Community-based malaria vector surveillance in Rusinga Island, Western Kenya

By

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June, 2008
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Community-based malaria vector
DECLARATION

Candidate
This thesis is my original work and has not been presented for a degree in any other university or any other award.

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To my family members, Susan, Catherine, Meshack, Lynne and Meek, and to Almighty God be the glory for the many blessings and great things He has done.
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<td>SPSS</td>
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ABSTRACT

Rural African communities have limited power over their own health facilities and public health services as these are mainly run from outside their localities by central governments or by local and foreign non-governmental organizations. As a result, community members do not identify themselves with national health goals and they believe that it is solely the role of the central government to implement all the health programs. One major drawback to malaria control is the general lack of accurate knowledge on its control strategies among community members. Rusinga Island community-owned malaria resource persons were trained and later carried out malaria vectors surveillance as one way of empowering communities to manage their own health initiatives. An assessment was done to evaluate the effectiveness of community-based malaria vector surveillance. The study assessed mosquito knowledge among trained and non-trained community members and evaluated the capability of trained community members in sampling adult mosquitoes using the Mbita trap. Their ability to identify, map, characterize mosquito breeding habitats and species density and diversity were determined. There was a significant difference between the trained and non-trained community members in malaria and non-malaria vectors knowledge, $p < 0.05$. The trained community members showed higher malaria and non-malaria vector knowledge one year after training, $p < 0.05$. There was no significant difference between the trained community members and laboratory identification of adult anopheline and culicine mosquitoes sampled using the Mbita trap, $p > 0.05$. In larval surveillance, there was a significant difference between the first and second larval mapping in the number, size of the breeding habitats, plants found within the breeding habitats, and determination of anopheline density by the trained community members, $p < 0.05$. Education of trained community-owned malaria resource persons was a significant predictor in determining the number, size of the breeding habitat, and plants within the breeding habitats. Gender of trained community-owned malaria resource persons was a significant predictor in determination of the size, water conditions and depth of the breeding habitats. Age of the trained community-owned malaria resource persons was a significant predictor in determination of size of plants and water depth of the breeding habitats. Gender and age of trained community-owned malaria resource persons were significant predictors in determining the size of the breeding habitats and correct identification of aquatic stages of the mosquitoes. Training had a positive impact on the community ability in the identification of breeding habitats and malaria vectors and the use of the Mbita trap in sampling adult mosquitoes. The finding from this study underscores the potential of engaging community members in malaria vector surveillance and control activities.
CHAPTER ONE

INTRODUCTION

1.1 Background

Tropical diseases pose a major obstacle to social and economic development due to the cost of treatment, days of labour lost or even death. Malaria is the world’s most important tropical disease affecting ninety countries inhabited by a total of some 2400 million people—40% of the world’s population (Philips, 2001). The worldwide prevalence of the disease is estimated to be about 300 - 500 million clinical cases each year and mortality attributed to it is estimated to be in the range of 1.5 – 2.7 million deaths every year. Almost 90% of the global malaria burden is concentrated in Sub-Saharan Africa (Greenwood and Mutabingwa, 2002; Boutin et al., 2005) (Figure 1), where it is directly responsible for one in five childhood mortality. The disease causes widespread pre-mature deaths and suffering, imposes financial hardship on poor households, retards economic growth, and undermines living standards (Breman et al., 2001; Sachs and Melaney, 2002)

In Kenya, malaria affects almost one third of the population and it is responsible for the greatest number of out-patient hospital consultations and most common reason for hospital admissions (MoH, 2001). Children under the age of five years and pregnant women are at the highest risk (Kindermans, 2002). The economic burden of malaria in households can be extremely high. Treatment costs of malaria for small-scale farmers in Kenya have been estimated to be as high as 5% of the total household expenditure in addition to the cost of prevention measures.
Challenges faced by the existing malaria control methods, changes, decline and later collapse of many national malaria control programs, poverty, natural disasters, political unrest, and population movement amongst malaria vulnerable communities are the factors that have hindered the control of malaria in affected areas (Greenwood and Mutabingwa, 2002).

Although malaria is both a preventable and curable disease, for which many intervention strategies are available, there are very few areas in Kenya where malaria has been effectively controlled. This is due to the fact that many of the malaria control and
surveillance tools, that are common elsewhere, are usually unaffordable or inaccessible to remote rural communities. The general lack of necessary awareness, social cohesiveness, stability and management skills to apply these tools further confound this situation (Karanja et al., 2002). Furthermore, rural African communities often have limited control of their own health facilities and public health services as these are mainly run by the central government or by local and foreign Non-Governmental Organizations (NGOs). Thus the community members do not identify themselves with the health programs as they have a notion that it is solely the role of the central government to implement all health programs including malaria control.

Malaria and HIV/AIDS are the main diseases affecting people in Rusinga Island (GoK, 2002). Malaria transmission is moderate with year round transmission (Fillinger et al., 2004). Clinical data collected in 2003 and 2004 show malaria prevalence to be 42% in average population and 60% in children under five years (Mbita health centre unpublished data). Malaria in this area is associated with ideal climatic conditions for transmission and the presence of most efficient vector species in the world (Beier et al., 1999). Anopheles gambiae Giles and Anopheles arabiensis Patton constitute the main malaria vectors in the area (Minakawa et al., 2002). Due to rapidly changing agricultural practices, urbanization of market areas, modern house constructions, deforestation, vegetation clearance and poorly planned infrastructure development, mosquito breeding habitats increase during the rainy season and as a result the mosquito population increases rapidly. During the dry season, cemented water storage pits, artificial holes and trenches used for construction and irrigation, respectively, may contain water, which acts
as breeding grounds as seen in the nearby Mbita mainland area (Fillinger et al., 2004). This has led to the increased breeding habitats suitable for malaria-transmitting *Anopheles* in close proximity to human settlements (Fillinger et al., 2004). Limited information relating to malaria treatment and control suggest that a change in approach is required to empower the communities to exert much firmer control over their local malaria problem.

Active and tangible participation by the community members in disease control affecting them is more interesting, rewarding and sustainable. This can lead to changes in behaviour with knowledge transfer amongst the family members. Furthermore, community members actively involved in malaria control activities such as surveillance of mosquito breeding habitats and training earn increasing respect from other community members consequently increasing their motivation and stimulating pride and morale. Training of the community members in malaria vector surveillance was seen therefore as the initial stage in empowering the community members to control malaria in their localities. Thus, this led to the establishment of community-based mosquito surveillance in Rusinga Island.

The project reported here aimed at empowering the Rusinga Island community for Malaria Control by equipping the community-owned resource persons with the knowledge and skills necessary for malaria prevention and control. A community-implemented malaria control programme can only be successful and, even more importantly, sustained, if community members consider malaria to be one of their major
problems and have the knowledge and skills to participate in its prevention. This was initiated by developing simple health education messages that built upon indigenous knowledge and practice. There was great need for up-to-date training and access to up-to-date information and technical support.

The training was conducted through demonstrations and education in the field, on the malaria vector life cycle and identification of different mosquito genera. Participatory learning methods were used and were most preferred by the community and effective in practice. This was done by surveying the Island, an approach that proved to be highly enjoyable and fostered steadily increasing participation and enthusiasm. The training aimed at equipping community members with the basic, essential knowledge and skills on malaria surveillance and initiate among the community members with the aim of developing and implementing community based malaria vector surveillance and control.

1.2 Statement of the problem and justification

Malaria is one of the major health problems affecting the poor rural communities. African community members lack the basic knowledge necessary for preventing and controlling malaria. In addition, they do not identify themselves with national health goals as health facilities and services have been managed mainly by central governments, or by local and foreign Non-governmental organizations. However, with the advent of the health sector reforms globally, there is a need to decentralize health services delivery. It is therefore important to empower the community members with accurate and up-to-date knowledge necessary for the management and control of major health problems like malaria.
Furthermore, community involvement and participation is key to the success and sustainability of any health program. Nonetheless, before engaging communities in disease control on a large scale, it is important to have the necessary evidence base that communities can effectively manage their health programs. This evidence base can only be obtained from microcosms of the wider communities. Rusinga Island community is an excellent microcosm of such wider communities. It was hoped that the lessons learned from this community-based malaria control approach could form a basis for subsequent and expansion of this approach more broadly across Suba District, Kenya and the rest of Africa. The focus of this study was to evaluate the capability of trained community members to carrying out mosquito surveillance in Rusinga Island

1.3 Hypotheses

1. There is no difference between the trained and non-trained community members in malaria and non-malaria vectors knowledge

2. Trained community members are unable to use the Mbita trap to monitor adult malaria vectors.

3. Community members, after training cannot correctly identify and map mosquito breeding habitats.

4. Trained community members are unable to correctly identify malaria vectors
1.4 Research questions

1. Does training the community members increase their knowledge of malaria and non-malaria vectors?

2. Are trained community-owned malaria resource persons able to use the Mbita trap as a tool for adult malaria vectors surveillance?

3. Are trained community-owned malaria resource persons able to identify and map mosquito breeding habitats?

4. Are trained community-owned malaria resource persons able to correctly identify aquatic and non-aquatic stages of malaria and non-malaria vectors?

1.5 Objectives of the study

1.5.1 General objective

To evaluate the capability of trained community-owned malaria resource persons in carrying out malaria vectors surveillance in Rusinga Island, Western Kenya

1.5.2 Specific objectives

1. To assess general mosquito knowledge among the trained community-owned malaria resource persons and non-trained community members.

2. To assess the capability of trained community-owned malaria resource persons in using the Mbita trap for adult malaria vector surveillance.

3. To evaluate the capability of trained community-owned malaria resource persons in identifying, mapping and characterizing mosquito breeding habitats.

4. To assess the capability of trained community-owned malaria resource persons in identifying malaria vectors.
CHAPTER TWO

LITERATURE REVIEW

2.1 Public health importance of malaria

Malaria imposes a huge burden upon the health and economic development of tropical nations, the distribution of which is primarily determined by environmental factors and synergizes with poverty (Sachs and Melaney, 2002). The full global burden of malaria is only now being revealed and has been identified as a major obstacle to sustainable development of the world’s poorest regions. The disease causes widespread premature death and suffering, imposes financial hardship on poor households, retards economic growth and undermines living standards (Breman et al., 2001).

