
**PMI | Africa IRS (AIRS) Project**

Indoor Residual Spraying (IRS 2) Task Order Six

# SENEGAL 2016 ENTOMOLOGICAL LABORATORY SUPPLEMENT

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# SENEGAL 2016 ENTOMOLOGICAL LABORATORY SUPPLEMENT

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# ACRONYMS

| | |
|---|---|
| **AIRS** | Africa Indoor Residual Spraying Project |
| **CDC** | Centers for Disease Control and Prevention |
| **CSP** | Circumsporozoite |
| **CSPI** | Circumsporozoite protein index |
| **EIR** | Entomological Inoculation Rate |
| **ELISA** | Enzyme-Linked Immuno-Sorbent Assay |
| **FST** | Faculty of Sciences and Technology |
| **HBR** | Human Biting Rate |
| **HLC** | Human Landing Catch |
| **IRD** | Indoor Resting Densities |
| **IRS** | Indoor Residual Spraying |
| **KDR** | Knock Down Resistant |
| **LEVP** | Laboratory of Vector and Parasite Ecology |
| **NMCP** | National Malaria Control Program |
| **PCR** | Polymerase Chain Reaction |
| **PMI** | President's Malaria Initiative |
| **PSC** | Pyrethrum Spray Catch |
| **UCAD** | University of Cheikh Anta Diop |
| **USAID** | United States Agency for International Development |
| **VGSC** | Voltage Gated Sodium Channel |
| **WHO** | World Health Organization |

# EXECUTIVE SUMMARY

Laboratory data for samples the team collected in 2016 showed that *An. arabiensis* was the predominant malaria vector found across most of Senegal, with exceptions in the south of the country in Kedougou and Velingara. In those areas, *An. gambiae* s.s. was most common during the rainy season. In general, the anthropophily index was low for *An. arabiensis*, with many having taken blood-meals from horses and cattle. In Kedougou (0.97) and in Velingara (0.93), the anthropophily index was high, with most *An. gambiae* having fed on humans. Sporozoite rates were very low in indoor residual spraying (IRS) districts and areas where *An. arabiensis* were dominant. In southern sites where *An. gambiae* were common, sporozoite rates were 0.6% in Kedougou and 1.1% in Velingara.

# 1. METHODS

## 1.1 MOSQUITO SAMPLING PERIOD & IRS TIMING

IRS was conducted in the villages of health posts where residual malaria transmission has been reported with malaria incidence greater than 15 confirmed cases per 1000 inhabitants. The teams sprayed pirimiphos-methyl (Actellic CS 300) at 1g/$m^2$ in the districts of Koungheul, Koumpentoum, Malem Hodar, and Nioro in July and early August 2016. Rainfall in IRS districts of Senegal is usually between June and October, with the dry season lasting 7 months, between November and May. *An. gambiae* and *An. funestus* were sampled in IRS and unsprayed sentinel sites from August 2016 to December 2016. Molecular analysis of these samples is included in this report.

## 1.2 LABORATORY MOLECULAR ANALYSES

**Species identification**

The molecular identification of *An. gambiae* sibling species was performed on a subsample of living and dead female mosquitoes from susceptibility tests, human landing catch (HLC) and pyrethrum spray catch (PSC). The molecular identification was performed by polymerase chain reaction (PCR), following the protocol of Wilkins et al. (2006). The number of specimens tested per site is presented in Annex 1A.

**Blood meal source**

The team used the direct enzyme-linked immuno-sorbent assay (ELISA) method described by Beier et al. (1986) to determine the origin of blood meals in *An. gambiae* s.l. collected by PSC. The team determined the anthropophily rate by the ratio of the number of blood meals taken from humans over the number of meals identified. The same ratio was used for the different animal hosts tested.

**Sporozoite rate**

To determine the sporozoite infection rate of *An. gambiae* s.l. collected by HLC, the team used the circumsporozoite (CSP) ELISA described by Burkot et al., (1984) and slightly modified by Wirtz et al., (1987). Infection rates were determined as a percentage by the ratio of the specimens carrying the *Plasmodium falciparum* CSP antigen over the total number of specimens tested by ELISA.

**Voltage gated sodium channel (VGSC) resistance mutations**

The Vgsc-1014F (knock down resistance (KDR) West) and 1014S (KDR East) mutations were respectively identified according to the protocols of Martinez-Torres et al. (1998) and Ranson et al. (2000).

