABONDO AND KALEMIE IN 2018

Site	Month*	Total *An. funestus* s.l. Collected (HLC)	HLC Trap-nights**	HBR per Night	Number of *An. funestus* s.l. Tested	Sporozoite Rate	EIR p/night	EIR p/month***
Kabondo	January	3	16	0.2	3	0.33	0.07	2.1
	June	15	16	0.9	15	0.07	0.06	1.9
	December	21	16	1.3	21	0.05	0.07	2.1
Kalemie	August	27	16	1.7	27	0.04	0.07	2.1

*Month = month where mosquitoes were found positive following ELISA.
**1 trap-night = a full night of HLC from 6 p.m. to 6 a.m. located either indoors or outdoors (i.e., indoors + outdoors = 2 trap-nights).
***1 month = 30 days.

TABLE A21: MONTHLY *AN. GAMBIAE* S.L. INDOOR EIR IN KABONDO, 2018

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2018 Total
Total *An. gambiae* s.l. (HLC-Indoor) collected	43	186	181	107	95	59	137	295	163	94	207	185	1752
HLC trap-nights (indoors)	8	8	8	8	8	8	8	8	8	8	8	8	96
HBR per night indoor	5	23	23	13	12	7	17	37	20	12	26	23	18 (mean)
Total *An. gambiae* s.l. tested by ELISA indoor	44	103	100	83	95	58	83	88	101	70	108	93	1026
Sporozoite Rate Indoor	0.11	0.01	0.01	0.07	0.06	0	0.01	0	0.02	0.03	0.01	0.03	0.03
EIR p/night indoor	0.55	0.23	0.23	0.91	0.72	0	0.17	0	0.4	0.36	0.26	0.69	0.54 (mean)
EIR p/month* indoor	16.5	6.9	7.2	27.3	21.6	0	5.1	13.8	12	10.8	7.8	20.7	16.2 (mean)

*****Nightly EIR is multiplied by number of nights in that month.

TABLE A22: MONTHLY *AN. GAMBIAE* S.L. OUTDOOR EIR IN KABONDO, 2018

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2018 Total
Total *An. gambiae* s.l. (HLC-outdoor) collected	43	242	202	174	77	101	155	433	203	164	275	118	2187
HLC trap-nights (indoors)	8	8	8	8	8	8	8	8	8	8	8	8	96
HBR per night outdoor	5	30	25	22	10	13	19	54	25	21	34	15	23 (mean)
Total *An. gambiae* s.l. tested by ELISA outdoor	42	97	100	117	77	102	117	112	99	130	90	107	1190
Sporozoite Rate outdoor	0.02	0.01	0.01	0.04	0.01	0.03	0.01	0.01	0	0.01	0	0.08	0.02
EIR p/night outdooor	0.1	0.3	0.25	0.88	0.1	0.39	0.19	0.54	0	0.21	0	1.2	0.46 (mean)
EIR p/month* outdoor	3	9	7.5	26.4	3	11.7	5.7	16.2	0	6.3	0	36	13.8(mean)

*****Nightly EIR is multiplied by number of nights in that month