The vast majority of the world’s malaria burden rests in sub-Saharan Africa where it is directly responsible for one in five childhood deaths and indirectly contributes to a sizeable proportion of childhood morbidity and mortality resulting from additional illnesses such as respiratory infections, diarrhoeal diseases and malnutrition (Breman et al., 2001). Malaria infection routinely exceeds 50% across much of sub-Saharan Africa, including Kenya (Beier et al., 1999). An estimated 8.2 million cases are reported in Kenya every year, out of a total population of 30 million (Kindermans, 2002). Malaria is responsible for the greatest number of consultations (30% of new cases in medical centers within public health services) and is the most common reason for hospital admission (22,000 cases/year in public hospitals) (Kindermans, 2002). In Kenya, malaria kills 26,000 children younger than five year annually or 72 children per day (Kindermans, 2002). The economic burden of malaria to households can be extremely
high. Treatment costs of malaria for small farmers in Kenya have been estimated to be as high as 5% of total household expenditure not considering any costs for prevention measures. Although malaria is a preventable disease for which many intervention strategies are available, there are few areas in Kenya where malaria has been effectively controlled or eliminated.

The overwhelming global burden of malaria is focussed primarily in the tropics and particularly in Africa because of clearly identified environmental risk factors that favour transmission of *Plasmodium* parasites. The stability and intensity of malaria transmission in any given area is largely determined by climate, hydrology and local mosquito ecology (Killeen *et al.*, 2000). Malaria transmission is much more difficult to control in Africa than most other places because poverty and insufficient health infrastructure allow chronic *Plasmodium falciparum* infections to survive undisturbed in human hosts until they are transmitted by long-lived and anthropophilic vectors that are the most efficient in the world (Killeen *et al.*, 2000). Untreated and drug-resistant malaria infections can persist in humans for months or years, and African mosquito vectors such as *An. gambiae*, *An. arabiensis* and *Anopheles funestus* Giles that pick them up are more likely than any others to survive and pass them on to another victim (Beier *et al.*, 1999). Thus stable endemic malaria can manifest itself in sub-Saharan Africa where people are exposed to less than one mosquito bite per week and transmission is undetectable (Beier *et al.*, 1999). Malaria risk and disease burden is inequitably distributed, not only at global and regional levels but also at household level because poor housing, education and access to healthcare services cause a vicious cycle between increased exposure, reduced
ability to pay for treatment, intensified household medical costs and back again (Lindsay et al., 2002; Sachs and Melaney, 2002). Furthermore, malaria transmission is often facilitated in sub-Saharan Africa because environmental degradation, poor drainage and clearing of vegetation readily promote the proliferation of mosquito species such as An. gambiae which propagates itself in small, sunlit, transient water bodies, notably artificial habitats associated with human activities (Minakawa et al., 1999; Gimnig et al., 2001; Minakawa et al., 2002). Malaria, poverty and environmental change are inextricably linked and remain closely associated across most of Africa today.

Although a variety of new drugs and vaccines for malaria will become available in the future, most of these remain years away from realisation and will not be sufficient to break the transmission cycle in most African settings (Killeen et al., 2000). This is because sub-Saharan Africa is home to the world’s most efficient malaria vectors where transmission levels are hundreds or thousands of times higher than the threshold required to maintain endemicity are often observed (Beier et al., 1999). Historically successful vector control methods, such as environmental management and systematic larviciding, have proved highly effective elsewhere across the globe and can just be as valuable against African vectors (Kitron and Spielman, 1989; Ault, 1994).

2.2. The biology of malaria

Human malaria is an acute infection caused by four species of the protozoan genus Plasmodium (Fritsche and Smith, 2001). Four species of Plasmodium are capable of causing malaria in humans, while other parasites belonging to this and related genera
cause malaria in monkeys, birds and reptiles. Generally, fever is the primary symptom of human malaria. The severity of attack and reaction to treatment differ according to the specific malaria parasite concerned. Consequently, the names of the main types of malaria correspond to those of the four principal parasite species infective to humans: *Plasmodium falciparum* Welch, *Plasmodium vivax* Grassi and Felleti, *Plasmodium ovale* Stephens and *Plasmosodium malariae* Grassi and Felleti. The disease is also designated by the periodicity of its cardinal sign, fever: *quotidian* malaria in which the febrile paroxysms occur at every 24-hour interval; *tertian* malaria, in which it recurs every third day (48 hours) and which is further classified as benign or simple (*vivax*) malaria, malignant tertian (*falciparum*) malaria or *subtertian* malaria (with low-grade fever between paroxysms) and *quantuan (malariae)* malaria, in which paroxysms recur every fourth day. In Africa, Papua New Guinea and Haiti, *P. falciparum* predominates whereas *P. vivax* is more common in Central and parts of South America, North Africa, the Middle East and the Indian subcontinent. *P. vivax* is rare in Sub-Saharan Africa whereas *P. ovale* is rare outside West Africa. *P. malariae* is found in most areas but is relatively uncommon outside Africa.

With the exception of a few cases of trans-placental and blood transfusion associated transmission, human malaria parasites are transmitted exclusively by female mosquitoes of the genus *Anopheles*, which feed on vertebrate blood. However, development of the parasite can also take place in males experimentally infected. Infected mosquitoes retain their infection and can transmit the parasite for life. The commonest malaria vectors in the Afro-tropical region are *An. gambiae* complex and *An. funestus*. 
2.3. Major malaria vectors

Sixty out of the 400 known species of anopheline mosquitoes have been proved as vectors of human malaria (Leonard, 1980). *Anopheles gambiae* and *An. funestus* complexes are the principal vectors of malaria in Africa (Culuzzi, 1984; Gimnig *et al.*, 2001; Coetzee, 2004). The *An. gambiae* complex comprises of six species namely *An. gambiae*, *An. arabiensis*, *Anopheles merus* Donitze, *Anopheles melas* Theobald, *Anopheles quadriannulatus* Theobald and *Anopheles bwambae* White (Coetzee, 2004). *An. gambiae* and *An. arabiensis* are found almost throughout Kenya (Gilles and Coetzee, 1987; Minakawa *et al.*, 2002). Among *An. funestus* complex, *An. funestus* is a major vector of malaria (Gilles and Coetzee, 1987) in Africa. *Anopheles gambiae*, *An. melas* and *An. arabiensis* are found in West Africa. *Anopheles gambiae* and *An. arabiensis* exist in Central Africa. *Anopheles gambiae* and *An. arabiensis* are vectors responsible for most of the malaria cases in East Africa. *Anopheles merus* is found in Eastern and Southern Africa. *Anopheles quadriannulatus* species B is specifically found in the Ethiopian highlands while *An. quadriannulatus* species A is found Southern Africa, south of the Zambezi River (Coetzee, 2004). *Anopheles bwambae* is uniquely found in Uganda in Bwamba forest, and is responsible for the local malaria transmission among the Bambute pygmies.

The major malaria vectors in Kenya are members of the *An. gambiae* complex and *An. funestus*. The *An. gambiae* complex consists of two species that breed in salt water (*An. melas* in West Africa and *An. merus* in East Africa) and three species that breed in freshwater (*An. gambiae*, *An. arabiensis* and *An. quadriannulatus*) *Anopheles bwambae*,
was described in the Semliki forest of Uganda associated with water with high mineral content. The *An. gambiae* complex now includes 7 species with the recent description of *An. quadriannulatus* B from Ethiopia (Coetzee, 2004).

### 2.4 Bionomics of malaria vectors in Kenya

The value of studies on the biology and behavior of malaria vectors lies mainly in the relationship of these properties to the epidemiology and control of the disease (Clyde 1987). An in-depth knowledge of mosquito bionomics can be exploited to design and evaluate control strategies. Vector characteristics such as biting behavior, resting behavior, host preference, and life cycle attributes can be used to determine the most appropriate control methods for each vector. In Kenya, *An. arabiensis* bites predominantly outdoors and *An. gambiae* predominantly indoors (Service, 1977). *Anopheles gambiae* s.s prefers to rest indoors while *An. arabiensis* shows both indoor and outdoor resting traits in the same individuals (Githeko *et al.*, 1996). *Anopheles gambiae* s.s and *An. funestus* were reported to be highly endophagic and anthropophagic while *An. arabiensis* was largely zoophilic but endophagic (Githeko *et al.*, 1994). The larval habitats of the *An. gambiae* are characteristically small or medium sized temporary collections of muddy water such as puddles, pools, ditches and small ponds while *An. funestus* can breed in much larger and more permanent waters like rice fields.

### 2.5 Malaria control methods and their challenges

The overall goal for malaria control is the prevention of mortality and the reduction in morbidity, social and economic loss due to malaria, through the progressive improvement
and strengthening of local and national capabilities for malaria control at national, district and community levels. The key strategies in the control of malaria include early diagnosis and prompt treatment, indoor residual spraying (IRS) and the use of insecticide-treated bed nets (ITNS) and source breeding reduction.

2.5.1 Anti-Malaria drugs

Anti-malaria drugs play an important role in malaria treatment and control (Butler and Roberts, 2001). Their efficiency is being reduced by the emergence of parasite resistant strains due to inadequate treatment compliance, inappropriate medication, and high population mobility together with intense transmission dynamics. Resistance to cheap and effective drugs such as chloroquine and sulphadoxine/pyrimethamine implies that the existing treatment will become progressively less and less effective and that new drugs or drug combination will be required in the future. The elimination of malaria in Europe and north America and the failure of global malaria eradication program led to the loss of interest in malaria eradication for a period of about 25 years from the early 1970s to 1990s. Only 3 out of 1223 new drugs developed during the period 1975-1996 were anti-malaria drugs (Trouiller and Ottiaro, 1998).

2.5.2 Indoor residual spraying and insecticides treated nets

Killing adult mosquitoes by spraying living rooms with insecticides have been used successfully in the past (Baird, 2000). The advent of dichlorodiethyltrichloroethane (DDT), which offered a standardized single attack, during the Global Malaria Eradication Campaign spearheaded by the World Health Organization gave great hope for malaria
control (Chandre et al., 1999). Recently, emphasis has been placed on the use of bednets that have been treated with synthetic pyrethroids to enhance their protection against mosquitoes and the disease they transmit, particularly malaria (Snow, 1987). Many studies have been carried out on the efficacy of bednets (particularly the insecticide treated ones) as a means of controlling malaria. Unfortunately, the remarkable ability of insect population to develop resistance to every class of insecticide that has been developed often leaves control programs with few insecticide options (Ferrari, 1996). Widespread insecticide resistance in vectors of malaria has been reported (Chandre et al., 1999). Thus the monitoring and management of insecticide resistance is important in malaria control programs. The early detection of resistance is a vital part of resistance management because it may lead to the development of insecticide use strategies that would minimize the rate of evolution resistance (Ferrari, 1996).