# 2. RESULTS

## SUPPLEMENTARY LABORATORY DATA FOR 2016 IRS CAMPAIGN

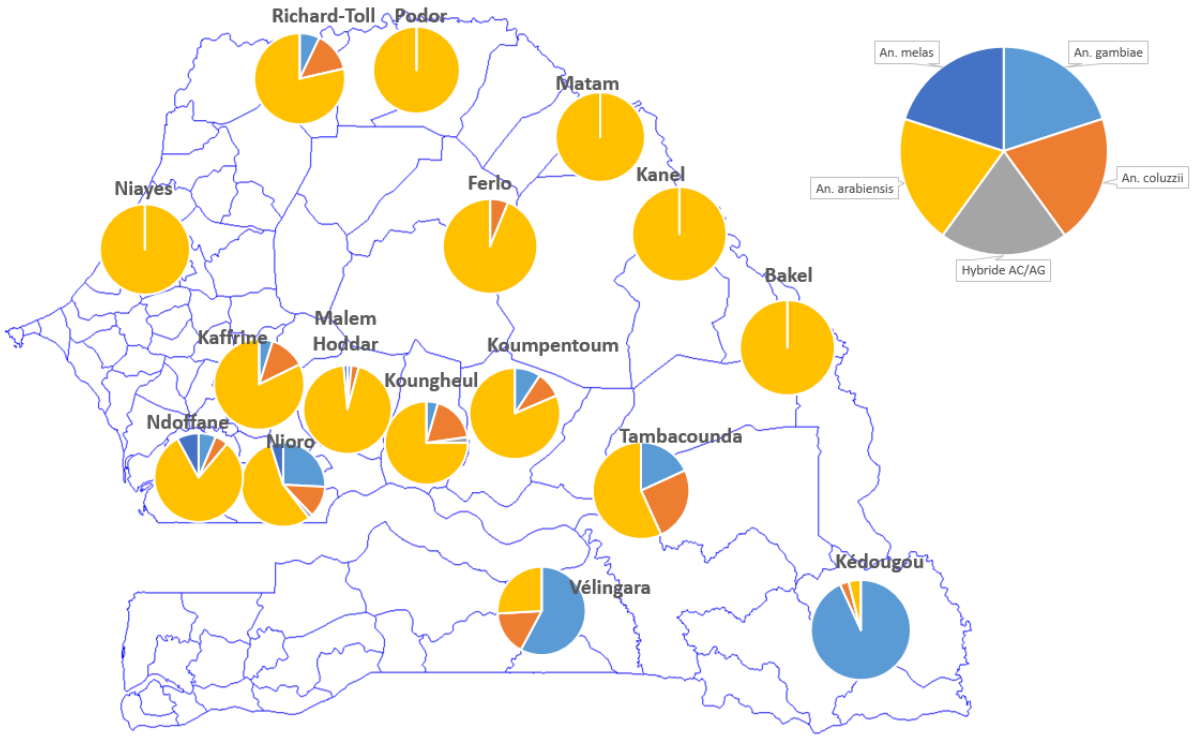
### 2.1 *ANOPHELES GAMBIAE* SIBLING SPECIES COMPOSITION

Figure 1 shows the percentage species composition by location according to PCR results. In the southern (Velingara) and south-east (Kedougou) districts of the country, a large predominance of *An. gambiae* was noted from specimens collected during the rainy season, and a higher frequency of *An. arabiensis* was recorded in the dry season. Everywhere else, *An. arabiensis* remained the predominant species of the *An. gambiae* complex in all seasons (See Annex 1).

The presence of *An. coluzzi* was noted in all districts (except for Niayes due to very low numbers). The frequency was higher in the southern half of the country, notably in the districts of Nioro, Kédougou, Tambacounda, and Vélingara (Figure 1).

Species PCR was not done for *An. funestus* s.l. found only in Nioro and Ndofane. In Senegal, PCR in previous years showed the presence of only *An. funestus* s.s.

**Figure 1: Proportion of the different species of the *An. gambiae* complex in the districts**




Annex 1 shows detailed results of identification of *An. gambiae* s.l. captured in the sprayed districts and their internal and external controls during the dry and rainy seasons. With a large predominance of *An. arabiensis* in both sprayed sites and untreated controls, insecticide treatment did not appear to have an impact on the composition of the *An. gambiae* complex.

For laboratory identified *An. gambiae* s.l. from susceptibly tests the proportion dead in susceptibility tests was 84% *An. arabiensis*, 2% *An. coluzzii* and 14% *An. gambiae*. A similar proportion was found for mosquitoes that survived exposure; 79% *An. arabiensis*, 2% *An. coluzzii* and 18% *An. gambiae*.

## 2.2 BLOOD MEAL ANALYSIS

### 2.2.1 IRS DISTRICTS AND PAIRED UNSPRAYED CONTROLS

Figures 2-6 show the results of blood meal source identification from endophilic *An. gambiae* s.l. and *An. funestus* s.l. females collected by PSC in sprayed districts. More detailed data are in Annex 2. In all districts where IRS was conducted, the proportion of malaria vectors that blood-fed on humans was low. The anthropophily index was 0.41 in Koungheul, 0.30 in Koumpentoum, 0.27 in Malem Hodar, and 0.24 in Nioro for *An. gambiae* s.l., and 0.27 in Nioro for *An. funestus* s.l. The blood feeding sources were similar for sprayed areas and unsprayed controls (see Annex 2). The most common blood meal source was horses in all sites, with cattle also being a common animal blood meal source.

