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The mtego® trap: a potential tool for monitoring and control of malaria and arbovirus vectors

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NM-AIST

THE MTego® TRAP: A POTENTIAL TOOL FOR MONITORING AND CONTROL OF MALARIA AND ARBOVIRUS VECTORS

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A Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Public Health Research of the Nelson Mandela African Institution of Science and Technology

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ABSTRACT

Odour-baited traps are valuable for vector surveillance and control; however, they often exhibit varying recapture rates among mosquito species due to the limited range of host cues they provide. Therefore, it is crucial to develop more effective traps capable of capturing a variety of mosquito species. One potential alternative is the MTego trap, which incorporates thermal stimuli as additional cues. This study aimed to evaluate the efficacy of the MTego trap for sampling different mosquito species in a semi-field system. To conduct the experiments, fully balanced Latin square design experiments were conducted in semi-field chambers using laboratory-reared female *Anopheles gambiae*, *Anopheles funestus*, *Anopheles arabiensis*, *Culex quinquefasciatus*, and *Aedes aegypti* mosquitoes. Fifty mosquitoes of each species were released in each chamber for 16 days. The evaluated traps included the MTego trap baited with PM6 (MT-PM6), the MTego trap baited with BG-Lure (MT-BGL), and the BGP trap baited with BG-Lure (BGP-BGL). In addition, the performance of the traps was compared to the human landing catch (HLC). The MTego traps (MT-PM6 and MT-BGL) captured a similar proportion of *Anopheles gambiae* and *Anopheles funestus*, and *Aedes aegypti* as the BGP-BGL. However, the traps did not match the performance of HLC against all mosquito species. The study underscores the promising application of the MTego trap as a monitoring and control tool for malaria and arbovirus vectors.

Keywords: MTego, BGP, Human landing catch, Trap, Odour-baited trap, Mosquito, *Anopheles*, *Culex*, *Aedes*

DECLARATION

I, Masudi Suleiman do hereby declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this dissertation titled *"The MTego trap: A Potential Tool for Monitoring and Control of Malaria and Arbovirus Vectors"* is my original work and has never been or intending to be submitted for a degree award in any other institution.

15/8/ 2023

Masudi Suleiman Date

The declaration is confirmed by:

15/8/ 2023

Dr. Mgeni Mohamed Tambwe Date

15/8/ 2023

Dr. Sarah Jane Moore Date

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CERTIFICATION

The undersigned certify that have read and hereby recommend for acceptance the dissertation titled, *"The MTego trap: A Potential Tool for Monitoring and Control of Malaria and Arbovirus Vectors"* in partial fulfilment of the requirements for the award of Master of Science in Public Health Research of the Nelson Mandela African Institution of Science and Technology.

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DEDICATION

To myself, for having the courage and faith to pursue my passions. This dissertation is a testament of hard work, perseverance, and self-discovery. Quitting my job was not an easy decision, but allowed me to fully immerse myself in my research, leading to the completion of this work and new career opportunities.

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LIST OF ABBREVIATIONS AND SYMBOLS

BGL	Biogents Lure
BGP	Biogents pro trap
BGP-BGL	Biogents pro trap baited with Biogents Lure
CI	Confidence interval
CO_2	Carbon dioxide
HLC	Human landing catch
IHI	Ifakara Health Institute
IRR	Incidence rate ratio
IRS	Indoor residual spraying
ITN	Insecticide-treated net
IVM	Integrated vector control management
MT-BGL	MTego trap baited with Biogents Lure
MT-PM6	MTego trap baited with PM6
OBTs	Odour-baited traps
OR	Odds ratio
PM	PreMal
SFS	Semi-field system
WHO	World health organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the problem

Mosquito-borne diseases such as malaria, dengue, chikungunya, yellow fever, lymphatic filariasis and Zika virus continue to overwhelm healthcare systems and cause fatalities, particularly in tropical and subtropical regions where they are most prevalent and disproportionately affecting the poorest populations (WHO, 2014; WHO, 2017). These diseases including malaria, dengue and chikungunya put over 80% of the world's population at risk, while causing significant morbidities and mortalities (WHO, 2020). Scale-up of vector control methods such as insecticide-treated nets (ITNs) and indoor residual spraying (IRS) have significantly reduced malaria cases and deaths globally (Bhatt *et al.,* 2015). However, ITNs and IRS are inadequate for malaria elimination because of ongoing transmission due to widespread pyrethroid resistance toward malaria vectors, mosquito behavioural change from indoor to outdoor biting and some human activities and behaviours that increase exposure (WHO, 2022). On top of that, the risk of infection for some mosquito-borne diseases especially arboviral infections has been increasing with rapid unplanned urbanisation and movement of people mostly in towns and cities where *Aedes* and *Culex* mosquitoes thrive (WHO, 2017).

The transmission of mosquito-borne diseases occurs when infected mosquitoes feed on vertebrate hosts to obtain proteins required for egg nourishment (Martinez *et al*., 2021). The behaviour is guided by a combination of visual, physical and chemical cues detected through olfactory receptors located on the mosquito's antennae (Takken, 1991; Takken & Knols, 1999). Carbon dioxide (CO_2) serves as a long-range signal that attracts mosquitoes towards a potential blood source (Takken, 1991). Once near a host, skin odours, heat, and moisture are used to stimulate landing and feeding (Takken *et al*., 1997; Wright & Kellogg, 1962). Alternative approaches such as odour-baited traps (OBTs) take advantage of this behavioural response using synthetic odours that mimic host cues and manipulative physical and visual cues to attract host-seeking mosquitoes (Sougoufara *et al*., 2020; Wooding *et al*., 2020). The capture mechanism used in traps varies depending on the specific model, but many traps use a fan to suck the mosquitoes as they fly near the inlet funnel (Batista *et al*., 2017).

Various traps, such as the Suna trap (Hiscox *et al*., 2014), Biogents Sentinel (BGS) trap (Degener *et al*., 2014), Biogents Mosquitaire (BGM) trap (Jahir *et al*., 2022), Ifakara odour-baited station (Okumu *et al*., 2010), and the MM-X trap (Njiru *et al*., 2006) have been developed and proved to attract a significant number of mosquitoes. Given their effectiveness in capturing sufficient numbers of mosquitoes, traps are increasingly recognised as potential tools for integrated vector management (Okumu *et al*., 2010; WHO, 2018). However, the performance of most existing traps has been inconsistent for different mosquito species and geographical locations, necessitating the need for modification and redevelopment. Hence, the MTego trap has been developed as an additional option. In addition to the chemical and visual cues that are normally used in OBTs, the MTego includes heat and moisture as additional cues, to increase attraction and capture. This study was undertaken to evaluate the trapping efficacy of the MTego trap for capturing adult mosquitoes in a simulated outdoor setting.

1.2 Statement of the problem

The control of mosquito-borne diseases remains a public health challenge, as mosquito vectors continue to evolve mechanisms to evade existing control strategies. Odour-baited traps have been developed to attract and capture host-seeking mosquitoes, but their performance varies across different mosquito species and locations. The MTego trap, which incorporates heat and moisture in addition to chemical and visual cues, represents a potential option for mosquito monitoring and control. A previous study showed that MTego was highly effective at sampling *Anopheles gambiae* mosquitoes, outperforming the Biogents Suna trap in both laboratory and semi-field environments (Cribellier *et al*., 2020). However, the efficacy of this trap to capture different mosquito species remains unknown. To address this knowledge gap, this study was undertaken to determine its efficacy for sampling adult mosquitoes of *Anopheles*, *Culex*, and *Aedes* genera in a semi-field system.

1.3 Rationale of the study

With the increasing burden of mosquito-borne diseases and the limitations of current control measures, there is a need for innovative approaches to address this public health challenge. By assessing the efficacy of the MTego trap, this study provides insights into the feasibility and utility of this tool as a potential disease monitoring and control intervention.

1.4 Research objectives

1.4.1 General objective

The study aimed to evaluate the trapping efficacy of the MTego trap for sampling adult mosquitoes in a semi-field system.

1.4.2 Specific objectives

This study was pursued to achieve the following specific objectives:

(i) Assessing the trapping efficacy of MTego traps, Biogents Pro (BGP) trap and human landing catch (HLC) in the no-choice test against *Anopheles gambiae, Anopheles arabiensis, Anopheles funestus, Culex quinquefasciatus* and *Aedes aegypti* mosquitoes.

(ii) Assessing the trapping efficacy of MTego and BGP traps in the dual-choice test against *Anopheles gambiae, Anopheles arabiensis, Anopheles funestus, Culex quinquefasciatus* and *Aedes aegypti* mosquitoes.

1.5 Research questions

(i) What is the trapping efficacy of the MTego traps relative to the BGP trap and HLC for capturing *Anopheles gambiae, Anopheles arabiensis, Anopheles funestus, Culex quinquefasciatus* and *Aedes aegypti* mosquitoes in the no-choice test?

(ii) What is the trapping efficacy of the MTego and BGP traps for capturing *Anopheles gambiae, Anopheles arabiensis, Anopheles funestus, Culex quinquefasciatus* and *Aedes aegypti* mosquitoes in the dual-choice test?

1.6 Significance of the study

The study underscores the promising application of the MTego trap as a monitoring and control tool for malaria and arbovirus vectors. The trap that captures adequate number of mosquitoes has the potential to mitigate the transmission of diseases by reducing mosquito populations and minimising bites.

1.7 Delineation of the study

The study was a semi-field trial to evaluate and compare the efficacy of the MTego trap to other methods for sampling different mosquito species that are vectors of human diseases. The mosquitoes used in the study were laboratory-reared and therefore the generalisability of the findings may be limited since laboratory-reared mosquitoes may have different behaviours and responses compared to wild mosquitoes.

CHAPTER TWO

LITERATURE REVIEW

2.1 Major mosquito-borne diseases and responsible vectors

Mosquitoes are significant disease vectors responsible for transmitting various parasites and pathogens to humans and animals (Takken & Verhulst, 2013). Of the several mosquito species available, *Anopheles*, *Culex* and *Aedes* species are the major vectors responsible for transmitting several of the world's most prevalent infectious diseases such as malaria, lymphatic filariasis, dengue, chikungunya, Rift Valley fever and Zika virus (WHO, 2014). Malaria is the most common and deadly disease claiming over 500 000 lives each year (WHO, 2022). It was reported in 2021 that global malaria cases increased slightly from 245 million in 2020 to 247 million with the African region harbouring over 95% and 96% of all cases and deaths, respectively (WHO, 2022). The disease is caused by *Plasmodium* parasites that are spread to humans by a bite of infected female *Anopheles* mosquitoes (WHO, 2017). In Africa, there are more than 128 *Anopheles* species, several of which, *Anopheles gambiae* sensu stricto, *Anopheles arabiensis*, and *Anopheles funestus* are the most efficient malaria vectors (WHO, 2014). Each species has unique ecological traits, with *Anopheles gambiae* and *Anopheles funestus* displaying a preference for human hosts, while *Anopheles arabiensis* exhibits opportunistic behaviour by feeding on both humans and animals (Takken & Verhulst, 2013).

