USAID Okoa Maisha Dhibiti Malaria (OMDM)

Entomological Surveillance in Lake Zone Regions of Mainland Tanzania: Year 4 Annual Report

October 31, 2022

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ENTOMOLOGICAL SURVEILLANCE IN LAKE ZONE REGIONS OF MAINLAND TANZANIA: YEAR 4 ANNUAL REPORT

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ABBREVIATIONS AND ACRONYMS

CBR	collection bottle rotator
CDC	Centers for Disease Control and Prevention
DC	district council
ELISA	enzyme-linked immunosorbent assay
HH	household
IBR	indoor biting rate
IRD	indoor resting density
IRS	indoor residual spraying
NIMR	National Institute for Medical Research
OMDM	Okoa Maisha Dhibiti Malaria
PCR	polymerase chain reaction
PMI	U.S. President's Malaria Initiative
s.l.	sensu lato
s.s.	senso stricto
TC	town council
USAID	United States Agency for International Development
WHO	World Health Organization

ACKNOWLEDGMENTS

We are indebted for the continued support extended to the assessment by the National Malaria Control Program under the Ministry of Health, the U.S. President's Malaria Initiative (PMI), Abt Associates Inc., and RTI International. We also recognize the logistics support rendered to the project by senior leadership of the National Institute for Medical Research (NIMR) Mwanza. We thank the District Executive Directors, District Medical Officers, Vector Control Officers, trained community mosquito collectors, and the communities in all targeted sentinel districts for their cooperation during the entomological surveillance evaluation task hereby reported.

The assessment was funded by a fixed amount award to NIMR Mwanza under the PMI-supported USAID Okoa Maisha Dhibiti Malaria (OMDM) Project led by RTI International (Cooperative Agreement No. 72062118CA-000002).

EXECUTIVE SUMMARY

To define the entomological impact of indoor residual spraying (IRS) of households (HHs) with insecticide with clothianidin (SumiShield® 50WG) and Fludora® Fusion, the U.S. President's Malaria Initiative (PMI) supported the USAID Okoa Maisha Dhibiti Malaria (OMDM) activity to carry out entomological surveillance and insecticide residual efficacy testing in IRS and non-IRS districts of the northwestern Lake Zone Regions.

Data included in this report were collected from 10 field sites; 6 of these sites were in 6 districts where IRS operations had been conducted in October and November 2021, and the remaining 4 sites were control sites where IRS operations had not been conducted.

For insecticide residual efficacy testing, cone and fumigant bioassays were carried out as per standard World Health Organization (WHO) protocol in randomly selected HHs that had been sprayed with clothianidin or Fludora® Fusion during programmatic IRS operations. For entomological surveillance activities, mosquito-collection techniques incorporated U.S. Centers for Disease Control and Prevention (CDC) light traps, clay pots, Prokopack aspirators, and CDC light traps with collection bottle rotators (CBRs) with monthly mosquito collections conducted in all study sites. The National Institute for Medical Research (NIMR) Mwanza Centre conducted all entomological activities.

Insecticide residual efficacy. Fludora® Fusion was retained effectively: all wall surfaces showed ≥80% mortality nine months after IRS. Clothianidin was also retained well: its sprayed wall surfaces showed ≥80% mortality eight months after IRS.

A total of 15,593 female *Anopheles* mosquitoes were collected by all collection methods from October 2021 through September 2022 in all districts, both those with IRS and those without. Of those, 4,604 (29.5%) were morphologically identified as *An. gambiae s.l.*; 10,204 (65.4%) as *An. funestus s.l.*; 411 (2.6%) as *An. coustani*; 323 (2.1%) as *An. pharoensis*; and 51 (0.3%) as *An. rufipes*. *An. gambiae* and *An. funestus* complex mosquitoes were the vast majority (14,808 or 95%) of those captured, with 7,550 (51%) of them captured by CDC light traps; 3,305 (22.3%) by CBR; 2,577 (17.4%) by Prokopack aspirator; and 1,376 (9.3%) by clay pots.

An. gambiae s.l. was the most abundant vector species sampled by all collection methods in the sprayed sites, with the exception of the Biharamulo, Kibondo, and Kasulu District Councils (DCs). Whereas in all the unsprayed sites, *An. funestus s.l.* was the main vector species collected. The percentage of parity was lower in sprayed sites compared to the unsprayed sites.

Identification of species by polymerase chain reaction (PCR)–based methods showed the vector population across sites to be predominantly *An. funestus s.s.* (8,505; 64.6%), *An. arabiensis* (3,013; 22.9%), *An. gambiae s.s.* (1,014; 7.7%), and *An. parensis* (48; 0.4%). Of the processed samples, 591 (4.5%) were not amplified by *An. gambiae s.l.* and *An. funestus s.l.* PCR. In sprayed sites the collected mosquito species varied. *An. gambiae s.s.* was the abundant collected species in Kakonko and Ukerewe sites while *An. arabiensis* was the most common species in Bukombe DC. *An. funestus s.s.* was found in most abundance in the Kibondo DC, Kasulu DC, and Biharamulo sentinel sites. A limited number of *An. parensis* was found in all the sentinel sites except Ukerewe. Moreover, in unsprayed sites *An. funestus s.s.* was the most dominant species.

Overall, sporozoite rates varied across the sites, ranging 0%–1.2 % in sprayed sites and 0.5%–2.6% in unsprayed sites. Sporozoite rate was higher in unsprayed sites (1%) compared to sprayed sites (0.3 %), and the observed difference was statistically significant with $p < 0.00001$. The highest of the sporozoites were found in *An. funestus s.s.* (1.1%) among the *Anopheles* species. The highest proportion of *An. gambiae s.l.* was observed indoors in sprayed sentinel sites, and the indoor biting rate (IBR) lowered post-IRS operations throughout the year except in Ukerewe, Kibondo, and Bukombe DCs. Among unsprayed sentinel sites *An. funestus s.l.* dominated in IBR.

In sprayed sites after IRS application, the level of *An. funestus s.l.* mean bites per person per night both indoors and outdoors was quite low compared with *An. gambiae s.l.*, whose peak biting hours after IRS were 11:00 p.m.–12:00 a.m. indoors and 12:00 a.m.–1:00 a.m. outdoors. Generally, there was a higher number of indoors and outdoors *An. funestus s.l.* in unsprayed sites compared with sprayed sites. Mean bites per person per hour were below 0.2 before and after deployment of IRS in contrast to the unsprayed sites.

Data showed a decrease in indoor resting density (IRD) nine to ten months after IRS operations were conducted in all districts, except for Bukombe, Kibondo, Kakonko, and Ukerewe DCs, which subsequently had the highest number of mosquitoes (mostly *An. gambiae s.l.*) resting indoors over the measured months. By contrast, the data showed higher observed trends of IRD in non-IRS districts, especially in Geita and Muleba DCs, throughout the entire monitoring period.

The majority of the tested blood-meal hosts indicated that *An. funestus s.s.* was the major vector whose blood-meal source was found to be human. In unsprayed sites the highest 12-month EIR was 58.1, unlike the sprayed sites where the highest EIR was 3.0.

The study indicates that continuous rounds of IRS using various insecticides has been fruitful in reducing the *An. gambiae s.l.* and *An. funestus s.l.* abundance and sporozoite rate. IRS contributed to reducing the sporozoite rate and significantly decreased the EIR.

1. INTRODUCTION

The Indoor Residual Spraying (IRS) program in Tanzania is a joint U.S. Government and Government of Tanzania initiative and is part of the U.S. President's Malaria Initiative (PMI) to reduce the impact of malaria in sub-Saharan African countries. RTI, through the PMI-funded Okoa Maisha Dhibiti Malaria (OMDM) activity, is in its fourth year of implementation, including entomological monitoring in IRS-targeted districts in the Lake Zone. OMDM supports Tanzania's National Malaria Control Program to facilitate the planning and implementation of the IRS program to reduce the incidence of malaria in the targeted districts.

In this report are the results of the assessment of the quality of IRS operations conducted in study sites (Table 1) and entomological monitoring. National Institute for Medical Research (NIMR) Mwanza staff conducted entomological monitoring, a vital component of any malaria prevention and control program, to evaluate the efficacy of the IRS operations, justify the selection of insecticides and target spray areas, and monitor the behavioral and ecological response of vector species to IRS operations.

During the period of October 2021–September 2022, NIMR Mwanza carried out the following entomological monitoring activities as per the fiscal year (FY) 2021–2022 work plan:

1. Identification of malaria vector species in IRS intervention and control districts
2. Assessment of vector ecology: density, distribution, and seasonality in intervention and control sentinel sites
3. Monitoring of vector feeding and resting behavior in designated sites across the IRS intervention and control districts
4. Assessment of insecticide residual efficacy after IRS using cone wall bioassays
5. Rearing and maintaining a colony of susceptible *An. gambiae* s.s. (Kisumu strain) in NIMR Mwanza's insectary.

In this report are the results of IRS-operations-related entomological monitoring activities carried out from October 2021–September 2022.

2. METHODS

2.1 Study Sites

Entomological data were collected October 2021–September 2022 from 10 villages in sentinel districts (Table 1 presents a summary of activities, and Figure 1 shows geographical locations).

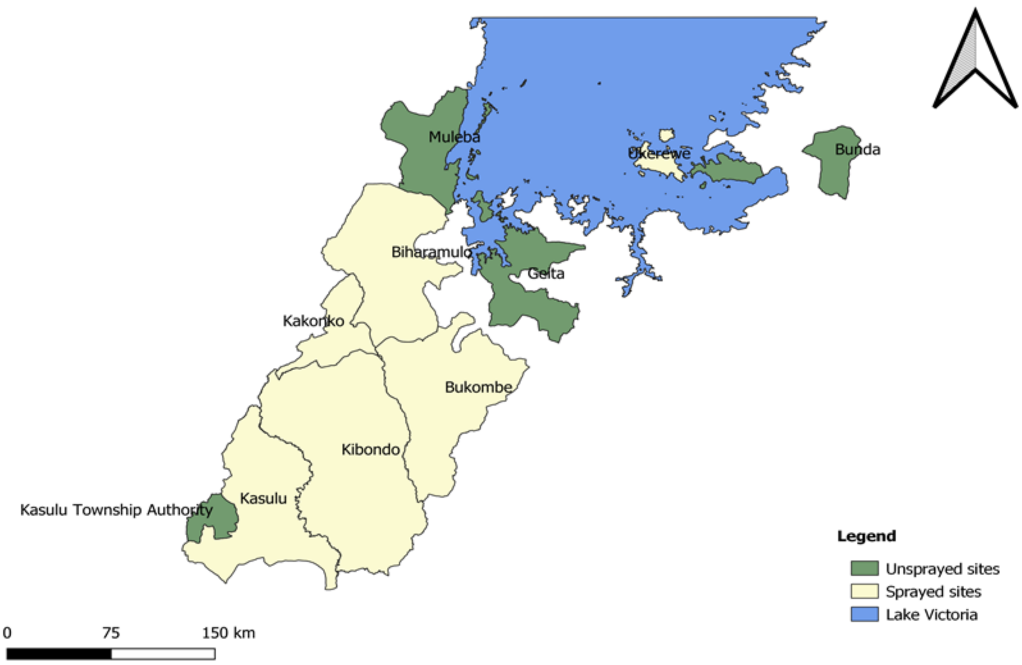
Table 1. Entomological surveillance and insecticide residual efficacy monitoring sites

Region	District	Sentinel Site Location	Sentinel Site Status	Intervention Status	Data Collected on Indicators
Geita	Bukombe DC	Lyambamgongo	Existing	SumiShield® 50WG sprayed	IRS quality, insecticide decay rate, species composition, vector abundance, parity, distribution and seasonality,

Region	District	Sentinel Site Location	Sentinel Site Status	Intervention Status	Data Collected on Indicators
					feeding time, and location.
	Geita DC	Chikobe	Existing	Unsprayed control	Species composition, vector abundance, parity, distribution and seasonality, feeding time, and location.
Kagera	Biharamulo DC	Kalebezo	Existing	SumiShield® 50WG sprayed	IRS quality, insecticide decay rate, species composition, vector abundance, parity, distribution and seasonality, feeding time, and location.
	Muleba DC	Kakoma	Existing	Unsprayed control	Species composition, vector abundance, parity, distribution and seasonality, feeding time, and location.
Kigoma	Kakonko DC	Itumbiko	Existing	Fludora® Fusion sprayed	IRS quality, insecticide decay rate, species composition, parity, vector abundance, distribution and seasonality, feeding time, and location.
	Kasulu DC	Kagerankanda	Existing	Fludora® Fusion sprayed	IRS quality, insecticide decay rate, species composition, parity, distribution and seasonality, feeding time, and location.
	Kasulu Town Council (TC)	Murufiti	Existing	Unsprayed	Species composition, vector abundance, distribution and seasonality, parity, feeding time, and location.
	Kibondo DC	Minyinya	Existing	Fludora® Fusion sprayed	IRS quality, insecticide decay rate, species composition, parity, vector

Region	District	Sentinel Site Location	Sentinel Site Status	Intervention Status	Data Collected on Indicators
					abundance, distribution and seasonality, feeding time, and location.
Mara	Bunda DC	Bwanza	Existing	Unsprayed control	Species composition, vector abundance, distribution and seasonality, parity; feeding time, and location.
Mwanza	Ukerewe DC	Bukongo	Existing	SumiShield® 50WG sprayed	IRS quality, insecticide decay rate, species composition, vector abundance, distribution and seasonality, parity, feeding time, and location.

Figure 1. Map showing the distribution of 10 districts used in entomological surveillance and insecticide residual efficacy monitoring



2.2 Rearing of Susceptible *An. gambiae s.s.* (Kisumu Strain)

Adult *An. gambiae s.s.* of the susceptible Kisumu strain had their numbers increased to meet the demand of field activities involving monthly cone wall bioassays and were reared according to standard protocol at the insectary of NIMR Mwanza.[1] The adult mosquito room was maintained at 27 ± 1°C and 60%–80% relative humidity; the larval room environment was maintained at 30 ± 1°C and 60%–80% relative humidity.

2.3 Insecticide Residual Efficacy Monitoring

Cone bioassays were carried out as per the standard WHO protocol.[2] The tests were carried out using two to five-day-old, sucrose-fed, and laboratory-reared, known susceptible *An. gambiae s.s.* Kisumu strain mosquitoes. Batches of 10 female mosquitoes were exposed for 30 minutes inside a WHO plastic cone on sprayed wall surfaces in each of the rooms and houses sampled (Figure 2). Generally, clothianidin is regarded as a slow-acting insecticide; Fludora® Fusion contains a mixture of clothianidin and deltamethrin. The usual WHO protocol for cone bioassays was modified so that mortality was recorded every 24 hours for 6 consecutive days after insecticide exposure; exposure time remained at 30 minutes. For the initial IRS quality assessment, three locations on walls were sampled: low (0.5 m above the floor), middle (1.0 m above the floor), and upper level (1.5 m above the floor). After the initial IRS quality assessment, measuring insecticide residual efficacy was limited to one sampled room, and two locations on the walls were sampled: low (0.5 m above the floor) and upper level (1.5 m above the floor).

A control cone bioassay was done for every house tested by exposing mosquitoes to an unsprayed surface of a similar wall material. Some insecticide formulations used for IRS, such as clothianidin and pirimiphos-methyl, have a fumigant airborne effect that can last for several months after spraying. A strong fumigant effect in sprayed rooms can result in cone bioassays on unsprayed walls showing 100% mosquito mortality. To avoid the possibility of control mortality increasing because of clothianidin's fumigant effect, bioassays on the unsprayed portable surface were conducted outside sprayed houses in the shade to avoid mosquito mortality from direct sunlight's heat (Figure 2E). To test the airborne efficacy of clothianidin and Fludora® Fusion, fumigant assays using nets suspended in a wire cylinder were carried out in all villages inside and outside of sampled houses (Figures 2F and 2G).

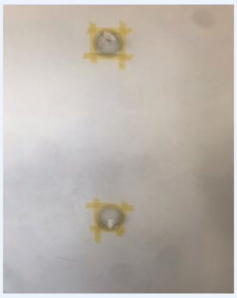
At the end of each bioassay, mosquitoes were transferred using an aspirator to paper cups and supplied with a 10% glucose solution. Cups were placed in a cool box that was covered with a wet towel. Knockdown was assessed 60 minutes after the end of exposure. A mosquito was considered alive if it could fly. When control mortality was 5%–20%, experimental mortality was corrected using Abbott's formula.[3]

Figure 2. Different wall surfaces during testing

(A) Cones attached to a sprayed burnt brick surface.

(B) Cones attached to a sprayed cement surface.

(C) Cones attached to a sprayed mud surface.



(D) Cones attached to a sprayed whitewashed surface.

(E) Control for an outside cement surface.

(F) Fumigant bioassay inside house.

(G) Fumigant bioassay outside house for control.

2.4 Vector Ecology

Entomological surveillance was carried out to determine vector ecology in IRS and non-IRS sites.

The entomological sampling methods used in all sites comprised Centers for Disease Control and Prevention (CDC) light traps, clay pots, Prokopack aspirators, and CDC light traps with collection bottle rotators (CBRs). These traps were utilized to collect adult mosquitoes to determine basic entomological indicators, including species distribution and abundance, resting behavior, feeding and biting behavior, and seasonality (Table 2).

Table 2. Mosquito collection methods used for entomological surveillance

Collection Method	Indicator Measured	Districts	Sites	Households (HHs) per site	Days Collecting per Month	Time Window of Sampling	Identification Method for Samples	
							Species	Sporozoite Rate
CDC light trap	Indoor abundance	10	10 (one per district)	2	28	6 p.m. – 6 a.m.	√	√
Clay pot	Outdoor abundance	10	10 (one per district)	2	28	6 p.m. – 6 a.m.	√	√
Prokopack aspirator	Resting behavior	10	10 (one per district)	5	10	6 p.m. – 6 a.m.	√	√
CBR	Indoor and outdoor biting behavior	10	10 (one per district)	1	10	6 p.m. – 6 a.m.	√	√

Identification of the collected specimens was done in the field, and mosquitoes were sorted by species according to standard morphological keys.[4] Subsamples of host-seeking females were dissected for determination of the parity rate. Blood-fed females were independently preserved in filter paper wraps to determine the blood-meal source, while unfed females were preserved for further laboratory analysis, including species-specific identification and detection of malaria infection.