**Figure 2. *An. gambiae* s.l. blood meals from Koungheul collected by PSC (n=263).**

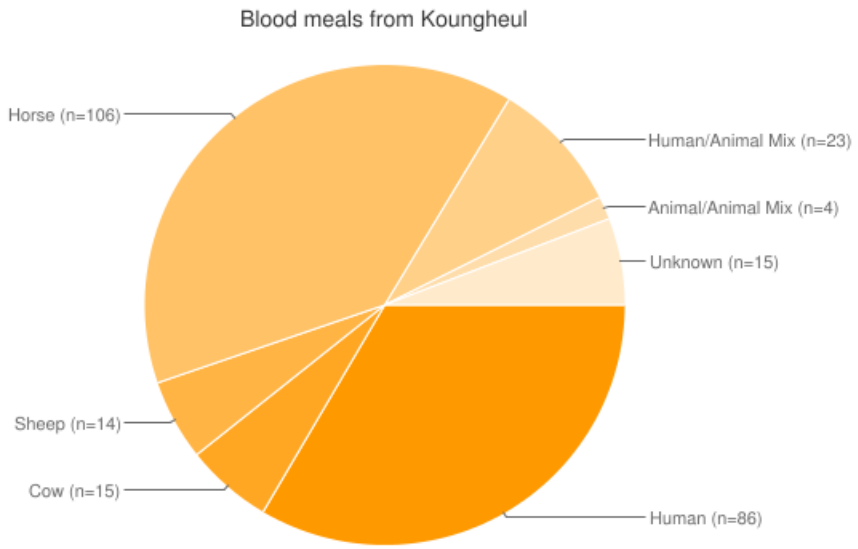



**Figure 3. *An. gambiae* s.l. blood meals from Koumpentoum collected by PSC (n=366).**

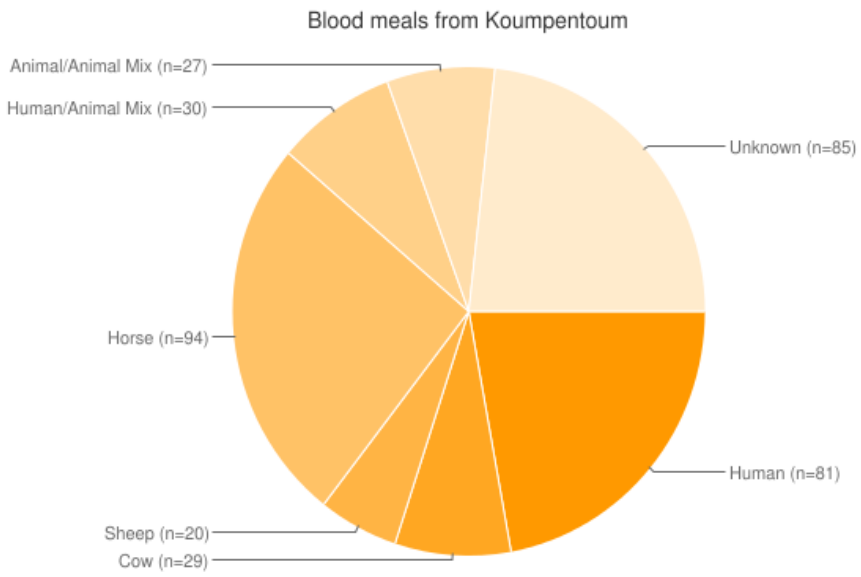



**Figure 4. *An. gambiae* s.l. blood meals from Malem Hodar collected by PSC (n=339).**

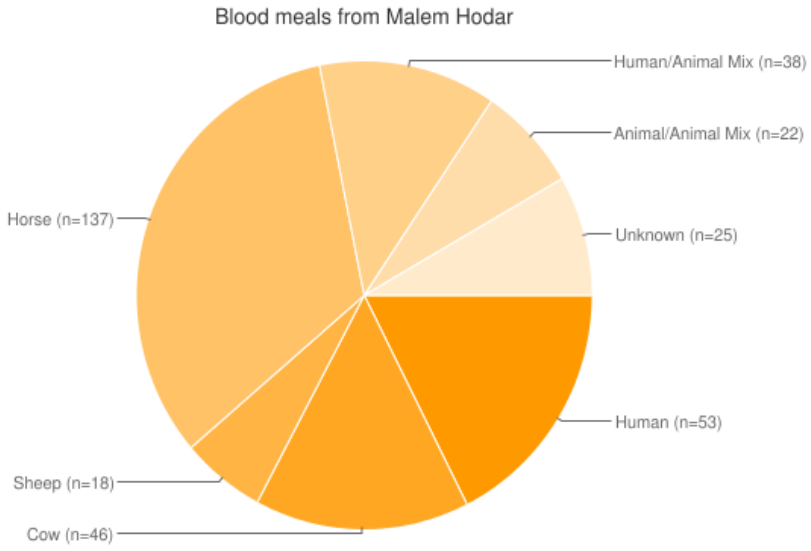



**Figure 5. *An. gambiae* s.l. blood meals from Nioro collected by PSC (n=506).**

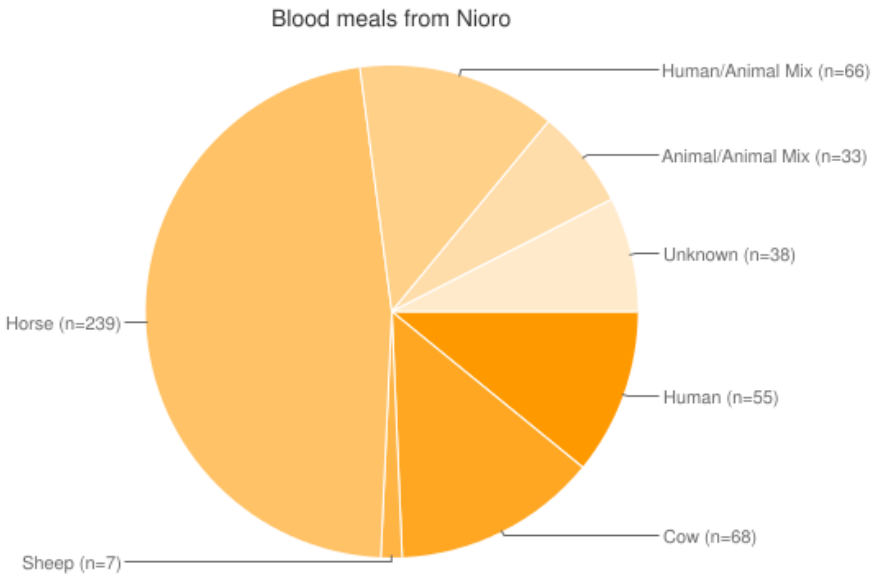
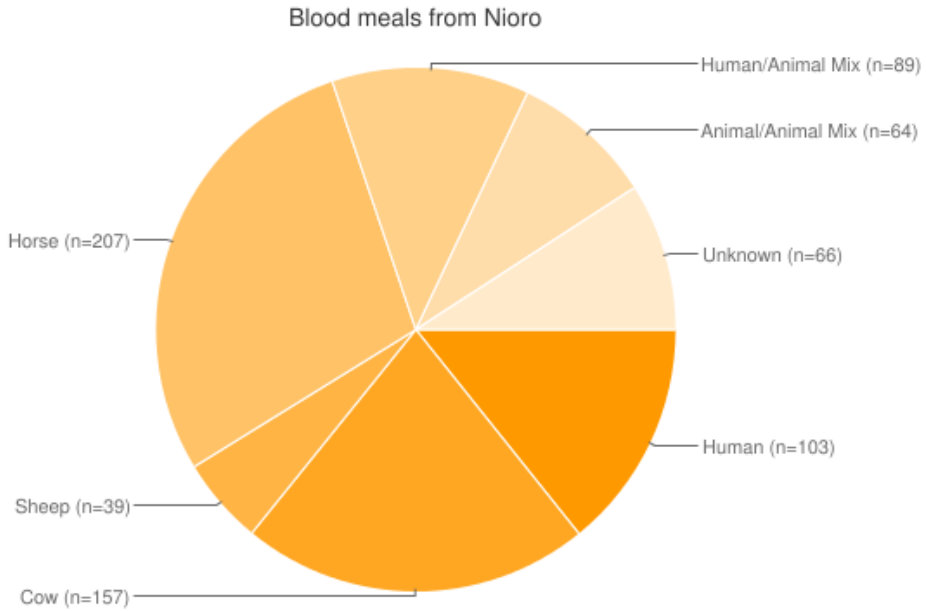



**Figure 6. *An. funestus* s.l. blood meals from Nioro collected by PSC (n=725).**



### 2.2.2 UNSPRAYED DISTRICTS

In the southern areas of Velingara and Kedougou, the anthropophily index of *An. gambiae* s.l. was high at 0.93 and 0.97, respectively. In northern sites of Richard Toll and Niayes, the anthropophily index was low and similar to the IRS districts.

**TABLE 1: BLOOD MEAL ANALYSIS OF *ANOPHELES* COLLECTED BY PSC IN UNSPRAYED DISTRICTS.**

| Species | Districts | N | T | U | Single source | | | | | MIX | MIX | IA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | H | C | S | Ch | Ho | H/A | A/A | |
| *An. gambiae* s.l. | Velingara | 46 | 46 | 3 | 40 | 0 | 2 | 0 | 1 | 0 | 0 | 0.93 |