Another group of mosquito-borne diseases are arboviral diseases caused by *flaviviruses* transmitted by infected *Aedes* mosquitoes (WHO, 2017). Dengue is the major arboviral disease affecting more than 3.9 billion people worldwide causing over 40 000 deaths and 96 million symptomatic cases every year in over 100 countries globally (WHO, 2014). The Pacific Regions are the most affected by dengue, followed by some countries in Africa, the Americas, Eastern Mediterranean and South-East Asia (WHO, 2014). *Aedes aegypti* is the main vector of dengue and other arboviral diseases such as chikungunya, Zika virus and yellow fever. The mosquito inhabits urban areas and primarily breeds in homemade containers, feeding on humans during the daytime with high activity levels in the early morning and before set (WHO, 2014). *Aedes albopictus* is a secondary dengue vector in Asia, spread to North America and Europe via the international trade in used goods such as tyres. The species can endure cooler temperatures in temperate regions while maintaining a wide geographic range, resilience, and adaptability to both rural and urban settings (WHO, 2014).

In addition to arboviral diseases, lymphatic filariasis is another significant mosquito illness that causes disfigurement and disability in about 40 million of the 120 million people infected mostly in South-East Asia and Africa, and some in other tropical areas (WHO, 2014). The disease is transmitted by different mosquitoes such as *Culex quinquefasciatus* in urban and semi-urban areas, *Anopheles* species in African rural areas; and *Aedes* mosquitoes in the Pacific Islands and parts of the Philippines (WHO, 2014). Overall, the increase in urbanization, international travel and trade, coupled with changes in climate and environment, have resulted in more frequent encounters between humans and mosquitoes, thus spreading mosquito-borne diseases that were once limited to tropical regions to become more prevalent in temperate areas (WHO, 2017).

2.2 Current mosquito control methods and their limitations

Insecticide-treated nets (ITNs) and indoor residual spraying (IRS) are effective tools in controlling malaria by physically and chemically preventing mosquito bites in indoor areas (WHO, 2022). However, the effectiveness of these core interventions is being jeopardised by: (a) the emergence of mosquitoes that are resistant to pyrethroid which is the main class of insecticides used in these tools (Hancock *et al*., 2020), (b) a shift in mosquito biting behaviour to earlier times in the morning and evening (Gatton *et al*., 2013), and (c) an increase in outdoor mosquito biting when individuals are not protected (Russell *et al*., 2011). Larvicides, which are chemical or biological agents used to eliminate mosquito larvae in water bodies, can reduce mosquito populations but require frequent application and may not be feasible in areas with large or hard-to-reach breeding habitats (WHO, 2012). While current vector control tools have been effective in reducing mosquito populations and the spread of mosquito-borne diseases, they face several limitations that require ongoing innovation and development of new tools. Alternative tools such as OBTs show promise but also require additional modification and testing.

2.3 Potential use of traps for mosquito monitoring and control

2.3.1 The mechanism of action of traps for capturing mosquitoes

Mosquito traps are devices that attract and capture mosquitoes at different physiological stages such as host-seeking or gravid female mosquitoes (WHO, 2018). Odour-baited traps targeting host-seeking mosquitoes use a variety of sensory signals, including visual and olfactory cues, to attract mosquitoes. One of the key attractants used by mosquito traps is carbon dioxide gas which is usually added to the traps from different sources, such as live animal odours, gas cylinders, dry ice or fermenting sugar and yeast (Dormont *et al*., 2021). In addition to CO_2, traps also use artificial chemicals such as BG-lure to mimic the smell of a potential host (Wooding *et al*., 2020). Some traps also use heat and moisture to make mosquitoes think they have found a warm-blooded animal to bite (Cribellier *et al*., 2020). The traps feature a fan that generates an airstream that draws attracted mosquitoes as they fly into the inlet funnel (Batista *et al*., 2017).

2.3.2 Strategies for using traps for mosquito control

There are different approaches to using traps as a tool for mosquito control such as: "capture-kill" and "capture-release" (WHO, 2018). In the capture-kill strategy, mosquitoes that enter the trap are removed and physically killed or are confined and exposed to a fast-acting insecticide such as pirimiphos-methyl and killed (Okumu *et al*., 2010). This approach can help control mosquito populations quickly, however, exposing mosquitoes to insecticides may modify their susceptibility status to first-line insecticides over time, so thus physical kill would be more appropriate.

In the capture-release approach, mosquitoes are contaminated with an insecticidal or sterilizing agent, for example, pyriproxyfen to infect and disseminate to a wider mosquito population or their aquatic habitats (Caputo *et al*., 2012; Lwetoijera *et al*., 2014). This approach can help target hard-to-reach areas that may not be accessible with conventional insecticide spraying. However, there have been ethical concerns about contaminating non-target species or ecosystems with insecticidal or sterilizing agents such as pyriproxyfen (Santos *et al*., 2014). Furthermore, traps can be used together with spatial repellents in a push-pull strategy. This approach has been successfully used in agricultural pest management and is now being tested for mosquito control (Menger *et al*., 2015; Njoroge *et al*., 2021; Tambwe *et al*., 2020). However, an effective push-pull system that operates synergistically is still an unanswered question.

2.3.4 Current traps and their potential utility

The use of OBTs through mass trapping, as a single tool or in combination with other vector control methods has proven effective in reducing populations of adult mosquitoes and controlling diseases in various settings. For example, a cluster randomised-controlled trial in Brazil demonstrated that mass trapping with BGS traps reduced the population of *Aedes aegypti* and dengue incidence (Degener *et al*., 2014). Additionally, a stepped wedge cluster-randomised trial in Kenya reported a substantial reduction of *Anopheles funestus* population and malaria prevalence in areas where homes were installed with Suna traps compared to the non-intervened areas (Homan *et al*., 2016). Furthermore, Jahir *et al.* (2022), recently demonstrated that BGM traps distributed at higher densities when used in combination with larval source management drastically reduced populations of *Aedes* and *Culex* mosquitoes by 93 - 98% in small Maldivian islands. Therefore, the use of OBTs can potentially reduce the number of mosquitoes that successfully locate and feed on vertebrate hosts, which could ultimately reduce the transmission of mosquito-borne diseases, further modification and improvement would increase their performance.

2.3.5 Potentials of the MTego trap as an additional option

The MTego trap exploit similar counter-flow technology as existing odour-baited traps that use a combination of human-mimicking odour, visual cues, and circulating airflow to attract and capture mosquitoes. Beyond these attributes, the MTego takes advantage of thermal stimuli encompassing heat and moisture. An initial study that was conducted to investigate how these additional cues enhance mosquito attraction and capture rate of the MTego trap. The MTego was found to have a better capture mechanism than the comparator trap: the BG-Suna against *Anopheles gambiae* in both laboratory and semi-field settings (Cribellier *et al*., 2020). However, the response of other mosquito species to this promising trap remains relatively unknown, and that was the drive for this research.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

The study was conducted in a large semi-field system (SFS) located at Ifakara Health Institute in Bagamoyo district, Tanzania (6.446º S and 38.901º E). The district experiences average annual rainfall of 800 - 1000 mm, average temperatures between 24ºC and 29ºC and average annual humidity of 73%. The SFS measures 29 by 21 by 4.5 m, screened with shade mesh walls and a polyethene roof mounted on an elevated concrete platform (Plate 1). It is divided into two compartments measuring 29 by 9 m with a middle buffer chamber. Using large netting cages, with polyethene sheath the compartments can be further divided into smaller independent chambers to suit the needs of a particular study.

Plate 1: The semi-field system

3.2 Mosquitoes

Laboratory reared *Anopheles gambiae* sensu stricto (s.s) (Ifakara strain), *Anopheles funestus* (Fumoz strain), *Anopheles arabiensis* (Kingani strain), *Culex quinquefasciatus* (Bagamoyo strain) and *Aedes aegypti* (Bagamoyo strain) mosquitoes aged 3 - 5 days were used in the experiments. Mosquitoes were reared at the insectary at 27ºC ± 2ºC and 70% ± 20% relative humidity (RH) and ambient 12:12 light dark, following MR4 guidelines (MR4, 2016). The mosquitoes were blood naive and sugar-starved for 6-10 hours before the experiments. *Anopheles arabiensis* mosquitoes were marked with fluorescent dye to distinguish their strains from *Anopheles gambiae*. Previous experiments showed that colour pigments neither affect mosquito survival nor host preference (Saddler *et al*., 2019).

3.3 Test items

3.3.1 MTego trap

The MTego (Premal BV, The Netherlands), is a novel mosquito trap that uses a counter-flow principle and a brushless 12 V DC fan to capture mosquitoes. The trap uses baits that attract mosquitoes and generates heat to mimic a human body using a lower-powered heating element wrapped at the base of its inlet, and it generates moisture using warm water that is added to the ripstop nylon before operation (Cribellier *et al*., 2020). The trap has a foldable ripstop nylon bag and an insect net on top that allows the circulation of odour-saturated air. The trap also has an inlet module with an integrated catching cage for easy removal of caught mosquitoes. The trap was assembled according to the manufacturer's instructions and hung 10 cm off the ground (Plate 2a) and 250 ml of warm water was poured inside at the start of each experiment.

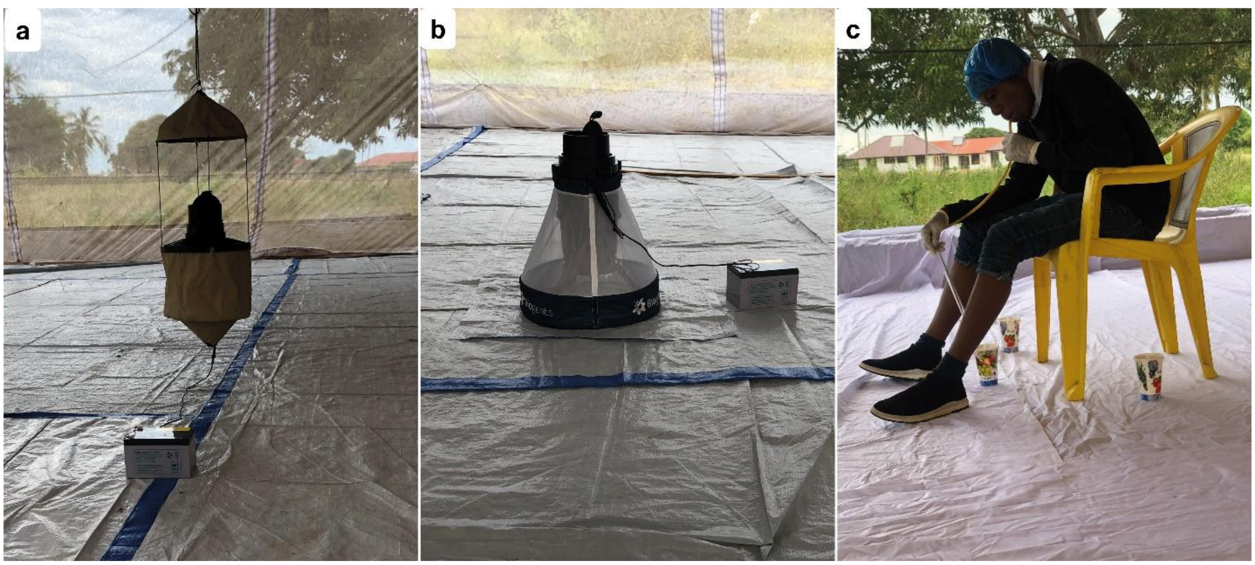


Plate 2: Test items investigated in the study (a) MTego trap (b) BGP trap (c) HLC

3.3.2 Biogents Pro trap

The BGP (Biogents AG, Regensburg, Germany), is a cone-shaped fabric trap that uses a 3-blade fan to generate airflow which sucks in mosquitoes that are close to the inlet funnel. The trap also uses bait such as BG-lure to attract mosquitoes. It can be powered by a 5 V AC power bank or a 6 V DC battery. The trap is collapsible and comes with a UV-LED light, rain cover, and internal tripod and can be configured to hang from the hook on the ceiling or stand on the ground. The trap is smaller and more portable than other similar traps that use traditional batteries (Degener *et al*., 2021). The trap was assembled according to the manufacturer's instructions, powered by a 12 V battery and stood direct on the ground (Plate 2b).

