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The PMI Africa IRS (AIRS) Project

Indoor Residual Spraying (IRS 2) Task Order Six

AIRS ANGOLA ANNUAL PROGRESS REPORT

APRIL 1, 2015 – MARCH 31, 2016

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AIRS ANGOLA
FINAL PROGRESS REPORT

APRIL 1, 2015 – MARCH 31, 2016

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ACRONYMS

AIRS	Africa Indoor Residual Spraying
CDC	Centers for Disease Control and Prevention
COP	Chief of Party
DPS	Direcção Provincial de Saúde/Provincial Health Department
ELISA	Enzyme-Linked Immunosorbent Assay
F&A	Finance and Administration
HLC	Human Landing Catch
IRS	Indoor Residual Spraying
KDR	Knock Down Rate
LLIN	Long-lasting Insecticidal Net
M&E	Monitoring and Evaluation
MOH	Ministry of Health
MOP	Malaria Operational Plan
MOU	Memorandum of Understanding
NGO	Non-governmental Organization
NMCP	National Malaria Control Program
PCR	Polymerase Chain Reaction
PMI	United States President's Malaria Initiative
PPE	Personal Protective Equipment
PSC	Pyrethrum Spray Collections
STTA	Short-Term Technical Assistance
TO	Task Order
USAID	United States Agency for International Development
WHO	World Health Organization

1. EXECUTIVE SUMMARY

From April 1, 2015 through March 31, 2016, AIRS Angola carried out monthly entomological monitoring activities in three sentinel sites over six months. These activities were conducted using Center for Disease Control and Prevention (CDC) light traps, Prokopack aspirators, and Pyrethrum Spray Catches (PSC). The three sentinel sites were located in Cunene, Huambo, and Malanje provinces and were selected based on malaria endemicity and conversations with local public health staff. One sentinel site was selected in a specific municipality in each province: Cuanhama municipality in Cunene province, Mungo municipality in Huambo province, and Cangandala municipality in Malanje province.

Assisted by seasonal workers hired to conduct regular entomological monitoring activities, AIRS Angola used CDC light traps in ten houses and two outdoor traps in each sentinel site for one night. Prokopack aspiration collections were also carried in ten houses in each sentinel site. PSC collections were carried out in five randomly selected houses in each sentinel site per visit.

From November 2015 through March 2016, a total of 5,075 *Anopheles* mosquitoes were collected from all three sentinel sites. The majority of these mosquitoes were collected from indoor light traps, followed by the PSC collection method. In October 2015, AIRS Angola only visited the Huambo sentinel and managed to get only one *An. pharoensis* by outdoor light trap. Delays in government approval prevented activities from commencing in all sentinel sites in October.

Out of all *Anophelines* collected 91.3% were *An. funestus* and 5.3% were *An. gambiae* s.l. and 3.4% were other *Anophelines* belonging to nine different species. Out of these nine other species, the majority were *An. coustani* and *An. squamosus*. These mosquitoes were identified using morphological identification keys and the project expects to send a representative sample for molecular analysis and species confirmation to an external institution. Three individual mosquitoes were unidentifiable.

Collections from the Malanje sentinel site produced 4,328 mosquitoes, the most of all of the sentinel sites. Of these, 94.4% were *An. funestus*, and 4.6% were *An. gambiae* s.l. From Huambo, a total of 709 mosquitoes were collected, where 77.3% were *An. funestus* and 5.1% were *An. gambiae* s.l. Only 38 mosquitoes were collected from the Cunene sentinel site, 92.1% of which were *An. gambiae* s.l. No *An. funestus* were collected in Cunene during the reporting period. Notable increases in collections were observed in Malanje with each subsequent field visit. This was a trend at the other two sites, but at lower levels.

The PSC collection method resulted in a total of 1,086 *Anophelines*. Of these, 98.4% were collected in Malanje, while the remainder came from Huambo. Over 90% of the indoor resting mosquitoes collected using the PSC was blood-fed. During this period, the number of indoor resting *An. funestus* per house ranged from 1.10 to 59.60 and blood-fed *An. funestus* per human host ranged from 0.47 to 20.57. The same trend was observed among samples collected using Prokopack aspiration in Malanje.

From these results, it is clear that *An. funestus* is the most prevalent species in the Malanje area. The rainy season may have largely contributed to the observed increases from December through March. High indoor resting densities in houses and the number of blood-fed *An. funestus* in Malanje should be studied, in detail, in conjunction with the region's malaria epidemiology. It is also worthwhile to carry out sporozoite Enzyme-Linked Immunosorbent Assay (ELISA) and blood meal analysis of those mosquitoes to elucidate the sporozoite rate and transmission dynamics.

2. INTRODUCTION

In August 2011, Abt Associates was awarded the three-year Africa Indoor Residual Spraying (AIRS) project, which was funded by the United States Agency for International Development (USAID) under the United States President's Malaria Initiative (PMI). The objective of the project was to contribute to PMI's goal to halve the burden of malaria in 70 percent of at-risk populations in sub-Saharan Africa. Abt worked closely with Ministries of Health (MOHs), national malaria control programs (NMCPs), district health offices, local non-governmental organizations, and community and business leaders to ensure that government, private sector, and communities were able to sustain and lead future indoor residual spraying (IRS) to prevent and control malaria.

In September 2014, Abt was awarded another three-year task order (the PMI AIRS Project) to continue the implementation of IRS and IRS-related entomological monitoring in 17 sub-Saharan African countries, including Angola.

The purpose of the PMI AIRS Project in Angola (hereinafter referred to as "AIRS Angola") is to achieve PMI's targets in monitoring vector behavior and insecticide resistance status in Angola to help guide malaria vector control programming. In particular, AIRS Angola contributes to achieve PMI goals in the country through the following activities:

- Providing technical assistance related to indoor residual spraying and entomological monitoring activities;
- Carrying out monthly entomological monitoring over six months of the year in three selected provinces representing three main malaria endemic areas in the country; and
- Carrying out a national-level vector susceptibility study to monitor vector resistance status to selected WHOPES-approved insecticides.

This report presents USAID/PMI-funded Angola, Africa Indoor Residual Spraying Project's entomological monitoring activity progress for the period covering April 1, 2015 to March 31, 2016. The report outlines the key project activities and achievements, the challenges and constraints faced, lessons learned, and recommendations for future implementation.

3. Start-Up Activities

3.1 Work Plan and Budget

The work plan and budget for the period April 2015 through March 2016 was approved by USAID/PMI in April 2015.

3.2 Organizational Structure and Staffing Composition

The Angola country team is comprised of three full-time staff (Chief of Party [COP], Entomology and Insectary Coordinator, and Finance and Administration Assistant) and seasonal entomological technicians hired for six months to conduct entomological monitoring activities in sentinel provinces.