| | Niayes | 22 | 22 | 3 | 10 | 2 | 0 | 0 | 7 | 0 | 0 | 0.53 |
| | Richard Toll | 151 | 54 | 7 | 11 | 10 | 5 | 0 | 16 | 4 | 1 | 0.32 |
| | Kédougou | 97 | 95 | 6 | 85 | 3 | 0 | 0 | 0 | 1 | 0 | 0.97 |
| *An.funestus* s.l. | Velingara | 9 | 9 | 3 | 0 | 5 | 0 | 0 | 0 | 1 | 0 | 0.17 |
| | Niayes | 4 | 3 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0.33 |
| | Richard Toll | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *An. pharoensis* | Richard Toll | 30 | 11 | 2 | 3 | 2 | 0 | 0 | 4 | 0 | 0 | 0.33 |

N= TOTAL BLOOD-FED, T= NUMBER TESTED, U= UNKNOWN, H= HUMAN, C= COW, S= SHEEP, CH= CHICKEN, HO= HORSE, H/A= MIXED HUMAN/ANIMAL, A/A = MIXED ANIMAL/ANIMAL

IA = INDEX OF ANTHROPOPHILY

## 2.3 VECTOR SPOROZOITE RATES

**IRS districts**

Table 2 presents the results of sporozoite ELISA for *Anopheles* collected by HLC in the sprayed sentinel sites and their paired untreated controls (internal and external). Light trap catches (CDC / LT) were only conducted in Nioro for comparison with HLC. In general, the sporozoite rate was low regardless of spray status, with only 12 sporozoite positives detected from 2,760 tested (0.43%). Infected *An. gambiae* s.l. in IRS areas were only detected in Malem Hodar and Nioro districts, where sporozoite rates were 4.5% (2/44) and 1.2% (1/83) respectively.