2.5.3 Breeding source reduction

Source reduction involves a wide range of methods that reduce mosquito breeding habitats. These include use of insecticides that kill the larva, reclamation of land by filling and draining, use of many biological organisms against mosquito larva stages such as bacteria (Bacillus thuringiensis var. israelensis de Barjac (Bti) and Bacillus sphaericus Neide (Bs), fish (Gambusia affinis), nematodes (Romanomermis culicivorax, Toxorhynchites) and fungi Laegenidium giganteum (Zaim et al., 1988; Scholte et al., 2003). Other methods include discarding old unused tyres, covering water storage containers, unblocking cisterns and roof gutters, and drainage of artificial holes and tree ponds which are able to harbor water where mosquitoes can lay eggs capable of
transmit malaria. Lack of community participation in source reduction contributes to creation and tolerance of breeding habitats. This has been attributed to lack of correct knowledge concerning identification of malaria vectors and their preferred habitats. The solution is to mount training programmes on malaria vector control for the affected communities.

2.5.4 Malaria vaccines

Medical research attempts to develop malaria vaccine began early in the 20th century and, in spite of advances in biomedical technology no effective vaccine is available for use today. Of the many vaccines that have been tried the only one to reach phase three was a multi-component synthetic peptide, SPf66, which was said to have protective effects in trials in Columbia but showed no protection in holoendemic Africa. Prospect of a viable malaria vaccine is still far due to antigenic polymorphism of the parasite and genetic restriction of the host immune response (Patarroyo and Armador, 1999).

2.5.5 Sterile insect technique (SIT)

Sterile insect technique (SIT) is a highly effective area-wide method of pest control (Alphney, 2002), that is species specific and non-polluting to the environment. It has a non-detectable host resistance and relies on the mass rearing, sterilization and release of large numbers of insects (Knippling, 1998). However, mass production, sexing strains, loss of male fitness and immigration into the release areas are some of the challenges of this method (Benedict and Robinson, 2003).
2.5.6 Malaria control options currently being explored

As a result of scientific and technological advancement in the 21st century, the entire genomes of *P. falciparum* and *An. gambiae* have been sequenced. This has opened a new era in malaria control research as molecular biologists are seek to replace the natural mosquito populations with refractory genetically modified strains incapable of transmitting malaria. It is anticipated that the sequencing of the *P. falciparum* genome will open up opportunities for anti-malaria drug and vaccine development (Greenwood and Mutabingwa, 2002). However, although these new technologies and approaches offer some hope for malaria control, new products are not likely to be available soon. Therefore, judicious use of the available malaria control tools should occupy center stage until alternative control tools are availed. However, the applications of the available malaria control options will not be successful and sustainable without full participation and support of the affected communities. There is therefore an urgent need to empower communities to take action to protect themselves against malaria.

2.6 Community health programs

Health issues and the affected community members go hand in hand in providing effective and sustainable control measures. In the past community members have been involved in different disease control and treatment programs including malaria, with great challenges that the community members should learn from. Community participation in health programmes became one of the main principles of Primary Health Care (PHC) following the health policy put forward in Alma Ata in 1978 by the World Health Organization (WHO) and the United Nation Children Fund (UNICEF) and, subsequently
adopted by the member states of WHO (WHO, UNICEF, 1978). This led to the acceptance of community participation in PHC and involvement of the people, and not just the professionals, in decision making process on development issues. Active involvement of the community members is a fundamental requirement of primary health care as set forth in the declaration of Alma Ata in 1978. In principle, the community residents should begin by identifying their priority health problems and then take the lead role in developing and implementing solutions to those problems with the Ministry of Health and research institutions acting as technical consultants. In practice however, most PHC projects have been initiated and designed from the top and implemented with little or no consultation with the community. This lack of community involvement may be the cause for the limited success of some of these programs.

2.6.1 Community participation in disease control

Community-based control of onchocerciasis at village level in Plateau state of Nigeria showed that the use of locally available human and remunerative resources is a prerequisite for true community ownership of a program. There was recruitment and training of personnel, mobilization and education of leaders and the general population, acquire; securely store, and account for the drugs, distribute the drugs to eligible populations of targeted communities, monitor for and treat adverse reactions and document program activities and report to national, local and international health authorities. The village leaders provided payment to their village based ivermectin distributors to sustain this cost effective distribution of drugs and surveillance program (Frank et al., 1996).
In Burkina Faso and Uganda village health volunteers were trained by the local ministry of health staff in guinea worm surveillance and prevention, whom they later mobilize the community. This increased awareness of the greater effectiveness of surveillance and prevention when performed by members of the community and resulted in a gradual shift towards more participatory approaches to both surveillance and intervention for Guinea worm eradication (Cairncross et al., 1996). The community learned of guinea disease as water borne disease. That their own skills, social organizations and resources could be mobilized to combat a pressing need and those resources would be available henceforth to help the community overcome other health and related problems through its own efforts. It is noted that partnership is essential to forge and tackle health problems and social concerns as they arise (Brieger, 1996). These programs generated feeling of empowerment, ownership and responsibility and the community experiences were in the spirit of the Alma Ata accords (WHO, 1978)

2.6.2 Community participation in malaria control and treatment

Community-based malaria control and treatment in Zimbabwe was successful due to their willingness and strong tie with the local health staff. For instance, schools were involved on weekly outings to destroy mosquito larvae, and where this was done properly mosquito populations were drastically reduced. In the two districts where community members were involved, deaths due to malaria were reduced, 40% of the clinics recorded the lowest number of clinical cases (Freeman, 1999). Studies conducted in Nakonde district, Northern Province of Zambia showed that identification of malaria was excellent
in intervention wards where vendors and motivators were trained and poorest in control wards where no motivators and vendors were trained (Kaona and Tuba, 2003). The use of volunteer village malaria workers in Latin America and Thailand yielded success in malaria diagnosis and treatment in terms of longevity and size (Okanurak and Ruebush, 1996).

Community health workers and mothers of young children in more than ten Districts in Uganda were trained to recognize the symptoms of malaria and seek immediate treatment as part of a home-based approach to the management of malaria. This approach encouraged active participation of local drugs sellers and the pharmaceutical industry in malaria efforts. Interim results showed a definite decline in the number of outpatient malaria cases in children under five. As a result Ghana and Nigeria have also introduced this home-based approach (WHO, 2003). Insecticides treated nets (ITNs) have been shown to offer substantial protection against malaria and success has been realized by involving the community actively in selling and re-treating of the nets with chemicals. The proper use of ITNs combined with proper treatment for malaria at community level can reduce malaria transmission, increase supply and usage of ITNs by the community as seen in Tanzania, Zambia and Kenya (WHO, 2003). Thus operation of an effective malaria control program requires trained staff at many levels ranging from community villagers to program managers (Greenwood and Mutabingwa, 2002).
CHAPTER THREE
MATERIALS AND METHODS

3.1 Study area

The study was carried out in Rusinga Island located in Mbita Division of Suba District, Western Kenya. Rusinga island lies between latitude 0° 20’ S and 0° 26’ S; and longitude 34° 8’ E and 34° 15’ E and covers an area of 43 square km (Figure 2). The island is located in Lake Victoria and connected by causeway to the mainland at Mbita Township. Over the last five years the island has had an average annual rainfall of 1700mm and temperature range of 17°C to 34°C. The island experiences heavy and light rains in the months of March to April and September to December respectively.

The Island is inhabited by a population of approximately 20,000 people (GoK, 1999) belonging mainly to the Luo and Luo-Abasuba ethnic groups. Most houses are mud-walled and roofed with corrugated iron sheets. The eaves of most houses are open and approximately 30cm in size. In addition to ventilating the houses these eaves also allow unlimited entry and exit of mosquitoes (Lindsay et al., 2002). The most common plants found around homesteads include Acacia spp, castor oil, Cassia, Tithonia spp, Sesbania spp, Lantana camara, Thevetia peruviana and Ocimum spp. The main economic activities are fishing, subsistence farming, and livestock keeping as well as small-scale businesses. Cattle, goats, chicken, dogs, cats and a few sheep constitute the domestic animal population. Maize, millet, sorghum, bananas, cassava, sweet potatoes and some fruit trees are cultivated at subsistence level.
Figure 2: Map of Suba District showing the location of Rusinga Island.
3.2 Selection and training of the community-owned malaria resource persons

Rusinga Island is divided into six administrative sub-locations. For the purposes of implementing the Christian Children fund-Kenya (CCF-Kenya) and Rusinga Island Child and Family Program (RICF) projects, the Island has been sub-divided into seven zones namely: Kauli, Town, Wakawa-Kowawa, Wanyama-Ngodhe, Kaswanga, Kawawasi and Kaknaga-Ufira (Figure 3). In this study, a stratified random sampling was used to select community-based malaria resource persons per village. Each zone was sub-divided into 7-9 villages. In each zone, community meetings were held where the community members were requested to select members to participate in matters related to malaria vector surveillance and control. This selection was based on the respect the persons commanded from the community members and their willingness to work for the community. The composition and characteristics of the selected community-owned malaria resource persons are summarized in table 1 below.

Table 1: Composition of trained community-owned malaria resource persons and their corresponding administrative zones

<table>
<thead>
<tr>
<th>Zones</th>
<th>Gender</th>
<th>Age bracket</th>
<th>Education level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>&lt;30yrs</td>
</tr>
<tr>
<td>Town</td>
<td>2</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Kauli</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>W/ Kowawa</td>
<td>5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Wanyama</td>
<td>3</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Kaswanga</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Kawawasi</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Kaknaga Ufira</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Totals</td>
<td>28</td>
<td>28</td>
<td>19</td>
</tr>
</tbody>
</table>

After the selection process, a malaria training workshop for the community-owned resource persons was conducted. The training focused on basic mosquito biology and
ecology, mosquito identification, as well as the available control methods for *Anopheles*, *Aedes* and *Culex* mosquitoes (Rozendaal, 1997). Practical demonstrations on larval habitats mapping and characterization, larval sampling and identification and estimation of mosquito larval density as well as adult mosquito sampling using the Mbita trap were conducted (Plate 1). Emphasis was laid on experiential learning methods as opposed to the lecture method. A simplified training manual (Appendix IV) was prepared and distributed to community-owned malaria resource persons for guidance and quick reference throughout the research period.