3.3.3 Human landing catch

Is a standard mosquito sampling method (WHO, 1975), that requires an adult volunteer to sit on a chair and collect any mosquitoes that land on exposed legs by aspirating them with a mouth aspirator. One adult male volunteer, fully trained and voluntarily recruited with written informed consent conducted HLC. Mosquitoes were captured using a mouth aspirator when they landed on exposed legs (Plate 2c).

3.3.4 BG-Lure

The BG-Lure (Biogents AG, Regensburg, Germany) is a blend of chemicals composed of ammonia solution, (S)-lactic acid, and caproic acid. The lure is designed to mimic the scent of human skin and other compounds that are attractive to mosquitoes (Krockel *et al*., 2006).

3.3.5 PreMal 6 lure

The PM6 odour blend supplied by the PreMal BV, The Netherlands is a synthetic attractant which imitates the process of human sweat evaporation, leading to better capture rates in the MTego trap. The scent is dispensed using a sachet that is suspended inside the trap. The sachet slowly releases the scent, producing sustained effectiveness for up to 90 days before requiring replacement (Premalbv.com).

3.4 Study design

A series of Latin square experiments were conducted in the semi-field system as illustrated below:

3.4.1 Trapping efficacy of the MTego traps, BGP trap and HLC in the no-choice test

A 4 × 4 Latin square design experiment was conducted to evaluate the trapping efficacy of MT-PM6, MT-BGL, BGP-BGL and HLC. The SFS was divided into four chambers using polyethene fabric where four large netting cages measuring 10 × 9 m were installed. The trapping methods were assigned to each chamber and rotated daily in a randomised Latin square pattern across the chambers such that after 16 days of experimentation each item had been tested on each chamber four times. Test mosquitoes were acclimatised in the middle compartment for 45 minutes before the experiment began. Fifty mosquitoes of each species were simultaneously released into each chamber from four releasing points (Fig. 1a). The experiment started at 16:00 for *Aedes aegypti* and 18:30 for *Anopheles* and *Culex* mosquitoes to ensure that tests captured natural host-seeking times for each species. Traps operated from 16:00 to 7:00 the next morning, while HLCs were conducted from 16:00 to 22:00 with one hour break (30 minutes between 18:00 to 18:30 hours and 10 minutes after each succeeding hour). Collected mosquitoes using HLC were subsequently placed in paper cups, with a new cup being utilised every hour. The HLCs were done for a shorter duration as the preliminary experiment showed that this duration was enough to recapture >60% of mosquitoes from the chamber. The captured mosquitoes were then transferred to the insectary after the experiment where they were refrigerated, identified, and manually counted. After every experiment, the SFS was thoroughly cleaned and searched for remaining mosquitoes using a prokopack aspirator. The traps were also cleaned using 70% ethanol and dried outdoors before they were reused again.

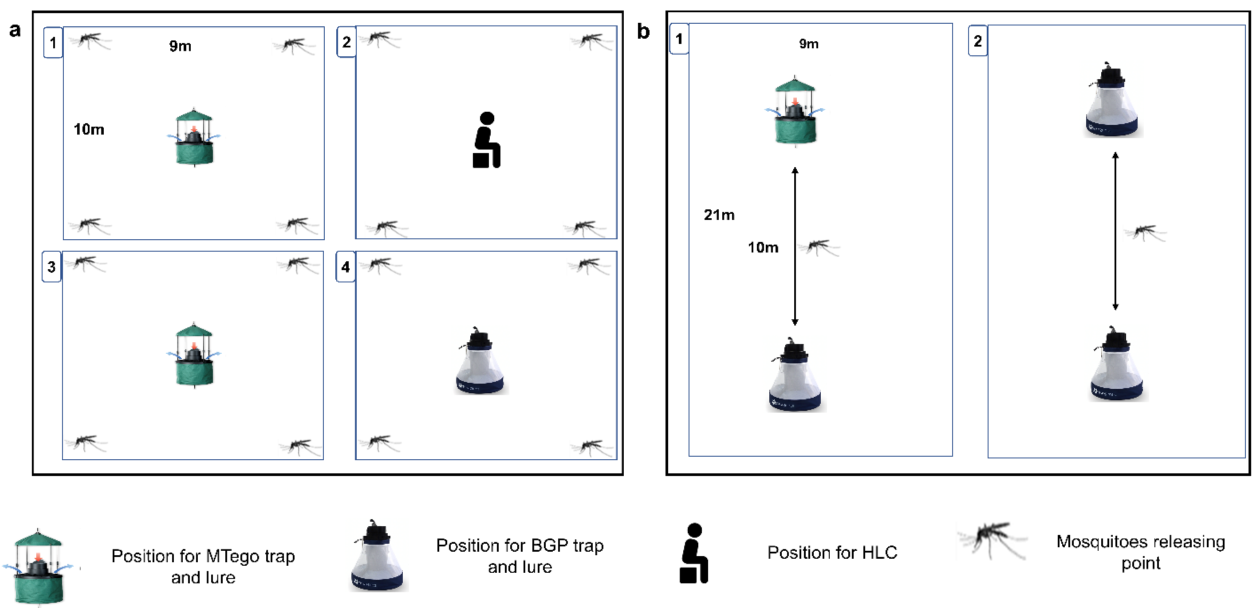


Figure 1: Schematic representation of experiments in the semi-field system showing (a) the no-choice test, and (b) the dual-choice test

3.4.2 Trapping efficacy of the MTego trap and BGP trap in the dual-choice test

A 2 × 2 balanced Latin square design experiment was conducted to compare the trapping efficacy of the MT-M6 relative to the BGP-BGL (Fig. 1b). Two large netting cages measuring 20 × 9 m were installed in the two chambers of the SFS. The MT-PM6 was placed 10 m from the BGP-BGL in one chamber and two BGP-BGL were positioned 10 m apart from one another in the other chamber (Fig. 1b). Fifty mosquitoes of each species were released at the centre of each chamber. The experiment was conducted for 16 replicates in which the traps were rotated daily across the positions in a randomised Latin square design. Other experimental procedures were maintained as in the previous experiment.

3.5 Sample size and power

To determine the appropriate sample size, a simulation-based power analysis was conducted in R software version 3.02 using generalised linear mixed-effects models as described by (Johnson *et al*., 2015). The models were run with 1000 simulations using a fully balanced Latin square design for 16 consecutive days in each experiment, with a significance level set at 0.05. The inter-observational variance among daily experiments was fixed at 5%, and variability between times based on previous experiments was set at 25%. The simulations showed that releasing 50 mosquitoes per species per day for 16 consecutive days would have a 90% probability of detecting differences in mosquito catch between the traps.

3.6 Data analysis

Data were double-entered in Microsoft Excel 2021 and analysed using STATA 17. Descriptive statistics were conducted to estimate the mean percentage and 95% confidence intervals (CI) of each mosquito species captured in each trap. In the no-choice experiment, Multilevel mixed-effect logistic regression following binomial distribution and logit function was used, while Multilevel mixed-effects generalised linear model with a negative binomial error and log link function was used to model the count data in the dual-choice experiment. In both analyses, the fixed effects were trap, position and chamber, while day was included as a random effect.

3.7 Ethical approval and consent to participate

The study was approved by the Ifakara Health Institute Review Board with certificate number IHI/IRB/No: 18-2022 and the National Institute for Medical Research-Tanzania with a certificate number NIMR/HQ/R.8a/Vol.IX/4160. The volunteer was an adult male, voluntarily recruited based on written informed consent and trained on performing HLC.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Trapping efficacy of MTego traps, BGP trap and HLC in the no-choice test

The average environmental conditions throughout the experiment were 23 °C (21 - 26°C) and 82% (70 - 92%) temperature and RH respectively. Approximately a total of 3200 mosquitoes of each species were released in the SFS, of which 1170 (37%) *Anopheles gambiae*, 1474 (46%) *Anopheles funestus*, 663 (21%) *Anopheles arabiensis*, 1321 (41%) *Aedes aegypti* and 2415 (75%) *Culex quinquefasciatus* were recaptured by the traps. Overall, HLC was the most efficient method for collecting all mosquito species, while the traps varied in their performance depending on the species. *Anopheles arabiensis* had a lower response to all traps, whereas *Culex quinquefasciatus* had a very higher response to all traps, especially BGP-BGL which nearly matched HLC (Fig. 2, Table 1).

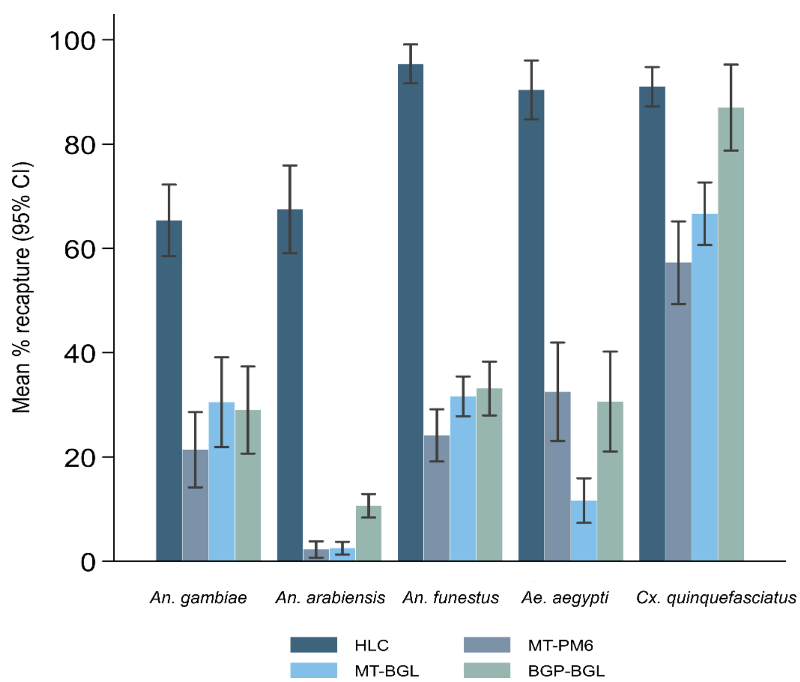


Figure 2: Percentage of mosquitoes recaptured by MTego traps, BGP trap and HLC in the no-choice test

Mosquitoes' responses to MT-BGL and BGP-BGL traps were similar for *Anopheles gambiae* (OR = 1.07 (95% CI: 0.86 - 1.34), *P* = 0.519) and *Anopheles funestus* (OR = 0.93 (95% CI: 0.76 - 1.15), *P* = 0.520). For *Anopheles arabiensis, Aedes aegypti* and *Culex quinquefasciatus* lower responses to MT-BGL relative to BGP-BGL were observed (*P* <0.0001 for all species) (Table 1).