**Unsprayed districts**

For unsprayed districts, only *An. gambiae s.*l. were found to be sporozoite positive, with infection rates of 1.10% (4/362) and 0.6% (8/1329) in Velingara and Kedougou, respectively (Table 3).

## 2.4 ENTOMOLOGICAL INOCULATION RATE (EIR)

**IRS districts**

The number of *Anopheles* collected in sprayed districts by HLC was low; therefore, an accurate estimate of sporozoite rates and entomological inoculation rate (EIR) could not be determined. In general, the biting rate and sporozoite rate were very low at all sites, with negligible nightly EIR. See Annex 3 for details.

**Unsprayed districts**

The EIR between August and December was approximately 0.09 infectious bites per night in Velingara and 0.28 infectious bites in Kédougou. (Table 2)

**TABLE 2: EIR OF *ANOPHELES* GAMBIAE COLLECTED BY PSC IN UNSPRAYED DISTRICTS (AUGUST TO DECEMBER 2016).**

| District | Indoor | | | Outdoor | | | Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | AR (b/h/n) | CSPI | EIR (ib/h/n) | AR (b/h/n) | CSPI | EIR (ib/h/n) | AR (b/h/n) | CSPI | EIR (ib/h/n) |
| **Vélingara** | **6.75** | **0.013** | **0.09** | **8.58** | **0.011** | **0.09** | **7.67** | **0.012** | **0.09** |
| **Niayes** | 0.03 | 0 | **0.00** | 0.06 | 0 | **0.00** | 0.04 | **0** | **0.00** |
| **Richard Toll** | 0.88 | 0 | **0.00** | 0.88 | 0 | **0.00** | 0.88 | **0** | **0.00** |
| **Kédougou** | **50.25** | **0.007** | **0.35** | **44.08** | **0.004** | **0.18** | **47.17** | **0.006** | **0.28** |

**TABLE 3: SPOROZOITE RATE OF *AN. GAMBIAE* S.L. AND *AN. FUNESTUS* ACCORDING COLLECTING METHOD IN SPRAYED DISTRICTS AUGUST 2016 – DECEMBER 2016**

| | Districts | Methods | Sprayed | | | | Internal control | | | | External control | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Collected | Tested | Positives | CSPI | Collected | Tested | Positives | CSPI | Collected | Tested | Positives | CSPI |
| *An. gambiae* s.l | Koungheul | HLC | 113 | 119 | 0 | 0.000 | 38 | 38 | 0 | 0.000 | 132 | 38 | 0 | 0.000 |
| | Malem Hodar | HLC | 45 | 44 | 2 | 0.045 | 66 | 68 | 0 | 0.000 | 144 | 68 | 0 | 0.000 |
| | Koumpentoum | HLC | 37 | 34 | 0 | 0.000 | 12 | 12 | 0 | 0.000 | 467 | 12 | 4 | 0.333 |
| | Nioro | HLC& CDC | 118 | 74 | 1 | 0.014 | 211 | 146 | 2 | 0.014 | 176 | 141 | 2 | 0.014 |
| *An. funestus* | Nioro | HLC& CDC | 635 | 415 | 0 | 0.000 | 450 | 309 | 0 | 0.000 | 595 | 604 | 1 | 0.002 |

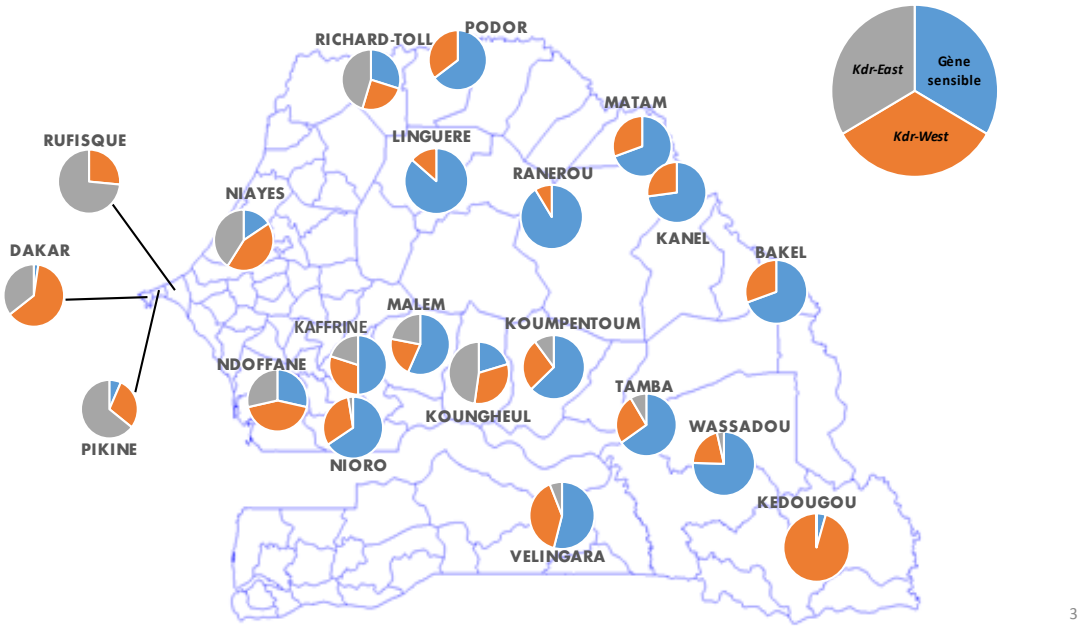
**TABLE 4: SPOROZOITE RATE OF FEMALES COLLECTED BY HLC IN UNSPRAYED DISTRICTS AUGUST 2016 – DECEMBER 2016**