*Plate 1: Training of community-owned malaria resource persons in mosquito identification, larval habitat identification, mapping, characterization and larval sampling.*
Figure 3: Map of Rusinga Island showing the seven administrative zones of Rusinga Island Child and Family Program (RICFP)
3.3. Assessment of trained community-owned malaria resource persons and non-trained community members in malaria vector knowledge

Immediately after the training, the trained community-owned malaria resource persons were assessed on their knowledge of malaria vector biology and ecology as well as on practical application of this knowledge in comparison with non-trained community members. Stratified random sampling was used in selecting non-trained community members. After one year, they were again subjected to the same assessment in order to determine their level of knowledge retention and improvement as a result of practice. The assessment entailed both written and practical identification of both the adult and aquatic stages of mosquitoes (Appendix 3).

3.4 Assessment of the capability of trained community-owned malaria resource persons in adult malaria vector surveillance

A stratified random sampling design was used to select five houses per zone. Each house was supplied with the Mbita trap for adult sampling (Mathenge et al, 2002, 2004) (Figure 4). Sampling was done twice a month for a period of six months. The trained community-owned malaria resource persons set the Mbita traps in the selected 35 houses and advised the owners on their use. In the morning, the trained community members counted, identified and recorded the genera of the mosquitoes trapped using observable morphological features. In addition, they recorded the total number of people who slept in the house the previous night, the number of people that slept under the Mbita trap, and the number of people who slept under any other kind of mosquito net (Appendix 1). They then aspirated the mosquitoes from the traps and transferred them into paper cups. These
were then collected by trained technicians and transferred to ICIPE Mbita Point laboratory. In the laboratory the collected mosquitoes were counted, sexed, identified morphologically using the keys of Gillies (Gillies and Coetzee, 1987), the data recorded. The data obtained by the trained community-owned malaria resource persons were compared with laboratory identification data in order to determine the competence of trained community members in the identification of adult mosquitoes using the Mbita trap.

Plate 2: Some of the houses used in sampling adult mosquitoes using the Mbita trap in Rusinga Island

3.5 Assessment of trained community-owned malaria resource persons capabilities in identifying, mapping and characterising mosquito breeding habitats.

After training, each trained community-owned malaria resource person was given the task of identifying, mapping and characterising all the mosquito breeding habitats found
in their villages. They were advised to name the breeding habitats using the physical features that they could easily remember so as to guide them in their subsequent visits. They characterized the breeding habitats in terms of presence or absence of water, water depth, and the plants available (Plate 3). They also carried out larval sampling to determine the species diversity, distribution, density and the information recorded in pre-designed field data sheets (Appendix 2). A schedule of activities was issued to the trained community members on when they were expected to carry out larval habitat identification, mapping, habitat characterization and larval sampling.

One day after a trained community-owned malaria resource person had completed identifying, mapping and characterising all the mosquito breeding habitats in his or her village, the trainer together with the community-owned malaria resource person conducted an assessment of how he/she had mapped and characterized the mosquito breeding habitats in his/her village. This was done by spotting the probable mosquito breeding habitats covered by the trained community members by careful reconnaissance and by checking the number and name of the breeding habitats using the physical features around the breeding habitats. Information about the specific mosquito breeding habitats, the exact areas in which the mosquitoes breed, wetness, size and vegetation, species diversity and density of larval mosquitoes were entered in pre-designed field data sheets (Appendix 2). The information filled in the data sheets were compared to determine the competence of the trained community-owned malaria resource persons in carrying out independent malaria vector larval habitats surveillance. This assessment also served as a support supervisory visit that helped clarify issues to the community-owned malaria
resource person. Although the trained community-owned malaria resource persons carried out the mapping and characterization of mosquito breeding habitats exercise on a monthly basis, this assessment was repeated again after six months to document any improvements in their capabilities in conducting this exercise as a result of practice.

3.6 Assessment of trained community-owned malaria resource persons capabilities in mosquito larval sampling, identification and density determination

The trained community-owned malaria resource persons used the orientation of the resting position of larvae in water to determine the mosquito species found in the breeding habitats (Service, 1976, Rozendaal, 1997) (Appendix 4). They used the standard WHO 350ml larval dippers to determine the larvae density (WHO, 1975). This was done by making up to ten dips depending on the size of the mosquito breeding habitats. If the total counts of mosquito larvae observed was more than ten the density was recorded as high, between 1-10 mosquito larvae the density was recorded as low and if no mosquito larvae observed it was designated as absent. The trained community-owned malaria resource persons also noted the presence or absence of the pupal stages of the mosquitoes. One day after a community-owned malaria resource person had completed the larval sampling, identification and density determination in his or her village, the trainer together with the community-owned malaria resource person conducted an assessment of how he/she had carried out the larval sampling, identification and density determination. This was done by revisiting the sampled larval habitats and verifying the information recorded on the field data sheets by repeating the sampling exercise.
Sketch of human sleeping under the Mbita trap

**Figure 4**: The Mbita trap (Mathenge et al., 2002, 2004)
Plate 3: Sampling of aquatic stages of mosquitoes in a breeding habitat in Rusinga Island by trained community-owned malaria resource persons.

3.7 Data analysis

Data on malaria vector knowledge among the trained community-owned malaria resource persons and non-trained community members, adult mosquito sampled by the Mbita trap, and larval mosquito sampling were entered in Microsoft excel, coded, transformed, restructured and analysed using SPSS (Andy, 2005). Independent t-test was used to compare malaria vector knowledge between trained community-owned malaria resource persons and non-trained community members. Dependent t-test was used to compare malaria vector knowledge of the trained community-owned malaria persons in the first and in the second assessment that was done one year later after the first assessment.
Independent t-test was used to assess the capability of trained community-owned malaria persons in correctly identify anopheline and culicine adult mosquitoes sampled by the Mbita trap. This was done by comparing the mean of mosquitoes counted. Binary logistic regression was used to test the capability of the trained community-owned malaria resource persons in identification and mapping of the breeding habitats, identification of anopheline larvae, culicine larvae, pupae and density determination of anopheline and culicine larvae. Binary logistic regression was performed using five predictors. The dichotomous grouping variables were: finding the breeding habitats (found or missed); habitat plants (present or absent); habitat water conditions (dry or contains water); habitat water depth (shallow or deep); anopheline larvae, culicine larvae and pupae (found or missed); density of anopheline and culicine larvae (right or wrong). The independent variables in determining the nature of group difference were: month of larval assessment; education level of the trained community members; type of the breeding habitats found; gender and age of the trained community members.

3.8 Ethical clearance

Ethical clearance was granted by The Kenya Medical Research Institute (KEMRI)/National Ethics Review Committee (KEMRI/7/3/1) and the University of Nairobi/Kenyatta National Hospital ethics and research committee (protocol approval number P102/7/2004). Kenyatta University also approved the study. Informed consent was sought from all community participants in the study.
CHAPTER FOUR

RESULTS

4.1 Community members knowledge on malaria and non-malaria vectors

An assessment of community members’ knowledge on malaria vectors revealed that 27.3% of the trained community-owned malaria resource persons could accurately describe the mosquito life cycle compared to 2.8% of the non-trained community members. The results also showed that, 61.4% of the trained community-owned malaria resource persons clearly knew where mosquitoes lay their eggs compared to 16.7% of the non-trained. Overall, 65.9% of the trained community-owned malaria resource persons could correctly identify adult Anopheline while 34% identified Culicine mosquitoes. In contrast, only 17.1% of the non-trained members identified Anopheline and a mere 8.6% of the non-trained identified Culicine.

![Malaria and non-malaria vector knowledge](image)

**Figure 5:** Non-trained (Non-MST) and trained community-owned malaria resource persons (MST) knowledge on malaria and non-malaria vectors

Results also showed that, 47.7%, 68.2% and 54.5% of the trained community-owned malaria resource persons were able to identify correctly Anopheline larvae, Culicine larvae
and pupae respectively. In contrast, 5.7%, 8.6% and 5.7% of the non-trained community members were able to identify correctly Anopheline larvae, Culicine larvae and pupae respectively (Figure 5). On average the trained community-owned malaria resource persons had more knowledge on malaria and non-malaria vectors (mean = 51.3, SE = 5.97), than the non-trained community members (mean = 9.31, SE = 2.10). This difference was significant $t_{12} = 6.64$, $p < 0.05$, $r = 0.886$.

The results also showed that 79.1% of the trained community-owned malaria resource persons could fully describe the life cycle of the mosquitoes compared to 27.3% one year earlier (Figure 6). The results showed that 88% of the trained community-owned malaria resource persons clearly knew where mosquitoes lay their eggs compared to 61.4% one year earlier. The results further revealed that, 83% of the trained community members could correctly identify adult Anopheline while 81.2% completely identified Culicine. In contrast, 66% of the trained community members were able to identify Anopheline while 34% identified Culicine one year earlier.

The results also showed that, 67% and 89% of the trained community-owned malaria resource persons could correctly identify the larval stage of Anopheline and Culicine mosquitoes compared to 48% and 68.2% respectively one year earlier. 87.2% of the trained community-owned malaria resource persons could identify correctly pupae compared to 54.5% one year earlier. On average, the trained community-owned malaria resource persons had higher knowledge on malaria and non-malaria vectors in the second
assessment test (mean = 82.13, SE = 2.88) than in the first assessment (mean = 51.36, SE = 5.97). This was statistically different, $t_6 = -5.89$, $p < 0.05$, $r = 0.92$.

![Graph showing the mean score (%) of different stages of the life cycle in MST first and second assessments.](image)

**Figure 6**: Malaria and non-malaria vector knowledge of the trained community-owned malaria resource persons one year later (MST second assessment) after the first training (MST first assessment)

### 4.2 Capability of trained community-owned malaria resource persons in adult malaria vector surveillance

Trained community-owned malaria resource persons were able to identify Anopheline adult mosquitoes (mean = 7.44, S.E = 3.27) as compared to the identification done by an expert in the laboratory (mean = 6.81, S.E = 2.99) (Figure 7). This difference was not significant, $t_{30} = 0.14$, $p > 0.05$. At the same time there was no significant difference in the identification of Culicine adult mosquitoes between the trained community-owned malaria
resource persons (mean = 18.75, SE = 4.59) and identification done in the laboratory (mean = 18.63, SE = 4.95). This difference was also not significant, $t_{30} = 0.019$, $p > 0.05$.

![Graph showing mean number of Anopheline and Culicine mosquitoes sampled using the Mbita trap and identified by trained community-owned malaria resource persons (MST Identification) compared to expert identification.]

![Graph showing mean number of culicines sampled using the Mbita trap and identified by trained community-owned malaria resource persons (MST Identification) compared to expert identification.]