2.4.1 CDC light trap

This collection method is used for indoor biting (endophagic) mosquitoes and can be seen in the top left image of Figure 3. Two houses per night were randomly selected in each village of a study district, with CDC light traps in place on 28 consecutive nights of each month. The traps were installed about 1.5 meters above the floor next to the head of a sleeping person in the room. Each person was requested to sleep under an untreated mosquito net overnight. The CDC light traps were set to trap mosquitoes overnight, from 6:00 p.m. through 6:00 a.m. Captured mosquitoes were transferred separately into mosquito-holding cups.

Figure 3. Entomological sampling methods

(Clockwise from top left) CDC light trap, clay pot, CBR, and Prokopack aspirator.

2.4.2 Clay pot method

This collection method is used for outdoor resting (exophilic) mosquitoes. Local clay pots (molded from clay soil, diameter of ~0.5 m, an opening of 20 cm, and a 2-cm hole at the bottom allowing rainwater to drain) were used to collect outdoor resting mosquitoes. Four clay pots were positioned outdoors overnight from 6:00 p.m. to 6:00 a.m.; houses were the same ones that were sampled using CDC light traps. The pots were positioned at an inclined angle to let mosquitoes enter and rest inside the dark inner wall surface of the pot. At 6:00 a.m., community mosquito collectors covered the openings with netting that had a small hole for inserting an aspirator to suck out mosquitoes and transfer them into a mosquito-holding cup.

2.4.3 Prokopack aspirator

This collection method is used to sample indoor resting (endophilic) mosquitoes. The Improved Prokopack Aspirator Model 1419 was used. Mosquitoes were collected from five selected houses (two of the houses were selected for the CDC light tap collection; three more were randomly selected houses) for 10 days a month. Aspiration was carried out between 6:00 a.m. and 8:00 a.m. Aspiration of resting adults produced collections of both sexes and all physiological stages directly from their resting sites, allowing better estimations of species diversity, abundance, sex ratio, and physiological status. The number of people who slept in the house the previous night was recorded on the data sheet.

The mosquitoes were put in clearly labeled moist Petri dishes and taken to the field office where they were sorted morphologically by species. The abdominal status of all female anophelines collected was noted, and mosquitoes were sorted into one of the following categories: gravid, semi-gravid, unfed, and blood-fed. The collected mosquitoes were preserved for later molecular assay analysis to identify the sibling species and determine malaria infection rates. The preserved mosquitoes were also subjected to enzyme-linked immunosorbent assays (ELISAs) to identify the source of the blood meal.

2.4.4 CBRs

This collection method is used to monitor indoor and outdoor mosquito biting times. Use of CBRs has replaced human landing catches because of the ethical concerns with using human subjects. One CBR was placed indoors and outdoors, respectively, in a randomly selected house.

CBR sampling was conducted over 10 nights each month, scheduled on nights near a new moon to minimize the effect of moonlight on the outdoor collection and to reduce bias when comparing species distribution across seasons. Moonlight can affect the biting behavior of mosquitoes and therefore the collections.[5] An estimate of the presence and period of moonlight was calculated using a lunar calendar.[6] It was assumed that the mosquitoes entering a trap were those actively seeking hosts and who in most cases would have bitten human hosts in the same hour and house if the bed-net trap had been absent. The indoor and outdoor human biting rates and bite timing of the *Anopheles* mosquitoes were determined and recorded throughout the whole sampling period.

CBRs were set indoors with a person sleeping under an untreated net and outdoors from 6:00 p.m. to 6:00 a.m.; the collection of mosquitoes occurred in an interval of one hour. Samples of anophelines were preserved in a 1.5-ml Eppendorf tube in silica gel for further ELISA and molecular analysis.

2.5 Laboratory Analyses

In the field, mosquitoes were morphologically identified, labeled, and transported to the NIMR Mwanza Centre laboratory for further analyses. An ELISA circumsporozoite assay was used to determine the sporozoite index in 13,171 samples of collected *An. gambiae s.l.* and *An. funestus s.l.*[7,8] A PCR-based assay was used to differentiate sibling species of *An. gambiae s.l.*[9] and *An. funestus s.l.*[10] mosquitoes.

Furthermore, blood-meal analysis to determine host preferences of collected mosquitoes was performed using a direct ELISA.[11] Mosquitoes for blood-meal analysis were obtained from clay pots, Prokopack aspirators, and CBRs.

2.6 Rainfall Data

Rainfall data to align with mosquito monthly abundance were accessed via an online database.[12]

2.7 Data Analysis

Vector density was calculated as the number of adult female vectors collected per sampling method and unit time. Indoor biting rate (IBR) was determined as a proportion of adult female vectors that attempted to feed or were freshly blood-fed per person per unit time. Biting time was calculated as the number of adult female vectors that attempted to feed or were freshly blood-fed per person per night. Indoor resting density (IRD) was calculated as the proportion of adult female vectors collected resting indoors by Prokopack aspirators.

3. RESULTS

3.1 Insecticide Residual Efficacy Monitoring

3.1.1 Residual efficacy of Fludora® Fusion and clothianidin against susceptible An. gambiae s.s. in cone wall bioassays

Figures 4–9 show the results of the cone wall bioassays by site and month postexposure to Fludora® Fusion–treated walls (Kakonko District Council [DC], Kibondo DC, and Kasulu DC) or clothianidin-treated walls (Biharamulo DC, Bukombe DC, and Ukerewe DC). Day 6 on the x-axes refers to when total mortality was determined with measurements being taken every 24 hours for 6 consecutive days after insecticide exposure.

Fludora® Fusion was retained effectively, with all wall surfaces showing ≥80% mortality on Day 6 for 9 months after IRS. Clothianidin was also retained effectively, with all wall surfaces showing ≥80% mortality on Day 6 for 8 months after IRS. The detailed results of cone wall bioassays for each district are shown in **Annex 1**.

Figure 4. Residual efficacy of Fludora® Fusion for *An. gambiae s.s.* for different wall surfaces in Kakonko DC

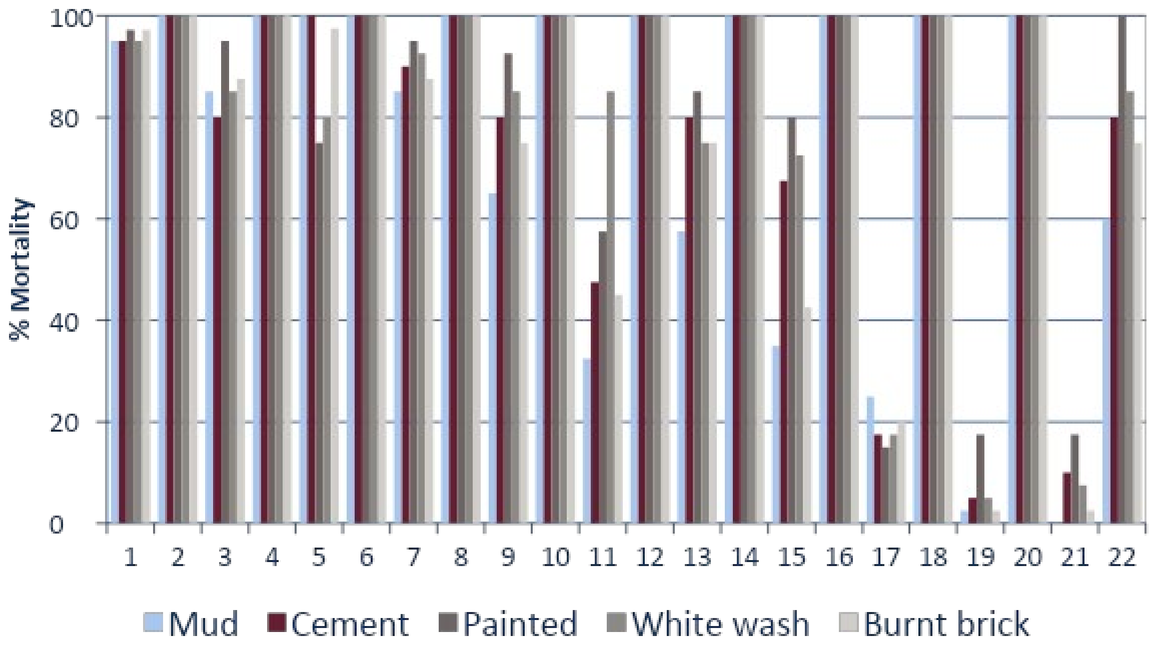


Figure 5. Residual efficacy of Fludora® Fusion for *An. gambiae s.s.* for different wall surfaces in Kibondo DC

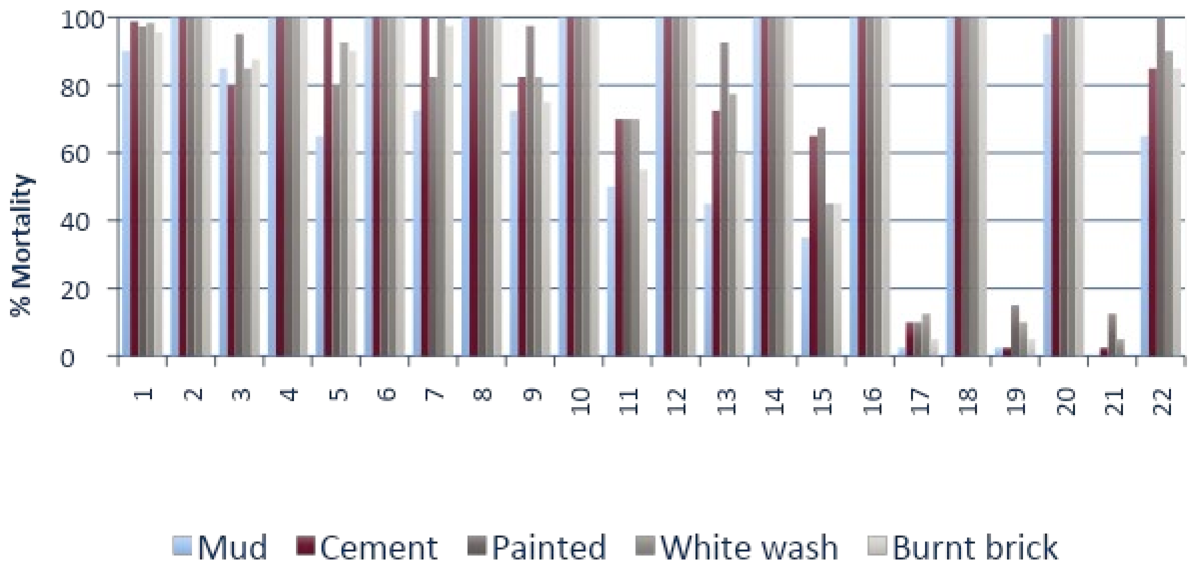


Figure 6. Residual efficacy of Fludora® Fusion for *An. gambiae s.s.* for different wall surfaces in Kasulu DC

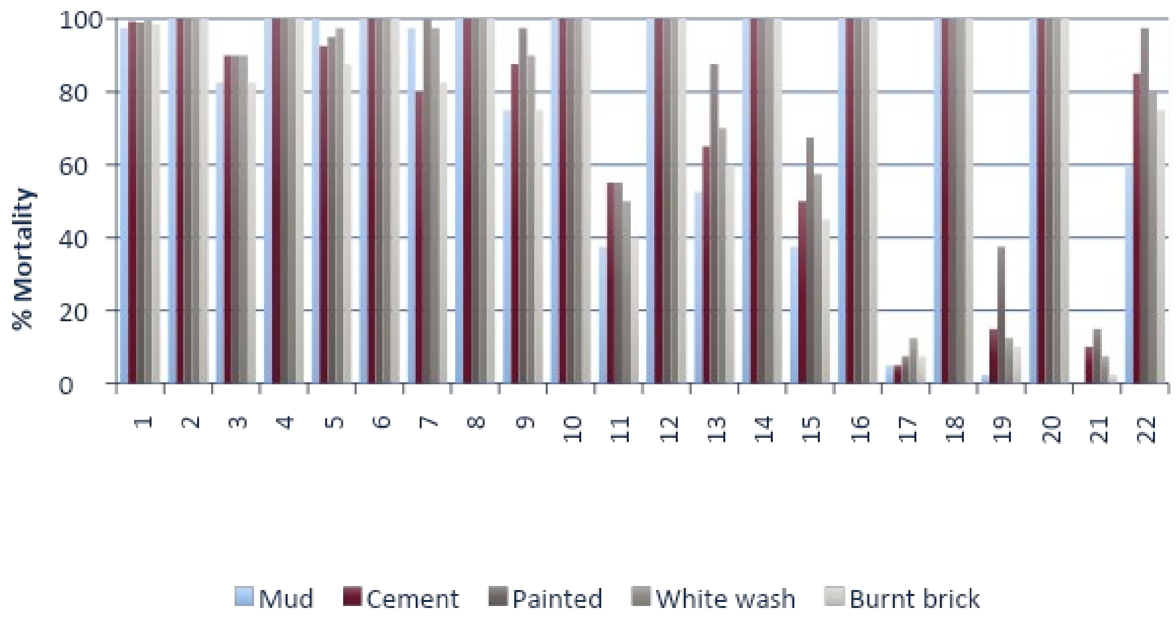


Figure 7. Residual efficacy of clothianidin for *An. gambiae s.s.* for different wall surfaces in Biharamulo DC

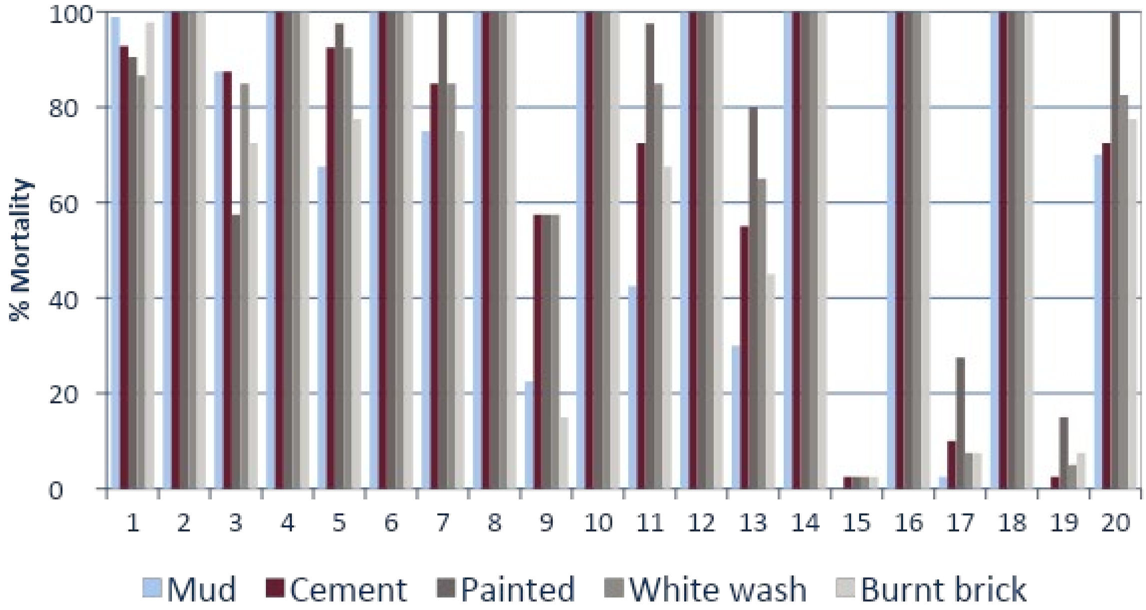


Figure 8. Residual efficacy of clothianidin for *An. gambiae s.s.* for different wall surfaces in Ukerewe DC

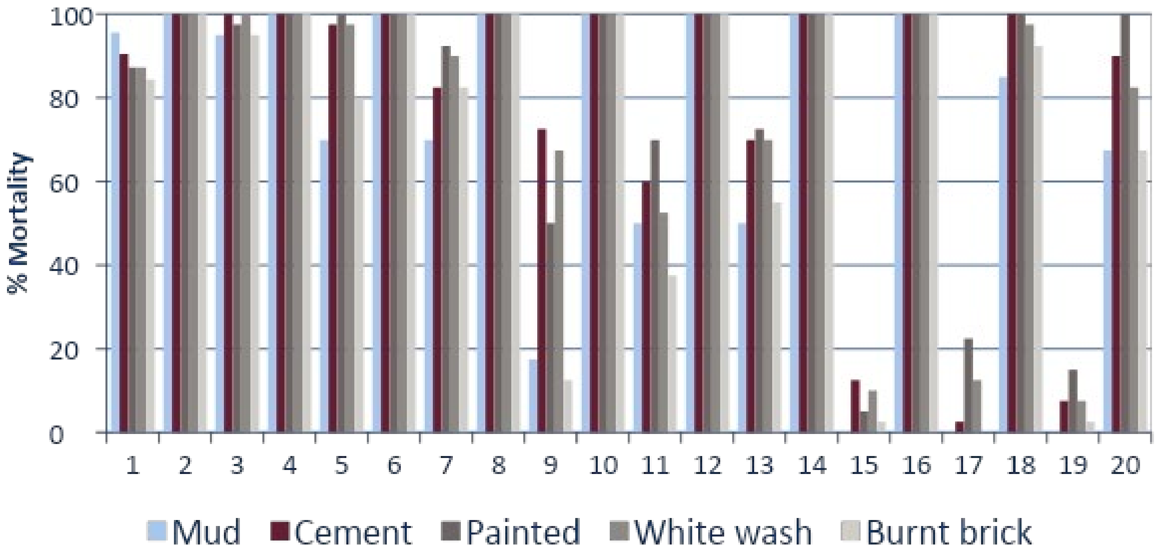
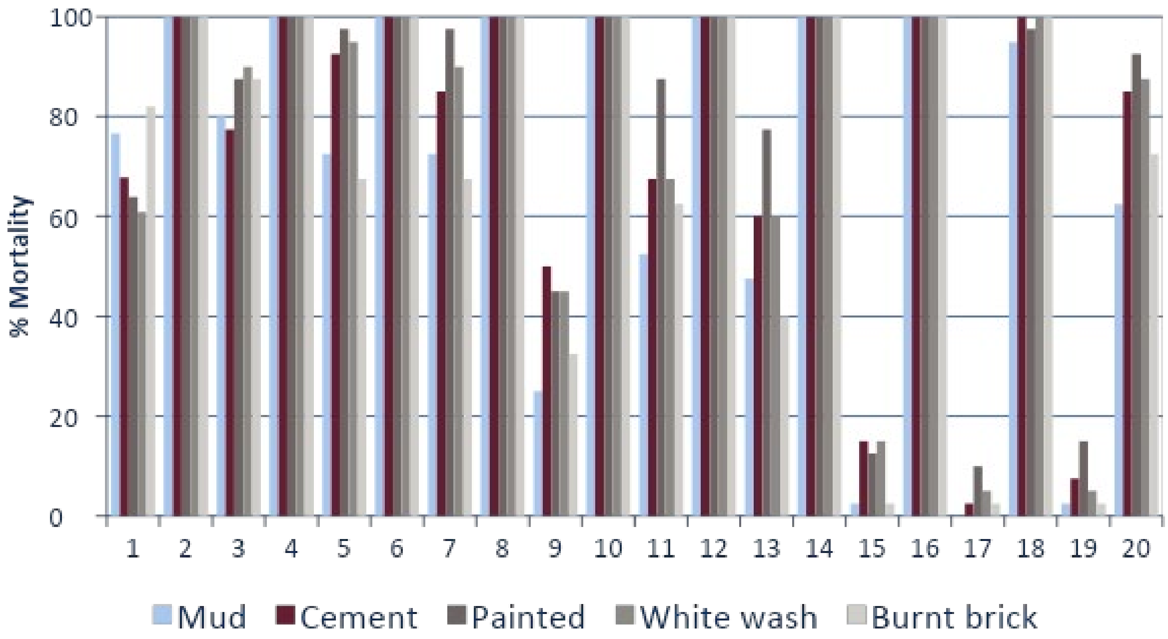


Figure 9. Residual efficacy of clothianidin for An. gambiae s.s. for different wall surfaces in Bukombe DC



3.1.2 Residual efficacy of Fludora® Fusion and clothianidin against susceptible An. gambiae s.s. in fumigant bioassays

Figures 10–15 show the results of the fumigant bioassays by site and month postexposure to Fludora® Fusion and clothianidin-treated walls. Day 6 on the x-axes refers to when total mortality was determined, with measurements taken every 24 hours for 6 consecutive days after insecticide exposure.