Aedes aegypti showed similar responses to MT-PM6 and BGP-BGL traps (OR = 1.12 (95% CI: 0.90 - 1.40), $P = 0.324$) while *Anopheles gambiae*, *Anopheles arabiensis*, *Anopheles funestus* and *Culex quinquefasciatus* showed a lower response (Table 1).

Table 1:Trapping efficacy of MTego traps, BGP trap and HLC in the no-choice test

Mosquito species	Trapping method	Total catch	Mean % (CI)	OR (95% CI)
Anopheles gambiae	BGP-BGL	232	29.0 (20.7 - 37.4)	Ref
	MT-PM6	171	21.4 (14.2 - 28.9)	0.66 (0.52 - 0.83)
	MT-BGL	244	30.5 (21.9 - 39.1)	1.07 (0.86 - 1.34) †
	HLC	523	65.4 (58.5 - 72.2)	4.88 (3.94 - 6.07)
Anopheles arabiensis	BGP-BGL	85	10.6 (8.4 - 12.9)	Ref
	MT-PM6	18	2.3 (0.7 - 3.8)	0.19 (0.11 - 0.32)
	MT-BGL	20	2.5 (1.3 - 3.7)	0.21 (0.13 - 0.35)
	HLC	540	67.0 (59.1 - 75.9)	19.74 (14.90 - 26.14)
Anopheles funestus	BGP-BGL	265	33.1 (27.7 - 38.3)	Ref
	MT-PM6	193	24.1 (19.1 - 29.1)	0.64 (0.52 - 0.80)
	MT-BGL	253	31.6 (27.8 - 35.4)	0.93 (0.76 - 1.15) †
	HLC	763	95.4 (91.7 - 99.1)	41.84 (29.14 - 60.08)
Aedes aegypti	BGP-BGL	245	30.6 (21.0 - 40.2)	Ref
	MT-PM6	260	32.5 (23.1 - 41.9)	1.12 (0.90 - 1.40) †
	MT-BGL	93	11.6 (7.3 - 15.91)	0.28 (0.21 - 0.36)
	HLC	723	90.4 (84.7 - 96.0)	33.47 (24.29 - 46.11)
Culex quinquefasciatus	BGP-BGL	696	87.0 (78.8 - 95.2)	Ref
	MT-PM6	458	57.3 (49.3 - 65.2)	0.18 (0.14 - 0.24)
	MT-BGL	533	66.6 (60.6 - 72.6)	0.28 (0.22 - 0.36)
	HLC	728	91.0 (87.2 - 94.8)	1.52 (1.10 - 2.10) *

The odds ratios (*OR*) were derived from multilevel mixed-effects logistic regression with a binomial distribution and logit function. Trap type, chamber and position were adjusted for fixed effects, and day was a random effect *CI:* Confidence interval, *BGP-BGL:* BGP trap baited with BG-Lure, *MT-PM6:* MTego trap baited with PM6, *MT-BGL:* MTego trap baited with BG-Lure, *HLC:* human landing catch, *Ref.* reference† $P > 0.32$, * $P = 0.011$; all other tests, $P < 0.0001$

4.1.2 Trapping efficacy of MTego trap relative to BGP trap in the dual-choice test

During the experiment, environmental conditions were 23°C (22 - 26°C) and 78% (61 - 84%) RH. Approximately, a total number of 1600 mosquitoes of each species were released throughout the experiment of which 724 (45%) *Anopheles gambiae*, 854 (53%) *Anopheles funestus*, 216 (13.5%) *Anopheles arabiensis*, 831 (51.9%) *Aedes aegypti*, and 1407 (87.9%) *Culex quinquefasciatus* were recaptured by the traps. Overall, the capture rates of traps (combined proportion) were again lower for *Anopheles arabiensis* and multiple times higher for *Culex quinquefasciatus* (Fig. 3, Table 2).

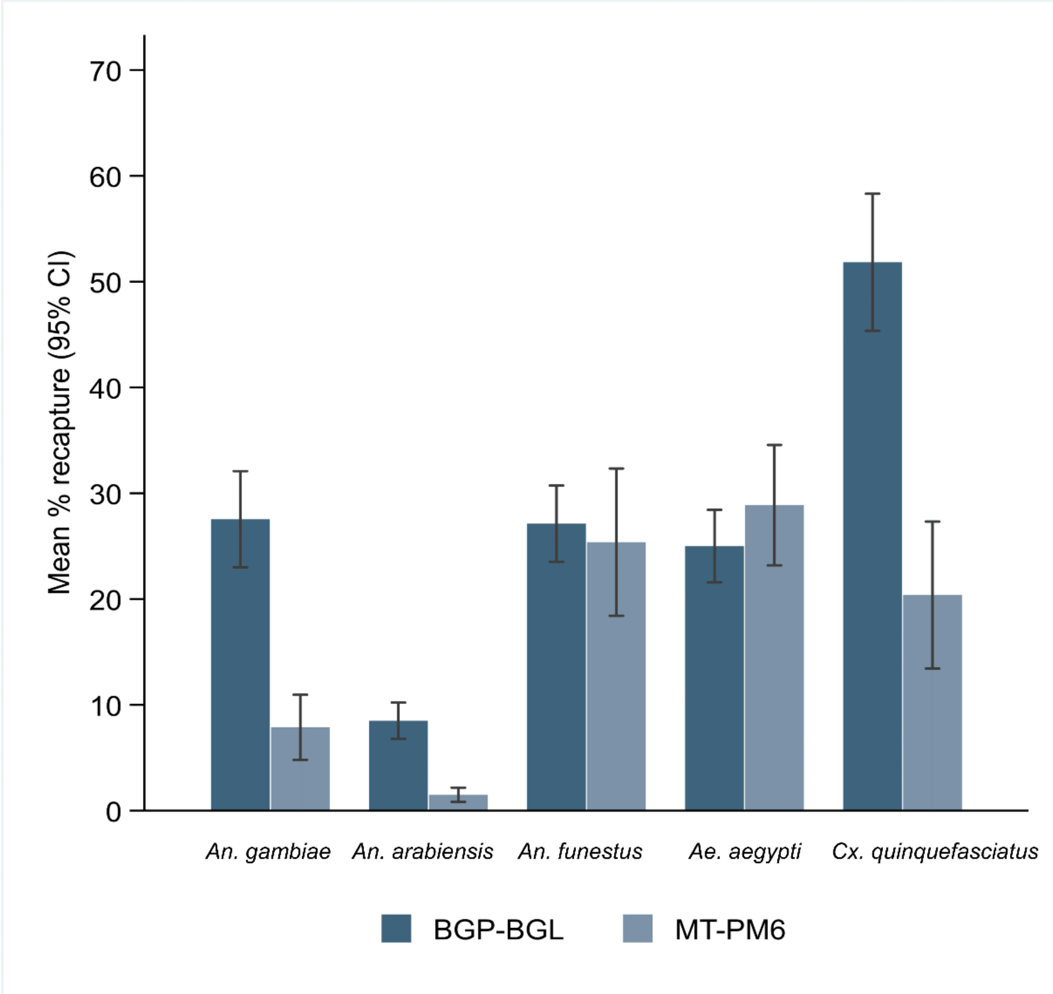


Figure 3: Percentage of mosquitoes recaptured by MTego trap and BGP trap in the dual-choice test

The MT-PM6 and BGP-BGL had similar capture rates for *Aedes aegypti* (IRR = 1.14 (95% CI: 0.90 - 1.45), *P* = 0.264), and *Anopheles funestus* (IRR = 0.93 (95% CI: 0.76 - 1.14), *P* = 0.473) (Table 2).

Conversely, MT-PM6 captured significantly fewer *Anopheles gambiae* (IRR = 0.28 (95% CI: 0.19 - 0.41), *P* < 0.0001), *Anopheles arabiensis* (RR = 0.18 (95% CI: 0.09 - 0.33), *P* < 0.0001), and *Culex quinquefasciatus* (IRR = 0.38 (95% CI: 0.31 - 0.47), *P* < 0.0001) than the BGP-BGL (Table 2).

Table 2: Relative trapping efficacy of MTego and BGP traps in the dual-choice test

Mosquito species	Trapping method	Total catch	Mean % (CI)	IRR (95% CI)
Anopheles gambiae	BGP-BGL	661	27.54 (22.99 - 32.09)	Ref
	MT-PM6	63	7.88 (4.80 - 10.95)	0.28 (0.19 - 0.41)
Anopheles arabiensis	BGP-BGL	204	8.50 (6.78 - 10.22)	Ref
	MT-PM6	12	1.50 (0.83 - 2.17)	0.18 (0.09 - 0.33)
Anopheles funestus	BGP-BGL	651	27.13 (23.52 - 30.73)	Ref
	MT-PM6	203	25.38 (18.41 - 32.34)	0.93 (0.76 - 1.14) †
Aedes aegypti	BGP-BGL	600	25.00 (21.57 - 28.43)	Ref
	MT-PM6	231	28.88 (23.18 - 34.57)	1.14 (0.90 - 1.45) †
Culex quinquefasciatus	BGP-BGL	1244	51.83 (45.35 - 58.31)	Ref
	MT-PM6	163	20.38 (13.43 - 27.32)	0.38 (0.31 - 0.47)

The incidence rate ratio (*IRR*) was derived from the multilevel mixed-effects generalised linear model with a negative binomial distribution and log link function. Trap type, chamber and position were adjusted for fixed effects, and day was a random effect † $P > 0.26$; all other tests, $P < 0.0001$

4.2 Discussion

Mosquito-borne diseases are expanding geographically as a result of rapid unplanned urbanisation, climate change, increasing global traffic of air travel and seaborne trade (WHO, 2017). New and improved methods are needed to control vector populations and the diseases they transmit. The use of traps in vector surveillance is a popular method for keeping track of the spread, number, and infection levels of vector populations. In this study, the MTego trap with integrated thermal stimuli and the BGP are explored as alternative devices for surveillance and control of *Anopheles*, *Culex* and *Aedes* mosquitoes.

The current study demonstrated that the performance of the MTego trap for different mosquito species depends on the attractant baited with. For example, when baited with BGL, the MTego showed comparable performance to the BGP-BGL at capturing *Anopheles gambiae* and *Anopheles funestus*. In contrast, when augmented with PM6, the trap exhibited high efficacy at capturing *Aedes aegypti* mosquitoes. These results are consistent with previous studies indicating that bait type (Batista *et al*., 2017; Busula *et al*., 2017), composition and concentration of chemicals in odour blends (Kim *et al*., 2021; Mukabana *et al*., 2012; Mweresa *et al*., 2016; Mweresa *et al*., 2014) can significantly impact the performance of OBTs. Contrary to the no-choice results, the MT-PM6 exhibited a similar level of efficacy as the BGP-BGL at capturing *Anopheles funestus* when the two traps were placed in direct competition in the same chamber. Perhaps, heat and moisture in the MTego trap influenced this response as seen in previous studies where mosquitoes tend to choose a human over traps at short distances (Okumu *et al*., 2010; Tambwe *et al*., 2021). Overall, the MTego trap shows potential as a valuable tool for sampling various mosquito species, and its performance can be enhanced by utilising diverse attractants, depending on the targeted species and the prevailing context.