**Figure 7:** Mean number of Anopheline and Culicine mosquitoes sampled using the Mbita trap and identified by trained community-owned malaria resource persons (MST Identification) compared to expert identification.

### 4.3. Trained community-owned malaria resource persons capabilities in larval mosquito surveillance

Trained community-owned malaria resource persons were able to map 2313 out of 3349 (69.1%) mosquito breeding habitats in Rusinga Island (Figure 8). They were able to
identify 373 out of 623 (60%) and 1909 out of 2687 (71%) mosquito breeding habitats as having water and dry respectively. Some of the identified mosquito breeding habitats with water included old boats, hoof prints, concrete tanks among others (Plate 4). Trained community-owned resource persons identified 96/167 (57%) breeding habitats as having a depth of $>$ ½ while 282/462 (61.0%) had a depth of $<$ ½ meter. The trained community-owned resource persons were able to characterize the vegetation types correctly in 4251 out of 4626 (91.9%) mosquito breeding habitats (Figure 9).

![Graph](image)

**Figure 8**: Number of mosquito breeding habitats identified and mapped by trained community-owned malaria resource persons (MST) and the trainer (ET)

Trained community-owned malaria resource persons were also able to identify correctly 58.2% and 62.8% of the breeding habitats as with and without anopheline larvae respectively, to identify correctly 60.4% and 60.7% of breeding habitats as with and
Plate 4: Common malaria vector breeding habitats identified and mapped by trained community-owned malaria resource persons in Rusinga Island

Natural breeding habitats

Artificial breeding habitats

Puddle showing the aquatic stages of mosquitoes

Partially dry puddle
without Culicine larvae respectively and identify correctly 64.4% and 55.1% of breeding habitats as with and without pupae respectively (Figure 10). They were also able to identify correctly 41.9% and 95.3% of mosquito breeding habitats as having a high and low density of Anopheline larvae respectively and identify correctly 52.6% and 80.0% mosquito breeding habitats as with and without high and low density of culicine larvae respectively (Figure 11).

![Bar chart showing percentage score of types of vegetation found in mosquito breeding habitats](image)

**Figure 9:** Percentage score of the types of plants found within the mosquito breeding habitats by trained community-owned malaria resource persons.
Figure 10: Number of breeding habitats identified by trained community-owned malaria resource persons (MST) and the trainer (ET) with and without larval and pupal developmental stages of mosquitoes

Figure 11: Number of breeding habitats identified by trained community-owned malaria resource persons (MST) and the trainer (ET) having low and high density of Culicine and Anopheline larvae
4.3.1 Capability of trained community-owned malaria resource persons in larval surveillance in the first and second larval assessment

The likelihood ratio of finding the breeding habitats by trained community-owned malaria resource persons was 4.494 times higher in the second than in the first larval breeding habitats surveillance (Figure 9). Analysis indicated that the trained community-owned malaria resource persons in the second larval surveillance were significantly more likely to identify the breeding habitats (mean = 83%) unlike in the first phase of larval surveillance (mean = 52%), \( \chi^2 (1, N = 3349) = 376.064, p < 0.001 \). Trained community-owned malaria resource persons in the first larval mapping were significantly more likely to determine the habitat size correctly, \( \chi^2 (1, N = 2313) = 24.183, p < 0.001 \) and identify the plants within the breeding habitats, than the second larval mapping phase, \( \chi^2 (1, N = 2313) = 30.058, p < 0.001 \) (Table 2).

![Figure 12: Percentage score of the number of mosquito breeding habitats mapped in the first (first assessment) and second (second assessment) larval surveillance assessment by trained community-owned malaria resource persons.](image-url)
There was no significant difference between the first and second larval assessment phases in determining the habitat water condition, $\chi^2 (1, N = 2313) = 1.467, p > 0.05$; habitat water depth, $\chi^2 (1, N = 345) = 0.499, p > 0.05$; identifying Anopheline larvae, $\chi^2 (1, N = 345) = 0.076, p > 0.05$; identifying Culicine larvae, $\chi^2 (1, N = 345) = 2.802, p > 0.05$ and identifying pupae $\chi^2 (1, N = 345) = 0.559, p > 0.05$ (Table 2).

**Table 2**: Summary of logistic regression analysis showing the capability of trained community-owned malaria resource persons members in larval surveillance in the first and second larval surveillance

<table>
<thead>
<tr>
<th>Predictor</th>
<th>First and second assessment</th>
<th>Exp (B) (CI)</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of breeding habitats</strong></td>
<td>1.503*** (0.081)</td>
<td>4.494 (3.836,5.026)</td>
<td>376.06**</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.415*** (0.120)</td>
<td>0.242</td>
<td></td>
</tr>
<tr>
<td><strong>Size of breeding habitats</strong></td>
<td>-0.505*** (0.102)</td>
<td>0.603 (0.494,0.737)</td>
<td>24.18**</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.358*** (0.156)</td>
<td>0.257</td>
<td></td>
</tr>
<tr>
<td><strong>Habitat plants</strong></td>
<td>-0.633*** (0.114)</td>
<td>0.531 (0.425,0.665)</td>
<td>30.058***</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.624*** (0.187)</td>
<td>0.536</td>
<td></td>
</tr>
<tr>
<td><strong>Habitat water condition</strong></td>
<td>-0.272 (0.228)</td>
<td>0.762 (0.487,1.192)</td>
<td>1.467</td>
</tr>
<tr>
<td>Constant</td>
<td>3.575*** (0.404)</td>
<td>35.705</td>
<td></td>
</tr>
<tr>
<td><strong>Habitat water depth</strong></td>
<td>0.272 (0.384)</td>
<td>1.312 (0.619,2.784)</td>
<td>0.499</td>
</tr>
<tr>
<td>Constant</td>
<td>1.925** (0.621)</td>
<td>6.857</td>
<td></td>
</tr>
<tr>
<td><strong>Anopheline</strong></td>
<td>0.084 (0.305)</td>
<td>1.088 (0.598,1.977)</td>
<td>0.076</td>
</tr>
<tr>
<td>Constant</td>
<td>1.596 ** (0.505)</td>
<td>4.932</td>
<td></td>
</tr>
<tr>
<td><strong>Culicine</strong></td>
<td>-0.658 (0.407)</td>
<td>0.518 (0.233,1.151)</td>
<td>2.802</td>
</tr>
<tr>
<td>Constant</td>
<td>3.336*** (0.723)</td>
<td>28.092</td>
<td></td>
</tr>
<tr>
<td><strong>Pupae</strong></td>
<td>-0.222 (0.298)</td>
<td>0.801 (0.447,1.438)</td>
<td>0.559</td>
</tr>
<tr>
<td>Constant</td>
<td>1.956*** (0.507)</td>
<td>7.072</td>
<td></td>
</tr>
<tr>
<td><strong>Anopheline density</strong></td>
<td>0.769* (0.336)</td>
<td>2.158 (1.117,4.168)</td>
<td>5.283*</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.388 (0.541)</td>
<td>0.679</td>
<td></td>
</tr>
<tr>
<td><strong>Culicine larvae</strong></td>
<td>-0.332 (0.330)</td>
<td>0.717 (0.375,1.370)</td>
<td>1.029</td>
</tr>
<tr>
<td>Constant</td>
<td>1.885** (0.558)</td>
<td>6.584</td>
<td></td>
</tr>
</tbody>
</table>

* considered at 0.05, ** considered at 0.01, and *** considered at 0.001 significant levels

The likelihood ratio of determining Anopheline larvae density correctly in the breeding habitats by trained community-owned malaria resource persons was 2.158 times higher in
the second than in the first larval habitats surveillance, B (SE) = 0.769 (0.336), constant (SE) = -0.388 (0.541), Exp (B) = 2.158 (1.117, 4.168). This was significantly different, $\chi^2 (1, N = 173) = 5.283, p < 0.05$, while there was no significant difference between the first and the second larval assessment phases in determining the density of Culicine larvae, $\chi^2 [1, N = 239] = 1.029, p > 0.05$ (Table 2)]

4.3.2 Capability of trained community-owned malaria resource persons in larval surveillance according to their education level

Trained community-owned malaria resource persons with primary education level were significantly more likely to identify the breeding habitats (75%) than members with post-primary level of education (72%). This difference was significant, $\chi^2 (1, N = 3349) = 8.854, p < 0.05$. The likelihood ratio of trained community-owned malaria resource persons with post-primary education level were 1.307 times higher than that of members with primary education in determining habitat size, B (SE) = 0.304 (0.110), constant (SE) = -1.754 (0.196), Exp (B) = 1.356 CI = (1.092 - 1.683). This difference was significant, $\chi^2 (1, N = 2313) = 7.799, p < 0.01$. The probability ratio of trained community-owned malaria resource persons finding the breeding habitats with plants correctly was 1.770 times with secondary than the primary education level, B (SE) = 0.571 (.132), constant (SE) = -2.624 (0.239), Exp (B) = 1.770 CI = (1.366 - 2.294). This difference was significant, $\chi^2 (1, N = 2313) = 19.986, p < 0.001$.

There was no significant difference between the trained community-owned malaria resource persons with primary and post-primary education levels in identifying correctly water conditions, $\chi^2 (1, N = 2313) = 1.441, p > 0.05$; determining correctly habitat water
depth, $\chi^2 (1, N = 345) = 1.811, p > 0.05$; determining Anopheline larvae density, $\chi^2 (1, N = 173) = 0.118, p > .05$ and Culicine larvae density, $\chi^2 (1, N = 239) = 0.611, p > 0.05$ in the breeding habitats. Education level of trained community-owned malaria resource persons was also not a significant predictor in identifying Anopheline larvae, $\chi^2 (1, N = 345) = 0.074, p > 0.05$, Culicine larvae, $\chi^2 (1, N = 345) = 0.008, p > 0.05$ and pupae $\chi^2 (1, N = 345) = 3.351, p > 0.05$ in the breeding habitats (Table 3).