The insecticide airborne effect in all treated wall surfaces eight months post-IRS with Fludora® Fusion was retained to 100% mortality on Day 6 at all sites. Similarly, seven months post-IRS with clothianidin the insecticide airborne effect in all treated surfaces was 100% mortality on Day 6 at all sites. The details of results of cone fumigant bioassays for each district are shown in Annex 2.

Figure 10. Residual efficacy of Fludora® Fusion for An. gambiae s.s. exposed on fumigant assay in Kakonko DC

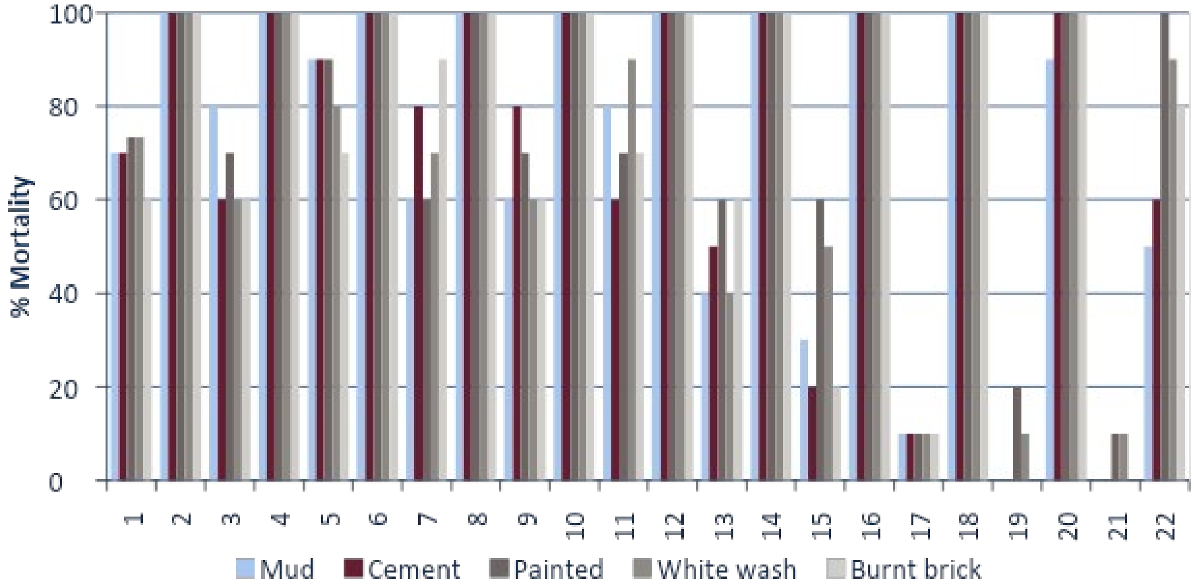


Figure 11. Residual efficacy of Fludora® Fusion for *An. gambiae s.s.* exposed on fumigant assay in Kibondo DC

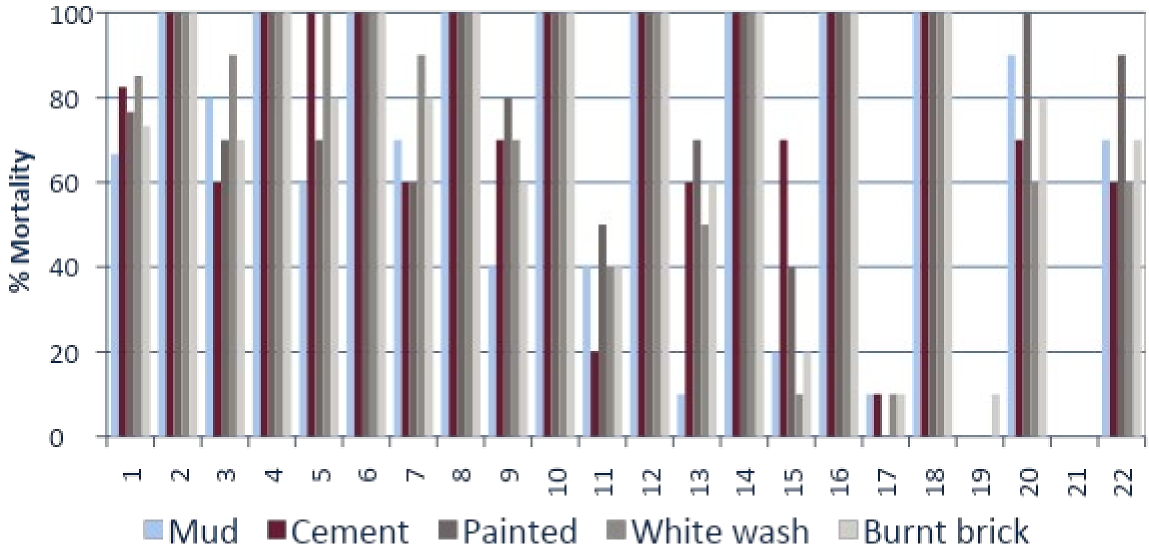


Figure 12. Residual efficacy of Fludora® Fusion for *An. gambiae s.s.* exposed on fumigant assay in Kasulu DC

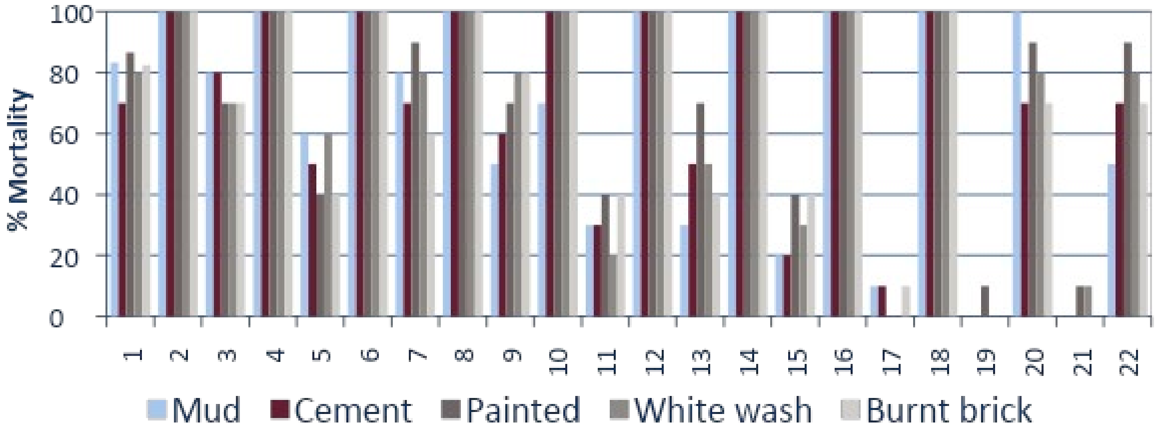


Figure 13. Residual efficacy of clothianidin for *An. gambiae s.s.* exposed on fumigant assay in Biharamulo DC

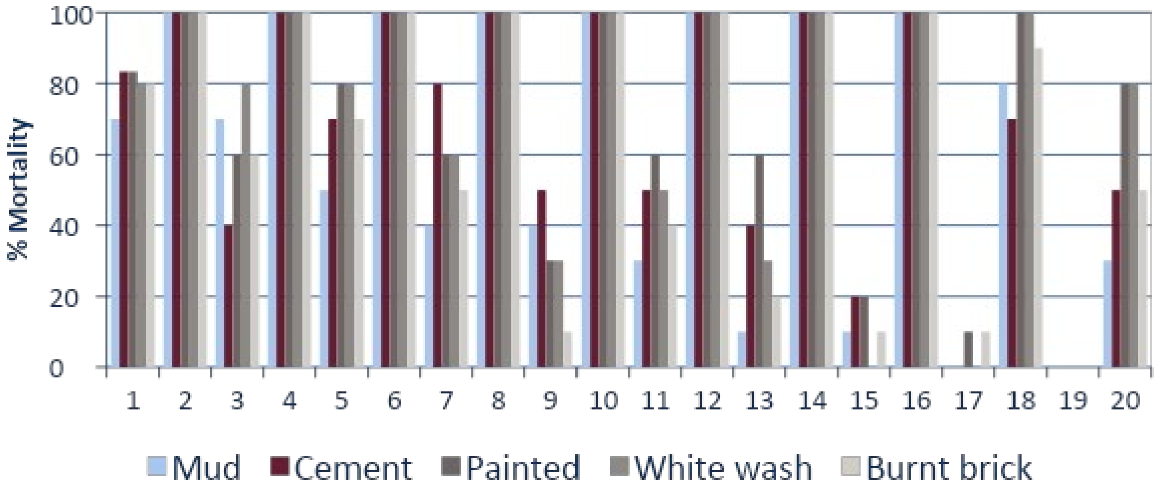


Figure 14. Residual efficacy of clothianidin for *An. gambiae s.s.* exposed on fumigant assay in Ukerewe DC

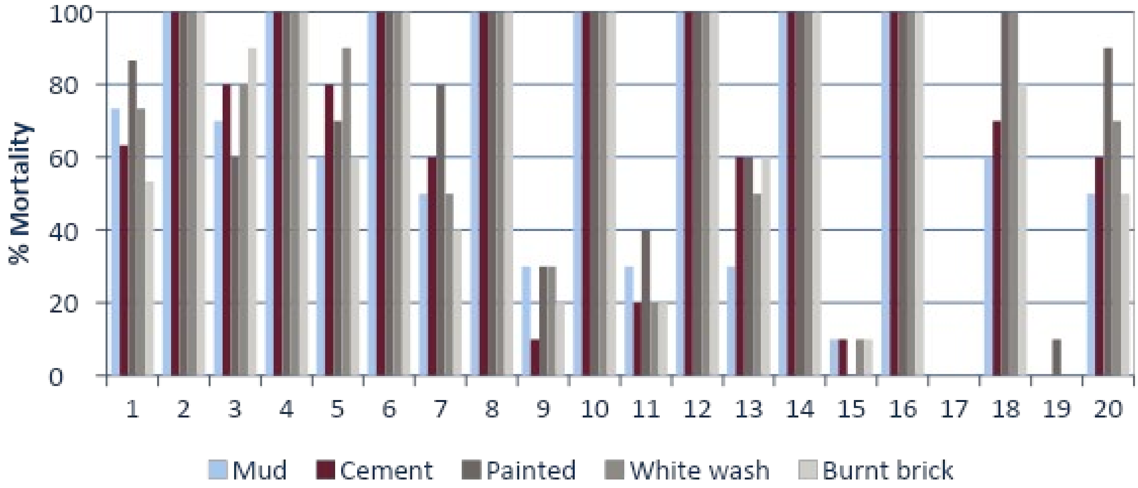
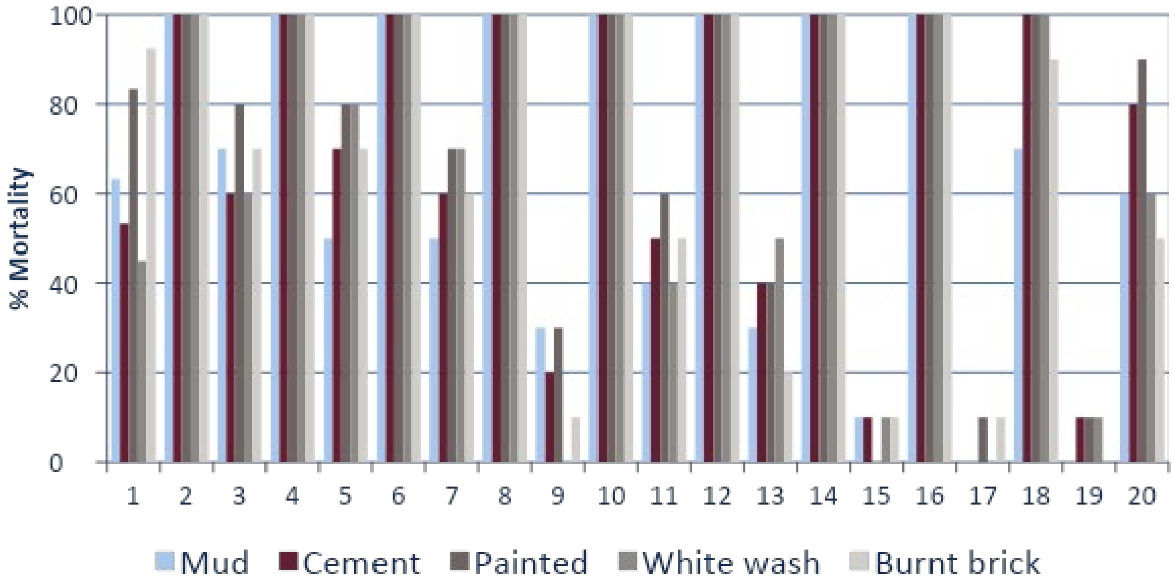


Figure 15. Residual efficacy of clothianidin for *An. gambiae s.s.* exposed on fumigant assay in Bukombe DC



3.2 Vector Ecology

3.2.1 Abundance, distribution, and species composition

A total of 15,593 female *Anopheles* mosquitoes were collected by all collection methods from October 2021 to September 2022 in all sprayed and unsprayed districts. A sum of 4,604 (29.5%) were morphologically identified as *An. gambiae s.l.*; 10,204 (65.4%) as *An. funestus s.l.*; 411 (2.6%) as *An. coustani*; 323 (2.1%) as *An. pharoensis*; and 51 (0.3%) as *An. rufipes*.

CDC light traps collected 7,550 (51% of total) female *An. gambiae* and *An. funestus* complex mosquitoes, CBRs collected 3,305 (22.3%), Prokopack aspirators collected 2,577 (17.4%), and clay pots collected 1,376 (9.3%) (Table 3).

An. gambiae s.l. was the most abundant vector species complex sampled by all collection methods in all sprayed sites except Biharamulo, Kibondo, and Kasulu DCs. Whereas in all the unsprayed sites, *An. funestus s.l.* was the main vector species complex collected.

A summary of other anopheline species collected during the period in both sprayed and unsprayed areas is indicated in Table 4.