The BGP-BGL displayed comparable efficacy at capturing the most anthropophagic species tested: *Anopheles gambiae*, *Anopheles funestus*, and *Aedes aegypti* (Fig. 2 & 3). This is in contrast to Degener *et al*. (2021), who reported poor effectiveness of the BGP for sampling *Anopheles* mosquitoes in a field study in Mozambique. This could be explained by the fact that in field environments, local mosquito population densities and competing sources of host kairomones may influence mosquitoes to select alternative options, whereas, in confined settings such as SFS, they may opt for the available potential host. These promising semi-field findings imply that additional field testing is necessary to confirm whether BGP-BGL can be a useful tool for assessing Afrotropical *Anopheles*.

Overall, the results showed that the capture performance of all traps for *Anopheles arabiensis* was much lower than for *Anopheles gambiae, Anopheles funestus*, and *Aedes aegypti*, while the response of *Culex quinquefasciatus* was multiple times higher than all other mosquito species (Fig. 2 & 3). These findings are consistent with previous studies observing that *Anopheles arabiensis* was less attracted to an MB5-baited MM-X trap than *Anopheles gambiae* (Mburu *et al*., 2017), and that *Culex quinquefasciatus* was strongly attracted to CO_2-baited BGS traps than *Aedes aegypti* (Kim *et al*., 2021).

It is important to develop attractants that are attractive across a range of mosquito species, as most current attractants have been optimised for anthropophilic *Anopheles gambiae* and *Aedes aegypti*. However, in certain situations, vectors with a broader host preference may also transmit diseases. For example, *Anopheles arabiensis* is an opportunistic vector feeding on both humans and animals because it utilises CO_2 as a generic host cue, while *Anopheles gambiae*, *Anopheles funestus*, and *Aedes aegypti* prefer humans and use CO_2 together with other odorants that are specific to humans for locating hosts (Busula *et al*., 2015; Takken & Verhulst, 2013; White *et al*., 2011). *Culex quinquefasciatus* is known to have a higher degree of plasticity in its host preferences, varying from 100% animal feeding to high degrees of preference for birds (Takken & Verhulst, 2013). This adds to the previous body of work that the specific blend of chemicals used in synthetic bait may be more attractive to certain species of mosquitoes than others.

The study also found that HLC consistently collected a higher proportion of all mosquito species than the MTego or BGP traps. This difference may be due to the complexity of human host cues and their dynamic nature in various environments (Martinez *et al*., 2021; Wooding *et al*., 2020). Okumu *et al.* (2010b) developed a highly attractive blend, but it did not match the short-range attractiveness of humans in competitive assays. The current study did not compare the traps and humans in a choice test, but based on the no-choice results, it is clear that humans remain more attractive to host-seeking mosquitoes than current lures. Similarly, recent studies have shown that odour-baited Suna (Njoroge *et al*., 2021) and BG-Sentinel traps (Tambwe *et al., 2020;* Tambwe *et al*., 2021) are less effective at capturing mosquitoes in the presence of humans. This should be considered when using traps with synthetic attractants, particularly in field settings, since traps may assist in drawing mosquitoes from a distance and then increasing biting exposure to nearby people who out-compete traps at the short range.

Although we did not measure the effect of heat and moisture in the MTego trap, it was clear that its effect did not significantly outperform the BGP trap. In a previous study, it was found that the addition of heat significantly improved the performance of the MTego trap. However, the study did not find a significant improvement in trap performance with the addition of warm water. (Cribellier *et al*., 2020). Further investigation is needed to quantify the effect of these features on overall attraction and catch. Furthermore, the results of this study may not be generalisable to all populations of the target mosquito species. Different populations of mosquitoes may have different behaviours and preferences and that affects trap performance. Similarly, the specific synthetic blends used in this study may not be effective for all populations of the target species, further research is necessary to validate these findings in additional field settings.

Nevertheless, the current study underscores the continued utility of OBTs within integrated vector management. These traps can consistently diminish mosquito populations on a daily or nightly basis, yielding a noticeable impact on disease prevention. Earlier studies have highlighted the substantial population reduction of *Anopheles funestus* and *Aedes aegypti* achieved through the implementation of mass trapping with Suna and BGS traps, consequently leading to lowered malaria prevalence and dengue incidence, respectively (Homan *et al*., 2016; Degener *et al*., 2014). Furthermore, simulation models have suggested that OBTs possess the potential to serve as cost-effective tools for malaria control in Africa (Okumu *et al*., 2010). This potential is particularly evident when these traps are utilised in conjunction with existing strategies like ITNs. To realise this potential, the traps do not necessarily need to outcompete humans in attractiveness but should be strategically positioned in areas with mosquito abundance and positioned at least 10 m from households (Okumu *et al*., 2010). However, before deploying traps in a given setting it is worth noting that their performance can vary from trap to trap, depending on the design, type of bait, setting and the mosquito species being targeted. Therefore, selection of the optimal trap-lure combination for each setting will maximise trap efficiency.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study demonstrated that the MTego trap performs similarly to the BGP trap for sampling anthropophilic mosquitoes including African malaria vectors *Anopheles gambiae* and *Anopheles funestus* and the principal arbovirus vector *Aedes aegypti*. Since the traps caught a substantial proportion of mosquitoes in a semi-field environment, they may be used outdoors for sampling a variety of mosquito species, including *Anopheles*, *Culex* and *Aedes* genera.

5.2 Recommendations

Based on the findings of this study, the following is recommended:

(i) While the current semi-field study provides valuable insights into the performance of the MTego trap, field trials are needed to validate its effectiveness and identify any potential challenges or limitations in using the trap for mosquito surveillance and control.

(ii) Similar to this study, future studies should conduct more comprehensive studies that assess trap efficacies across multiple mosquito species simultaneously, rather than focusing on a single species at a time. This approach will provide a more holistic understanding of trap performance.

(iii) Although the MTego and BGP traps were effective at capturing multiple mosquito species, they did not match the attractiveness of a human. Further research exploring highly attractive attractants to enhance trap performance is necessary.

(iv) When used as a vector control strategy, traps should be used as part of integrated vector management (IVM), involving multiple control measures. Traps can be used in conjunction with other methods, such as insecticide-treated nets, larval control and spatial repellents.

REFERENCES

Batista, E. P. A., Ngowo, H. S., Opiyo, M., Shubis, G. K., Meza, F. C., Okumu, F. O., & Eiras, A. E. (2017). Semi-field assessment of the BG-Malaria trap for monitoring the African malaria vector, *Anopheles arabiensis*. *PLoS One*, *12*(10), 320-337. https://dx.plos.org/0186610.0181371/journal.pone.0186696

Bhatt, S., Weiss, D. J., Cameron, E., Bisanzio, D., Mappin, B., Dalrymple, U., Battle, K. E., Moyes, C. L., Henry, A., Eckhoff, P. A., Wenger, E. A., Briët, O., Penny, M. A., Smith, T. A., Bennett, A., Yukich, J., Eisele, T. P., Griffin, J. T., Fergus, C. A., & Gething, P. W. (2015). The effect of malaria control on *Plasmodium falciparum* in Africa between 2000 and 2015. *Nature*, *526*(7572), 207-211. https://doi.org/10.1038/nature15535

Busula, A. O., Takken, W., De Boer, J. G., Mukabana, W. R., & Verhulst, N. O. (2017). Variation in host preferences of malaria mosquitoes is mediated by skin bacterial volatiles. *Medical and Veterinary Entomology*, *31*(3), 320-326. https://doi.org/10.1111/mve.12242

Busula, A. O., Takken, W., Loy, D. E., Hahn, B. H., Mukabana, W. R., & Verhulst, N. O. (2015). Mosquito host preferences affect their response to synthetic and natural odour blends. *Malaria Journal*, *14*(1), 133-222. https://doi.org/10.1186/s12936-015-0635-1

Caputo, B., Ienco, A., Cianci, D., Pombi, M., Petrarca, V., Baseggio, A., Devine, G. J., & della Torre, A. (2012). The "auto-dissemination" approach: A novel concept to fight *Aedes albopictus* in urban areas. *PLoS Neglected Tropical Diseases*, *6*(8), 1793-1803.

Cribellier, A., Spitzen, J., Fairbairn, H., Van De Geer, C., Van Leeuwen, J. L., & Muijres, F. T. (2020). Lure, retain, and catch malaria mosquitoes. How heat and humidity improve odour-baited trap performance. *Malaria Journal*, *19*(1), 357-373. https://doi.org/10.1186/s12936-020-03403-5

Degener, C. M., Eiras, A. E., Azara, T. M. F., Roque, R. A., Rösner, S., Codeço, C. T., Nobre, A. A., Rocha, E. S. O., Kroon, E. G., Ohly, J. J., & Geier, M. (2014). Evaluation of the effectiveness of mass trapping with BG-sentinel traps for dengue vector control: A cluster randomised controlled trial in Manaus, Brazil. *Journal of Medical Entomology*, *51*(2), 408-420.

Degener, C. M., Staunton, K. M., Bossin, H., Marie, J., Da Silva, R. D., Lima, D. C., Eiras, Á. E., Akaratovic, K. I., Kiser, J., & Gordon, S. W. (2021). Evaluation of the new modular

Biogents BG-Pro Mosquito trap in comparison to CDC, EVS, BG-Sentinel, and BG-Mosquitaire traps. *Journal of the American Mosquito Control Association*, *37*(4), 224-241. https://doi.org/10.2987/21-7003

Dormont, L., Mulatier, M., Carrasco, D., & Cohuet, A. (2021). Mosquito attractants. *Journal of Chemical Ecolgy*, *47*(4-5), 351-393. https://doi.org/10.1007/s10886-021-01261-2

Gatton, M. L., Chitnis, N., Churcher, T., Donnelly, M. J., Ghani, A. C., Godfray, H. C. J., Gould, F., Hastings, I., Marshall, J., Ranson, H., Rowland, M., Shaman, J., & Lindsay, S. W. (2013). The importance of mosquito behavioural adaptations to malaria control in Africa. *Evolution*, *67*(4), 1218-1230. https://doi.org/10.1111/evo.12063

Hancock, P. A., Hendriks, C. J. M., Tangena, J.A., Gibson, H., Hemingway, J., Coleman, M., Gething, P. W., Cameron, E., Bhatt, S., & Moyes, C. L. (2020). Mapping trends in insecticide resistance phenotypes in African malaria vectors. *PLOS Biology*, *18*(6), e3000633. https://doi.org/10.1371/journal.pbio.3000633

Hiscox, A., Otieno, B., Kibet, A., Mweresa, C. K., Omusula, P., Geier, M., Rose, A., Mukabana, W. R., & Takken, W. (2014). Development and optimisation of the Suna trap as a tool for mosquito monitoring and control. *Malaria Journal*, *13*(1), 257.

Homan, T., Hiscox, A., Mweresa, C. K., Masiga, D., Mukabana, W. R., Oria, P., Maire, N., Pasquale, A. D., Silkey, M., Alaii, J., Bousema, T., Leeuwis, C., Smith, T. A., & Takken, W. (2016). The effect of mass mosquito trapping on malaria transmission and disease burden (SolarMal): A stepped-wedge cluster-randomised trial. *The Lancet*, *388*(10050), 1193-1201. https://doi.org/10.1016/s0140-6736(16)30445-7

Jahir, A., Kahamba, N. F., Knols, T. O., Jackson, G., Patty, N. F. A., Shivdasani, S., Okumu, F. O., & Knols, B. G. J. (2022). Mass trapping and larval source management for mosquito elimination on small Maldivian islands. *Insects*, *13*(9), 805.