| Districts | *An. gambiae* s.l | | | *An. pharoensis* | | |
|---|---|---|---|---|---|---|
| | Tested | Positives | CSPI (%) | Tested | Positives | CSPI (%) |
| Velingara | 362 | 4 | 1.10 | 2 | 0 | 0 |
| Niayes | 3 | 0 | 0 | - | - | - |
| Richard Toll | 13 | 0 | 0 | 112 | 0 | 0 |
| Kedougou | 1329 | 8 | 0.6 | 0 | 0 | 0 |
| Total | **1707** | **12** | **0.007** | **114** | **0** | **0** |

## 2.5 VGSC 1014F AND 1014S FREQUENCY

Figure 7 shows the allelic frequency of mutations *vgsc*-1014F (*kdr-w*) and *vgsc*-1014S (*kdr-e*) in the different districts.

**Figure 7: Nationwide allele frequencies of VGSC mutations.**




Both the VGSC 1014S and 1014F mutations were present in Senegal, with different frequencies in different locations. The highest frequencies of VGSC mutations were in Kedougou, where VGSC-1014F was found at close to fixation. In the Dakar suburbs, few wild type alleles were detected, but both VGSC 1014F and 1014S were present. In the departments of Pikine and Rufisque (including Bargny), the frequencies of the VGSC-1014S mutation were higher than that of the VGSC-1014F, which predominates in the city of Dakar. In Niayes, both mutations were present at relatively similar frequencies.

In IRS districts (Koungheul, Koumpentoum, Malem Hodar, and Nioro), both mutations were present at varying frequency. Wild type alleles remained at a relatively high frequency in Koumpentoum, Malem Hodar, and Nioro.

In the districts of the Senegal River Valley (Matam, Kanel and Bakel) and Ferlo (Ranérou and Linguère), only the VGSC-1014F mutation was detected. The allelic frequency ranged from 21% (Kanel) to 35% (Podor). In Ferlo, the allelic frequencies of the VGSC-1014F mutation were relatively low, especially in Ranérou district (9%). In Richard-Toll district, the VGSC-1014F and 1014S mutations were very common in F1 females exposed to insecticides (73%).

# 3. ANNEX

**ANNEX 1A: NUMBER OF SPECIMENS IDENTIFIED BY PCR AND DISTRIBUTION ACCORDING TO THE DIFFERENT SPECIES OF THE *AN. GAMBIAE* COMPLEX (AUGUST-DECEMBER 2016)**

| Districts | Total identified | Species | | | | |
|---|---|---|---|---|---|---|
| | | *A. arabiensis* | *An. coluzzii* | *An. gambiae* | *An. melas* | AC/AG |
| Koungheul | 44 (14) | 33 (14) | 8 | 2 | - | 1 |
| Koumpentoum | 43 (9) | 35 (9) | 4 | 4 | - | - |
| Malem Hoddar | 72 (50) | 68 (47) | 2 (1) | 1 (1) | 1 (1) | - |
| Nioro | 125 (46) | 69 (34) | 15 (2) | 33 (7) | 6 | 2 (1) |
| Kaffrine | 62 (29) | 51 (29) | 8 | 3 | - | - |
| Ndoffane | 63 (20) | 51 (16) | 3 | 4 (2) | 5 (2) | - |
| Niayes | 3 | 3 | - | - | - | - |
| Kédougou | 720(20) | 28 (13) | 20 | 671 (7) | 1 | |
| Tambacounda | 132 (41) | 75 (28) | 33 (5) | 24 (8) | - | - |
| Vélingara | 166 (13) | 43 (6) | 27 (2) | 96 (5) | - | - |
| Richard-Toll | 13 | 11 | 2 | 1 | - | - |
| Bakel | 47 (1) | 47 (1) | - | - | - | - |
| Matam | 5 | 5 | - | - | - | - |
| Podor | 38 (9) | 38 (9) | - | - | - | - |
| Linguere | 28 (4) | 26 (4) | 2 | - | - | - |
| Total | 1561 (256) | 583 (210) | 124 (10) | 839 (30) | 13 (3) | 3 (1) |