Table 3. Number of Anopheles collected by collection method and location

Location			CDC Light Trap, *N* (*n*)		CBR, *N* (*n*)		Prokopack, *N* (*n*)		Outdoor Clay Pot, *N* (*n*)		Total, *N* (*n*)	
Region	**District**	**Study site**	***An. gambiae s.l.***	***An. funestus s.l.***	***An. gambiae s.l.***	***An. funestus s.l.***	***An. gambiae s.l.***	***An. funestus s.l.***	***An. gambiae s.l.***	***An. funestus s.l.***	***An. gambiae s.l.***	***An. funestus s.l.***
Sprayed Sites												
Kagera	Biharamulo	Kalebezo	58 (0.2)	134 (0.4)	34 (0.3)	56 (0.5)	28 (0.2)	70 (0.6)	16 (0.1)	29 (0.1)	136 (0.2)	289 (0.3)
Mwanza	Ukerewe	Bukongo	640 (1.9)	36 (0.1)	33 (0.3)	3 (0.0)	68 (0.6)	6 (0.1)	73 (0.2)	6 (0.0)	814 (0.9)	51 (0.1)
Geita	Bukombe	Lyambamgongo	590 (1.8)	11 (0.0)	321 (2.7)	18 (0.2)	147 (1.2)	0 (0.0)	165 (0.5)	5 (0.0)	1,223 (1.3)	34 (0.0)
Kigoma	Kasulu DC	Kagerankanda	18 (0.1)	91 (0.3)	3 (0.0)	37 (0.3)	6 (0.1)	22 (0.2)	0 (0.0)	7 (0.0)	27 (0.0)	157 (0.2)
	Kibondo	Minyinya	281 (0.8)	337 (1.0)	95 (0.8)	99 (0.8)	117 (1.0)	101 (0.8)	94 (0.3)	138 (0.4)	587 (0.6)	675 (0.7)
	Kakonko	Itumbiko	149 (0.4)	2 (0.0)	60 (0.5)	1 (0.0)	98 (0.8)	0 (0.0)	17 (0.1)	0 (0.0)	324 (0.4)	3 (0.0)
Total Sprayed Sites			**1,736 (0.9)**	**611 (0.3)**	**546 (0.8)**	**214 (0.3)**	**464 (0.6)**	**199 (0.3)**	**365 (0.2)**	**185 (0.1)**	**3,111 (0.6)**	**1,209 (0.2)**
Unsprayed Sites												
Mara	Bunda	Bwanza	453 (1.4)	2,386 (7.1)	99 (0.8)	404 (3.4)	65 (0.5)	268 (2.2)	39 (0.1)	266 (0.8)	656 (0.7)	3,324 (3.6)
Kagera	Muleba	Kakoma	158 (0.5)	1,126 (3.4)	52 (0.4)	831 (6.9)	50 (0.4)	782 (6.5)	4 (0.0)	212 (0.6)	264 (0.3)	2,951 (3.2)
Geita	Geita	Chikobe	123 (0.4)	490 (1.5)	119 (1.0)	406 (3.4)	76 (0.6)	451 (3.8)	32 (0.1)	214 (0.6)	350 (0.4)	1,561 (1.7)
Kigoma	Kasulu TC	Murufiti	57 (0.2)	410 (1.2)	116 (1.0)	518 (4.3)	40 (0.3)	182 (1.5)	10 (0.0)	49 (0.2)	223 (0.2)	1,159 (1.3)
Total Unsprayed Sites			791 (0.6)	4,412 (3.3)	386 (0.8)	2,159 (4.5)	231 (0.5)	1,683 (3.5)	85 (0.1)	741 (0.6)	1,493 (0.4)	8,995 (2.5)
TOTAL SITES			**2,527 (0.8)**	**5,023 (1.5)**	**932 (0.8)**	**2,373 (2.0)**	**695 (0.6)**	**1,882 (1.6)**	**450 (0.1)**	**926 (0.3)**	**4,604 (0.5)**	**10,204 (1.1)**

Abbreviations: *N,* Number collected; (*n*), mean number per trap night

Table 4.Table showing other anopheline species collected

District	IRS status	Other anopheline species	Number of mosquitoes collected (n)
Biharamulo	Sprayed	*An. coustani*	24
		An. pharoensis	12
		An. rufipes	21
Kasulu DC	Sprayed	*An. coustani*	0
		An. pharoensis	0
		An. rufipes	9
Kibondo	Sprayed	*An. coustani*	12
		An. pharoensis	0
		An. rufipes	9
Kakonko	Sprayed	*An. coustani*	3
		An. pharoensis	1
		An. rufipes	0
Bukombe	Sprayed	*An. coustani*	1
		An. pharoensis	2
		An. rufipes	0
Ukerewe	Sprayed	*An. coustani*	11
		An. pharoensis	2
		An. rufipes	11
Bunda	Unsprayed	*An. coustani*	355
		An. pharoensis	305
		An. rufipes	1
Muleba	Unsprayed	*An. coustani*	4
		An. pharoensis	0
		An. rufipes	0
Geita DC	Unsprayed	*An. coustani*	0
		An. pharoensis	0
		An. rufipes	0
Kasulu TC	Unsprayed	*An. coustani*	1
		An. pharoensis	1
		An. rufipes	0

3.2.2 *Parity*

Ten percent of unfed mosquitoes collected from all traps from October 2021 to September 2022 were dissected to determine whether they were parous or nulliparous before and after IRS intervention. Dissection results show that Biharamulo had the highest percentage of parity pre-IRS among other intervention sites while Geita DC had the highest percentage of parity against all other unsprayed sites. Results indicate that after deployment of IRS the percentage of parity significantly decreased in Biharamulo (Table 5).

Table 5. Parity results in both sprayed and unsprayed sentinel sites pre- and post-IRS

District	IRS status	Collection type	Parity (%) as per IRS status (number parous/ total number dissected)	
			Before IRS	After IRS
Biharamulo	Sprayed	CDC light trap	93.8 (15/16)	0 (0/10)
		Prokopack	66.7 (6/9)	0 (0/0)
		Clay pot	0 (0/4)	0 (0/0)
Kasulu DC	Sprayed	CDC light trap	0 (0/3)	0 (0/8)
		Prokopack	0 (0/1)	0 (0/2)
		Clay pot	0 (0/0)	0 (0/0)
Kibondo	Sprayed	CDC light trap	0 (0/2)	0 (0/60)
		Prokopack	0 (0/0)	0 (0/21)
		Clay pot	0 (0/0)	0 (0/23)
Kakonko	Sprayed	CDC light trap	0 (0/3)	0 (0/12)
		Prokopack	0 (0/1)	0 (0/8)
		Clay pot	0 (0/0)	0 (0/2)
Bukombe	Sprayed	CDC light trap	0 (0/0)	0 (0/60)
		Prokopack	0 (0/0)	0 (0/15)
		Clay pot	0 (0/0)	0 (0/17)
Ukerewe	Sprayed	CDC light trap	0 (0/2)	0 (0/63)
		Prokopack	0 (0/0)	0 (0/7)
		Clay pot	57.1 (4/7)	0 (0/7)
Bunda	Unsprayed	CDC light trap	0 (0/284)	
		Prokopack	27.8 (10/36)	
		Clay pot	0 (0/31)	
Muleba	Unsprayed	CDC light trap	3.1 (4/128)	
		Prokopack	0 (0/83)	
		Clay pot	0 (0/22)	
Geita	Unsprayed	CDC light trap	0 (0/61)	
		Prokopack	30.2 (16/53)	
		Clay pot	32 (8/25)	
Kasulu TC	Unsprayed	CDC light trap	21 (13/62)	
		Prokopack	9.1 (2/22)	
		Clay pot	0 (0/23)	

3.2.3 Molecular analysis of mosquito species composition and sporozoite rate

Molecular analysis of mosquito species

A total of 13,171 mosquito samples were analyzed by PCR for speciation and ELISA for detection of sporozoites (Table 6).

Mosquito species composition

PCR showed the local vector population across sites to be *An. funestus s.s.* with 8,505 (64.6%); *An. arabiensis* 3,013 (22.9%); *An. gambiae s.s.* 1,014 (7.7%); and *An. parensis* 48 (0.4%). Of the processed samples, 591 (4.5%) were not amplified by *An. gambiae s.l.* and *An. funestus s.l.* PCR (Table 6).

Furthermore, the species collected in sprayed sites varied. *An. gambiae s.s.* was the main species in Kakonko and Ukerewe sites, while *An. arabiensis* was the most abundant species in Bukombe DC. *An. funestus s.s.* was found in most abundance in the Kibondo DC, Kasulu DC, and Biharamulo sentinel sites. A limited number of *An. parensis* was found in all the sentinel sites except Ukerewe. However, *An. funestus s.s.* was the most dominant species in all the unsprayed sites (Table 6).

The different mosquito species and the sporozoite rate collected by CBR traps to assess the human biting rate are indicated in Table 7. All mosquitoes collected in sprayed sites had no sporozoite unlike to unsprayed sites in which the sporozoite rate ranged 0.7% to 5% in Bunda and Kasulu TC sentinel sites, respectively.

Table 6. Results on species identification by PCR and sporozoite ELISA results in sprayed and unsprayed districts

	by PCR					by ELISA		
District	***An. gambiae s.s.* *n* (%)**	***An. arabiensis* *n* (%)**	***An. funestus s.s.* *n* (%)**	***An. parensis* *n* (%)**	**Unidentified by PCR *n* (%)**	**Total tested (*N*)**	**Number positive**	**Sporozoite rate (%)**
Sprayed Sites								
Biharamulo	29 (6.8)	129 (30.4)	251 (59.1)	8 (1.9)	8 (1.9)	425	1	0.2
Kasulu DC	14 (8.1)	46 (26.7)	103 (59.9)	2 (1.2)	7 (4.1)	172	2	1.2
Kibondo	242 (20.3)	234 (19.6)	679 (57.0)	1 (0.3)	35 (2.9)	1191	7	0.6
Kakonko	213 (65.3)	46 (14.1)	45 (13.8)	1 (0.3)	21 (6.4)	326	0	0.0
Bukombe	6 (0.5)	1,084 (93.8)	32 (2.8)	1 (0.1)	33 (2.9)	1156	0	0.0
Ukerewe	289 (43.5)	274 (41.2)	46 (6.9)	0 (0.0)	56 (8.4)	665	0	0.0
Total (Sprayed sites)	793 (20.2)	1,813 (46.1)	1,156 (29.4)	13 (0.3)	160 (4.1)	3804	10	0.3
Unsprayed Sites								
Bunda	55 (1.5)	573 (16.1)	2,807 (78.8)	20 (0.6)	108 (3.0)	3,563	19	0.5
Muleba	66 (2.5)	187 (7.1)	2,249 (84.8)	12 (0.5)	137 (5.2)	2,651	22	0.8
Geita	4 (0.2)	316 (17.7)	1,355 (75.7)	3 (0.2)	112 (6.3)	1,790	21	1.2
Kasulu TC	96 (7.8)	124 (10.1)	938 (76.1)	0 (0.0)	74 (6.0)	1,232	29	2.6
Total (Unsprayed sites)	221 (2.4)	1,200 (13.0)	7,349 (79.6)	35 (0.4)	431 (4.7)	9,236	91	1.0
Total (All sites)	1,014 (7.7)	3,013 (22.9)	8,505 (64.6)	48 (0.4)	591 (4.5)	1,3171	101	0.8

Table 7. Results on species identification by PCR and sporozoite ELISA collected by CBR in sprayed and unsprayed districts

				GA		AR		PA		FUN		PCR POSITIVE	PCR NEGATIVE	Number Positive		Sporozoite Rate	
DISTRICT	**CBR IN**	**CBR OUT**	**TOTAL**	**CBR IN**	**CBR OUT**	**CBR IN**	**CBR OUT**	**CBR IN**	**CBR OUT**	**CBR IN**	**CBR OUT**	**CBR IN&CBR OUT**	**CBR IN&CBR OUT**	**CBR IN**	**CBR OUT**	**CBR IN**	**CBR OUT**
Sprayed Sites																	
Biharamulo	45	53	98	2	2	19	13	0	2	23	34	95	3	0	0	0.0	0.0
Kasulu DC	31	5	36	3	2	7	0	0	0	21	3	36	0	0	0	0.0	0.0
Kibondo	92	91	183	24	16	23	20	0	0	42	51	176	7	1	0	1.1	0.0
Kakonko	56	8	64	43	4	6	1	0	0	6	3	63	1	0	0	0.0	0.0
Bukombe	130	199	329	1	0	115	182	0	0	11	7	316	13	0	0	0.0	0.0
Ukerewe	29	6	35	16	2	11	3	0	0	2	1	35	0	0	0	0.0	0.0
Total (Sprayed Sites)	383	362	745	89	26	181	219	0	2	105	99	721	24	1	0	0.3	0.0
UNSPRAYED SITES (October 2021–August 2022)																	
Bunda	324	143	467	6	3	50	31	8	0	242	107	447	20	1	1	0.3	0.7
Muleba	459	248	707	11	1	29	8	0	1	380	218	648	59	1	2	0.2	0.8
Geita	290	208	498	0	1	61	49	1	0	207	146	465	33	2	2	0.7	1.0
Kasulu TC	381	180	561	39	12	44	17	0	0	275	137	524	37	10	9	2.6	5.0
Total (Unsprayed Sites)	1454	779	2233	56	17	184	105	9	1	1104	608	2084	149	14	14	1.0	1.8
Total (All Sites)	1837	1141	2978	145	43	365	324	9	3	1209	707	2805	173	15	14	0.8	1.2

Mosquito sporozoite rate

Overall, sporozoite rates were found to vary across the sites, ranging 0%–1.2 % in sprayed sites and 0.5%–2.6% in unsprayed sites. Sporozoite rate was higher in unsprayed sites (1%) compared to sprayed sites (0.3 %), and the observed difference was statistically significant with p < 0.00001(Table 6). Further analysis to the species level showed that the highest of the sporozoites were found in *An. funestus s.s.* (1.1%) among the *Anopheles* species (Table 8).

Table 8. Sporozoite results by PCR-identified mosquito species

Mosquito species	Number of samples analyzed	Number of sporozoite-positive samples	Sporozoite rate (%)
An. gambiae s.s.	1014	4	0.4
An. arabiensis	3013	3	0.1
An. funestus s.s.	8505	94	1.1
An. parensis	48	0	0.0
Unidentified by PCR	591	0	0.0

As shown in Table 9, preliminary results indicate that the sporozoite rates for *An. gambiae s.s.* were significantly higher in unsprayed (1.8%) than in sprayed sites (0.0%) (P = 0.0002). Although, the sporozoite rate of *An. funestus* was higher in unsprayed sites (1.1%) than in sprayed sites (0.9%), the difference was not statistically significant (P = 0.5395).

Table 9. Species sporozoite results in sprayed and unsprayed sites

Mosquito species	Spray status	Number of samples analyzed	Number of sporozoite-positive samples	Sporozoite rate (%)	P-value
An. Gambiae s.s.	Sprayed	793	0	0.0	0.0002
	Unsprayed	221	4	1.8	
An. Arabiensis	Sprayed	1,813	0	0.0	
	Unsprayed	1,200	3	0.3	
An. funestus s.s.	Sprayed	1,156	10	0.9	0.5395
	Unsprayed	7,349	84	1.1	
An. parensis	Sprayed	13	0	0.0	
	Unsprayed	35	0	0.0	
Unidentified by PCR	Sprayed	160	0	0.0	
	Unsprayed	431	0	0.0	

Blood-Meal Analysis

A total of 29 samples were analyzed to determine their blood-meal source. Out of those, 20 were from sprayed sites and nine from unsprayed sites. The samples were from six sites, four from sprayed sites (Bukombe, Ukerewe, Kasulu, and Kibondo DCs) and two from unsprayed sites (Geita and Bunda DCs). There were no samples from Kasulu TC, Muleba, Kakonko, and Biharamulo DCs. Human, cow, goat, and dog antibodies were used for blood-meal analysis. Table 10 shows the species composition for mosquitoes analyzed for their blood meal, and Table 11 shows host preference of the analyzed mosquitoes through ELISA to determine the blood meal, hence the use of antibodies and not primers. Overall, the proportion of *Anopheles* that fed exclusively on humans was 34.5% (10/29). Molecular species identification indicated that the majority tested for blood-meal host were *An. funestus s.s.* (65.5%), followed by *An. arabiensis* (17.2%). All *An. arabiensis* analyzed fed on both humans and animals, showing opportunistic feeding behavior (Table 11).

Table 10. Table showing mosquitoes species composition and their blood meal source

District Sentinel Site	Species	No. Tested	Blood-meal sources					
			Human	Cow or Goat	Dog	Mixed (human-animal)	Mixed (animal-animal)	Unidentified meal
Sprayed Sites								
Biharamulo	*An. gambiae s.s.*	0	0	0	0	0	0	0
	An. arabiensis	0	0	0	0	0	0	0
	An. funestus s.s.	0	0	0	0	0	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0
Kasulu DC	*An. gambiae s.s.*	1	0	0	0	1	0	0
	An. arabiensis	2	0	0	0	2	0	0
	An. funestus s.s.	0	0	0	0	0	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0
Bukombe	*An. gambiae s.s.*	0	0	0	0	0	0	0
	An. arabiensis	0	0	0	0	0	0	0
	An. funestus s.s.	1	1	0	0	0	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0
Ukerewe	*An. gambiae s.s.*	0	0	0	0	0	0	0
	An. arabiensis	1	0	0	0	1	0	0
	An. funestus s.s.	0	0	0	0	0	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0
Kibondo	*An. gambiae s.s.*	1	0	0	0	1	0	0
	An. arabiensis	2	0	0	0	2	0	0

District Sentinel Site	Species	No. Tested	Blood-meal sources					
			Human	Cow or Goat	Dog	Mixed (human-animal)	Mixed (animal-animal)	Unidentified meal
	An. funestus s.s.	9	1	0	0	8	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	3	0	0	0	3	0	0
Kakonko	*An. gambiae s.s.*	0	0	0	0	0	0	0
	An. arabiensis	0	0	0	0	0	0	0
	An. funestus s.s.	0	0	0	0	0	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0
TOTAL	*An. gambiae s.s.*	2	0	0	0	2	0	0
	An. arabiensis	5	0	0	0	5	0	0
	An. funestus s.s.	10	2	0	0	8	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	3	0	0	0	3	0	0
Unsprayed Sites								
Bunda DC	*An. gambiae s.s.*	0	0	0	0	0	0	0
	An. arabiensis	0	0	0	0	0	0	0
	An. funestus s.s.	1	0	1	0	0	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0
Muleba	*An. gambiae s.s.*	0	0	0	0	0	0	0
	An. arabiensis	0	0	0	0	0	0	0
	An. funestus s.s.	0	0	0	0	0	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0

District Sentinel Site	Species	No. Tested	Blood-meal sources					
			Human	Cow or Goat	Dog	Mixed (human-animal)	Mixed (animal-animal)	Unidentified meal
Geita DC	*An. gambiae s.s.*	0	0	0	0	0	0	0
	An. arabiensis	0	0	0	0	0	0	0
	An. funestus s.s.	8	8	0	0	0	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0
Kasulu TC	*An. gambiae s.s.*	0	0	0	0	0	0	0
	An. arabiensis	0	0	0	0	0	0	0
	An. funestus s.s.	0	0	0	0	0	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0
TOTAL	*An. gambiae s.s.*	0	0	0	0	0	0	0
	An. arabiensis	0	0	0	0	0	0	0
	An. funestus s.s.	9	8	1	0	0	0	0
	An. parensis	0	0	0	0	0	0	0
	Unidentified	0	0	0	0	0	0	0
OVERALL TOTAL SAMPLES		**29**						