3.3 Inventory Transfer and Disposition

Fresh quantification was carried out and inventories were prepared on all previous project items. The proposed transition plan was approved by PMI. We separated the items to be kept with the current project and others were marked for donation/transfer or disposal. As per the disposal plan, all IRS-related equipment and excess office equipment was to be handed over to provinces on the recommendation of NMCP. Among the items for transfer or disposal were 17,000 sachets of expiring Deltamethrin insecticide, left over from the previous project. AIRS Angola is presently exploring the possibilities of environmentally-conscious disposal and incineration in another country, as adequate facilities are not available in Angola. All spray-related equipment and some furniture are being stored at the former Bailundo warehouse, belonging to Huambo's Provincial Health Department (DPS). Currently, because the distribution of the supplies has not yet been agreed upon by the NMCP, the Huambo DPS has taken responsibility of storage purposes only. Final distribution of these items will be decided based on the PMI activities in the new provinces. Insecticides are being kept in the Huambo office until proper disposition plans are finalized.

4. IRS Technical Assistance Workshop

In coordination with PMI Angola, AIRS Angola held a workshop jointly with the National Malaria Control Program to encourage Provincial Departments of Health to fund and lead IRS implementation as a malaria intervention in their respective provinces. Private Sector Partners also participated in the workshop to help everyone explore opportunities for partnerships in malaria vector control program using IRS. The following were the main objectives of this workshop:

- Describe the importance of entomological monitoring in malaria vector control;
- Present preliminary results of the 2015 Angolan national susceptibility study results;
- Train participants on planning, implementation, and budgeting of IRS in provinces and discuss how AIRS can provide technical assistance on these topics in the future; and
- Develop and finalize Memoranda of Understanding (MOU) on how PMI AIRS will provide IRS technical assistance to provinces.

Initially participants from all nine provinces where the national susceptibility study was carried out were expected, as well as the four municipalities bordering Huambo province. In addition, the NMCP also invited some private sector organizations and non-governmental organizations (NGOs). However, only eleven participants from six provinces attended the workshop. There were four participants from NGOs and three entomologists from the NMCP. Dr. Rafael Pedro Dimbu, NMCP Parasitologist, who represented Dr. Filomeno Fortes, NMCP Program Manager, formally opened the workshop.

All participants were very keen on learning about IRS planning and implementation and raised several important points related to vector control activities in their individual provinces. When it came time to develop an estimated budget for IRS for a given number of structures, all were somewhat disappointed. All of the participants believed that the cost of IRS was prohibitive for their provincial health budgets. Despite this, all participants clearly understood the rationale of IRS and said they would take the knowledge they gathered in this workshop when they plan future vector control activities in their respective provinces.

Draft MOUs on providing technical assistance and capacity building support on IRS for provincial governments was distributed to all the participants. Dr. Dimbu explained the contents of the MOU to participants and requested them to distribute these memoranda to their respective provincial directors of health. Provincial directors were expected to review and submit their observations to make the final draft between the PMI AIRS Project, NMCP, and provincial governments. This has not yet taken place as provinces may not have adequate funding from the government to carry out this work on their own.

5. ENTOMOLOGY

5.1 ENTOMOLOGICAL MONITORING

During the reporting period, with the assistance of respective DPS staff, PMI AIRS Angola carried out all planned activities for entomological monitoring activities in the three selected provinces. These monthly entomological monitoring activities commenced in Huambo in November 2015, with activities in the remaining two provinces beginning in December 2015. This staggered start was due to some delays obtaining MOH permission.

5.1.1 SENTINEL SITES

In early August 2015, we initiated discussions with DPS staff in the three selected provinces (Cunene, Huambo, and Malanje) on selecting the sentinel municipalities and locations. At this time, DPS staff provided any available annual municipality-level malaria epidemiological data to inform these discussions. After analyzing the provincial and municipal malaria situations with provincial malaria supervisors and relevant public health staff, the following municipalities were selected for entomological monitoring activities:

TABLE 1: ENTOMOLOGICAL SURVEILLANCE SITES

	Province	Municipality	Sentinel Site	Endemicity/Ecozone
1	Cunene	Ondjiva	Cuanhama	Mesoendemic (unstable)/border
2	Huambo	Mungo	Ganderia	Mesoendemic (stable)
3	Malange	Cangandala	Cangandala	Hyperendemic

The selections were mainly based on the epidemiological situation, distance, population, provincial boarders and other malaria-related geographical factors were also considered.

Monthly entomological monitoring activities conducted according to the approved monitoring plan in three sentinel provinces (Table 2).

TABLE 2: MONTHLY ENTOMOLOGICAL MONITORING PLAN, NOV 2015-MAR 2016

Province	Nov 2015	Dec 2015	Jan 2016	Feb 2016	Mar 2016
Huambo	11/09	12/15	01/04	02/01	03/14
Cunene	11/16	11/30	01/25	02/22	03/21
Malanje	11/23	12/08	01/18	02/08	03/07

Not conducted (blue): Cunene Nov 2015, Cunene Jan 2016, Malanje Nov 2015. *Completed* (pink): all other cells.

5.2 NATIONAL SUSCEPTIBILITY STUDY

Although field work of this study was carried out in two phases in February and March 2015, analysis of data and report preparation were done in the 2015/2016 work plan period. In this study, the resistance levels of *Anopheles gambiae* s.l. to five public health insecticides approved by WHOPES for use in IRS and Long-lasting Insecticidal Net (LLIN) impregnation was assessed. These five insecticides are:

1. Deltamethrin (pyrethroid class);
2. Lambda-cyhalothrin (pyrethroid class);
3. Pirimiphos-methyl (organophosphate class);
4. Fenitrothion (organophosphate class); and
5. Bendiocarb (carbamate class).

These were studied in the nine provinces of Angola – Benguela, Cunene, Huambo, Huila, Luanda, Malanje, Namibe, Uige and Zaire – using the standard WHO bioassay tube test. Only female *Anopheles* mosquitoes reared from larvae collected from different breeding sites and visually/morphologically identified as *An. gambiae* s.l. were tested.

TABLE 3: MUNICIPALITY SENTINEL SITES FOR NATIONAL SUSCEPTIBILITY STUDY

	Province	Municipalities
1	Benguela	Catumbela and Benguela Sede
2	Cunene	Cuanhama and Ombadja
3	Huambo	Bailundo and Huambo
4	Huila	Chibia and Lubango
5	Luanda	Kilamba Kiaxi, Viana and Cacuaco
6	Malanje	Malanje Sede, Kiwaba Ngozi, Kwand-Dia-Baze and Kalandula
7	Namibe	Namibe and Bibala
8	Uíge	Uíge Sede, Negage and Quitexe
9	Zaire	Tomboco, Cuimba, N'zeto and Mbanza Congo

Preliminary results of this study indicate the possible emergence of pyrethroid resistance in Angola, as most of the provinces have shown decreased susceptibility to Deltamethrin and/or Lambda-cyhalothrin. In the most recent IRS campaigns, pyrethroids were used in five provinces at different times. Additionally, pyrethroids are the only group of insecticide used for LLIN treatment in Angola. Hence, it is important to take the emerging pyrethroid resistance into account when planning any vector control measures. Bendiocarb (carbamate class) and Pirimiphos-methyl (organophosphate class) showed full susceptibility in all provinces where testing was conducted and could be good candidates for future vector control, particularly for IRS. Fenitrothion was only tested in three provinces. Results are presented in Table 3.