Kim, D.Y., Leepasert, T., Bangs, M. J., & Chareonviriyaphap, T. (2021). Semi-field evaluation of novel chemical lures for *Aedes aegypti*, *Culex quinquefasciatus*, and *Anopheles minimus* (Diptera: Culicidae) in Thailand. *Parasites & Vectors*, *14*(1), 203.

Krockel, U., Rose, A., Eiras, A. E., & Geier, M. (2006). New tools for surveillance of adult yellow fever mosquitoes: Comparison of trap catches with human landing rates in an urban environment. *Journal of the American Mosquito Control Association*, *22*(2), 229-238.

Lwetoijera, D., Harris, C., Kiware, S., Dongus, S., Devine, G. J., Mccall, P. J., & Majambere, S. (2014). Effective autodissemination of pyriproxyfen to breeding sites by the exophilic malaria vector *Anopheles arabiensis* in semi-field settings in Tanzania. *Malaria Journal*, *13*(1), 161. https://doi.org/10.1186/1475-2875-13-161

Martinez, J., Showering, A., Oke, C., Jones, R. T., & Logan, J. G. (2021). Differential attraction in mosquito–human interactions and implications for disease control. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *376*(1818), 20190811. https://doi.org/10.1098/rstb.2019.0811

Mburu, M. M., Mweresa, C. K., Omusula, P., Hiscox, A., Takken, W., & Mukabana, W. R. (2017). 2-Butanone as a carbon dioxide mimic in attractant blends for the Afrotropical malaria mosquitoes *Anopheles gambiae* and *Anopheles funestus. Malaria Journal*, *16*(1), 1-9. https://doi.org/10.1186/s12936-017-1998-2

Menger, D. J., Omusula, P., Holdinga, M., Homan, T., Carreira, A. S., Vandendaele, P., Derycke, J.L., Mweresa, C. K., Mukabana, W. R., Van Loon, J. J. A., & Takken, W. (2015). Field evaluation of a push-pull system to reduce malaria transmission. *PLoS One*, *10*(4), e0123415. https://doi.org/10.1371/journal.pone.0123415

MR4. (2016). *Methods in Anopheles Research Manual 2015 Edition*. https://www.google.com

Mukabana, W. R., Mweresa, C. K., Otieno, B., Omusula, P., Smallegange, R. C., van Loon, J. J. A., & Takken, W. (2012). A novel synthetic odorant blend for trapping of malaria and other African mosquito species. *Journal of Chemical Ecology*, *38*(3), 235-244.

Mweresa, C. K., Mukabana, W. R., Omusula, P., Otieno, B., Van Loon, J. J., & Takken, W. (2016). Enhancing attraction of African malaria vectors to a synthetic odour blend. *Journal of Chemical Ecology*, *42*(6), 508-516. https://doi.org/10.1007/s10886-016-0711-1

Mweresa, C. K., Omusula, P., Otieno, B., Van Loon, J. J., Takken, W., & Mukabana, W. R. (2014). Molasses as a source of carbon dioxide for attracting the malaria mosquitoes *Anopheles gambiae* and *Anopheles funestus*. *Malaria Journal*, *13*(1), 160.

Njiru, B. N., Mukabana, W. R., Takken, W., & Knols, B. G. (2006). Trapping of the malaria vector *Anopheles gambiae* with odour-baited MM-X traps in semi-field conditions in western Kenya. *Malaria Journal*, *5* (39), 1-8. https://doi.org/10.1186/1475-2875-5-39

Njoroge, M. M., Fillinger, U., Saddler, A., Moore, S., Takken, W., Van Loon, J. J. A., & Hiscox, A. (2021). Evaluating putative repellent ‘push’ and attractive ‘pull’ components for manipulating the odour orientation of host-seeking malaria vectors in the peri-domestic space. *Parasites & Vectors*, *14*(1), 1320. https://doi.org/10.1186/s13071-020-04556-7

Okumu, F. O., Govella, N. J., Moore, S. J., Chitnis, N., & Killeen, G. F. (2010). Potential benefits, limitations and target product-profiles of odour-baited mosquito traps for malaria control in Africa. *PLoS One*, *5*(7), e11573. https://doi.org/10.1371/journal.pone.0011573

Okumu, F. O., Killeen, G. F., Ogoma, S., Biswaro, L., Smallegange, R. C., Mbeyela, E., Titus, E., Munk, C., Ngonyani, H., Takken, W., Mshinda, H., Mukabana, W. R., & Moore, S. J. (2010). Development and field evaluation of a synthetic mosquito lure that is more attractive than humans. *PLoS One*, *5*(1), e11162.

Okumu, F. O., Madumla, E. P., John, A. N., Lwetoijera, D. W., & Sumaye, R. D. (2010). Attracting, trapping and killing disease-transmitting mosquitoes using odour-baited stations - The Ifakara odour-baited stations. *Parasites & Vectors*, *3*(1), 12. https://doi.org/10.1186/1756-3305-1183-1112.

Premalbv.com. *The PM6 is Extremely Attractive to Human-biting Mosquitoes*. https://www.premalbv.com/the-mtego

Russell, T. L., Govella, N. J., Azizi, S., Drakeley, C. J., Kachur, S. P., & Killeen, G. F. (2011). Increased proportions of outdoor feeding among residual malaria vector populations following increased use of insecticide-treated nets in rural Tanzania. *Malaria Journal*, *10*(1), 80. https://doi.org/10.1186/1475-2875-10-80

Saddler, A., Kreppel, K. S., Chitnis, N., Smith, T. A., Denz, A., Moore, J. D., Tambwe, M. M., & Moore, S. J. (2019). The development and evaluation of a self-marking unit to estimate malaria vector survival and dispersal distance. *Malaria Journal*, *18*(1), 336. https://doi.org/10.1186/s12936-019-3077-3

Santos, V. S. V., Caixeta, E. S., Júnior, E. O. C., & Pereira, B. B. (2017). Ecotoxicological effects of larvicide used in the control of *Aedes aegypti* on nontarget organisms: Redefining the use of pyriproxyfen. *Journal of Toxicology and Environmental Health*, *80*(3), 155-160. https://doi.org/10.1080/15287394.2016.1266721

Sougoufara, S., Ottih, E. C., & Tripet, F. (2020). The need for new vector control approaches targeting outdoor biting *Anopheline* malaria vector communities. *Parasites & Vectors*, *13*(1), 295. https://doi.org/210.1186/s13071-13020-04170-13077.

Takken, W. (1991). The role of olfaction in host-seeking of mosquitoes: A review. *International Journal of Tropical Insect Science*, *12*(1-2-3), 287-295.

Takken, W., & Knols, B. G. (1999). Odour-mediated behaviour of Afrotropical malaria mosquitoes. *Annual Review of Entomology*, *44*, 131-157.

Takken, W., Knols, B. G. J., & Otten, H. (1997). Interactions between physical and olfactory cues in the host-seeking behaviour of mosquitoes: The role of relative humidity. *Annals of Tropical Medicine and Parasitology*, *91*(Suppl. 1), S119-S120.

Takken, W., & Verhulst, N. O. (2013). Host preferences of blood-feeding mosquitoes. *Annual Review of Entomology*, *58*, 433-453. https://doi.org/10.1146/annurev-ento-120811-153618

Tambwe, M. M., Moore, S. J., Chilumba, H., Swai, J. K., Moore, J. D., Stica, C., & Saddler, A. (2020). Semi-field evaluation of freestanding transfluthrin passive emanators and the BG sentinel trap as a “push-pull control strategy” against *Aedes aegypti* mosquitoes. *Parasites & Vectors*, *13*(1), 392. https://doi.org/310.1186/s13071-13020-04263-13073

Tambwe, M. M., Saddler, A., Kibondo, U. A., Mashauri, R., Kreppel, K. S., Govella, N. J., & Moore, S. J. (2021). Semi-field evaluation of the exposure-free mosquito electrocuting trap and BG-Sentinel trap as an alternative to the human landing catch for measuring the efficacy of transfluthrin emanators against *Aedes aegypti*. *Parasites & Vectors*, *14*(1), 265. https://doi.org/210.1186/s13071-13021-04754-x

White, B. J., Collins, F. H., & Besansky, N. J. (2011). Evolution of *Anopheles gambiae* in relation to humans and malaria. *Annual Review of Ecology, Evolution, and Systematics*, *42*(1), 111-132. https://doi.org/10.1146/annurev-ecolsys-102710-145028

WHO. (1975). *Manual on Practical Entomology in Malaria Part-I: Vector Bionomics and Organisation of Anti-malaria Activities*. In. Geneva. https://apps.who.int. int/iris/handle/10

WHO. (2012). *The Role of Larviciding for Malaria Control in Sub-Saharan Africa*: *Interim Position Statement*. In: Geneva.https://apps.who.int/iris/handle/10665/337991

WHO. (2014). *A global Brief on Vector-borne Diseases.* In. Geneva: Worl Health Organisation. https://apps.who.int. int/iris/handle/10774/4769576

WHO. (2017). *Global Vector Control Response 2017–2030*. In. Geneva: Worl Health Organisation. https://apps.who.int/iris/handle/20884/275801

WHO. (2018). *Efficacy-testing of Traps for Control of Aedes spp*. *Mosquito Vectors.* In: World Health Organisation.https://apps.who.int/iris/handle/10665/275801

WHO. (2020). *Vector-borne Diseases*. https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases

WHO. (2022). *World Malaria Report 2022*. https://www.who.int/teams/global-malaria-programme/reports/worldd%20impact%20of%20COVID,further%20setbacks%20to%20 malaria%20control

Wooding, M., Naudé, Y., Rohwer, E., & Bouwer, M. (2020). Controlling mosquitoes with semiochemicals: A review. *Parasites & Vectors*, *13*(1), 80.

Wright, R. H., & Kellogg, F. E. (1962). Response of *Aedes aegypti* to moist convection currents. *Nature*, *194*, 402-403.

APPENDICES

Appendix 1: Informed consent form

ISO 9001:2015 certified

Consent form for participants in: Evaluation of the M-Teg trap for sampling adult mosquitoes in the semi-field system in Bagamoyo

Researcher: Masudi Suleiman

Organization: Ifakara Health Institute

Sponsor: Ifakara Health Institute

This consent form has two parts:

Information Sheet (Sharing information with you about research) Certificate of consent (correct if you agree to participate in this study)You will be provided with a complete copy of this consent form

Date: |________|______| / |_______|______| / |_______|______|______|______| (Day / Month / Year)

SECTION I: Information sheet

My name is ……………………………………..., I am a researcher at Ifakara Health Institute. We are researching ways to prevent Anopheles, Culex and Aedes mosquito bites. Bites from these mosquitoes may spread many diseases such as Malaria, yellow fever, Dengue and Zika viruses. These diseases are life-threatening and can cause death in our society. I will give you information on the research we want to do and invite you to become part of this study. You do not have to decide today whether you will participate or not. Before you decide, you can talk to anyone you see fit about this study. If there any words that you do not understand, please you are allowed to ask me any time as we continue to go through this information and I will answer you. If you will havequestions later, you can ask me through my phone number 0769 200 169.