Table 11. Table showing blood-meal source, species, and host preference

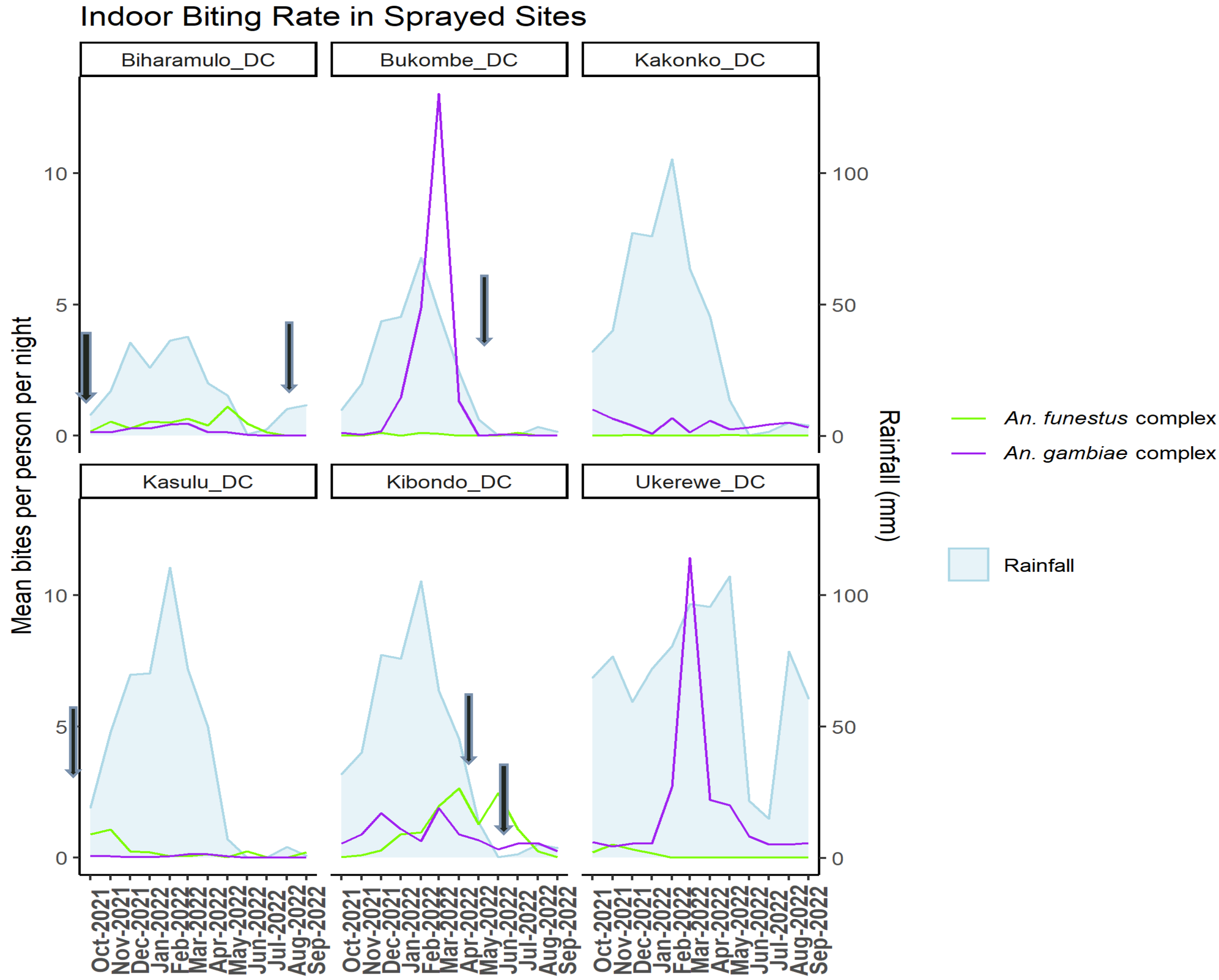
Blood-meal source	*An. gambiae s.s.*	*An. arabiensis*	*An. funestus s.s.*	*An. parensis*	Unidentified	TOTAL
Human	0	0	10	0	0	10
Cow	0	0	0	0	0	0
Goat	0	0	1	0	0	1
Dog	0	0	0	0	0	0
Human + Cow	0	0	0	0	0	0
Human + Goat	0	0	0	0	0	0
Human + Dog	2	5	8	0	3	18
Cow + Goat	0	0	0	0	0	0
Cow + Dog	0	0	0	0	0	0
Goat + Dog	0	0	0	0	0	0
Human + Cow + Goat	0	0	0	0	0	0
Human + Cow + Dog	0	0	0	0	0	0
Human + Goat + Dog	0	0	0	0	0	0
Cow + Goat + Dog	0	0	0	0	0	0
Human + Cow + Goat + Dog	0	0	0	0	0	0
Unidentified Meal	0	0	0	0	0	0
TOTAL	2	5	19	0	3	29

3.2.4 Biting and resting behavior

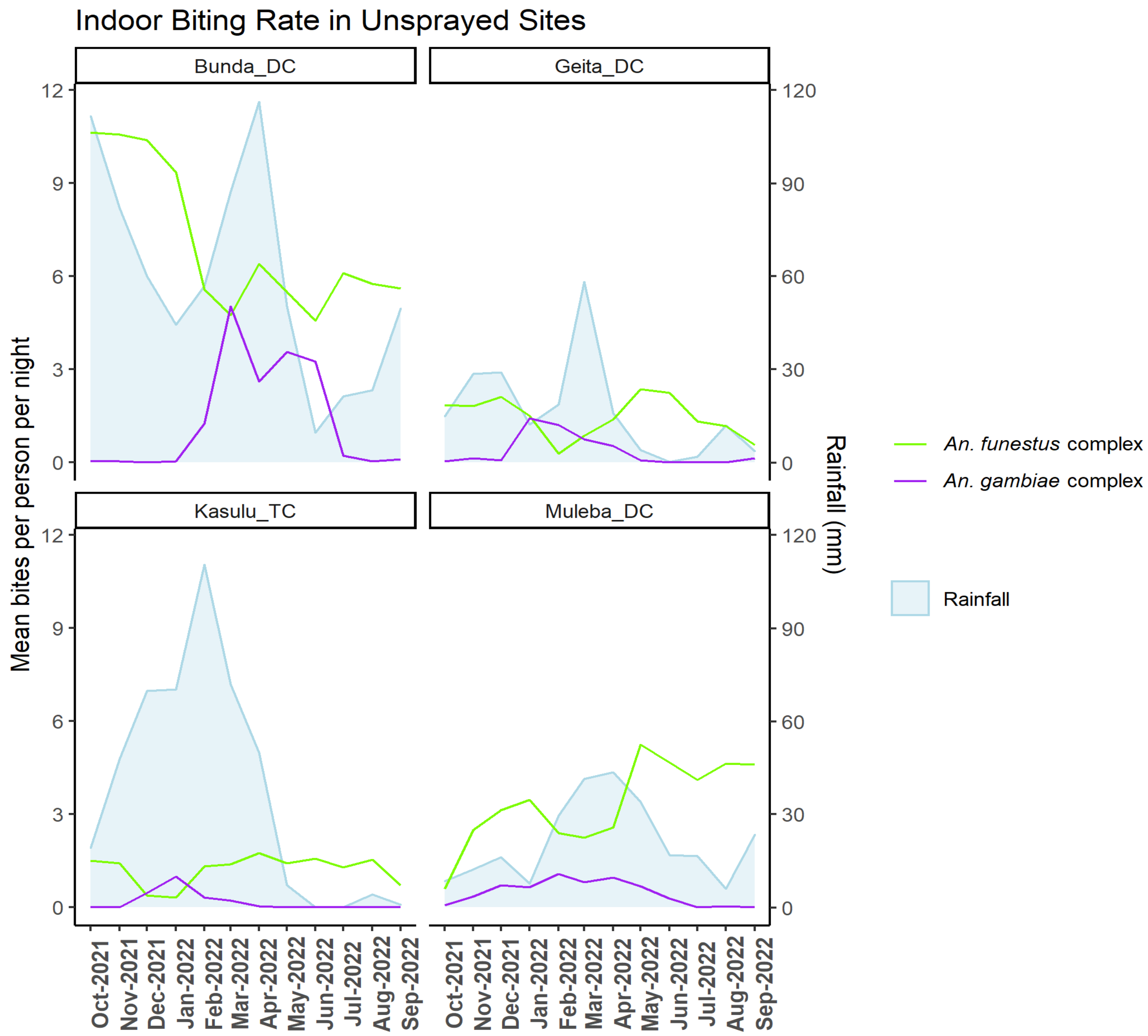
IBR of An. gambiae s.l. and An. funestus s.l.

IBR lowered in all sprayed sentinel sites except for Ukerewe, Kibondo, and Bukombe DCs where the highest proportion of *An. gambiae s.l.* was observed. Bunda DC had the highest IBR among unsprayed sentinel sites, with *An. funestus s.l.* exhibiting the highest IBR in unsprayed sites (Figure 16).

Figure 16. Monthly IBR (using CDC light traps) of Anopheles mosquitoes in sprayed (n = 6), and unsprayed (n = 4)



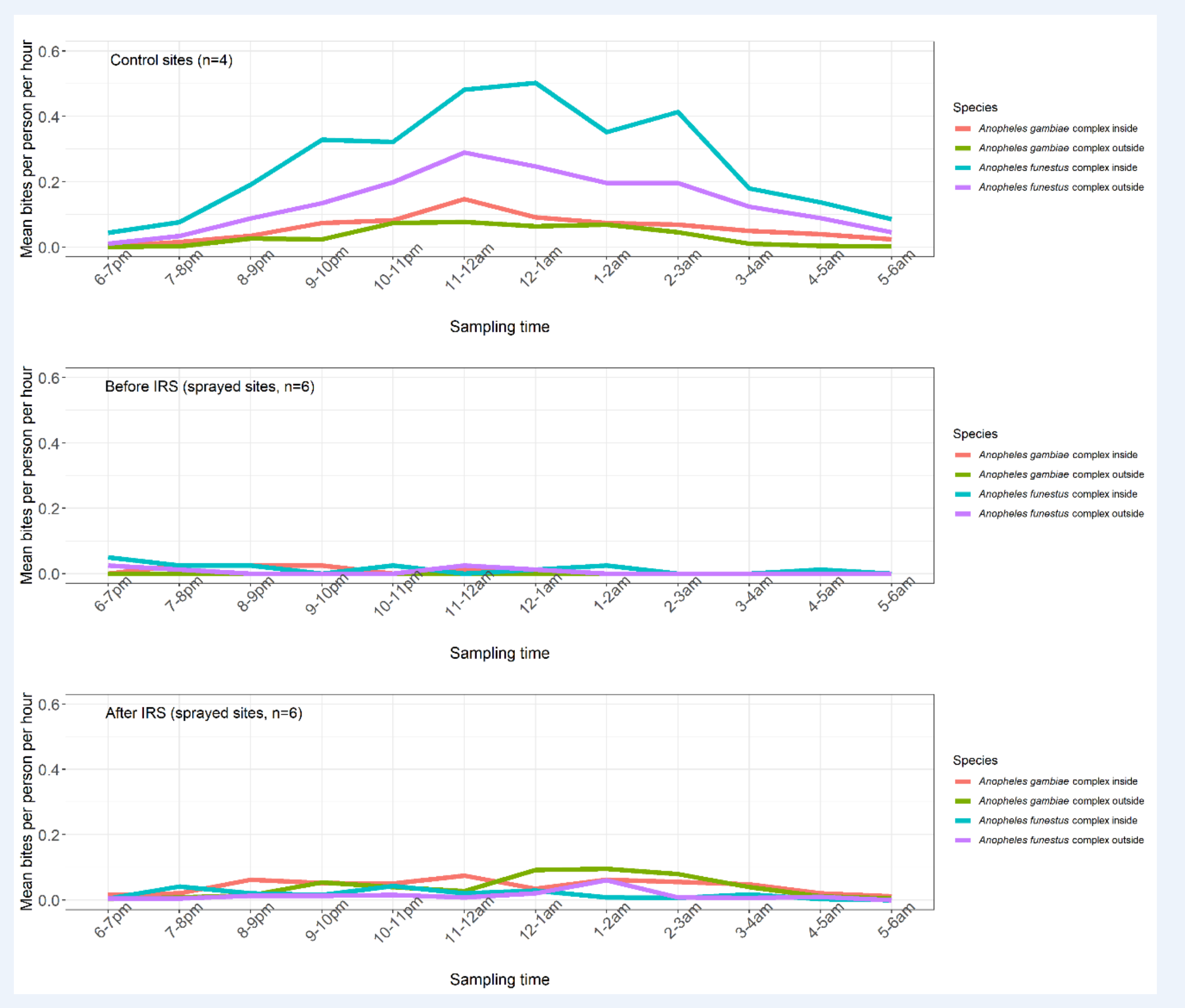
Arrows indicate when IRS operations were carried out.



Biting times of An. gambiae s.l. and An. funestus s.l.

In sprayed sites post-IRS, the level of *An. funestus s.l.* mean bites per person per night both indoors and outdoors was quite low compared with *An. gambiae s.l.* Generally, there was a higher number of indoor and outdoor *An. funestus s.l.* in unsprayed sites compared to sprayed sites (Figure 17). The biting rate of *An. funestus* complex indoors peaked at 12:00 a.m.–1:00 a.m. and 2:00 a.m.–3:00 a.m., while outdoors peaked at 11:00 p.m.–12:00 a.m. and 2:00 a.m.–3:00 a.m. in control sites. Moreover the biting rate of *An. gambiae* complex indoors peaked at 11:00 p.m.–12:00 a.m. while outdoors peaked at 10:00 p.m.–11:00 p.m.

After IRS the biting rate of *An. gambiae* complex indoors peaked at 11:00 p.m.–12:00 a.m., while outdoors peaked at 12:00 a.m.–1:00 a.m. Biting rate of *An. funestus* complex outdoors peaked at 1:00 a.m.–2:00 a.m. but indoors 7:00 p.m.–8:00 p.m. and 10:00 p.m.–11:00 p.m. (Figure 17). Mean indoor and outdoor biting rates of Anopheles collected by CBR in sprayed and unsprayed districts



IBR for both *An. gambiae s.l.* and *An. funestus s.l.* was higher in unsprayed sites compared to sprayed sites except for Bukombe DC, which had a slight increase of IBR, especially in *An. gambiae s.l.*, which were confirmed to be mostly *An. arabiensis* post-PCR (Table12). This confirms the zoophilic and anthropophilic feeding tendencies of *An. arabiensis*.

Table 12. Table showing biting rates for mosquitoes collected by CBR

District	INDOOR CBR [N(n)]		OUTDOOR CBR[N(n)]	
	NUMBER OF Anopheles gambiae s.l.	***NUMBER OF Anopheles funestus s.l.***	***NUMBER OF Anopheles gambiae s.l.***	***NUMBER OF Anopheles funestus s.l.***
Biharamulo	20 (0.2)	23 (0.2)	14 (0.1)	33 (0.3)
Ukerewe	28 (0.2)	2 (0.0)	5 (0.0)	1 (0.0)
Bukombe	129 (1.1)	11 (0.1)	192 (1.6)	7 (0.1)
Kasulu DC	3 (0.0)	31 (0.3)	0 (0.0)	6 (0.1)
Kibondo	53 (0.4)	45 (0.4)	42 (0.4)	54 (0.5)
Kakonko	54 (0.5)	0 (0.0)	6 (0.1)	1 (0.0)
Bunda*	66 (0.6)	286 (2.4)	33 (0.3)	118 (1.0)
Muleba*	43 (0.4)	527 (4.4)	9 (0.1)	304 (2.5)
Geita DC*	65 (0.5)	256 (2.1)	54 (0.5)	150 (1.3)

District	INDOOR CBR [N(n)]		OUTDOOR CBR[N(n)]	
	NUMBER OF Anopheles gambiae s.l.	***NUMBER OF Anopheles funestus s.l.***	***NUMBER OF Anopheles gambiae s.l.***	***NUMBER OF Anopheles funestus s.l.***
Kasulu TC*	86 (0.7)	336 (2.8)	30 (0.3)	182 (1.5)
	547 (4.6)	1517 (12.6)	385 (3.2)	856 (7.1)

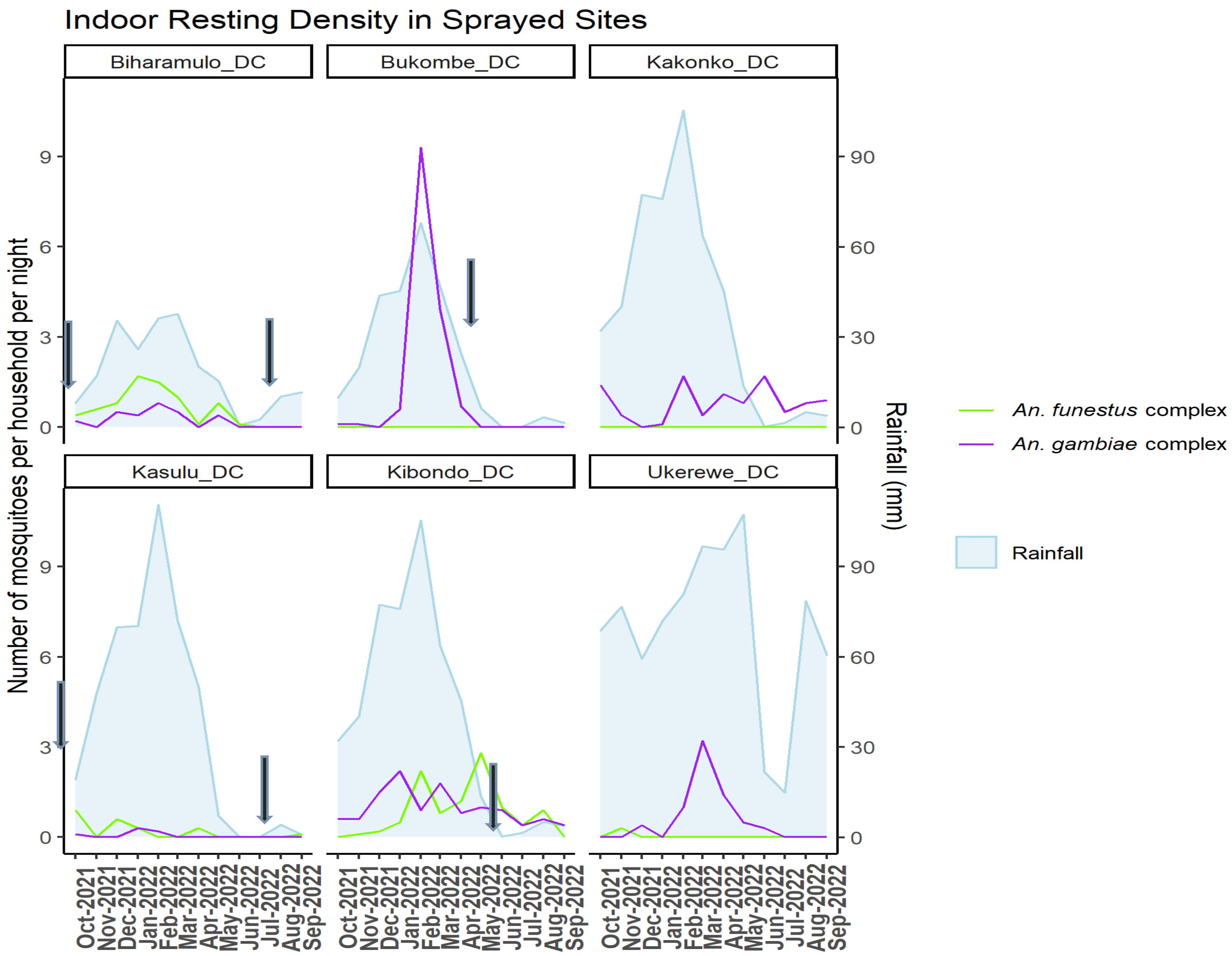
* Control sites)