TABLE 4: PERCENTAGE 24-HOUR HOLDING MORTALITY OF *AN. GAMBIAE* S.L.

	Benguela	Cunene	Huambo	Huila	Luanda	Malanje	Namibe	Uige	Zaire
Deltamethrin	96% (100)	100% (100)	97% (100)	100% (100)	97% (100)	92% (100)	93% (100)	98% (100)	96% (100)
Lambda-cyhalothrin	N/D	91% (100)	N/D	99% (120)	100% (20)	97% (75)	100% (60)	100% (100)	N/D
Bendiocarb	100% (100)	100% (100)	100% (100)	100% (100)	100% (100)	100% (100)	100% (100)	100% (100)	100% (30)
Pirimiphos-methyl	100% (100)	100% (100)	100% (100)	98% (100)	100% (100)	100% (100)	99% (100)	100% (100)	N/D
Fenitrothion	N/D	100% (100)	N/D	98% (100)	N/D	N/D	97% (100)	N/D	N/D

KEY:

Confirmed resistance	Probable resistance	Susceptible

( ) No. of mosquitoes tested
N/D – Not Done

5.3 Huambo Insectary

Huambo insectary will continue to be the main facility for entomology-related activities. These include larval and adult rearing, morphological identification, and preservation and storage of field specimens. We are not maintaining any mosquito colonies at present. Establishment of a susceptible vector colony in the insectary is more delayed than expected, as there are many regulatory processes involved with importing eggs from outside Angola. Parallel to the establishment of a susceptible colony, we are planning to establish an animal house on the insectary premises for the maintenance of the susceptible colony. Additionally, we endeavor to establish a local vector mosquito colony from field-collected samples.

5.4 Molecular Analysis and Sporozoite Rate Determination

As agreed earlier, 3,629 *Anopheles* mosquitoes all collected from national susceptibility study were shipped to the CDC in July 2015 for molecular and biochemical analysis, mainly focusing on species identification and resistance mechanisms. As mentioned previously, we have only received results of 348 mosquitoes collected from the Huambo. Details of those results are given in Table 5.

TABLE 5: CDC MOLECULAR IDENTIFICATION OF *ANOPHELES* MOSQUITOES, PRELIMINARY RESULTS (HUAMBO ONLY)

Species	Number
An. arabiensis	149
An. rufipes	136
An. coustani	19
An. coustani-like	8 (92% similarity)
An. theileri-like	6
An. vagus-like	6 (60% similarity)
No amplification	24
Total	**348**

5.5 Regional Entomology Training

AIRS Angola COP attended PMI AIRS Project-wide entomology training program in Ethiopia in July 2015. The training included mosquito sampling methods, species identification, and insecticide resistance testing. Training also covered the collection of data on insecticide resistance intensity, resistance mechanisms (metabolic detoxification enzymes) using CDC bottle bioassay with synergists, and some secondary PMI entomological indicators like parity rates.

6. RESULTS

6.1 SPECIES COMPOSITION

Between November 2015 and March 2016, a total of 5,075 *Anopheles* mosquitoes were collected from all three sentinel sites using the CDC light traps, Prokopack aspirator, and Pyrethrum Spray Catch (PSC) collection methods. Table 6 presents the distribution of all vectors collected, by sentinel site. Of the mosquitoes collected, 91.3% were *An. funestus* and 5.3% were *An. gambiae* s.l. Others were found to belong to nine different species. A higher percentage of *An. funestus* were collected from Malanje, with notable increases from November 2015 to March 2016. Similar increases were also observed in Huambo although the overall number of mosquitoes collected was much fewer than in Malanje. No *An. funestus* were collected from Cunene. In October 2015, collections only took place in Huambo, where 1 *An. pharoensis* was collected by outdoor light trap.

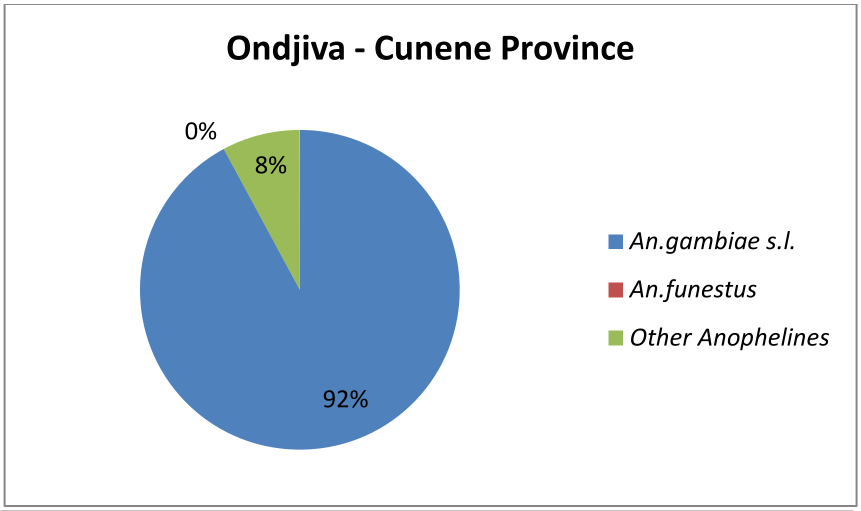
TABLE 6: SPECIES COMPOSITION OF COLLECTED *ANOPHELES* MOSQUITOES BY PROVINCE, OCT 2015 – MAR 2016

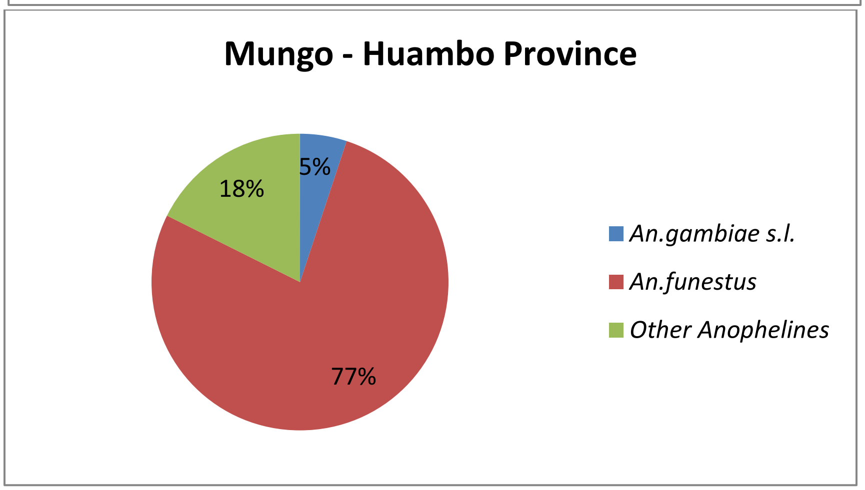
Species	Cunene	Huambo	Malanje	Species Total
An. funestus	0	548	4,084	4,632
An. gambiae s.l.	35	36	197	268
An. coustani	1	56	12	69
An. squamosus	0	53	9	62
An. parensis	0	3	21	24
An. pretoriensis	0	7	1	8
An. salbaii	2	0	2	4
An. pharoensis	0	1	1	2
An. implexus	0	1	0	1
An. rodhesiensis	0	0	1	1
An. tenebrosus	0	1	0	1
Unidentified	0	3	0	3
Province Total	**38**	**709**	**4,328**	**5,075**