( ) = Dry season
AC/AG = hybrid *coluzzii/gambiae*

**ANNEX 1B: NUMBER OF SPECIMENS IDENTIFIED BY PCR AND DISTRIBUTION OF THE DIFFERENT SPECIES OF THE *AN. GAMBIAE* COMPLEX ACCORDING TO THE SPRAYED VILLAGES AND THEIR UNSPRAYED INTERNAL AND EXTERNAL CONTROLS (AUGUST-DECEMBER 2016)**

| Method | District | | Number tested (Total) | Did not amplify | *An. gambiae* | *An. coluzzii* | Hybrid *AC/AG* | *An. arabiensis* | *An. melas* |
|---|---|---|---|---|---|---|---|---|---|
| HLC | Malem Hodar | Hot Spots | 20 (45) | 0 | 0 | 1 | 0 | 19 | 0 |
| | | Internal C. | 29 (71) | 0 | 1 | 1 | 0 | 26 | 1 |
| | | External C. | 45 (150) | 3 | 3 | 3 | 0 | 36 | 0 |
| | Koungheul | Hot Spots | 38 (125) | 4 | 1 | 6 | 1 | 26 | 0 |
| | | Internal C. | 11 (38) | 1 | 1 | 2 | 0 | 7 | 0 |
| | | External C. | 44 (132) | 1 | 0 | 5 | 0 | 38 | 0 |
| | Koumpentoum | Hot Spots | 34 (37) | 1 | 3 | 4 | 0 | 26 | 0 |
| | | Internal C. | 12 (12) | 2 | 1 | 0 | 0 | 9 | 0 |
| | | External C. | 143 (467) | 11 | 24 | 33 | 0 | 75 | 0 |
| | Nioro | Hot Spots | 42 (131) | 1 | 15 | 6 | 1 | 19 | 0 |
| | | Internal C. | 65 (217) | 1 | 13 | 7 | 1 | 41 | 2 |
| | | External C. | 55 (179) | 6 | 3 | 1 | 0 | 41 | 4 |
| CDC-LT | | Hot Spots | 3 (3) | 0 | 2 | 0 | 0 | 0 | 1 |
| | | Internal C. | 19 (64) | 3 | 2 | 2 | 0 | 9 | 3 |
| | | External C. | 16 (36) | 2 | 1 | 2 | 0 | 10 | 1 |
| **Total** | | | **576 (1707)** | **36** | **70** | **73** | **3** | **382** | **12** |

**ANNEX 2: ORIGIN OF BLOOD MEAL AND ANTHROPOPHILIC RATE OF *AN. GAMBIAE* S.L. IN SPRAYED SENTINEL SITES AND THEIR INTERNAL AND EXTERNAL CONTROLS (AUGUST TO DECEMBER 2016).**

| Species | Districts | Localities | N | T | F | Monospecific | | | | | MIX H/A | MIX A/A | IA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | H | B | S | C | Ho | | | |
| *An. gambiae* s.l. | Koungheul | Hot spot | 68 | 64 | 9 | 11 | 9 | 3 | 0 | 31 | 1 | 0 | 0.218 |
| | | Internal control | 42 | 42 | 4 | 8 | 5 | 2 | 0 | 20 | 2 | 1 | 0.263 |
| | | External control | 213 | 157 | 2 | 67 | 1 | 9 | 0 | 55 | 20 | 3 | 0.561 |
| | Koumpentoum | Hot spot | 63 | 36 | 1 | 12 | 6 | 1 | 0 | 12 | 3 | 1 | 0.429 |
| | | Internal control | 23 | 13 | 0 | 4 | 0 | 1 | 0 | 7 | 1 | 0 | 0.385 |
| | | External control | 443 | 316 | 83 | 65 | 23 | 18 | 0 | 75 | 26 | 26 | 0.391 |
| | Malem Hodar | Hot spot | 94 | 90 | 7 | 16 | 14 | 4 | 0 | 36 | 9 | 4 | 0.301 |
| | | Internal control | 75 | 71 | 5 | 14 | 19 | 4 | 0 | 22 | 5 | 2 | 0.287 |
| | | External control | 209 | 177 | 13 | 22 | 14 | 10 | 0 | 79 | 24 | 15 | 0.280 |
| | Nioro | Hot spot | 150 | 90 | 3 | 5 | 8 | 0 | 0 | 57 | 8 | 9 | 0.149 |
| | | Internal control | 405 | 265 | 17 | 26 | 28 | 4 | 0 | 123 | 54 | 13 | 0.322 |
| | | External control | 144 | 63 | 2 | 7 | 21 | 0 | 0 | 25 | 0 | 1 | 0.114 |
| *An. funestus* s.l. | | Hot spot | 134 | 92 | 7 | 14 | 8 | 2 | 0 | 38 | 18 | 5 | 0.376 |
| | | Internal control | 266 | 119 | 8 | 9 | 41 | 5 | 0 | 28 | 16 | 12 | 0.225 |
| | | External control | 284 | 106 | 11 | 14 | 27 | 5 | 0 | 41 | 3 | 5 | 0.178 |

N= Total blood-fed, T= tested, F= Failed to identify host, H= Human, B= Bovine, S= Sheep, C= Chicken, Ho= Horse, H/A= Human/Animal mix, A/A= Animal mix, IA = Index of anthropophily