Table 3: Summary of logistic regression analysis showing the capability of trained community-owned malaria resource persons as per their education level in larval surveillance

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Primary and post-primary education level</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Number of breeding habitats</td>
<td>-0.171** (0.082)</td>
<td>0.843 (0.718,0.989)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.094*** (0.144)</td>
<td>2.985</td>
</tr>
<tr>
<td>Size of breeding habitats</td>
<td>0.304* (0.110)</td>
<td>1.307 (1.092,1.683)</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.754*** (0.196)</td>
<td>0.173</td>
</tr>
<tr>
<td>Habitat plants</td>
<td>0.571*** (0.132)</td>
<td>1.770 (1.366,2.294)</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.624*** (0.239)</td>
<td>0.073</td>
</tr>
<tr>
<td>Habitat water condition</td>
<td>-0.225 (0.188)</td>
<td>0.798 (0.553,1.154)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.514*** (0.352)</td>
<td>33.590</td>
</tr>
<tr>
<td>Habitat water depth</td>
<td>-0.584 (0.433)</td>
<td>0.569 (0.243,1.330)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.334*** (0.800)</td>
<td>28.057</td>
</tr>
<tr>
<td>Anopheline</td>
<td>0.085 (0.310)</td>
<td>1.086 (0.592,2.000)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.586 *** (0.542)</td>
<td>4.886</td>
</tr>
<tr>
<td>Culicine</td>
<td>-0.034 (0.382)</td>
<td>0.966 (0.457,2.044)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.304 ** (0.673)</td>
<td>10.017</td>
</tr>
<tr>
<td>Pupae</td>
<td>-0.574 (0.323)</td>
<td>0.563 (0.299,1.061)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.594*** (0.591)</td>
<td>13.382</td>
</tr>
<tr>
<td>Anopheline density</td>
<td>-0.116 (0.340)</td>
<td>0.890 (0.457,1.735)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.018 (0.611)</td>
<td>2.767</td>
</tr>
<tr>
<td>Culicine larvae</td>
<td>-0.259 (0.334)</td>
<td>0.772 (0.401,1.486)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.797** (0.598)</td>
<td>6.031</td>
</tr>
</tbody>
</table>

* considered at 0.05, ** considered at 0.01, and *** considered at 0.001 significant levels
4.3.3 Capability of trained community-owned malaria resource persons in larval surveillance as by the type of breeding habitats.

The type of breeding habitats was a significant predictor on whether trained community-owned malaria resource persons could locate or miss to identify mosquito breeding habitats, $\chi^2 (1, N = 3349) = 4.427, p < 0.05$; identifying correctly or not plants within the mosquito breeding habitats, $\chi^2 (1, N = 2313) = 10.948, p < 0.01$ and in identification of Anopheline larvae in the breeding habitats, $\chi^2 (1, N = 345) = 5.532, p < 0.05$ (Table 4).

Table 4: Summary of logistic regression analysis showing the performance of trained community-owned malaria resource persons as per the type of breeding habitat identified

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Type of breeding habitats</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
<td></td>
</tr>
<tr>
<td>Number of breeding habitats</td>
<td>-0.028*** (0.012)</td>
<td>0.973 (0.949,0.996)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.006*** (0.098)</td>
<td>2.734</td>
</tr>
<tr>
<td>Size of breeding habitats</td>
<td>0.22 (0.016)</td>
<td>1.022 (0.990,1.055)</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.395*** (0.128)</td>
<td>0.248</td>
</tr>
<tr>
<td>Habitat plants</td>
<td>0.062** (0.019)</td>
<td>1.064 (1.025,1.105)</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.098** (0.155)</td>
<td>1.23</td>
</tr>
<tr>
<td>Habitat water condition</td>
<td>-0.004 (0.033)</td>
<td>0.996 (0.933,1.063)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.148*** (0.261)</td>
<td>23.296</td>
</tr>
<tr>
<td>Habitat water depth</td>
<td>0.038 (0.053)</td>
<td>1.039 (0.937,1.153)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.064*** (0.431)</td>
<td>7.875</td>
</tr>
<tr>
<td>Anopheline</td>
<td>-0.112* (0.050)</td>
<td>0.894 (0.810,0.987)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.639*** (0.457)</td>
<td>13.996</td>
</tr>
<tr>
<td>Culicine</td>
<td>-0.055 (0.057)</td>
<td>0.946 (0.847,1.057)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.687*** (0.500)</td>
<td>14.687</td>
</tr>
<tr>
<td>Pupae</td>
<td>0.032 (0.040)</td>
<td>1.032 (0.954,1.117)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.359*** (0.333)</td>
<td>3.892</td>
</tr>
<tr>
<td>Anopheline density</td>
<td>-0.008 (0.045)</td>
<td>0.992 (0.909,1.084)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.872* (0.358)</td>
<td>2.392</td>
</tr>
<tr>
<td>Culicine larvae</td>
<td>0.030 (0.044)</td>
<td>1.031 (0.946,1.123)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.136** (0.350)</td>
<td>3.115</td>
</tr>
</tbody>
</table>

* considered at 0.05, ** considered at 0.01, and *** considered at 0.001 significant levels
Analysis showed that, the type of breeding habitats identified by trained community-owned malaria resource persons was not a significant predictor in determining the size of the breeding habitats, $\chi^2 (1, N = 2313) = 1834, p > 0.05$; identification of breeding habitat water conditions, $\chi^2 (1, N = 2313) = 0.017, p > 0.05$; determination of breeding habitat water depth, $\chi^2 (1, N = 345) = 0.512, p > 0.05$; identification of Culicine larvae in the breeding habitats, $\chi^2 (1, N = 345) = 1.006, p > 0.05$; finding pupae in the breeding habitats, $\chi^2 (1, N = 345) = 0.608, p > 0.05$. The type of breeding habitats identified by trained community-owned malaria resource persons was also not a significant predictor in determining the density of Anopheline larvae, $\chi^2 (1, N = 173) = 0.030, p > 0.05$ and Culicine larvae density, $\chi^2 (1, N = 239) = 2.383, p > 0.05$ in the breeding habitats (Table 4).

4.3.4 Capability of trained community-owned malaria resource persons in larval surveillance based on gender

There was no significant difference between the trained male and female community members in finding the breeding habitats, $\chi^2 (1, N = 3349) = 1.046, p > 0.05$; determining the size of the breeding habitat, $\chi^2 (1, N = 4626) = 0.166, p > 0.05$; identification of plants within mosquito breeding habitats, $\chi^2 (1, N = 2313) = 3.212, p > 0.05$, determining density of Anopheline larvae, $\chi^2 (1, N = 173) = 0.248, p > .05$ and density of Culicine larvae, $\chi^2 (1, N = 239) = 0.536, p > 0.05$.

Analysis also showed that the likelihood ratio of identifying habitat water conditions was 1.709 times higher in female than in the male trained community-owned malaria resource
persons, B (SE) = 0.536 (0.213), constant (SE) = 2.344 (.312), Exp (B) = 1.709 CI (1.127 – 2.593). This difference was significant, $\chi^2$ (1, N = 2313) = 6.550, p < 0.05. Result further showed that the probability of determining habitat water depth was 2.058 times higher in female than male trained community-owned malaria resource persons, B (SE) = 0.722 (0.292), constant (SE) = 0.514 (0.447), Exp (B) = 2.058 CI (1.160 – 3.651). This was significantly different $\chi^2$ (1, N = 345) = 6.203, p < 0.05 (Table 5).

Table 5: Summary of logistic regression analysis showing the performance of trained community-owned malaria resource persons as per gender in larval surveillance

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Male and female trained community members</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male and female trained community members</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
<td>$\chi^2$</td>
</tr>
<tr>
<td>Number of breeding habitats</td>
<td>0.076 (0.075)</td>
<td>1.079 (0.932,1.250)</td>
<td>2.09</td>
</tr>
<tr>
<td>Constant</td>
<td>0.689** (0.118)</td>
<td>1.991</td>
<td></td>
</tr>
<tr>
<td>Size of breeding habitats</td>
<td>0.041 (0.100)</td>
<td>1.041 (0.857,1.266)</td>
<td>0.166</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.299*** (0.158)</td>
<td>0.273</td>
<td></td>
</tr>
<tr>
<td>Habitat plants</td>
<td>-0.202 (0.113)</td>
<td>0.815 (0.654,1.019)</td>
<td>3.212</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.342*** (0.176)</td>
<td>0.261</td>
<td></td>
</tr>
<tr>
<td>Habit water condition</td>
<td>0.536* (0.213)</td>
<td>1.709 (1.127,2.593)</td>
<td>6.550*</td>
</tr>
<tr>
<td>Constant</td>
<td>2.344*** (0.312)</td>
<td>10.425</td>
<td></td>
</tr>
<tr>
<td>Habitat water depth</td>
<td>0.722* (0.292)</td>
<td>2.058 (1.160,3.651)</td>
<td>6.203*</td>
</tr>
<tr>
<td>Constant</td>
<td>0.514 (0.447)</td>
<td>1.672</td>
<td></td>
</tr>
<tr>
<td>Anopheles</td>
<td>1.145*** (0.319)</td>
<td>3.141 (1.682,5.869)</td>
<td>13.781***</td>
</tr>
<tr>
<td>Constant</td>
<td>0.054 (0.462)</td>
<td>1.055</td>
<td></td>
</tr>
<tr>
<td>Culicine</td>
<td>0.754* (0.374)</td>
<td>2.126 (1.021,4.427)</td>
<td>4.170*</td>
</tr>
<tr>
<td>Constant</td>
<td>1.125* (0.599)</td>
<td>3.081</td>
<td></td>
</tr>
<tr>
<td>Pupae</td>
<td>0.722* (0.292)</td>
<td>2.058 (1.160,3.651)</td>
<td>6.203*</td>
</tr>
<tr>
<td>Constant</td>
<td>0.514 (0.447)</td>
<td>1.672</td>
<td></td>
</tr>
<tr>
<td>Anopheles density</td>
<td>0.168 (0.337)</td>
<td>1.183 (0.612,2.288)</td>
<td>0.248</td>
</tr>
<tr>
<td>Constant</td>
<td>0.548 (0.562)</td>
<td>1.729</td>
<td></td>
</tr>
<tr>
<td>Culicine larvae</td>
<td>0.201(0.323)</td>
<td>1.222 (0.649,2.303)</td>
<td>0.536</td>
</tr>
<tr>
<td>Constant</td>
<td>1.039* (0.529)</td>
<td>2.826</td>
<td></td>
</tr>
</tbody>
</table>

* considered at 0.05, ** considered at 0.01, and *** considered at 0.001 significant levels
The likelihood ratio of correctly identifying anopheline larvae in the breeding habitats was 3.141 times higher in female than in the male trained community-owned malaria resource persons, $B (SE) = 1.145 (.319)$, constant $(SE) = 0.054 (0.462)$, Exp $(B) = 3.141 CI (1.682 - 5.869)$. This was significantly different, $\chi^2 (1, N = 345) = 13.781, p < 0.001$. The probability of correctly identifying Culicine larvae in the breeding habitats was 2.126 times higher in female than male trained community-owned malaria resource persons, $B (SE) = 0.754 (0.374)$, constant $(SE) = 1.125 (.599)$, Exp $(B) = 2.126 CI (1.021 - 4.427)$. This was significantly different, $\chi^2 (1, N = 345) = 4.170, p < 0.05$. The probability of identifying pupae in the breeding habitats was 2.058 times higher in female than male trained community-owned malaria resource persons, $B (SE) = 0.722 (0.292)$, constant $(SE) = 0.514 (0.447)$, Exp $(B) = 2.058 CI (1.160 - 3.651)$. This was significantly different, $\chi^2 (1, N = 345) = 6.203, p < 0.05$ (Table 5).