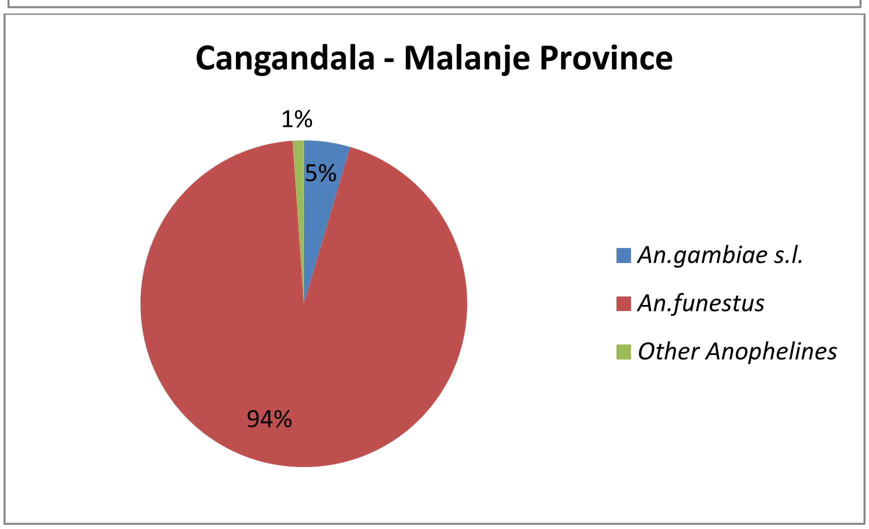
Out of all *Anophelines* collected, 91.3% were *An. funestus*, 5.3% were *An. gambiae* s.l. and 3.4% were other *Anophelines* belonging to nine different species. Out of these nine other species, the majority were *An. coustani* and *An. squamosus*. These mosquitoes were identified using morphological identification keys and the project expects to send a representative sample for molecular analysis and species confirmation to an external institution. Three individual mosquitoes were unidentifiable.

Collections from the Malanje sentinel site produced 4,328 mosquitoes, the most of all of the sentinel sites. Of these, 94.4% were *An. funestus*, and 4.6% were *An. gambiae* s.l. From Huambo, a total of 709 mosquitoes were collected, where 77.3% were *An. funestus* and 5.1% were *An. gambiae* s.l. Only 38 mosquitoes were collected from the Cunene sentinel site, 92.1% of which were *An. gambiae* s.l. No *An. funestus* were collected in Cunene during the reporting period. Notable increases in collections were observed in Malanje with each subsequent field visit. This was a trend at the other two sites, but at lower levels.