Purpose of the study

While Malaria and Dengue diseases are transmitted through bites by female Anopheles and Aedes mosquitoes, culex cause nuisance bites. Expertise on mosquito behaviour has developed new ways to adapt and keep mosquitoes away from humans which will reduce mosquito density at home and nearby places thus protecting people from mosquito bites and preventing disease transmission. Previous reports indicate that these traps are effective in capturing disease-transmitting mosquitoes so we want to test this new mosquito trap in a semi-fieldsetting.

Types of research methods and procedures

- You will be asked to sit and capture mosquitoes using an aspirator between 6:30 p.m. to 9:30 pm.
- You will be asked not to apply any mosquito repellent, soft oil or perfume before starting catching mosquitoes.
- You will be asked to wear a net jacket so that mosquitoes cannot bite your body
- You will be required not to smoke or use alcohol for the days or weeks you will be participating.

Voluntary participation

Your participation in this study is voluntary. It is your choice to participate or not to participate. You can changethe decision at any time even later and stop participating even if you agreed at first. This will not affect your working relationship with IHI. It's you to decide and all your rights will be respected.

Anticipated risks

There is no risk in participating in this study. The synthetic blend tested here do not carry any insecticides and they are safe to human. Mosquitoes used in this experiment are laboratory reared that are free from diseases soeven if they accidentally bite you, no diseases transmission will occur. Also, you will be provided with bug jacketto protect you from mosquitoes that may bite other part of your body and only legs will be exposed. However, in case you experience any discomfort you should immediately contact the investigator Mr. Masudi Suleiman through 0769 200 169 and we will provide you with necessary assistance.

Benefits

If you participate in this research, you will contribute to the science of Tanzania in searching for new methods to control disease transmitting mosquitoes.

Duration of research/participation

The duration of this study is only 16 days.

Payment

For your time involvement, you will be compensated 15,000Tsh per day and you will be given a bonus of 5,000 per day if you participate in all days of the experiment.

Who to contact?

If you have any questions, you can ask them now or even later, even after the project has started. If you wouldlike to ask questions later, you can contact the investigator Mr. Masudi Suleiman through 0769 200 169.

Ethical review

This proposal has been reviewed and approved by the Health Institute Ethics Board of Ifakara Health Institute (IHI) and the ethics board of the National Institute for Medical Research (NIMR) which are committees responsible for ensuring that study participants are protected from any risks.

If you would like to know more about the review procedures, please contact Dr. Mwifadhi Mrisho who is the secretary of the Ethics Committee at IHI: 0788 766 676 or Ms Sia Malekia, (Telephone: +255 754 499 293) National Institute of Medical Research.

PART II: Certificate of Participation

I, ……………………………. I fully understand the purpose of this project titled “Evaluation of M-Tego trap for sampling adult mosquitoes in the semi-field system in Bagamoyo.” and I agree to participate. I acknowledge thatI have received information about the study procedures, such as collecting mosquitoes using an aspirator. I havebeen given additional information about the study by the researcher.

I acknowledge the purpose of this study, all the procedures, benefits such as contributing to finding a new methodfor people to protect themselves from Anopheles and Aedes mosquitoes. I have been given enough time to ask questions and for any further question I can ask the investigator Mr. Masudi Suleiman through 0769 200 169.

I agree to participate in this study.

Participant name: ____

Participant signature:______________________Date_______________(Day / Month / Year)

Name of witness: ____
Witness signature:_______________________Date_____________(Day / Month / Year)

If the participant does not know how to read or write;

I have witnessed the correct reading of the consent form for the participant and the participant has been givenan opportunity to ask questions. I certify that the participant has freely given consent.

Write the name of the witness_____________________________thumb of the participant's thumbWitness's signature ___________________________________

Date____________________________(Date / Month / Year)

Words from the researcher / person taking the consent

I have correctly read the information sheet for the participant and to the best of my knowledge, I have madesure that the participant understands that the following will happen:

- The participant has been asked to stay and catch mosquitoes in the semi-field system between 4:00 pmto 9:30 pm.
- This trap is safe for human use and has been approved by the Research Institute of Tanzania Medicines (TPRI).
- Participant is asked to wear a net jacket so that mosquitoes do not bite other part of the body.
- Participant is asked not to smoke or drink alcohol for days or weeks involved in the study.
- I certify that the participant has been allowed to ask questions about the project and all the questions asked by the participant have been answered correctly and to the best of my knowledge. I confirm thatthe participant was not obliged to give consent to participate in this study and that consent was grantedvoluntarily and freely.
- I certify that a copy of this form has been provided to the participant.

Write the Name of the researcher / person who taking consent_________________________________

Signature of researcher / person seeking consent______________________________

Date: |____|_____| / |_____|_____| / |_____|_____|_____|_____|

TOLEO LA KISWAHILI

ISO 9001:2015 certified

Fomu ya ridhaa kwaajili ya washiriki katika: Tathmini ya mitego kwaajili ya kudhibiti mbu.

Mtafiti: Masudi Suleiman

Shirika: Taasisi ya Afya Ifakara

Mfadhili: Taasisi ya Afya Ifakara

Fomu hii ya ridhaa ina sehemu mbili:

1. Karatasi ya taarifa (Kupeana taarifa na wewe kuhusu utafiti)

2. Cheti cha ridhaa (kwa sahihi kama unakubali kushiriki utafiti huu)Utapatiwa nakala kamili ya fomu hii ya ridhaaa

Tarehe:|_________|_______|/ |______|_______|/|______|_______|_______|_______|(Siku/Mwezi/Mwaka)

SEHEMU I: Karatasi ya taarifa

Mimi………………………………Ni mtafiti kutoka taasisi ya afya ya Ifakara. Tunafanya utafiti kuhusu njia zakuzuia watu kuumwa na mbu aina ya Anopheles, Culex na Aedes. kuumwa na mbu aina ya Anopheles na Aedes huweza kueneza ugonjwa wa homa ya malaria, manjano, Dengu na virusi vya Zika, haya ni magonjwa yanayoweza kusababisha vifo katika jamii zetu. Nitakupatia taarifa za utafiti tunaotaka kuufanya na kukualika kuwa sehemu ya utafiti huu. Huna haja ya kuamua leo kama utashiriki au la. Kabla ya kuamua, unaweza kuongea na yeyote unayeona anafaa kuhusu utafiti huu. Inawezakuwa kuna maneno hujayaelewa. Tafadhali ninakuruhusu uniulizemaswali wakati wowote wakati tunaendelea kupitia hii taarifa na nitakuelimisha. Kama utakuwa na maswali baadae, unaweza kumuuliza mtafiti Bw. Masudi kupitia namba 0769 200 169.

Dhumuni la utafiti

Ugonjwa wa malaria, homa ya manjano, virus vya Dengu na Zika huambukizwa kupitia kuumwa na mbu jike ainaya Anophelesi na Aedes. Utaalamu kuhusu tabia za mbu na jinsi njia mpya za kuweza kuwaweka mbu mbali na binadamu itasaidia jinsi ya kuboresha njia ya kuzuia mbu katika maeneo ya watu na itasaidia kuzuia watu kupatamagonjwa haya. Katika utafiti huu, tunafanya majaribio ya mtego mpya wa kuwavuta na kukamata mbu ili wasiwaume watu katika maeneo yetu. Taarifa mbalimbali za kiuchunguzi zinaonesha kuwa mitego hii ni madhubuti katika kuvuta na kukamata mbu waenezao malaria na dengu hivyo tunataka kujaribu mtego huu mpyawenye uwezo zaidi ya mitego iliyopo sasa. Ili kuweza kuthibitisha matokeo hayo kwa mbu aina ya Anopheles naAedes waenezao malaria na dengu, mtego huu mpya utawekwa umbali wa mita 10 kutoka mtego mwingine na umbali wa mita 10 kutoka alipo binadamu katika mazingira yaliyodhibitiwa.

Aina ya njia za utafiti na taratibu zake

- Mshiriki, utaambiwa kukaa na kukamata mbu kwa kutumia aspirator cha mbu kati kati ya saa 10:00 jioni mpaka saa 3:30 usiku.
- Kazi hii itafanyika katika mazingira yaliyodhibitiwa (semi-field).
- Utaombwa kutopaka dawa yoyote yakufukuza mbu, mafuta laini au manukato kabla ya kukamata mbu.
- Kifaa utakachotumia ni salama kwa matumizi ya binadamu na zimepitishwa na taasisi ya utafiti wa madawaTanzania(TPRI).
- Ni lazima uvae jaketi la wavu ili mbu wasiweze kukung’ata sehemu nyingine ya mwili
- Utatakiwa kutokuvuta sigara au kutumia kilevi kwa siku au majuma utakayokuwaunashiriki.

Ushirikiwahiari

Ushiriki wako katika huu utafiti ni wa hiari. Ni chaguo lako kushiriki au kutoshiriki. Unaweza kubadili uamuzi wakati wowote hata baadae na kusimama kushiriki hata kama ulikubali hapo mwanzo. Hii haitaathiri ufanyaji kaziwako na IHI. Ni chaguo lako na haki zako zote zitaheshimiwa.

Athari

Hakuna hatari yoyote katika kushiriki katika utafiti huu. Huwezi kuumwa mbu kwakuwa utatumia kifaa maalulmu kinachozuia kuumwa na mbu. Pia, Utapatiwa mavazi maalumu ya kukukinga na mbu ili wasikuume sehemu yoyoteya mwili wako. Vilevile mbu wanaotumika ni mbu waliozalishwa maabara hivyo hawana vimelea vya ugojwa wowote. Endapo utapata shida yoyote ya kiafya katika kipindi cha utafiti, tafadhari wasiliana na mtafiti bwana Masudi Suleiman kupitia namba ya simu 0769 200 169 na atachukua hatua sitahiki kukupatia msaada wa kiafya.

Faida

Kama ukishiriki utafiti huu, utakuwaumechangia sayansi ya Tanzania katika kutafuta njia mpya ya kuthibiti mbu aina ya Anopheles, Culex na Aedes waenezao magonjwa mbalimbali na hivyo kusaidia kuyadhibiti.

Muda wa utafiti/ushiriki Muda wa utafiti huu ni siku 16 tu.

Malipo

Kwa ushiriki wako utafidiwa Tsh 15,000 kwa siku na utapewa bonasi ya Tsh 5,000 kwa siku ikiwa utashiriki katika siku zote za utafiti huu.

Nani wa kuwasiliana nae

Kama una maswali yoyote unaweza kuyauliza sasa au hata baadae, hata baada yamradi kuanza. Kama utapendakuuliza maswali baadae, unaweza kuwasiliana na mtafiti bwana Masudi Suleiman kwakupitia namba 0769 200 169.

Mapitio ya kimaadili

Pendekezo hili limepitiwa na kupata kibali kutoka Bodi ya maadili ya Taasisi ya Afya Ifakara (IHI) na bodi ya maadili ya Taasisi ya Taifa ya utafiti wa magonjwa yabinadamu (NIMR) ambazo ni kamati zenye jukumu la kuhakikisha kuwa washiriki wa utafiti wanalindwa na hatari zozote.

Kama utapenda kufahamu zaidi kuhusu taratibu za kimapitio, wasiliana na Daktari Mwifadhi Mrisho wa Bodi ya Maadili IHI kupitia simu namba 255788766676 au or Bi Sia Malekia, (simu: +255 754 499 293) kutoka taasisi ya tafitiza afya taifa.