4.3.5 Capability of trained community-owned malaria resource persons in larval surveillance based on age

There was no significant difference between trained community-owned malaria resource persons of ages above 30 years and below 30 years in the number of breeding habitats identified, $\chi^2 (1, N = 3349) = 0.690, p > 0.05$, identification of the breeding habitat water conditions, $\chi^2 (1, N = 2313) = 1.595, p > 0.05$, determining the density of Anopheline larvae, $\chi^2 (1, N = 173) = 1.641, p > .05$ and identifying density of Culicine larvae, $\chi^2 (1, N = 239) = 0.123, p > 0.05$. Trained community-owned malaria resource persons above 30 years of age were significantly more likely to determine correctly breeding habitats size.
than members below 30 years, \( \chi^2 (1, N = 2313) = 15.984, p < 0.001 \). Results also showed that trained community members below 30 years were significantly more likely to determine correctly habitat water depth than members above 30 years, \( \chi^2 (1, N = 345) = 8.426, p < 0.01 \) (Table 6).

**Table 6**: Summary of logistic regression analysis showing the performance of trained community members in larval surveillance.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Age of the trained community members (&gt;30&lt; Years)</th>
<th>( \chi^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of breeding habitats</strong></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Number of breeding habitats</td>
<td>-0.046 (0.078)</td>
<td>0.955 (0.820,1.113)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.878*** (0.133)</td>
<td>2.407</td>
</tr>
<tr>
<td><strong>Size of breeding habitats</strong></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Size of breeding habitats</td>
<td>0.425*** (0.108)</td>
<td>1.529 (1.237,1.889)</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.943*** (0.189)</td>
<td>0.143</td>
</tr>
<tr>
<td><strong>Habitat plants</strong></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Habitat plants</td>
<td>0.256* (.120)</td>
<td>1.294 (1.020,1.635)</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.066*** (0.209)</td>
<td>0.127</td>
</tr>
<tr>
<td><strong>Habitat water condition</strong></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Habitat water condition</td>
<td>-0.278 (0.224)</td>
<td>0.757 (0.489,1.174)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.580*** (0.392)</td>
<td>35.873</td>
</tr>
<tr>
<td><strong>Habitat water depth</strong></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Habitat water depth</td>
<td>-0.873** (0.312)</td>
<td>0.418 (0.227,0.769)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.003*** (0.543)</td>
<td>20.146</td>
</tr>
<tr>
<td><strong>Anopheline</strong></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Anopheline</td>
<td>-1.350*** (0.359)</td>
<td>0.259 (0.128,0.524)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.956*** (0.649)</td>
<td>52.241</td>
</tr>
<tr>
<td><strong>Culicine</strong></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Culicine</td>
<td>-1.981*** (0.545)</td>
<td>0.138 (0.047,0.402)</td>
</tr>
<tr>
<td>Constant</td>
<td>5.645*** (1.033)</td>
<td>282.750</td>
</tr>
<tr>
<td><strong>Pupae</strong></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Pupae</td>
<td>-0.873** (0.312)</td>
<td>0.418 (0.227,0.769)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.003*** (0.543)</td>
<td>20.146</td>
</tr>
<tr>
<td><strong>Anopheline density</strong></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Anopheline density</td>
<td>-0.424(0.332)</td>
<td>0.655 (0.342,1.254)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.450 **(0.529)</td>
<td>4.264</td>
</tr>
<tr>
<td><strong>Culicine larvae</strong></td>
<td>B (SE)</td>
<td>Exp (B) (CI)</td>
</tr>
<tr>
<td>Culicine larvae</td>
<td>-0.498 (0.325)</td>
<td>0.608 (0.321,1.149)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.117*** (0.534)</td>
<td>8.310</td>
</tr>
</tbody>
</table>

* considered at 0.05, ** considered at 0.01, and *** considered at 0.001 significant levels

Trained community-owned malaria resource persons aged above 30 years were significantly more likely to identify the plants within the breeding habitats than members below 30 years of age, \( \chi^2 (1, N = 2313) = 4.610, p < 0.05 \). Trained community-owned malaria resource persons below 30 years of age were significantly more likely to identify
Anopheline larvae in the breeding habitats than members above 30 years of age, \( \chi^2 (1, N = 345) = 6.697, p < 0.001 \).

The likelihood ratio also of identifying correctly culicine larvae in the breeding habitats was 0.138 times in trained community-owned malaria resource persons above 30 than those below 30 years of age, \( B (SE) = -1.981 (0.545), \text{constant (SE)} = 5.645 (1.033), \text{Exp (B)} = 0.138 \text{ CI (.047 - 0.402).} \) This was significantly different, \( \chi^2 (1, N = 345) = 19.559, p < 0.01 \). The likelihood ratio of identifying pupae in the breeding habitats was 0.418 times in trained community-owned malaria resource persons above 30 than below 30 years of age, \( B (SE) = -0.873 (0.312), \text{constant (SE)} = 3.003 (0.543), \text{Exp (B)} = 0.418 \text{ CI (0.227 - 0.769).} \) This was significantly different, \( \chi^2 (1, N = 345) = 8.426, p < 0.01 \) (Table 6).
CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

Trained community-owned malaria resource persons were significantly better than the non-trained community members in the description of the life cycle of the mosquitoes, identification of mosquito breeding habitats, and identification of both aquatic and adult stages *Anopheles* and *Culex* mosquitoes. This indicated a substantive impact of the training in equipping the community members with the relevant and critical knowledge on malaria vectors. The findings are in agreement with those from other studies carried out in Bolivia on Chaga's disease (Herrera *et al.*, 2004) and in Kenya on schistosomiasis (Katsivo *et al.*, 1993; Cline and Hewlett, 1996) which indicated that knowledge level increased significantly among the trained as compared to the non-trained community members.

There was a significant difference in knowledge on malaria and non-malaria vectors in trained community-owned malaria resource persons between the first and second assessment that was done one year later after the first assessment. Trained community members performed much better one year after the first assessment test in the description of the life cycle of the mosquitoes, identification of breeding habitats, and identification of both aquatic and adult stages of *Anopheles* and *Culex*. This indicated that they were able to retain the knowledge and that continuous practical application of the knowledge and skills gained reinforced this retention.
There was no significant difference between trained community-owned malaria resource persons and laboratory identification in identifying adult *Anopheles* and *Culex* mosquitoes. This implies that this form of training that used experiential learning methods to build community members' knowledge on malaria vectors was effective. This experiential learning approach has been successfully used in the integrated pest management in Asia as well as in the management of dengue and its vector in Vietnam (Nam et al., 2004). Trained community-owned malaria resource persons were able to use the Mbita trap in sampling adult mosquitoes in view of the fact that it can be applied extensively, it is less expensive, requires less skilled personnel and samples mosquitoes in an exposure free manner (Mathenge et al., 2004). The Mbita trap thus can be used by the community members in sampling adult mosquitoes.

The trained community-owned malaria resource persons were able to map and characterize mosquito breeding habitats very well. They were also able to sample the aquatic stages of mosquitoes and to quantify the productivity of the larval habitats. The trained community-owned malaria resource persons could therefore be relied upon in mapping and characterizing mosquito breeding habitats and to participate in mosquito larval control initiatives. This is attributed to continuous practice, training and re-training of the community members. The ability of the trained Rusinga Island community members in mapping and characterization of the mosquito breeding habitats increased as was shown by studies done in Nakonde District in Zambia and Latin America and Thailand (Onkanurak and Ruebush, 1996; Kaona and Tuba, 2003). This shows the important role that community members can play in mosquito larval control which has
always been dismissed as being very difficult to implement due to the wide dispersal of the larval habitats and being labour intensive. This has enormous potential to Roll Back Malaria and constitutes the primary means to achieve the Abuja targets (WHO, 2000).

The findings from this study indicated that majority of larval habitats for malaria vector breeding sites were as a result of human activities. This is in agreement with other studies conducted in other regions around Lake Victoria (Fillinger et al., 2004 and Minakawa et al., 2002). Educating and training the community members on the types of mosquito breeding habitats, possible locality, and their role in creation and sustenance of the malaria vector breeding habitats can equip them with knowledge that is useful in the fight against malaria disease. Trained community can therefore actively be involved in environmental management through elimination of larval habitats as it is postulated to be a more effective approach for reducing adult mosquitoes (Killeen et al., 2002 and Minakawa et al., 2002).

Knowledge and skills are recognized as important within the community members for any successful control program (Utzinger et al., 2001). Training is an important component to equip the community members with relevant information before/or in the process of surveillance and control (Breman et al., 2004). As a result of training and practice, Rusinga Island community members showed increased knowledge and skills in malaria vector surveillance. This was consistent with previous observed reports in Malaysia district of Kudat Sabah where the Village Health Volunteers trained in diagnosis and treatment of malaria showed improved malaria surveillance system and antimalaria drug distribution.
network (Hii et al., 1996). In Mpumalanga Province, South Africa, knowledge and skills were also of value among the health program staff to efficiently conduct essential operational research at control program level (Durrheim et al., 2002).

Training the community members of Rusinga Island on malaria vector surveillance is seen as an essential approach to reduce malaria disease as was reported in the control of microfilaria in Haiti (Amanda et al., 2001), onchocerciasis and guinea worm in Nigeria (Brieger, 1996; Frank et al., 1996). The diagnosis of Plasmodium falciparum using an antigen-detecting dipstick in Brazil, Cote d’ Ivoire and India (Banchongaksorn et al., 1997; Cunha et al., 2001) and malaria control in Zimbabwe (Freeman 1999) further support the findings of this study. Other studies in Zaire showed that over 65% cases were treated at community level by the community health workers (Delacollette et al., 1996) and annual incidence of malaria and malaria mortality showed a decline in Mangalore due to an integrated community centered malaria control program (Kakkilaya et al., 2000).