Figure 1: Species Composition of *Anopheles* Mosquitoes, Nov 2015 - Mar 2016



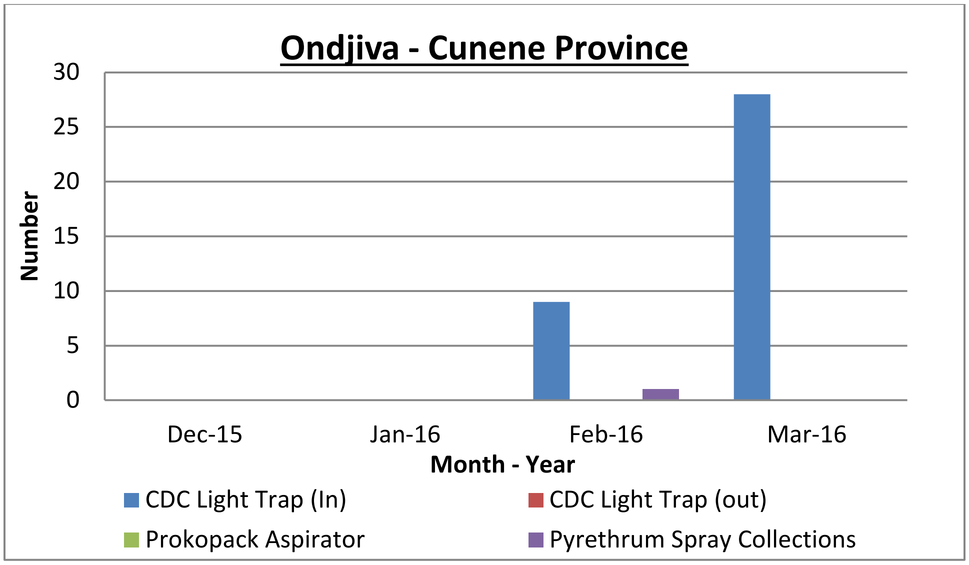


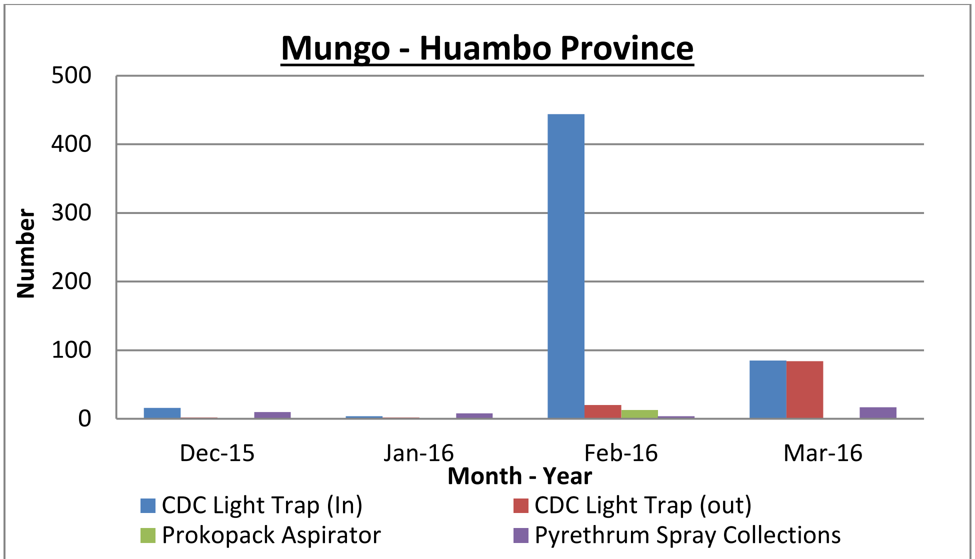


6.2 COLLECTION TECHNIQUES

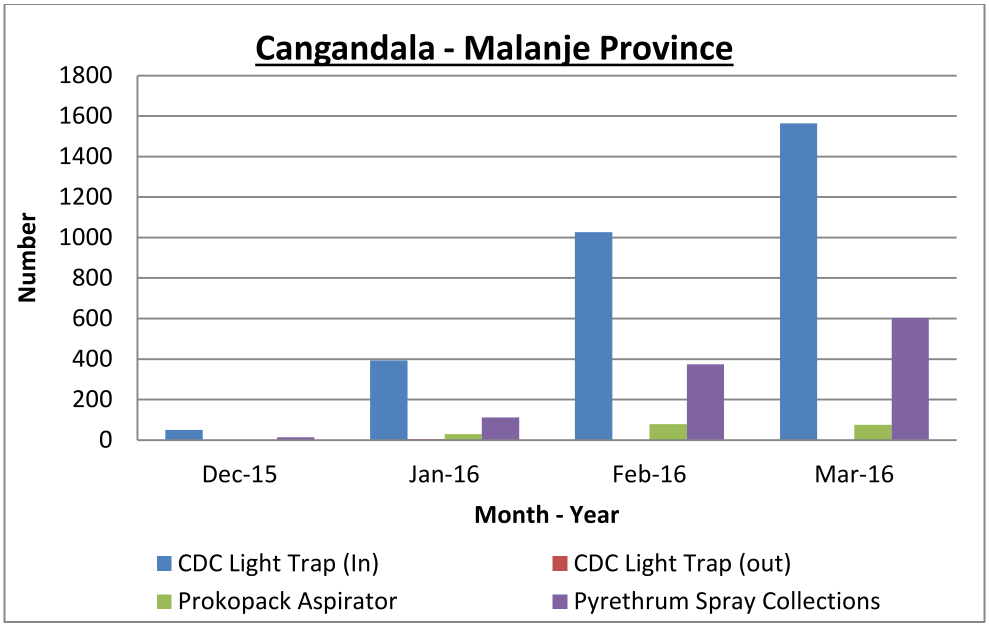
Overall, the largest number of *Anopheline* mosquitoes was collected from CDC indoor light traps. The PSC method resulted in the collection of more indoor resting mosquitoes in comparison to the Prokopack aspirator method. The few mosquitoes collected from the Cunene sentinel site during this period only came from CDC light trap collection, and not from Prokopack aspirator or PSC collection.

Figure 2: Total Number of *Anophelines* Collected Each Month by Different Techniques in Each Province, Nov 2015 - Mar 2016





Note: In November 2015 only 1 *An. pharoensis* was collected by CDC light trap



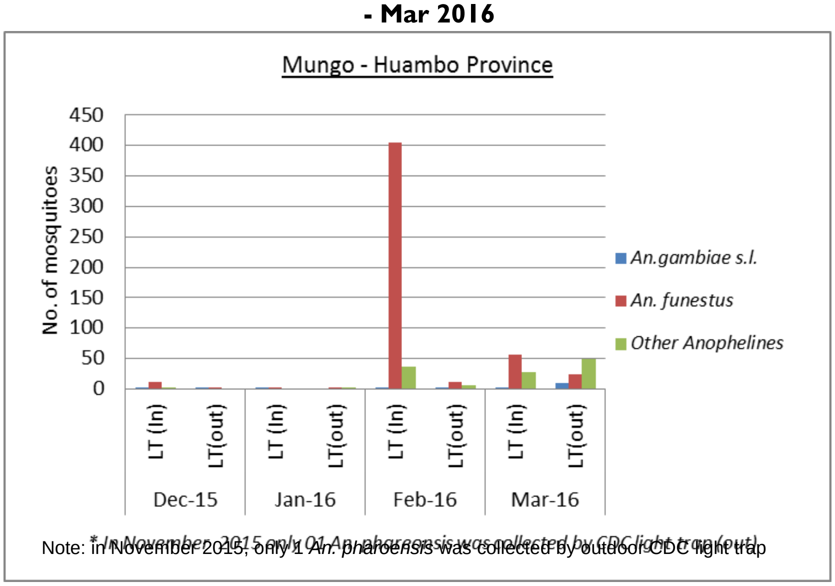
6.2.1 CDC Light Trap Collections

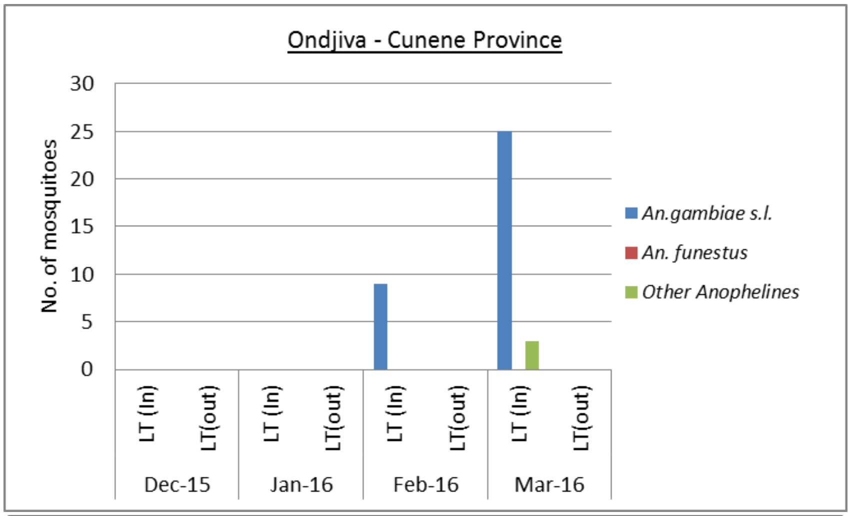
In Cunene, *An. gambiae* s.l. was the most prevalent species, whereas no *An. funestus* were collected during the reporting period.

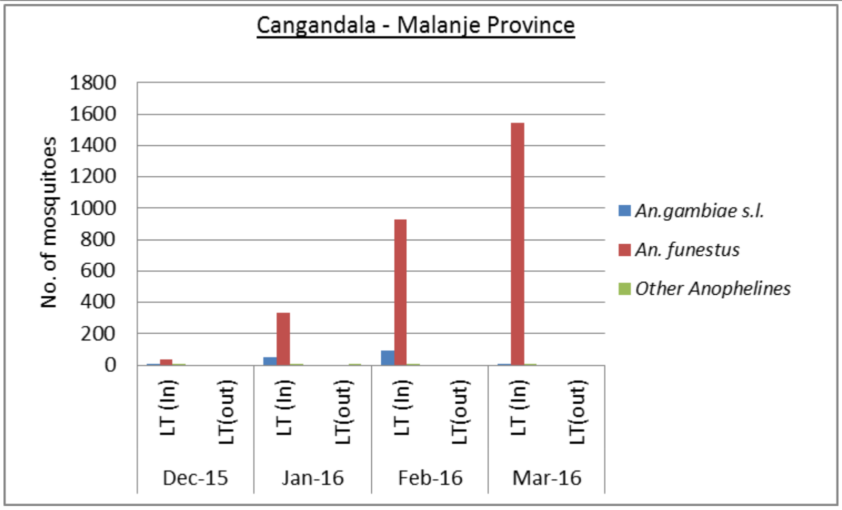
In Huambo, the number of *An. funestus* per indoor CDC light trap was notably high in February 2016. In March 2016, however, a much lower number was observed, while outdoor traps resulted in more *An. gambiae* s.l. and *An. funestus*. It was noted that a high number of other *Anopheline* species were collected from outdoor traps in March 2016.

In Malanje, the dominant species was *An. funestus*. Collection of this species markedly increased over the monthly visits during this reporting period.