SEHEMU II: Cheti cha Ushiriki

Mimi, ... nimeelewa vizuri madhumuni ya mradi huu unaoitwa " Tathmini ya MTego kwaajili ya kudhibiti mbu jamii ya Anopheles, Culex na Aedes" na ninakubali kushiriki. Nakiri ya kuwa, nimepokea maelezo kuhusu taratibu za utafiti, kama vile kukusanya mbu ambao watakufa kwa kugusa mtego. Nimepewa maelezo yaziada kuhusu taarifa katika karatasi yamaelezo kutoka kwa Mtafiti.

Nakiri kufahamu lengo la utafiti huu, taratibu zote, faida kama vile kuchangia katika kutafuta njia mpya ya kujikinga na mbu aina ya Anopheles na Aedes. Nimepewa muda wa kutosha kuuliza maswali na maswali niliyouliza yamejibiwa vizuri na mtafiti na nimeridhika. Kama nitakuwa na swali lolote la ziada nitawasiliana na mfanyakazi wa utafiti kupitia namba za simu kama inavyoonyeshwa.

Ninafahamu kuwa, kama nitakuwa na swali Zaidi kuhusu utafiti huu, nitaweza kuwasiliana na mtafiti bwana Masudi Suleimani kupitia namba 0769 200 169.

Ninaridhia kushiriki katika utafiti huu.

Jina la mshiriki: ____

Sahihi ya mshiriki:__________________________Tarehe____________________(Siku/Mwezi/Mwaka)

Jina la shahidi: _____________________________________

Sahihi ya shahidi:____________________________Tarehe _____(Siku/Mwezi/Mwaka)

Kama hajui kusoma wala kuandika;

Nimeshuhudia usomaji sahihi wa fomu ya ridhaa kwa mshiriki na mshiriki amepata na fasi ya kuuliza maswali.

Ninathibitisha mshiriki ametoa ridhaa kwa uhuru wake mwenyewe.

Andika jina la shahidi___________________________________Sahihi ya shahidi_________dole gumba lamshiriki

Tarehe_________________-_____(Tarehe/Mwezi/Mwaka)

Maneno ya mtafiti/ mtu anayechukua ridhaa

Nimesoma kwa usahihi karatasi ya taarifa kwa mshiriki na kwa uwezo wangu wote nimehakikisha kuwa mshiriki ameelewa kuwa yafuatayo yatafanyika:

- Mshiriki ameombwa kukaa na kukamata mbu katika mazingira ya semi-field kati ya saa 10:00 jioni mpaka saa 3:30 usiku.
- Kifaa kitachotumika ni salama
- Mshiriki ameombwa kuvaa koti la wavu ili mbu wasiweze kumuuma sehemu nyingine za mwili.
- Mshiriki ameombwa kutokuvuta sigara au kunywa kilevi kwa siku au majuma atakayokuwaanashiriki katika utafiti huu.
- Ninathibitisha kuwa mshiriki amepewa nafasi ya kuuliza maswali kuhusu mradi na maswali yote yaliyoulizwa na mshiriki yamejibiwa sahihi na kwa uwezo wangu.
- Ninathibitisha kuwamshiriki hajalazimishwa kutoa ridhaa ya kushiriki utafiti huu na kwamba ridhaa imetolewakwahiari nakwauhuru.
- Ninathibitisha kuwa nakala ya fomu hii amepatiwa mshiriki

Andika Jina la mtafiti/Mtu anayechukua ridhaa_______________________________________

Sahihi ya mtafiti/mtu anayechukua ridhaa_________________________________Tarehe:|_______|_______|__|

Appendix 2: Data collection form

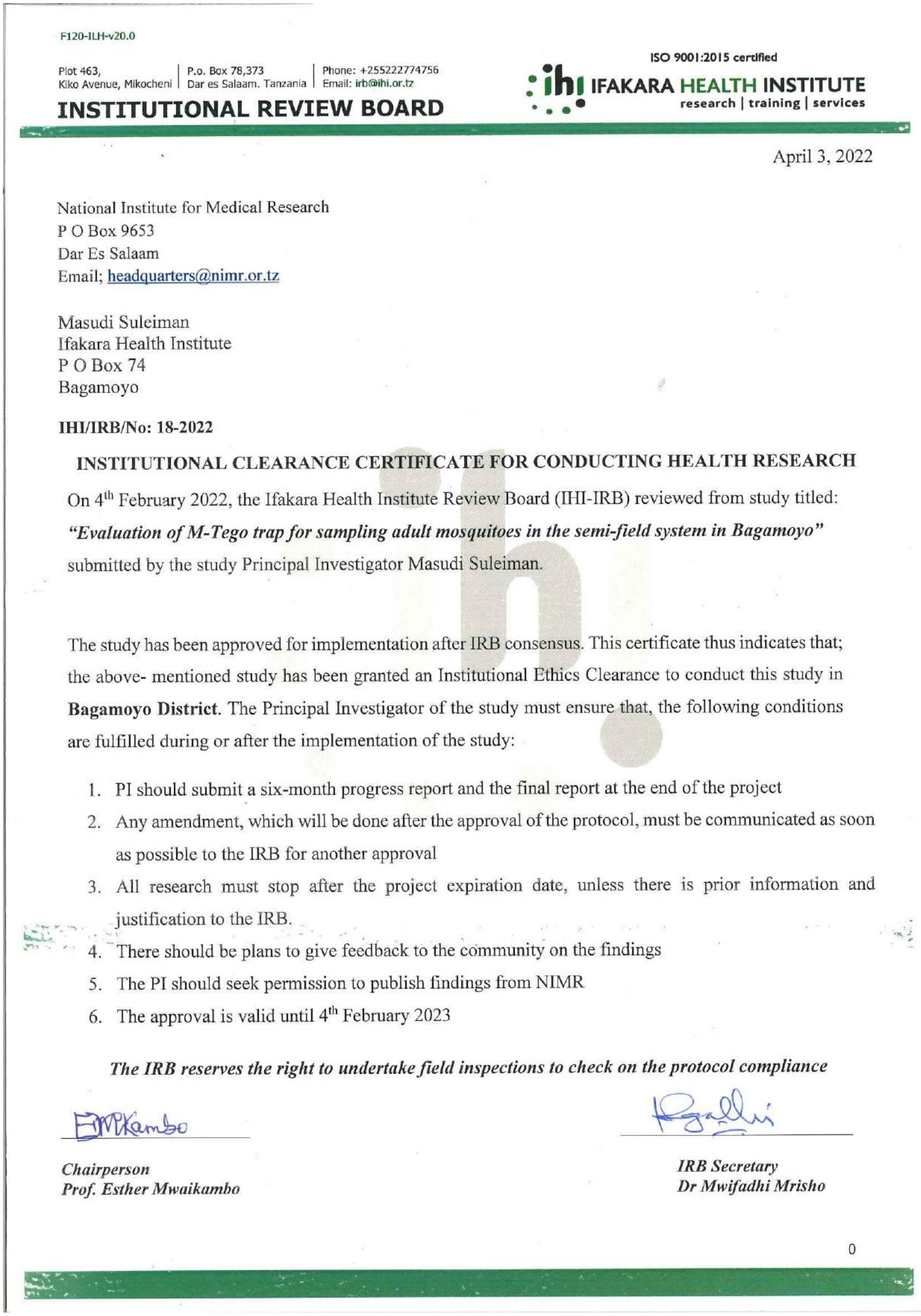
Traps evaluation data sheet									
Project code ________________ Study director (initials) ___________ performed by ______________ data entry _________									
Mosq. Strain ________ Age _______ Tiny Tag SN _______________ Date ________________									
Trap	Chamber	Position	Replicate	Start time	End time	No. mos exposed	Captured	not captured	Total retrieved

Comments ____

Study coordinator (initials) ____________ Date _____________

Mosquito strain coding: *Anopheles gambiae* (ifakara) – 1, *Anopheles arabiensis* (kingani) – 2, *Anopheles funestus* (Fumoz) – 3, *Culex quinquefasciatus – 7, Aedes aegypti* – 6

Appendix 3: Institutional clearance certificate



F120-ILH-v20.0

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IFAKARA HEALTH INSTITUTE
research | training | services

INSTITUTIONAL REVIEW BOARD

April 3, 2022

National Institute for Medical Research
P O Box 9653
Dar Es Salaam
Email; headquarters@nimr.or.tz

Masudi Suleiman
Ifakara Health Institute
P O Box 74
Bagamoyo

IHI/IRB/No: 18-2022

INSTITUTIONAL CLEARANCE CERTIFICATE FOR CONDUCTING HEALTH RESEARCH

On 4th February 2022, the Ifakara Health Institute Review Board (IHI-IRB) reviewed from study titled: ***"Evaluation of M-Tego trap for sampling adult mosquitoes in the semi-field system in Bagamoyo"*** submitted by the study Principal Investigator Masudi Suleiman.

The study has been approved for implementation after IRB consensus. This certificate thus indicates that; the above- mentioned study has been granted an Institutional Ethics Clearance to conduct this study in **Bagamoyo District.** The Principal Investigator of the study must ensure that, the following conditions are fulfilled during or after the implementation of the study:

1. PI should submit a six-month progress report and the final report at the end of the project
2. Any amendment, which will be done after the approval of the protocol, must be communicated as soon as possible to the IRB for another approval
3. All research must stop after the project expiration date, unless there is prior information and justification to the IRB.
4. There should be plans to give feedback to the community on the findings
5. The PI should seek permission to publish findings from NIMR
6. The approval is valid until 4th February 2023

The IRB reserves the right to undertake field inspections to check on the protocol compliance

Chairperson
Prof. Esther Mwaikambo

IRB Secretary
Dr Mwifadhi Mrisho

0

Appendix 4: National clearance certificate

THE UNITED REPUBLIC
OF TANZANIA

National Institute for Medical Research
3 Barack Obama Drive
P.O. Box 9653
11101 Dar es Salaam
Tel: 255 22 2121400
Fax: 255 22 2121360
E-mail: ethics@nimr.or.tz

Permanent Secretary
Ministry of Health
Government City Mtumba,
Health Road
P.O. Box 743
40478 Dodoma

NIMR/HQ/R.8a/Vol.IX/4160

30 November 2022

Mr. Masudi Seleman
Ifakara Health Institute
P O Box 74
Bagamoyo, Pwani

RE: ETHICAL CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: **Evaluation of MTego trap for sampling adult mosquitoes in the semi-field system in Bagamoyo (Seleman M. et al.)**, has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine as per NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Sites: Pwani region.

Approval is valid for one year: 30 November 2022 to 29 November 2023

Name: Prof. Said S. Aboud

Signature
CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Prof. Tumaini J. Nagu

Signature
CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH

CC:Director, Health Services-TAMISEMI, Dodoma.
RMO of Pwani region.
DMO/DED of Bagamoyo district.

RESEARCH OUTPUTS

(i) Publication

Maasayi, M. S., Machange, J. J., Kamande, D. S., Kibondo, U. A., Odufuwa, O. G., Moore, S. J., & Tambwe, M. M. (2023). The MTego trap: A potential tool for monitoring malaria and arbovirus vectors. *Parasites & Vectors, 16*(1), 212

(ii) Poster Presentation