Abbreviations: *N,* Number collected; (*n*), mean number per trap night

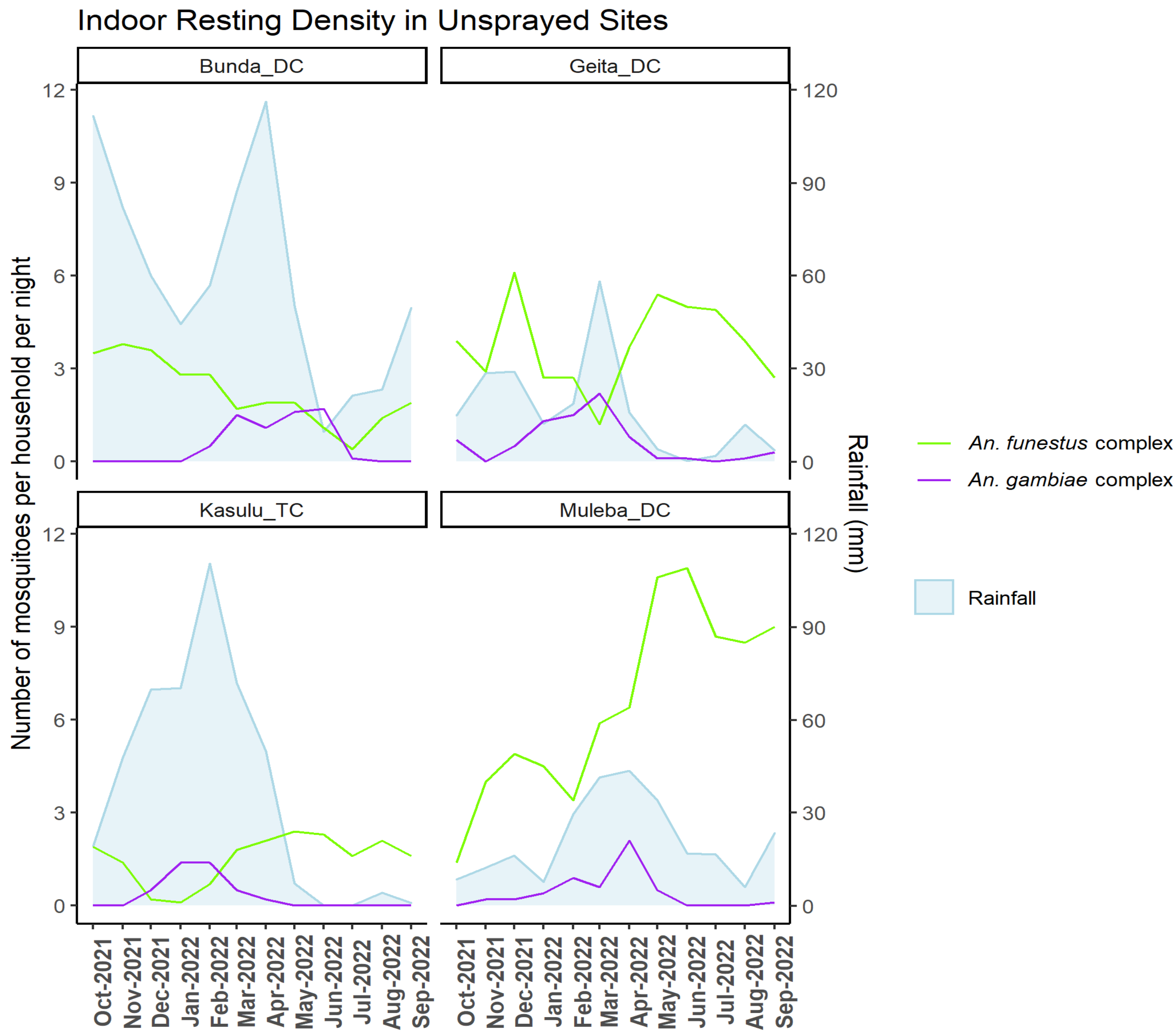
IRD of An. gambiae s.l. and An. funestus s.l.

In most sprayed sites, with the exception of Biharamulo and Kibondo DCs, *An. gambiae s.l.* was dominant to *An. funestus s.l.* The sentinel sites of Bukombe, Kibondo, and Ukerewe DCs had the highest number of *An. gambiae s.l.* mosquitoes resting indoors (Figure 18). There were more *An. funestus s.l.* than *An. gambiae s.l.* in all unsprayed sites.

Figure 17. Monthly IRD (using Prokopack aspirators) of Anopheles mosquitoes in sprayed (n = 6), and unsprayed (n = 4) districts



Arrows indicate when IRS operations were carried out.



Entomological Inoculation Rate

Entomological inoculation rate is a measure of exposure to infectious mosquitoes. It is used to assess the impact of vector control on malaria parasite transmission and elimination from data collected both indoors and outdoors. Here CBR was used to collect mosquitoes to estimate EIR.

Overall, the entomological inoculation rate (EIR) was lower in sprayed sites when compared to the unsprayed from October 2021 to September 2022, with exception of Kibondo (Table 13).

Table 13. Entomological inoculation rate for sprayed and unsprayed sites

Study site	IRS status	Sporozoite rate (%), (number of CBR positive/ number of CBR tested)	Human biting rate * (Total Anopheles collected/sampling duration)	EIR (Sporozoite rate X HBR X 365)
Biharamulo	Sprayed	(0/98)	0.8 (98/120)	0
Kasulu DC	Sprayed	(0/36)	0.3 (36/120)	0
Kibondo	Sprayed	(1/183)	1.5 (183/120)	3.0
Kakonko	Sprayed	(0/64)	0.5 (64/120)	0
Bukombe	Sprayed	(0/329)	2.7 (329/120)	0
Ukerewe	Sprayed	(0/35)	0.3 (35/120)	0
Bunda	Unsprayed	(2/467)	3.9 (467/120)	6.1
Muleba	Unsprayed	(3/707)	5.9 (707/120)	9.1
Geita DC	Unsprayed	(4/498)	4.2 (498/120)	12.3
Kasulu TC	Unsprayed	(19/561)	4.7 (561/120)	58.1

*Note: The human biting rate was obtained from mosquitoes collected by CBR both indoor and outdoor

4. DISCUSSION AND CONCLUSION

The use of clothianidin and Fludora® Fusion as insecticides of choice during IRS operations in the six sprayed sites has shown to be efficacious. Fludora® Fusion was retained effectively, with all wall surfaces showing ≥80% mortality for nine months after IRS. Clothianidin was also retained effectively, with all wall surfaces showing ≥80% mortality for eight months after IRS.

Among the six sprayed sites, sporozoites were only found in Biharamulo DC (0.2%), Kibondo DC (0.6%), and Kasulu DC (1.2%). Overall, unsprayed sites had greater sporozoite rates when compared with the sprayed sites. Further analysis to the species level showed that within PCR-identified species the sporozoites were found only in *An. funestus s.s.*, *An. Arabiensis*, and *An. gambiae s.s.*, with *An. funestus s.s.* showing 0.9% sporozoite rate in sprayed sites and 1.1% in unsprayed sites. *An. arabiensis* exhibited no sporozoites in sprayed sites and a 0.3% sporozoite rate in unsprayed sites, while *An. gambiae s.s.* displayed no sporozoites in sprayed sites and a 1.8% sporozoite rate in unsprayed sites. Despite Bunda DC having the highest number of mosquitoes collected, the sporozoite rate was the lowest (0.5%) compared to other unsprayed sites, of which Kasulu TC had the highest (2.6%). All unsprayed sites had *An. funestus s.s.* as the dominant species. Meanwhile, 65.5% tested blood-meal host was *An. funestus s.s.* whose blood-meal source was found to be approximately 53% human.

An. gambiae s.l. was the most common mosquito type resting indoors in Ukerewe, Kibondo, Kakonko, and Bukombe DCs. The most *An. gambiae s.l.* biting indoors was found in Ukerewe, Kakonko, and Bukombe DCs. In Bukombe DC, *An. gambiae s.l.* had the highest IBR after IRS during the reporting period, unlike the rest of the sprayed sites. However, unsprayed sites had higher IBR and IRD when compared to sprayed sites. *An. gambiae s.l.* was observed to be dominant in sprayed sites compared to unsprayed sites, where *An. funestus s.l.* exhibited the highest IBR and IRD. Also, the mean bites per person per hour were below 0.2 before and after deployment of IRS in contrast to the unsprayed sites.

The impact on how IRS has affected the parity of mosquitoes post-IRS could have been much better if there were more than just one-month surveillance pre-IRS. The percentage of parity pre-IRS was higher compared to post-IRS in all sprayed sites. The percentage of parity in unsprayed sites was higher with Geita DC taking the lead compared to the sprayed sites pre-IRS and post-IRS. Moreover, the EIR was lower in sprayed sites unlike the unsprayed sites with exception to Kibondo. In unsprayed sites the highest 12-month EIR was 58.1 (Kasulu TC), whereas in sprayed sites the highest EIR was 3.0 (Kibondo DC). These data indicate that IRS has reduced the level of human exposure to infective mosquito bites in sprayed sites.

Annex 1: Cone wall bioassay tests. Percentage mortality obtained for female An. gambiae s.s. Kisumu exposed on sprayed surfaces