**ANNEX 3A: ENTOMOLOGICAL INOCULATION RATE (IB/H/N) OF VECTORS COLLECTED BY HLC ACCORDING TO THE LOCALITY AND THE TIME IN IRS DISTRICTS (AUGUST2016-DECEMBER 2016)**

| Species | IRS Districts | Locality | Indoor | | | Outdoor | | |
|---|---|---|---|---|---|---|---|---|
| | | | AR (b/h/n) | CSPI | EIR (ib/h/n) | AR (b/h/n) | CSPI | EIR (ib/h/n) |
| *An. gambiae* s.l | Koungheul | Hot spot | 0.63 | 0 | 0 | 0.66 | 0 | 0 |
| | | Internal control | 0.21 | 0 | 0 | 0.17 | 0 | 0 |
| | | External control | 0.79 | 0 | 0 | 0.58 | 0 | 0 |
| | Koumpentoum | Hot spot | 0.20 | 0 | 0 | 0.17 | 0 | 0 |
| | | Internal control | 0.09 | 0 | 0 | 0.03 | 0 | 0 |
| | | External control | **1.73** | **0.008** | **0.014** | **2.59** | **0.017** | **0.044** |
| | Malem Hodar | Hot spot | **0.20** | **0.1** | **0.021** | 0.26 | 0 | 0 |
| | | Internal control | 0.36 | 0 | 0 | 0.37 | 0 | 0 |
| | | External control | 0.63 | 0 | 0 | 0.75 | 0 | 0 |
| | Nioro | Hot spot | **0.56** | **0.028** | **0.016** | 0.82 | 0 | 0 |
| | | Internal control | **1.32** | **0.027** | **0.036** | 1.38 | 0 | 0 |
| | | External control | **1.20** | **0.026** | **0.031** | 1.27 | 0 | 0 |
| *An. funestus* | Nioro | Hot spot | 3.28 | 0 | 0 | 3.72 | 0 | 0 |
| | | Internal control | 1.62 | 0 | 0 | 1.71 | 0 | 0 |
| | | External control | **6.30** | **0.002** | **0.013** | 5.41 | 0 | 0 |

**ANNEX4 : NUMBER OF MOSQUITOES AND ALLELIC FREQUENCY OF THE MUTATIONS L1014F (KDR-W) AND L1014S (KDR-E) IN *AN. GAMBIAE* S.L ACCORDING TO THE DISTRICTS (AUGUST -DECEMBER 2017)**

| | | | Genotypes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | KDR-w | | | Allelic frequency (%) | | KDR_e | | | Allelic frequency (%) | |
| Districts | N | SS | RwRw | RwRe | RwS | S | Rw | ReRe | ReRw | ReS | S | Re |
| **Sprayed (center)** | | | | | | | | | | | | |
| Koungheul | 44 | - | 1 | 25 | 1 | 20.45 | 31.81 | - | 25 | 17 | 20.45 | 47.73 |
| Koumpentoum | 58 | 25 | 2 | 6 | 21 | 62.93 | 26.72 | 2 | 6 | 2 | 62.93 | 10.34 |
| Malèm Hodar | 59 | 19 | - | 8 | 17 | 56.78 | 21.19 | 3 | 8 | 12 | 56.78 | 22.03 |
| Nioro | 57 | 23 | - | 5 | 26 | 65.79 | 31.58 | - | 5 | 3 | 65.79 | 2.63 |
| **Unsprayed** | | | | | | | | | | | | |
| Ndoffane | 51 | 7 | 1 | 27 | 15 | 28.43 | 43.14 | 1 | 27 | - | 28.43 | 28.43 |
| Kaffrine | 52 | 16 | 1 | 12 | 17 | 50 | 29.81 | 3 | 12 | 3 | 50 | 20.19 |
| Tambacounda | 52 | 20 | 2 | 2 | 21 | 65.38 | 25.96 | - | 2 | 7 | 65.38 | 8.65 |
| Wassadou | 56 | 34 | 5 | 1 | 12 | 75.45 | 20.91 | - | 1 | 3 | 75.45 | 3.64 |
| Kédougou | 55 | 1 | 51 | - | 3 | 4.55 | 95.45 | - | - | - | 4.55 | 0 |
| Vélingara | 49 | 15 | 6 | 5 | 22 | 54.08 | 39.80 | - | 5 | 1 | 54.08 | 6.12 |
| Niayes | 60 | 1 | 2 | 33 | 15 | 15.83 | 43.33 | 7 | 33 | 2 | 15.83 | 40.83 |
| Dakar | 41 | - | 19 | 11 | 2 | 2.44 | 62.20 | 9 | 11 | - | 2.44 | 35.37 |
| Pikine | 45 | 1 | 12 | 2 | - | 6.67 | 28.89 | 26 | 2 | 4 | 6.67 | 64.44 |
| Rufisque | 51 | - | 5 | 17 | - | 0 | 26.47 | 29 | 17 | - | 0 | 73.53 |
| Richard-Toll | 42 | 2 | 2 | 17 | - | 26.92 | 26.92 | - | 17 | 21 | 26.92 | 46.15 |
| Podor | 212 | 64 | 1 | - | 147 | 64.86 | 35.14 | - | - | - | - | - |
| Matam | 294 | 122 | 7 | - | 165 | 69.56 | 30.44 | - | - | - | - | - |
| Kanel | 48 | 22 | - | - | 26 | 72.92 | 27.08 | - | - | - | - | - |
| Bakel | 69 | 27 | - | - | 42 | 69.57 | 30.43 | - | - | - | - | - |
| Ranérou | 85 | 70 | - | - | 15 | 91.18 | 8.82 | - | - | - | - | - |
| Linguère | 69 | 50 | - | - | 19 | 86.23 | 13.77 | - | - | - | - | - |