Figure 3: Total Number of *Anophelines* Collected by CDC Light Traps by Province by Month, Nov 2015 - Mar 2016





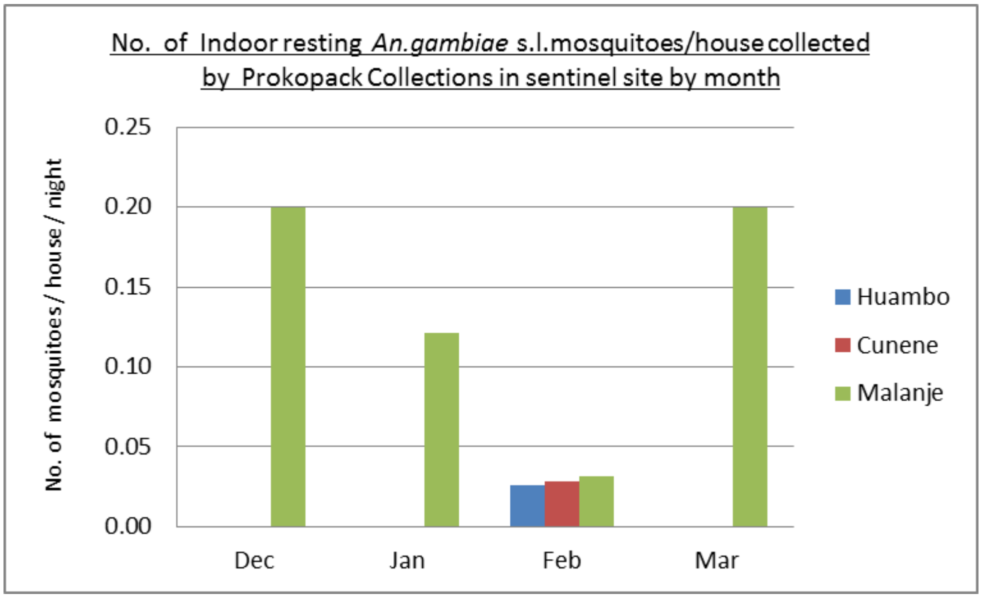


6.2.2 PROKOPACK ASPIRATOR COLLECTIONS

A total of 200 *Anopheles* mosquitoes were collected using Prokopack aspirators during this reporting period, where 187 (93.5%) were from Malanje and 13 (6.5%) were from Huambo. None were collected using this method in Cunene site, and none were collected using this method until December 2015. A higher percentage of *An. funestus* were observed in both sites over total collections (93%, Huambo; 97%, Malanje).

During the reporting period, Prokopack collections showed that the number of indoor resting *An. funestus* ranged from 0.20 to 2.44 per house in data collected from Malanje (Figure 4). Further, the number of blood-fed *An. funestus* ranged from 0.25 to 2.31 per human host for the same period in Malanje (Figure 5). This demonstrates higher indoor resting densities of blood-fed *An. funestus* in Malanje when compared with *An. gambiae* s.l. and other sites.

Figure 4: Number of Indoor-Resting *Anophelines* per House per Night by Month and Province, Dec 2015 - Mar 2016



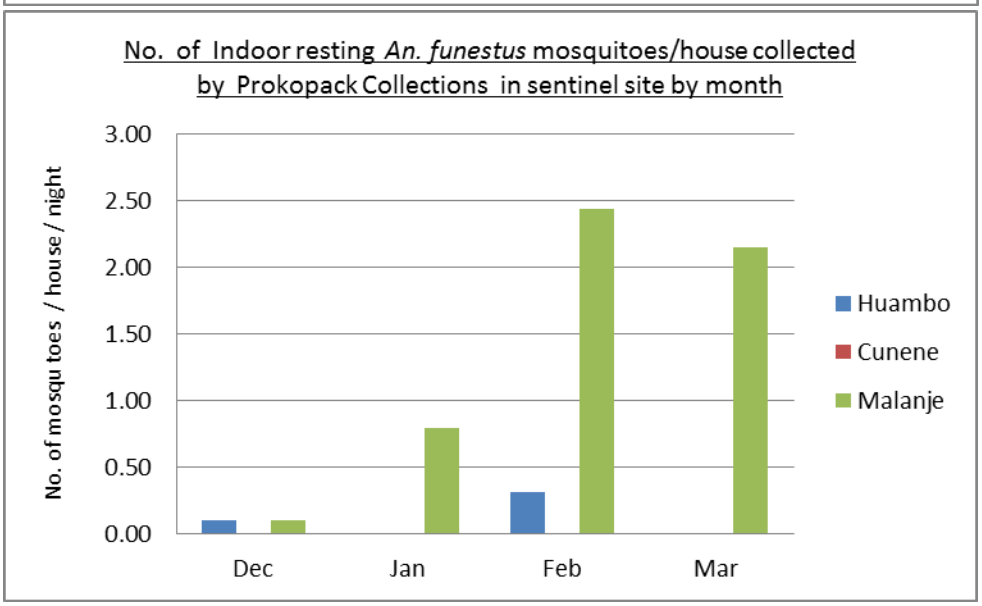
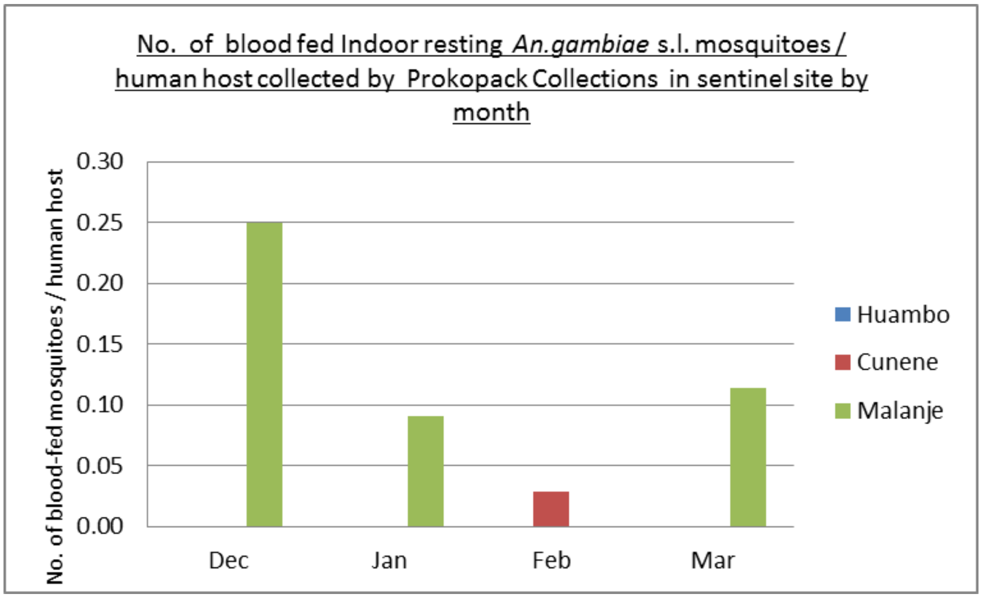
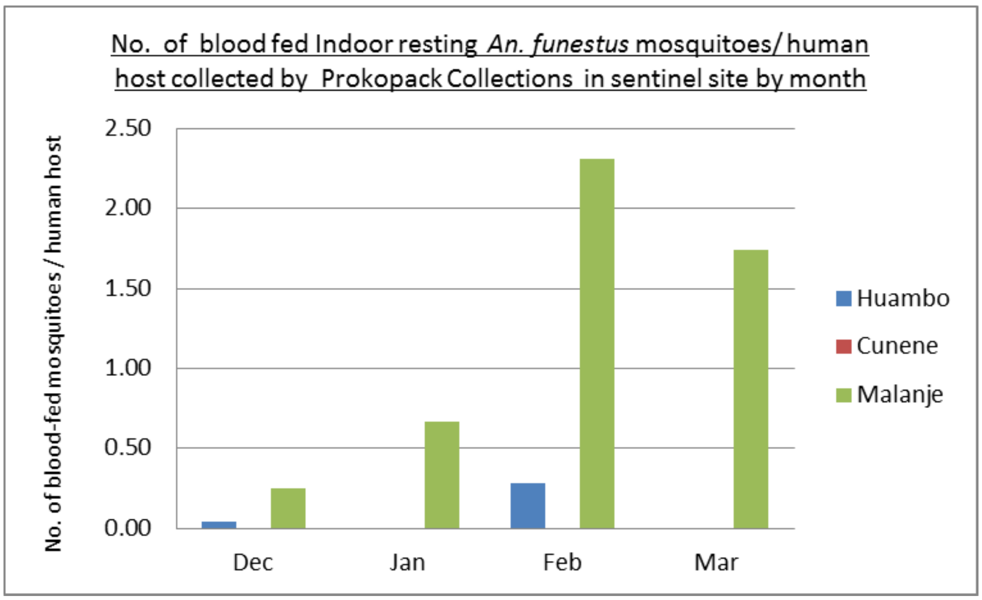