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kasulu DC	October	Mud	97.5	100	100	100	100	100	100
Kasulu DC	October	Cement	99.2	100	100	100	100	100	100
Kasulu DC	October	Painted	98.9	100	100	100	100	100	100
Kasulu DC	October	Whitewash	99.4	100	100	100	100	100	100
Kasulu DC	October	Burnt brick	98.3	100	100	100	100	100	100
Kibondo	October	Mud	90.0	100	100	100	100	100	100
Kibondo	October	Cement	98.8	100	100	100	100	100	100
Kibondo	October	Painted	97.2	100	100	100	100	100	100
Kibondo	October	Whitewash	98.3	100	100	100	100	100	100
Kibondo	October	Burnt brick	95.6	100	100	100	100	100	100
Kakonko	October	Mud	95.0	100	100	100	100	100	100
Kakonko	October	Cement	95.0	100	100	100	100	100	100
Kakonko	October	Painted	97.2	100	100	100	100	100	100
Kakonko	October	Whitewash	95.0	100	100	100	100	100	100
Kakonko	October	Burnt brick	97.2	100	100	100	100	100	100
Kasulu DC	November	Mud	82.5	100	100	100	100	100	100
Kasulu DC	November	Cement	90	100	100	100	100	100	100
Kasulu DC	November	Painted	90	100	100	100	100	100	100
Kasulu DC	November	Whitewash	90	100	100	100	100	100	100
Kasulu DC	November	Burnt brick	82.5	100	100	100	100	100	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kibondo	November	Mud	85	100	100	100	100	100	100
Kibondo	November	Cement	80	100	100	100	100	100	100
Kibondo	November	Painted	95	100	100	100	100	100	100
Kibondo	November	Whitewash	85	100	100	100	100	100	100
Kibondo	November	Burnt brick	87.5	100	100	100	100	100	100
Kakonko	November	Mud	85	100	100	100	100	100	100
Kakonko	November	Cement	80	100	100	100	100	100	100
Kakonko	November	Painted	95	100	100	100	100	100	100
Kakonko	November	Whitewash	85	100	100	100	100	100	100
Kakonko	November	Burnt brick	87.5	100	100	100	100	100	100
Biharamulo	November	Mud	98.9	100	100	100	100	100	100
Biharamulo	November	Cement	92.8	100	100	100	100	100	100
Biharamulo	November	Painted	90.6	100	100	100	100	100	100
Biharamulo	November	Whitewash	86.7	100	100	100	100	100	100
Biharamulo	November	Burnt brick	97.8	100	100	100	100	100	100
Bukombe	November	Mud	76.7	100	100	100	100	100	100
Bukombe	November	Cement	67.8	100	100	100	100	100	100
Bukombe	November	Painted	63.9	100	100	100	100	100	100
Bukombe	November	Whitewash	60.8	100	100	100	100	100	100
Bukombe	November	Burnt brick	82.1	100	100	100	100	100	100
Ukerewe	November	Mud	95.6	100	100	100	100	100	100
Ukerewe	November	Cement	90.6	100	100	100	100	100	100
Ukerewe	November	Painted	87.2	100	100	100	100	100	100
Ukerewe	November	Whitewash	87.2	100	100	100	100	100	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Ukerewe	November	Burnt brick	84.4	100	100	100	100	100	100
Kasulu DC	December	Mud	100	100	100	100	100	100	100
Kasulu DC	December	Cement	92.5	100	100	100	100	100	100
Kasulu DC	December	Painted	95	100	100	100	100	100	100
Kasulu DC	December	Whitewash	97.5	100	100	100	100	100	100
Kasulu DC	December	Burnt brick	87.5	100	100	100	100	100	100
Kibondo	December	Mud	70	100	100	100	100	100	100
Kibondo	December	Cement	100	100	100	100	100	100	100
Kibondo	December	Painted	100	100	100	100	100	100	100
Kibondo	December	Whitewash	100	100	100	100	100	100	100
Kibondo	December	Burnt brick	80	100	100	100	100	100	100
Kakonko	December	Mud	100	100	100	100	100	100	100
Kakonko	December	Cement	100	100	100	100	100	100	100
Kakonko	December	Painted	75	100	100	100	100	100	100
Kakonko	December	Whitewash	80	100	100	100	100	100	100
Kakonko	December	Burnt brick	97.5	100	100	100	100	100	100
Biharamulo	December	Mud	87.5	100	100	100	100	100	100
Biharamulo	December	Cement	87.5	100	100	100	100	100	100
Biharamulo	December	Painted	57.5	100	100	100	100	100	100
Biharamulo	December	Whitewash	85	100	100	100	100	100	100
Biharamulo	December	Burnt brick	72.5	100	100	100	100	100	100
Bukombe	December	Mud	80	100	100	100	100	100	100
Bukombe	December	Cement	77.5	100	100	100	100	100	100
Bukombe	December	Painted	87.5	100	100	100	100	100	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Bukombe	December	Whitewash	90	100	100	100	100	100	100
Bukombe	December	Burnt brick	87.5	100	100	100	100	100	100
Ukerewe	December	Mud	95.0	100	100	100	100	100	100
Ukerewe	December	Cement	100.0	100	100	100	100	100	100
Ukerewe	December	Painted	97.5	100	100	100	100	100	100
Ukerewe	December	Whitewash	100.0	100	100	100	100	100	100
Ukerewe	December	Burnt brick	95.0	100	100	100	100	100	100
Kasulu DC	January	Mud	97.5	100	100	100	100	100	100
Kasulu DC	January	Cement	80	100	100	100	100	100	100
Kasulu DC	January	Painted	100	100	100	100	100	100	100
Kasulu DC	January	Whitewash	97.5	100	100	100	100	100	100
Kasulu DC	January	Burnt brick	82.5	100	100	100	100	100	100
Kibondo	January	Mud	62.5	92.5	100	100	100	100	100
Kibondo	January	Cement	87.5	100	100	100	100	100	100
Kibondo	January	Painted	87.5	100	100	100	100	100	100
Kibondo	January	Whitewash	85	100	100	100	100	100	100
Kibondo	January	Burnt brick	75	97.5	100	100	100	100	100
Kakonko	January	Mud	85	100	100	100	100	100	100
Kakonko	January	Cement	90	100	100	100	100	100	100
Kakonko	January	Painted	95	100	100	100	100	100	100
Kakonko	January	Whitewash	92.5	100	97.5	100	100	100	100
Kakonko	January	Burnt brick	87.5	100	97.5	100	100	100	100
Biharamulo	January	Mud	67.5	100	100	100	100	100	100
Biharamulo	January	Cement	92.5	100	100	100	100	100	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Biharamulo	January	Painted	97.5	100	100	100	100	100	100
Biharamulo	January	Whitewash	92.5	100	100	100	100	100	100
Biharamulo	January	Burnt brick	77.5	100	100	100	100	100	100
Bukombe	January	Mud	72.5	100	100	100	100	100	100
Bukombe	January	Cement	92.5	100	100	100	100	100	100
Bukombe	January	Painted	97.5	100	100	100	100	100	100
Bukombe	January	Whitewash	95	100	100	100	100	100	100
Bukombe	January	Burnt brick	67.5	100	100	100	100	100	100
Ukerewe	January	Mud	70	97.5	100	100	100	100	100
Ukerewe	January	Cement	97.5	100	100	100	100	100	100
Ukerewe	January	Painted	100	100	100	100	100	100	100
Ukerewe	January	Whitewash	97.5	100	100	100	100	100	100
Ukerewe	January	Burnt brick	80	100	100	100	100	100	100
Kasulu DC	February	Mud	75	97.5	100	100	100	100	100
Kasulu DC	February	Cement	87.5	100	100	100	100	100	100
Kasulu DC	February	Painted	97.5	100	100	100	100	100	100
Kasulu DC	February	Whitewash	90	100	100	100	100	100	100
Kasulu DC	February	Burnt brick	75	95	100	100	100	100	100
Kibondo	February	Mud	47.5	67.5	100	100	100	100	100
Kibondo	February	Cement	75	82.5	100	100	100	100	100
Kibondo	February	Painted	75	85	100	100	100	100	100
Kibondo	February	Whitewash	65	77.5	100	100	100	100	100
Kibondo	February	Burnt brick	65	62.5	100	100	100	100	100
Kakonko	February	Mud	65	90	100	100	100	100	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kakonko	February	Cement	80	97.5	100	100	100	100	100
Kakonko	February	Painted	92.5	100	100	100	100	100	100
Kakonko	February	Whitewash	85	100	100	100	100	100	100
Kakonko	February	Burnt brick	75	90	100	100	100	100	100
Biharamulo	February	Mud	75	95	100	100	100	100	100
Biharamulo	February	Cement	85	100	100	100	100	100	100
Biharamulo	February	Painted	100	100	100	100	100	100	100
Biharamulo	February	Whitewash	85	100	100	100	100	100	100
Biharamulo	February	Burnt brick	75	92.5	100	100	100	100	100
Bukombe	February	Mud	72.5	92.5	100	100	100	100	100
Bukombe	February	Cement	85	100	100	100	100	100	100
Bukombe	February	Painted	97.5	100	100	100	100	100	100
Bukombe	February	Whitewash	90	100	100	100	100	100	100
Bukombe	February	Burnt brick	67.5	97.5	100	100	100	100	100
Ukerewe	February	Mud	70	92.5	100	100	100	100	100
Ukerewe	February	Cement	82.5	100	100	100	100	100	100
Ukerewe	February	Painted	92.5	100	100	100	100	100	100
Ukerewe	February	Whitewash	90	100	97.5	100	100	100	100
Ukerewe	February	Burnt brick	82.5	97.5	97.5	100	100	100	100
Kasulu DC	March	Mud	37.5	62.5	85	100	100	100	100
Kasulu DC	March	Cement	55	67.5	87.5	100	100	100	100
Kasulu DC	March	Painted	55	80	100	100	100	100	100
Kasulu DC	March	Whitewash	50	77.5	97.5	100	100	100	100
Kasulu DC	March	Burnt brick	40	65	85	100	100	100	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kibondo	March	Mud	25	42.5	90	100	100	100	100
Kibondo	March	Cement	40	50	100	100	100	100	100
Kibondo	March	Painted	42.5	52.5	100	100	100	100	100
Kibondo	March	Whitewash	45	57.5	100	100	100	100	100
Kibondo	March	Burnt brick	30	42.5	87.5	100	100	100	100
Kakonko	March	Mud	32.5	52.5	80	100	100	100	100
Kakonko	March	Cement	47.5	70	95	100	100	100	100
Kakonko	March	Painted	57.5	80	100	100	100	100	100
Kakonko	March	Whitewash	85	95	95	100	100	100	100
Kakonko	March	Burnt brick	45	62.5	82.5	100	100	100	100
Biharamulo	March	Mud	22.5	47.5	95	100	100	100	100
Biharamulo	March	Cement	57.5	80	100	100	100	100	100
Biharamulo	March	Painted	57.5	82.5	100	100	100	100	100
Biharamulo	March	Whitewash	57.5	82.5	100	100	100	100	100
Biharamulo	March	Burnt brick	15	45	100	100	100	100	100
Bukombe	March	Mud	25	65	87.5	100	100	100	100
Bukombe	March	Cement	50	95	100	100	100	100	100
Bukombe	March	Painted	45	75	100	100	100	100	100
Bukombe	March	Whitewash	45	82.5	100	100	100	100	100
Bukombe	March	Burnt brick	32.5	67.5	97.5	100	100	100	100
Ukerewe	March	Mud	17.5	35	72.5	100	100	100	100
Ukerewe	March	Cement	72.5	92.5	100	100	100	100	100
Ukerewe	March	Painted	50	77.5	100	100	100	100	100
Ukerewe	March	Whitewash	67.5	92.5	100	100	100	100	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Ukerewe	March	Burnt brick	12.5	30	62.5	100	100	100	100
Kasulu DC	April	Mud	52.5	80	100	100	100	100	100
Kasulu DC	April	Cement	65	92.5	100	100	100	100	100
Kasulu DC	April	Painted	87.5	100	100	100	100	100	100
Kasulu DC	April	Whitewash	70	90	100	100	100	100	100
Kasulu DC	April	Burnt brick	60	85	100	100	100	100	100
Kibondo	April	Mud	45	85	97.5	100	100	100	100
Kibondo	April	Cement	72.5	97.5	100	100	100	100	100
Kibondo	April	Painted	92.5	100	100	100	100	100	100
Kibondo	April	Whitewash	77.5	100	100	100	100	100	100
Kibondo	April	Burnt brick	60	90	100	100	100	100	100
Kakonko	April	Mud	57.5	80	100	100	100	100	100
Kakonko	April	Cement	80	95	100	100	100	100	100
Kakonko	April	Painted	85	100	100	100	100	100	100
Kakonko	April	Whitewash	75	97.5	100	100	100	100	100
Kakonko	April	Burnt brick	75	97.5	100	100	100	100	100
Biharamulo	April	Mud	42.5	77.5	100	100	100	100	100
Biharamulo	April	Cement	72.5	95	100	100	100	100	100
Biharamulo	April	Painted	97.5	100	100	100	100	100	100
Biharamulo	April	Whitewash	85	100	100	100	100	100	100
Biharamulo	April	Burnt brick	67.5	95	100	100	100	100	100
Bukombe	April	Mud	52.5	82.5	97.5	100	100	100	100
Bukombe	April	Cement	67.5	95	100	100	100	100	100
Bukombe	April	Painted	87.5	100	100	100	100	100	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Bukombe	April	Whitewash	67.5	92.5	100	100	100	100	100
Bukombe	April	Burnt brick	62.5	87.5	97.5	100	100	100	100
Ukerewe	April	Mud	50	80	100	100	100	100	100
Ukerewe	April	Cement	60	92.5	100	100	100	100	100
Ukerewe	April	Painted	70	100	100	100	100	100	100
Ukerewe	April	Whitewash	52.5	82.5	90	100	100	100	100
Ukerewe	April	Burnt brick	37.5	70	100	100	100	100	100
Kasulu DC	May	Mud	37.5	45	65	82.5	100	100	100
Kasulu DC	May	Cement	50	57.5	75	85	100	100	100
Kasulu DC	May	Painted	67.5	70	85	97.5	100	100	100
Kasulu DC	May	Whitewash	57.5	57.5	80	95	100	100	100
Kasulu DC	May	Burnt brick	45	55	75	92.5	100	100	100
Kibondo	May	Mud	35	55	72.5	90	100	100	100
Kibondo	May	Cement	65	65	85	100	100	100	100
Kibondo	May	Painted	67.5	77.5	92.5	100	100	100	100
Kibondo	May	Whitewash	45	60	85	97.5	100	100	100
Kibondo	May	Burnt brick	45	50	75	92.5	100	100	100
Kakonko	May	Mud	35	42.5	65	85	100	100	100
Kakonko	May	Cement	67.5	65	87.5	97.5	100	100	100
Kakonko	May	Painted	80	70	90	100	100	100	100
Kakonko	May	Whitewash	72.5	75	90	100	100	100	100
Kakonko	May	Burnt brick	42.5	45	65	85	100	100	100
Biharamulo	May	Mud	30	50	70	87.5	100	100	100
Biharamulo	May	Cement	55	70	80	90	100	100	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Biharamulo	May	Painted	80	70	82.5	92.5	100	100	100
Biharamulo	May	Whitewash	65	65	80	92.5	100	100	100
Biharamulo	May	Burnt brick	45	55	80	92.5	100	100	100
Bukombe	May	Mud	47.5	55	80	97.5	100	100	100
Bukombe	May	Cement	60	75	92.5	100	100	100	100
Bukombe	May	Painted	77.5	87.5	100	100	100	100	100
Bukombe	May	Whitewash	60	80	95	100	100	100	100
Bukombe	May	Burnt brick	40	55	75	92.5	100	100	100
Ukerewe	May	Mud	50	57.5	72.5	92.5	100	100	100
Ukerewe	May	Cement	70	75	87.5	92.5	100	100	100
Ukerewe	May	Painted	72.5	67.5	80	92.5	100	100	100
Ukerewe	May	Whitewash	70	85	92.5	100	100	100	100
Ukerewe	May	Burnt brick	55	62.5	67.5	85	92.5	100	100
Kasulu DC	June	Mud	5	7.5	15	32.5	50	62.5	100
Kasulu DC	June	Cement	5	12.5	27.5	45	60	67.5	100
Kasulu DC	June	Painted	7.5	12.5	30	40	57.5	70	100
Kasulu DC	June	Whitewash	12.5	12.5	27.5	47.5	70	85	100
Kasulu DC	June	Burnt brick	7.5	15	40	52.5	65	72.5	100
Kibondo	June	Mud	2.5	10	20	37.5	52.5	62.5	100
Kibondo	June	Cement	10	15	42.5	67.5	82.5	97.5	100
Kibondo	June	Painted	10	10	42.5	55	67.5	75	100
Kibondo	June	Whitewash	12.5	17.5	40	62.5	80	90	100
Kibondo	June	Burnt brick	5	12.5	27.5	45	57.5	72.5	100
Kakonko	June	Mud	25	35	47.5	55	70	100	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kakonko	June	Cement	17.5	25	50	67.5	92.5	100	100
Kakonko	June	Painted	15	22.5	40	60	85	100	100
Kakonko	June	Whitewash	17.5	22.5	45	65	80	100	100
Kakonko	June	Burnt brick	20	22.5	45	70	77.5	100	100
Biharamulo	June	Mud	0	5	20	32.5	52.5	100	100
Biharamulo	June	Cement	2.5	20	32.5	75	80	100	100
Biharamulo	June	Painted	2.5	7.5	32.5	60	75	100	100
Biharamulo	June	Whitewash	2.5	12.5	27.5	60	75	100	100
Biharamulo	June	Burnt brick	2.5	7.5	30	70	77.5	100	100
Bukombe	June	Mud	2.5	10	20	37.5	60	100	100
Bukombe	June	Cement	15	27.5	42.5	52.5	67.5	100	100
Bukombe	June	Painted	12.5	25	35	40	62.5	100	100
Bukombe	June	Whitewash	15	25	37.5	50	57.5	100	100
Bukombe	June	Burnt brick	2.5	35	45	57.5	67.5	100	100
Ukerewe	June	Mud	0	5	10	27.5	60	100	100
Ukerewe	June	Cement	12.5	12.5	20	52.5	70	100	100
Ukerewe	June	Painted	5	5	12.5	40	60	100	100
Ukerewe	June	Whitewash	10	12.5	15	45	65	100	100
Ukerewe	June	Burnt brick	2.5	5	10	62.5	70	100	100
Kasulu DC	July	Mud	2.5	7.5	12.5	22.5	42.5	70	100
Kasulu DC	July	Cement	15	12.5	20	40	52.5	72.5	100
Kasulu DC	July	Painted	37.5	27.5	37.5	57.5	75	100	100
Kasulu DC	July	Whitewash	12.5	15	25	45	65	87.5	100
Kasulu DC	July	Burnt brick	10	17.5	25	35	52.5	72.5	100

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kibondo	July	Mud	2.5	0	7.5	22.5	47.5	72.5	95
Kibondo	July	Cement	2.5	10	22.5	37.5	57.5	85	100
Kibondo	July	Painted	15	22.5	37.5	60	82.5	100	100
Kibondo	July	Whitewash	10	15	32.5	45	62.5	85	100
Kibondo	July	Burnt brick	5	12.5	25	45	67.5	85	100
Kakonko	July	Mud	2.5	7.5	12.5	35	50	72.5	100
Kakonko	July	Cement	5	15	22.5	45	55	82.5	100
Kakonko	July	Painted	17.5	22.5	40	60	85	100	100
Kakonko	July	Whitewash	5	17.5	25	50	70	92.5	100
Kakonko	July	Burnt brick	2.5	12.5	27.5	42.5	57.5	80	100
Biharamulo	July	Mud	2.5	2.5	7.5	20	37.5	70	100
Biharamulo	July	Cement	7.5	10	17.5	30	50	95	100
Biharamulo	July	Painted	20	27.5	37.5	55	85	100	100
Biharamulo	July	Whitewash	10	7.5	17.5	32.5	52.5	85	100
Biharamulo	July	Burnt brick	12.5	7.5	20	30	55	90	100
Bukombe	July	Mud	0	2.5	10	25	42.5	70	95
Bukombe	July	Cement	2.5	7.5	20	32.5	62.5	87.5	100
Bukombe	July	Painted	10	17.5	37.5	47.5	72.5	92.5	97.5
Bukombe	July	Whitewash	5	20	37.5	50	77.5	95	100
Bukombe	July	Burnt brick	2.5	5	22.5	30	55	80	100
Ukerewe	July	Mud	0	2.5	5	10	25	50	85
Ukerewe	July	Cement	2.5	2.5	15	25	45	70	100
Ukerewe	July	Painted	22.5	15	22.5	45	75	97.5	100
Ukerewe	July	Whitewash	12.5	7.5	22.5	40	47.5	70	97.5

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Ukerewe	July	Burnt brick	0	2.5	15	30	40	67.5	92.5
Kasulu DC	August	Mud	0	2.5	7.5	12.5	30	45	60
Kasulu DC	August	Cement	10	10	20	35	45	62.5	85
Kasulu DC	August	Painted	15	17.5	35	55	67.5	85	97.5
Kasulu DC	August	Whitewash	7.5	15	22.5	35	57.5	62.5	80
Kasulu DC	August	Burnt brick	2.5	7.5	15	25	37.5	55	75
Kibondo	August	Mud	0	2.5	5	15	25	42.5	65
Kibondo	August	Cement	2.5	5	17.5	35	45	65	85
Kibondo	August	Painted	12.5	22.5	35	50	75	95	100
Kibondo	August	Whitewash	5	7.5	17.5	35	52.5	70	90
Kibondo	August	Burnt brick	0	5	12.5	27.5	45	62.5	85
Kakonko	August	Mud	0	2.5	7.5	20	32.5	45	60
Kakonko	August	Cement	10	12.5	20	32.5	47.5	62.5	80
Kakonko	August	Painted	17.5	15	27.5	47.5	65	85	100
Kakonko	August	Whitewash	7.5	12.5	30	35	57.5	62.5	85
Kakonko	August	Burnt brick	2.5	5	17.5	27.5	37.5	50	75
Biharamulo	August	Mud	0	5	10	22.5	32.5	50	70
Biharamulo	August	Cement	2.5	10	20	27.5	45	55	72.5
Biharamulo	August	Painted	15	15	30	42.5	60	85	100
Biharamulo	August	Whitewash	5	10	22.5	35	47.5	67.5	82.5
Biharamulo	August	Burnt brick	7.5	15	20	35	45	62.5	77.5
Bukombe	August	Mud	2.5	7.5	10	20	35	52.5	62.5
Bukombe	August	Cement	7.5	15	25	30	45	65	85
Bukombe	August	Painted	15	20	35	50	65	90	92.5

District	Month	Type of Wall Surface	% Knockdown (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Bukombe	August	Whitewash	5	17.5	27.5	42.5	52.5	67.5	87.5
Bukombe	August	Burnt brick	2.5	5	17.5	25	35	47.5	72.5
Ukerewe	August	Mud	0	5	5	17.5	30	42.5	67.5
Ukerewe	August	Cement	7.5	12.5	17.5	30	47.5	65	90
Ukerewe	August	Painted	15	20	35	55	72.5	97.5	100
Ukerewe	August	Whitewash	7.5	15	20	25	45	62.5	82.5
Ukerewe	August	Burnt brick	2.5	7.5	12.5	17.5	30	42.5	67.5

Annex 2: Fumigant bioassay tests. Percentage mortality obtained for female An. gambiae s.s. Kisumu exposed on sprayed surfaces

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kasulu DC	October	Mud	83.3	100	100	100	100	100	100
Kasulu DC	October	Cement	70.0	100	100	100	100	100	100
Kasulu DC	October	Painted	86.7	100	100	100	100	100	100
Kasulu DC	October	Whitewash	80.0	100	100	100	100	100	100
Kasulu DC	October	Burnt brick	82.5	100	100	100	100	100	100
Kibondo	October	Mud	66.7	100	100	100	100	100	100
Kibondo	October	Cement	82.5	100	100	100	100	100	100
Kibondo	October	Painted	76.7	100	100	100	100	100	100
Kibondo	October	Whitewash	85.0	100	100	100	100	100	100
Kibondo	October	Burnt brick	73.3	100	100	100	100	100	100
Kakonko	October	Mud	70.0	100	100	100	100	100	100
Kakonko	October	Cement	70.0	100	100	100	100	100	100
Kakonko	October	Painted	73.3	100	100	100	100	100	100
Kakonko	October	Whitewash	73.3	100	100	100	100	100	100
Kakonko	October	Burnt brick	60.0	100	100	100	100	100	100
Kasulu DC	November	Mud	80	100	100	100	100	100	100
Kasulu DC	November	Cement	80	100	100	100	100	100	100
Kasulu DC	November	Painted	70	100	100	100	100	100	100
Kasulu DC	November	Whitewash	70	100	100	100	100	100	100
Kasulu DC	November	Burnt brick	70	100	100	100	100	100	100
Kibondo	November	Mud	80	100	100	100	100	100	100
Kibondo	November	Cement	60	100	100	100	100	100	100

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kibondo	November	Painted	70	100	100	100	100	100	100
Kibondo	November	Whitewash	90	100	100	100	100	100	100
Kibondo	November	Burnt brick	70	100	100	100	100	100	100
Kakonko	November	Mud	80	100	100	100	100	100	100
Kakonko	November	Cement	60	100	100	100	100	100	100
Kakonko	November	Painted	70	100	100	100	100	100	100
Kakonko	November	Whitewash	60	100	100	100	100	100	100
Kakonko	November	Burnt brick	60	100	100	100	100	100	100
Biharamulo	November	Mud	70.0	100	100	100	100	100	100
Biharamulo	November	Cement	83.3	100	100	100	100	100	100
Biharamulo	November	Painted	83.3	100	100	100	100	100	100
Biharamulo	November	Whitewash	80.0	100	100	100	100	100	100
Biharamulo	November	Burnt brick	80.0	100	100	100	100	100	100
Bukombe	November	Mud	63.3	100	100	100	100	100	100
Bukombe	November	Cement	53.3	100	100	100	100	100	100
Bukombe	November	Painted	83.3	100	100	100	100	100	100
Bukombe	November	Whitewash	45.0	100	100	100	100	100	100
Bukombe	November	Burnt brick	92.5	100	100	100	100	100	100
Ukerewe	November	Mud	73.3	100	100	100	100	100	100
Ukerewe	November	Cement	63.3	100	100	100	100	100	100
Ukerewe	November	Painted	86.7	100	100	100	100	100	100
Ukerewe	November	Whitewash	73.3	100	100	100	100	100	100
Ukerewe	November	Burnt brick	53.3	100	100	100	100	100	100
Kasulu DC	December	Mud	60	100	100	100	100	100	100
Kasulu DC	December	Cement	50	100	100	100	100	100	100