Figure 5: Number of Blood-fed, Indoor-Resting *Anopheles* Vectors per Human Host per Night by Month and Province, Dec 2015 - Mar 2016





6.2.3 Pyrethrum Spray Catch (PSC) Collections

Out of the 1,086 *An. funestus* collected from PSC collection methods, 1,069 (98.4%) were collected in Malanje, while the remaining 17 (1.6%) came from Huambo. None were collected from Cunene using this method, and none were collected using this method until December 2015. All 27 *An. gambiae* s.l. were collected in Malanje. Over 90% of these mosquitoes were blood-fed, demonstrating possible exophilic behavior in both species in Malanje and in *An. funestus* in Huambo.

TABLE 7: SPECIES COMPOSITION OF *ANOPHELES* MOSQUITOES COLLECTED USING PSC, WITH ABDOMINAL STAGE, NOV 2015 – MAR 2016

	Ondjiva (Cunene)					Mungo (Huambo)					Cangandala (Malanje)				
	U	F	H	G	**Total**	U	F	H	G	**Total**	U	F	H	G	**Total**
An. gambiae s.l.	0	0	0	0	**0**	0	0	0	0	**0**	1	25	0	1	**27**

An. funestus	0	0	0	0	**0**	1	16	0	0	**17**	58	987	0	0	**1,069**

Based on the PSC collections, the number of indoor resting *An. funestus* ranged from 0.20 to 59.60 per house in Malanje site (Figure 6) which also shows steady increase over time. But with *An. gambiae* s.l., numbers are much lower (1.10 – 0.18), showing a decrease over time.

The same trends can be seen in the Malanje area for the number of blood-fed *Anophelines.* These values ranged from 0.11 to 20.57 per human host for *An. funestus* and 0.47 to 0.18 for *An. gambiae* s.l. (Figure 7). These are very high indoor resting densities of blood-fed *An. funestus* in Malanje when compared with other sites. This also favors the high anthropophagic and indoor-resting nature of the said species.

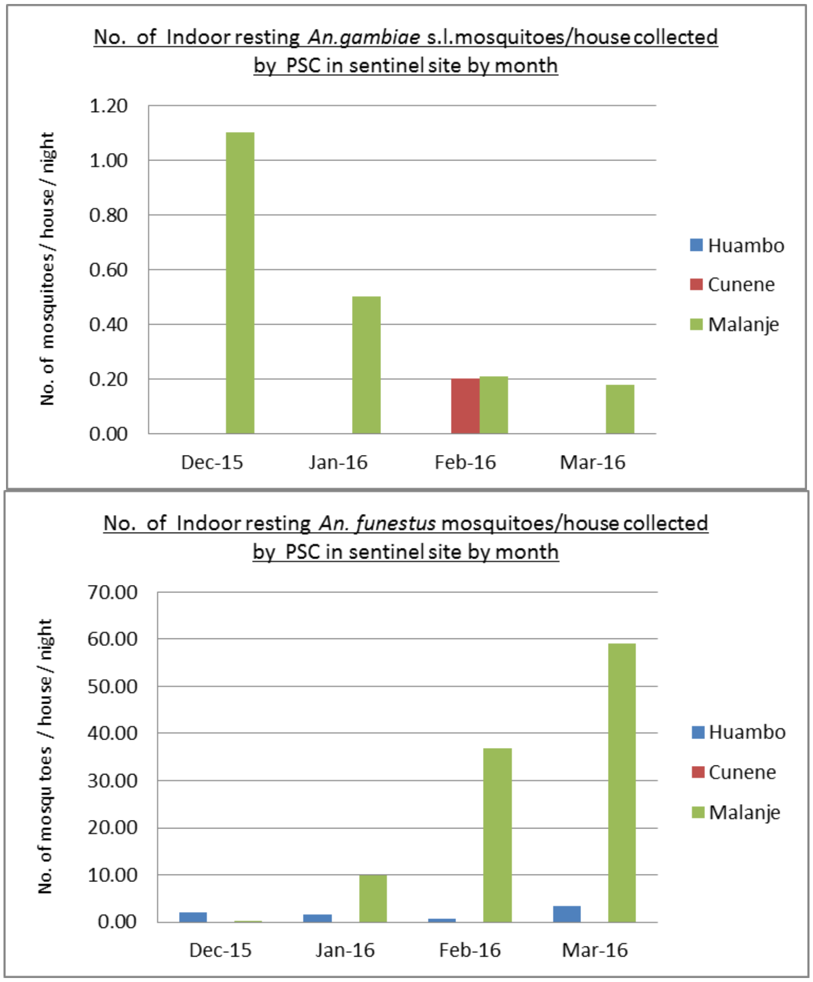


Figure 6: Number of Indoor-resting *Anophelines* per House per Night by Month and Province, Dec 2015 - Mar 2016