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kasulu DC	December	Painted	40	100	100	100	100	100	100
Kasulu DC	December	Whitewash	60	100	100	100	100	100	100
Kasulu DC	December	Burnt brick	40	100	100	100	100	100	100
Kibondo	December	Mud	60	100	100	100	100	100	100
Kibondo	December	Cement	100	100	100	100	100	100	100
Kibondo	December	Painted	70	100	100	100	100	100	100
Kibondo	December	Whitewash	100	100	100	100	100	100	100
Kibondo	December	Burnt brick	80	100	100	100	100	100	100
Kakonko	December	Mud	90	100	100	100	100	100	100
Kakonko	December	Cement	90	100	100	100	100	100	100
Kakonko	December	Painted	90	100	100	100	100	100	100
Kakonko	December	Whitewash	80	100	100	100	100	100	100
Kakonko	December	Burnt brick	70	100	90	100	100	100	100
Biharamulo	December	Mud	70	100	100	100	100	100	100
Biharamulo	December	Cement	40	90	100	100	100	100	100
Biharamulo	December	Painted	60	100	100	100	100	100	100
Biharamulo	December	Whitewash	80	100	100	100	100	100	100
Biharamulo	December	Burnt brick	60	100	100	100	100	100	100
Bukombe	December	Mud	70	100	100	100	100	100	100
Bukombe	December	Cement	60	100	100	100	100	100	100
Bukombe	December	Painted	80	100	100	100	100	100	100
Bukombe	December	Whitewash	60	100	100	100	100	100	100
Bukombe	December	Burnt brick	70	100	100	100	100	100	100
Ukerewe	December	Mud	70	100	100	100	100	100	100
Ukerewe	December	Cement	80	100	100	100	100	100	100

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Ukerewe	December	Painted	60	100	100	100	100	100	100
Ukerewe	December	Whitewash	80	100	100	100	100	100	100
Ukerewe	December	Burnt brick	90	100	100	100	100	100	100
Kasulu DC	January	Mud	80	100	100	100	100	100	100
Kasulu DC	January	Cement	70	100	100	100	100	100	100
Kasulu DC	January	Painted	90	100	100	100	100	100	100
Kasulu DC	January	Whitewash	80	100	100	100	100	100	100
Kasulu DC	January	Burnt brick	60	90	100	100	100	100	100
Kibondo	January	Mud	70	100	100	100	100	100	100
Kibondo	January	Cement	60	100	100	100	100	100	100
Kibondo	January	Painted	60	80	100	100	100	100	100
Kibondo	January	Whitewash	90	100	100	100	100	100	100
Kibondo	January	Burnt brick	80	100	100	100	100	100	100
Kakonko	January	Mud	60	100	100	100	100	100	100
Kakonko	January	Cement	80	100	100	100	100	100	100
Kakonko	January	Painted	60	70	100	100	100	100	100
Kakonko	January	Whitewash	70	100	100	100	100	100	100
Kakonko	January	Burnt brick	90	100	100	100	100	100	100
Biharamulo	January	Mud	50	80	100	100	100	100	100
Biharamulo	January	Cement	70	100	100	100	100	100	100
Biharamulo	January	Painted	80	100	100	100	100	100	100
Biharamulo	January	Whitewash	80	100	100	100	100	100	100
Biharamulo	January	Burnt brick	70	100	100	100	100	100	100
Bukombe	January	Mud	50	80	100	100	100	100	100
Bukombe	January	Cement	70	100	100	100	100	100	100

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Bukombe	January	Painted	80	100	100	100	100	100	100
Bukombe	January	Whitewash	80	100	100	100	100	100	100
Bukombe	January	Burnt brick	70	100	100	100	100	100	100
Ukerewe	January	Mud	60	90	100	100	100	100	100
Ukerewe	January	Cement	80	100	100	100	100	100	100
Ukerewe	January	Painted	70	90	100	100	100	100	100
Ukerewe	January	Whitewash	90	100	100	100	100	100	100
Ukerewe	January	Burnt brick	60	80	100	100	100	100	100
Kasulu DC	February	Mud	50	70	100	100	100	100	100
Kasulu DC	February	Cement	60	100	100	100	100	100	100
Kasulu DC	February	Painted	70	100	100	100	100	100	100
Kasulu DC	February	Whitewash	80	90	100	100	100	100	100
Kasulu DC	February	Burnt brick	80	100	100	100	100	100	100
Kibondo	February	Mud	40	80	100	100	100	100	100
Kibondo	February	Cement	70	90	100	100	100	100	100
Kibondo	February	Painted	80	100	100	100	100	100	100
Kibondo	February	Whitewash	70	100	100	100	100	100	100
Kibondo	February	Burnt brick	60	90	100	100	100	100	100
Kakonko	February	Mud	60	70	100	100	100	100	100
Kakonko	February	Cement	80	100	100	100	100	100	100
Kakonko	February	Painted	70	100	100	100	100	100	100
Kakonko	February	Whitewash	60	90	100	100	100	100	100
Kakonko	February	Burnt brick	60	80	100	100	100	100	100
Biharamulo	February	Mud	40	70	100	100	100	100	100
Biharamulo	February	Cement	80	100	100	100	100	100	100

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Biharamulo	February	Painted	60	100	100	100	100	100	100
Biharamulo	February	Whitewash	60	100	100	100	100	100	100
Biharamulo	February	Burnt brick	50	80	100	100	100	100	100
Bukombe	February	Mud	50	90	100	100	100	100	100
Bukombe	February	Cement	60	90	100	100	100	100	100
Bukombe	February	Painted	70	100	100	100	100	100	100
Bukombe	February	Whitewash	70	100	100	100	100	100	100
Bukombe	February	Burnt brick	60	90	100	100	100	100	100
Ukerewe	February	Mud	50	70	100	100	100	100	100
Ukerewe	February	Cement	60	90	100	100	100	100	100
Ukerewe	February	Painted	80	100	100	100	100	100	100
Ukerewe	February	Whitewash	50	80	100	100	100	100	100
Ukerewe	February	Burnt brick	40	70	100	100	100	100	100
Kasulu DC	March	Mud	30	40	50	100	100	100	100
Kasulu DC	March	Cement	30	50	80	100	100	100	100
Kasulu DC	March	Painted	40	50	70	100	100	100	100
Kasulu DC	March	Whitewash	20	40	70	100	100	100	100
Kasulu DC	March	Burnt brick	40	40	80	100	100	100	100
Kibondo	March	Mud	40	60	80	100	100	100	100
Kibondo	March	Cement	20	50	80	100	100	100	100
Kibondo	March	Painted	50	70	90	100	100	100	100
Kibondo	March	Whitewash	40	60	90	100	100	100	100
Kibondo	March	Burnt brick	40	60	80	100	100	100	100
Kakonko	March	Mud	10	30	70	100	100	100	100
Kakonko	March	Cement	30	70	100	100	100	100	100

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kakonko	March	Painted	50	60	100	100	100	100	100
Kakonko	March	Whitewash	30	70	100	100	100	100	100
Kakonko	March	Burnt brick	30	50	90	100	100	100	100
Biharamulo	March	Mud	40	60	80	100	100	100	100
Biharamulo	March	Cement	50	60	100	100	100	100	100
Biharamulo	March	Painted	30	60	100	100	100	100	100
Biharamulo	March	Whitewash	30	60	100	100	100	100	100
Biharamulo	March	Burnt brick	10	30	100	100	100	100	100
Bukombe	March	Mud	30	60	90	100	100	100	100
Bukombe	March	Cement	20	40	70	100	100	100	100
Bukombe	March	Painted	30	60	90	100	100	100	100
Bukombe	March	Whitewash	0	50	70	100	100	100	100
Bukombe	March	Burnt brick	10	50	80	100	100	100	100
Ukerewe	March	Mud	30	50	50	100	100	100	100
Ukerewe	March	Cement	10	50	100	100	100	100	100
Ukerewe	March	Painted	30	70	100	100	100	100	100
Ukerewe	March	Whitewash	30	90	100	100	100	100	100
Ukerewe	March	Burnt brick	20	50	60	100	100	100	100
Kasulu DC	April	Mud	30	50	70	100	100	100	100
Kasulu DC	April	Cement	50	80	100	100	100	100	100
Kasulu DC	April	Painted	70	100	100	100	100	100	100
Kasulu DC	April	Whitewash	50	60	90	100	100	100	100
Kasulu DC	April	Burnt brick	40	60	100	100	100	100	100
Kibondo	April	Mud	10	50	70	100	100	100	100
Kibondo	April	Cement	60	90	100	100	100	100	100

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kibondo	April	Painted	70	100	100	100	100	100	100
Kibondo	April	Whitewash	50	70	100	100	100	100	100
Kibondo	April	Burnt brick	60	100	100	100	100	100	100
Kakonko	April	Mud	40	70	100	100	100	100	100
Kakonko	April	Cement	50	80	100	100	100	100	100
Kakonko	April	Painted	60	100	100	100	100	100	100
Kakonko	April	Whitewash	40	70	100	100	100	100	100
Kakonko	April	Burnt brick	60	90	100	100	100	100	100
Biharamulo	April	Mud	30	60	80	100	100	100	100
Biharamulo	April	Cement	50	80	100	100	100	100	100
Biharamulo	April	Painted	60	90	100	100	100	100	100
Biharamulo	April	Whitewash	50	60	90	100	100	100	100
Biharamulo	April	Burnt brick	40	60	100	100	100	100	100
Bukombe	April	Mud	40	70	90	100	100	100	100
Bukombe	April	Cement	50	80	100	100	100	100	100
Bukombe	April	Painted	60	100	100	100	100	100	100
Bukombe	April	Whitewash	40	70	100	100	100	100	100
Bukombe	April	Burnt brick	50	80	100	100	100	100	100
Ukerewe	April	Mud	30	50	70	100	100	100	100
Ukerewe	April	Cement	20	40	70	100	100	100	100
Ukerewe	April	Painted	40	80	100	100	100	100	100
Ukerewe	April	Whitewash	20	40	70	100	100	100	100
Ukerewe	April	Burnt brick	20	60	100	100	100	100	100
Kasulu DC	May	Mud	20	30	40	60	70	100	100
Kasulu DC	May	Cement	20	30	50	60	90	100	100

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kasulu DC	May	Painted	40	50	60	80	100	100	100
Kasulu DC	May	Whitewash	30	20	50	60	100	100	100
Kasulu DC	May	Burnt brick	40	30	50	60	90	100	100
Kibondo	May	Mud	20	40	50	80	100	100	100
Kibondo	May	Cement	70	80	90	100	100	100	100
Kibondo	May	Painted	40	50	60	70	100	100	100
Kibondo	May	Whitewash	10	30	60	80	100	100	100
Kibondo	May	Burnt brick	20	40	60	80	100	100	100
Kakonko	May	Mud	30	40	50	70	100	100	100
Kakonko	May	Cement	20	40	50	60	100	100	100
Kakonko	May	Painted	60	50	70	100	100	100	100
Kakonko	May	Whitewash	50	40	60	90	100	100	100
Kakonko	May	Burnt brick	20	30	50	60	100	100	100
Biharamulo	May	Mud	10	30	50	60	80	100	100
Biharamulo	May	Cement	40	30	50	70	80	100	100
Biharamulo	May	Painted	60	50	70	80	100	100	100
Biharamulo	May	Whitewash	30	40	60	80	90	100	100
Biharamulo	May	Burnt brick	20	40	60	90	100	100	100
Bukombe	May	Mud	30	50	60	80	100	100	100
Bukombe	May	Cement	40	60	70	100	100	100	100
Bukombe	May	Painted	40	50	60	80	100	100	100
Bukombe	May	Whitewash	50	60	80	100	100	100	100
Bukombe	May	Burnt brick	20	40	70	70	100	100	100
Ukerewe	May	Mud	30	50	60	70	100	100	100
Ukerewe	May	Cement	60	80	90	100	100	100	100

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Ukerewe	May	Painted	60	50	60	80	100	100	100
Ukerewe	May	Whitewash	50	50	60	80	90	100	100
Ukerewe	May	Burnt brick	60	50	50	70	100	100	100
Kasulu DC	June	Mud	10	10	20	30	40	50	100
Kasulu DC	June	Cement	10	20	20	30	40	60	100
Kasulu DC	June	Painted	0	10	20	30	50	70	100
Kasulu DC	June	Whitewash	0	10	30	50	60	90	100
Kasulu DC	June	Burnt brick	10	10	20	30	30	40	100
Kibondo	June	Mud	10	10	20	30	30	50	100
Kibondo	June	Cement	10	10	20	20	50	70	100
Kibondo	June	Painted	0	10	20	40	50	60	100
Kibondo	June	Whitewash	10	20	20	20	50	60	100
Kibondo	June	Burnt brick	10	20	20	40	60	70	100
Kakonko	June	Mud	10	20	20	30	60	100	100
Kakonko	June	Cement	10	40	60	70	70	100	100
Kakonko	June	Painted	10	20	30	30	60	100	100
Kakonko	June	Whitewash	10	10	10	30	40	100	100
Kakonko	June	Burnt brick	10	10	30	40	70	100	100
Biharamulo	June	Mud	10	10	30	30	40	100	100
Biharamulo	June	Cement	20	20	50	80	90	100	100
Biharamulo	June	Painted	20	20	40	60	80	100	100
Biharamulo	June	Whitewash	0	0	20	50	70	100	100
Biharamulo	June	Burnt brick	10	10	30	90	90	100	100
Bukombe	June	Mud	10	10	20	30	50	100	100
Bukombe	June	Cement	10	10	20	40	50	100	100

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Bukombe	June	Painted	0	10	20	30	30	100	100
Bukombe	June	Whitewash	10	20	40	50	60	100	100
Bukombe	June	Burnt brick	10	10	20	40	50	100	100
Ukerewe	June	Mud	10	10	10	30	40	100	100
Ukerewe	June	Cement	10	10	20	60	70	100	100
Ukerewe	June	Painted	0	0	10	30	40	100	100
Ukerewe	June	Whitewash	10	10	10	30	50	100	100
Ukerewe	June	Burnt brick	10	10	20	30	40	100	100
Kasulu DC	July	Mud	0	0	10	30	50	80	100
Kasulu DC	July	Cement	0	0	10	10	30	40	70
Kasulu DC	July	Painted	10	20	20	30	30	50	90
Kasulu DC	July	Whitewash	0	10	20	20	20	20	80
Kasulu DC	July	Burnt brick	0	0	10	20	20	50	70
Kibondo	July	Mud	0	0	10	10	20	50	90
Kibondo	July	Cement	0	10	10	30	50	50	70
Kibondo	July	Painted	0	20	20	30	50	80	100
Kibondo	July	Whitewash	0	10	10	20	30	50	60
Kibondo	July	Burnt brick	10	10	20	20	30	60	80
Kakonko	July	Mud	0	0	10	10	30	50	90
Kakonko	July	Cement	0	20	20	40	50	70	100
Kakonko	July	Painted	20	20	40	70	90	100	100
Kakonko	July	Whitewash	10	30	40	40	70	90	100
Kakonko	July	Burnt brick	0	0	20	30	50	70	100
Biharamulo	July	Mud	0	0	10	30	50	50	80
Biharamulo	July	Cement	0	0	10	10	30	50	70

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Biharamulo	July	Painted	10	0	10	30	50	70	100
Biharamulo	July	Whitewash	0	0	0	20	40	70	100
Biharamulo	July	Burnt brick	10	0	10	20	40	60	90
Bukombe	July	Mud	0	0	0	10	30	50	70
Bukombe	July	Cement	0	10	10	30	40	70	100
Bukombe	July	Painted	10	30	30	60	80	100	100
Bukombe	July	Whitewash	0	20	40	40	60	70	100
Bukombe	July	Burnt brick	10	10	30	40	40	70	90
Ukerewe	July	Mud	0	0	0	10	10	30	60
Ukerewe	July	Cement	0	0	10	10	30	40	70
Ukerewe	July	Painted	0	10	30	30	60	90	100
Ukerewe	July	Whitewash	0	10	20	40	60	80	100
Ukerewe	July	Burnt brick	0	0	10	10	30	50	80
Kasulu DC	August	Mud	0	0	0	20	30	50	50
Kasulu DC	August	Cement	0	0	20	20	30	50	70
Kasulu DC	August	Painted	10	20	30	50	70	80	90
Kasulu DC	August	Whitewash	10	10	20	30	30	50	80
Kasulu DC	August	Burnt brick	0	0	20	20	40	50	70
Kibondo	August	Mud	0	0	0	0	20	40	70
Kibondo	August	Cement	0	0	10	20	20	50	60
Kibondo	August	Painted	0	10	30	40	60	60	90
Kibondo	August	Whitewash	0	10	20	30	30	40	60
Kibondo	August	Burnt brick	0	0	0	20	20	40	70
Kakonko	August	Mud	0	0	0	10	10	30	50
Kakonko	August	Cement	0	0	10	20	20	40	60

District	Month	Type of Wall Surface	% Knock-down (KD) after 60 min	% Mortality					
				Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Kakonko	August	Painted	10	20	20	50	60	90	100
Kakonko	August	Whitewash	10	10	30	30	40	60	90
Kakonko	August	Burnt brick	0	0	10	10	30	50	80
Biharamulo	August	Mud	0	0	0	0	20	20	30
Biharamulo	August	Cement	0	0	0	10	30	30	50
Biharamulo	August	Painted	0	10	30	50	50	70	80
Biharamulo	August	Whitewash	0	10	20	20	50	60	80
Biharamulo	August	Burnt brick	0	0	10	10	20	20	50
Bukombe	August	Mud	0	0	0	10	20	40	60
Bukombe	August	Cement	10	10	30	30	50	60	80
Bukombe	August	Painted	10	20	20	40	60	70	90
Bukombe	August	Whitewash	10	20	30	30	40	40	60
Bukombe	August	Burnt brick	0	0	10	20	20	30	50
Ukerewe	August	Mud	0	0	0	10	10	30	50
Ukerewe	August	Cement	0	0	10	20	20	40	60
Ukerewe	August	Painted	10	10	30	40	60	70	90
Ukerewe	August	Whitewash	0	0	10	30	30	50	70
Ukerewe	August	Burnt brick	0	0	0	0	10	30	50

Signed by Dr. Alphaxard Manjurano

Principal Investigator-Entomological Surveillance Project

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