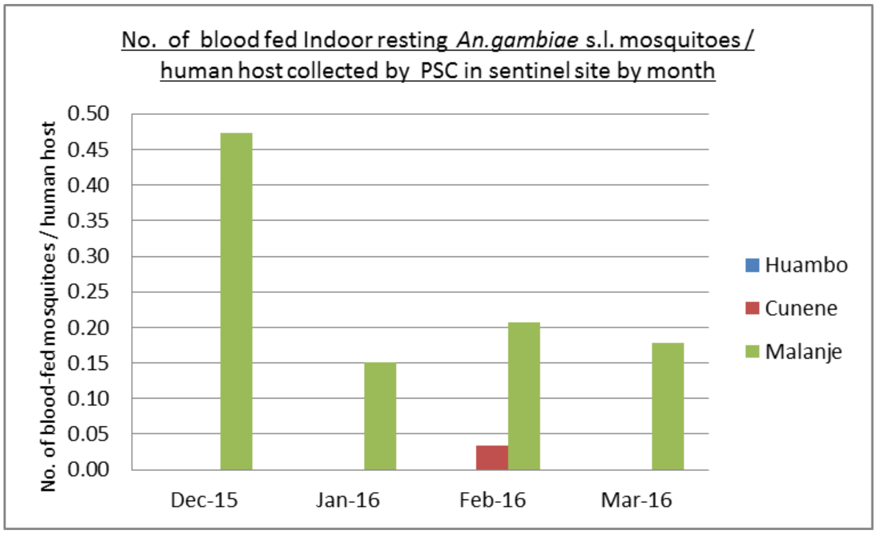
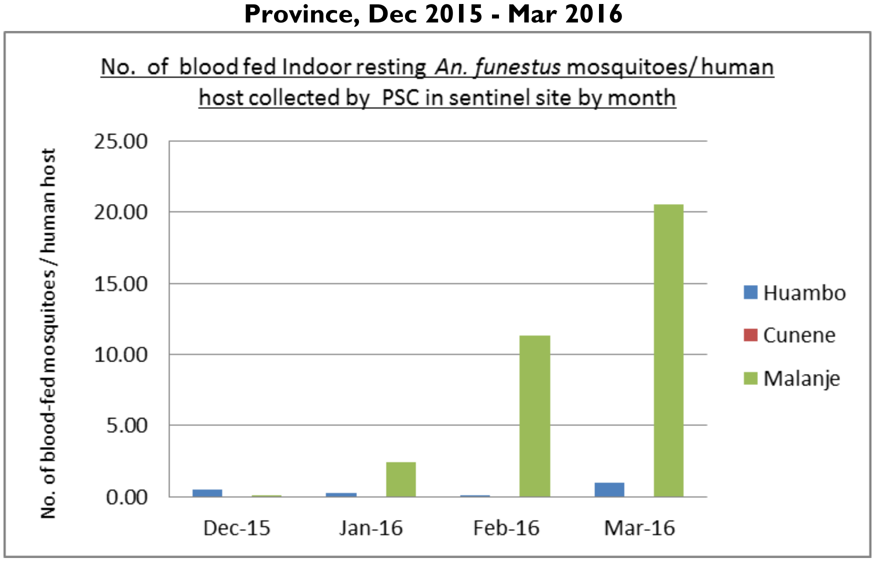


Figure 7: Number of Blood-fed, Indoor-resting *Anophelines* per House per Night by Month and Province, Dec 2015 - Mar 2016



7. DISCUSSION

Of the four mosquito-sampling methods conducted, indoor CDC light traps were the most efficient for collecting female *An. gambiae* s.l. and *An. funestus* mosquitoes, followed by the PSC, and finally the Prokopack aspirator. PSC and Prokopack collect mainly endophilic mosquitoes and are less sensitive where mosquito populations are more exophagic and exophilic. This may be the case in Cunene. Besides mosquito collection method and mosquito species, samples collected also differed by season and sentinel site.

The high number of *An. funestus* in the Malanje region, along with the increase from December 2015 to March 2016 is highly related to the availability of breeding places. This is similarly the case in the Huambo region. With excessive rain, temporary water pools and some lowland marshy areas provide favorable breeding conditions for *An. funestus*. In contrast, the absence of *An. funestus* in Cunene may be related to non-availability of suitable breeding places in the dry climatic conditions. AIRS Angola also suspects that *An. arabiensis* is the prevalent species in this area which can only be confirmed by molecular identification.

This variability clearly shows that presence, seasonality and species distribution vary with the different climatic zones. High anthropophagic and indoor resting behavior of *An. funestus* may be the major contributory factor for high malaria transmission in Huambo and Malanje. Collection results show high *An. funestus* in the northern Malanje area while their numbers gradually diminish towards the southern Cunene area. Malanje, being in the hyper endemic region in the country, has ecology and climatic conditions that favor mosquito breeding throughout the year.

An. funestus belongs to a group of nine morphologically similar species, which belongs to 2 subgroups (Funestus and Rivulorum), where identification of individual adults members need molecular analysis. In addition to *An. funestus*, the primary malaria vector in Africa, some other members of these groups have also shown their potential to transmit malaria. Hence, molecular identification of these samples is needed for further species confirmation.

No data is available for insecticide resistance of *An. funestus* in Angola. Most of the previous insecticide susceptibility tests were carried out using adults from larval collections morphologically identified as*An. gambiae* s.l, *An. coustani*, and a mix of *Anophelines* due to a lack of adequate number of mosquitoes of a single species. All mosquitoes tested during the last national susceptibility study were sent to the CDC in Atlanta for molecular analysis. Results from eight provinces (all except Huambo) are still pending. Results of the molecular analyses received so far indicate that no *An.funestus* and *An. gambiae* s.s. were present in Huambo; the majority of mosquitoes were *An. arabiensis* and *An. rufipes* as shown in Table 5.

Sporozoite ELISA and blood meal analyses on collected vector species should be carried out to know the transmission dynamics of malaria. In Huambo and Cunene, vector seasonality may vary with the seasonal changes of the climatic conditions and it is strongly suggested that entomological surveillance be carried out throughout the year with suitable frequency.

Lack of reliable and efficiently-collected malaria epidemiology data also prevent understanding the transmission dynamics of the country. Hence, incorporating an enhanced epidemiology surveillance component to this project would help to properly understand the seasonal malaria situation, spatial distribution, and effective vector control measures.

8. Challenges and Lessons Learned

8.1 Challenges

- Lack of trained entomology technicians/assistants in the provinces
- Conducting routine entomological work with seasonally hired personnel
- Long travel time/distances from Huambo to sentinel provinces
- Lack of susceptible mosquito colony for insectary functioning
- Low involvement from NMCP/DPS staff
- Lack of accurate malaria epidemiology data in provinces

8.2 Lessons Learned

- AIRS Angola continues discussions with NMCP and DPS officials on getting local MOH staff assistance on entomological monitoring to reduce the employment of seasonal workers, ultimately making the work more sustainable.
- AIRS Angola would appreciate if the Angolan government authorities would secure permission to send field-collected mosquitoes outside the country and bring susceptible mosquito colony eggs into the country.
- Suitable facilities for molecular and biochemical analyses of collected mosquito specimens are not available in Angola. Until these facilities are available in-country, send these specimens to a facility outside the country.

9. RECOMMENDATIONS

- Build entomology capacity in provinces
- DPS takes over the maintenance of insectary
- Develop processes to absorb project-trained entomological technicians into provincial health system
- Develop malaria risk map for Angola
- Continuous monitoring of vector susceptibility statuses
- Develop mechanism to monitor LLIN efficacy
- Change the sentinel site from Cunene province to another highly endemic and PMI-prioritized region