Educating the Rusinga Island community members on malaria disease would enhance capacity building at the community level leading to reduction in marginal cost and sustainability which is essential for successful health programs. This is comparable to previous reports on the control of Ae. aegypti in Singapore (Chan et al., 1990), dengue epidemic in Taiwan (Hwang et al., 1992), schistosomiasis control in Kenya (Katsivo et al., 1993) and malaria intervention using insecticides treated nets at the Kenyan Coast.
The Rusinga Island community-based malaria vector surveillance is envisaged to supplement the government efforts, provide prompt data and interventions towards malaria control (Ruebesh et al., 1992; Pagnoni et al., 1997; Rojas et al., 2001; Amir and Vasant, 2003). Timely and prompt data will be useful in planning for a successful control program rather than relying on people from outside the community to sustain the project. This effort will contribute to the international goal of reducing current malaria situation by half by the year 2015 (Shiff, 2000; Utzinger et al., 2001). The malaria vector surveillance data could be incorporated into malaria vector surveillance maps to guide targeted larval control interventions as well as predict possible malaria outbreaks.

5.2 Conclusions

1. Trained community-owned malaria resource persons were significantly better than the non-trained community members in the description of the life cycle of the mosquitoes and identification of both aquatic and adult stages of *Anopheles* and *Culex* mosquitoes.

2. Experiential learning approach, continuous practice and re-training ensured that the trained community-owned malaria resource persons improved their malaria vector knowledge.

3. Trained community-owned malaria resource persons were able to use the Mbita trap in sampling adult mosquitoes.
3. Trained community-owned malaria resource persons were able to use the Mbita trap in sampling adult mosquitoes.

4. Trained community-owned malaria resource persons regardless of education level and gender could be relied upon in mapping and characterization of the mosquito breeding habitats.

5.3 Recommendations

1. The solution to the malaria problem lies at the community level where it impacts severely. To control malaria at this level, strategies should focus on communities to take action to protect and treat themselves. Such strategies may succeed if there is effective communication and genuine understanding the causes, symptoms and means of preventing and treating malaria.

2. Communication at this level has to go beyond message delivery and social marketing and to include a genuine exchange of understanding between agencies and local people as to what will work best in the local context.

3. Community members should be empowered with the relevant knowledge for effective and sustainable malaria control.
REFERENCES


APPENDICES

Appendix 1: Data sheet for adult mosquito sampling using the Mbita trap

Collector's name: Zone: Date:

Instructions for using the Mbita trap:

1. On the night before the collection of the mosquitoes on the specified days sleep under the Mbita trap.
2. Before hanging the Mbita trap remove all mosquito predators such as spiders, if there are any.
3. Do not hang the Mbita trap too high, the larger metal ring should be at the same height as the gap between the roof and the wall.
4. Make sure that the sleeve to the sleeping compartment is tied.
5. Before sleeping the edges of the bed net trap should be tucked tightly under the beddings not to allow any mosquitoes to pass through.
6. In the morning count, identify, and record mosquitoes trapped in the upper chamber using their resting position.
7. Aspirate all mosquitoes and transfer to the labeled paper cups.
8. Store the mosquitoes in a cool place to await collection by the technical team.
9. Also record on the data sheet the total number of people who slept in the house on 1) the previous night, 2) under the Mbita trap, 3) under any bed nets (NOT including the Mbita trap).

| Number of Anopheles | Number of Culicines | Total number of people that slept in the house the previous night | Number of people that slept under the Mbita trap | Number of people that slept under any bednet (not in the Mbita trap) |
Appendix 2: Data sheet for larval sampling

<table>
<thead>
<tr>
<th>Data sheets for mapping of larval habitats in Rusinga Island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone:</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Appendix 3: Assessment of trained community-owned malaria resource persons

malaria vector knowledge

Name / Nyingi: 
Zone / Gwen'g: 
Sub-zone / Aluora: 
Man or women: 
Dichuo / dhako: 
Age / Hiki: 
Education: 
Somo mari: Primary School (class 1-8) (tick the appropriate) 
Secondary School (Form 1-4) (gweth ma donjo kodi) 
College 
Others / Mopogore / gimago, en mane:

Since when do you live on Rusinga? Ichako dak Rusinga karan'go?

Have you attended the first CCF/ICIPE malaria training activities in your zone? Bende isebedo etiegruok mar malaria mane jo CCF kod jo ICIPE okuongo timo egwen'gu?

If not, who has trained you? Kane ok isebedo to kare ne iyudo tiegruok kuom n'ga kata kuom jokmage?

When did you join the malaria surveillance team? Karan’go mane ibedoe a chiel kuom jogo ma puonjo weche mag malaria ei Rusinga?

Are you a CCF member? Bende injakanyo mar project CCF?

Tick the appropriate / gweth ma donjo kodi:

Are you a: 
Fishermen / In jalupo 
Business man/women / In ja ohala ma dichuo koso madhako 
Housewife/man / In dhako ma ok ti tich mar misara, koso dichuo ma ok cham misara 
Teacher / In Japuonj 
Others, specify / mamoko / mopogore / gimagi?

Please write the answers of question (1) in the table, answer questions (2) – (13) on a separate paper. Indicate the number of question. You can write the answer in English or in Dholuo.

If you do not know the answer of a question, write: I DO NOT KNOW.
Ka ok in'geyo duoko mar penjo moro to ndiki ni: OK AN'GEYO

(1) What are symptoms of Malaria? Answer with yes or no.
Ranyisi mar malaria gin mage? Duokni en kata ok en.

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache / wichbar</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Running nose / athun'ga mamol (othinyo)</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Shivering, body shaking / del ma tetni</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Sweating / kuok wuok e del</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>High fever / ka dendi ohoire (liet)</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Body rush / ka dendi oruodho</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Pain in the back / ondin'g maremo</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Vomiting / n'gok (n'gogruko)</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Diarrhoea / diep</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Repeated attacks with phases of recovering / sama tin ituo, sama tin ingima</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Long periods of sickness leads to anaemia and general weakness</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>kinde ma lach mar tuo makelo remo matin e del kod ola</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joints pain / rem kata jony mar fuoni</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Blood in sputum / n'gudho okego ma oriwore gi remo</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Loss of appetite / onge mar ndhadhu e dhok</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Difficulties in breathing / kor mathun’g</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

(2) If you suspect you or a member of your family has malaria, what do you do?
Ka ichich ni in kata n'gato moro kuom joodi nigi malaria, to ere gima onego itim?

Go to or take him/her to the nearest health facility/Hospital
Give first aid if and only if the health facility is not within easy reach
Give anti malarial if and only if the health facility/hospital is not within reach

(3) List all groups of people that are at highest risk of suffering from malaria?
Ndik tienge mag ji ma tuo mar malaria ohewo ahinya?

Children under five years of age
Pregnant women
Old and immunosuppressed people
Visitors/tourists from none malarious areas
Fishermen who fish at night
Others: people living close to mosquito breeding sites

(4) How can you catch Malaria? List all possible ways you know!

Yes or No
En / ok en
Ere kaka inyalo yudo tuo mar malaria? Ndik yore tee min’geyo ni nyalho ke lo tuo mar malaria.

You can only catch malaria when bitten by a female Anopheles mosquito infected with malaria parasites.

(5) How does the malaria parasite enter your body? Where does the parasite come from?
Ere kaka kute mag malaria donjo edend dhano? Kute mag malaria wuok kanye?

When a mosquito bites a person sick with malaria, it picks malaria parasites and then later transmits them to a healthy person and he gets malaria.

(6) Which methods do you know to prevent yourself and others from getting malaria? List all methods you know.
Ere yo min’geyo minyalo gen’gogo malaria ne in iwuon to-gi joma moko? Ndik yore go duto min’geyo.

Eliminating or changing the breeding places to make them unsuitable for development of larvae (e.g. draining swampy areas & stagnant water, fill holes or pits with soil or sand, have a good drainage system.
Making the breeding places inaccessible for adult mosquitoes to lay their eggs (cover water storage containers with netting, even the smallest holes, cover holes in pit latrines, etc).
Rearing fish or other natural enemies of mosquito larvae in the breeding habitats
Applying larvicides (insecticides that kill mosquito larvae in the breeding places)
Spraying houses with insecticides that have a long lasting effect (mosquitoes die when sitting on the walls).
By constructing mosquito proof houses (i.e. having fine mesh on windows, eaves and door ways, by fitting ceilings)
Use of self protection methods like insecticide treated mosquito nets, application of some mosquito repellent oils and creams/lotion.
Repelling mosquitoes from the houses by burning mosquito coils and use of mosquito repellent plants
Taking the sick to the hospital for treatment
Taking recommended drugs that prevents us from getting malaria

(7) Describe a mosquito’s life cycle.
Wachane ngima mar suna chakre kar nyuolne.
The female anopheles adult mosquitoes feed on blood for the development of the eggs, and then they lay eggs on stagnant water surfaces.
The eggs hatch into tiny larvae, which after feeding on tiny particles and organisms found in water develops into bigger larvae
The big larvae then develop into a stage called pupae.
From the pupae, the adult mosquitoes emerge
(8) Name 3 different habitats where mosquitoes lay their eggs.
Wach kuonde adek mopogore ma suna tokoe tongue.

- Swamps
- Puddles
- Tyre tracks
- Artificial containers

(9) In which type of water bodies do you NEVER find mosquito larvae?
En pige mogudore mage ma ok inyal yude nyamilmil mag suna (nyithi).

- Fast flowing rivers or streams
- Large water bodies (eg. Lakes, seas and oceans)
- Hot water springs

(10) Which methods do you know to prevent mosquito larvae from breeding?
Ere yore min’geyo minyalo thiro go dongo mar nyamilmil (nyithi) su na.

- Eliminating or changing the breeding places to make them unsuitable for development of larvae (e.g. draining swampy areas & stagnant water, fill holes or pits with soil or sand, have a good drainage system.
- Making the breeding places inaccessible for adult mosquitoes to lay their eggs (cover water storage containers with netting, even the smallest holes, cover holes in pit latrines etc).
- Rearing fish or other natural enemies of mosquito larvae in the breeding habitats
- Applying larvicides (insecticides that kills mosquito larvae in the breeding places).

(11) Do you think you need to use more than one method to control malaria? Give reasons for your answer.
Bende iparo ni nitie yore mopogore ma inyalo gen’gogo malaria? Ka nitie kaonge to wachane gima omiyo.

Yes!
There is no single method that is absolutely perfect in all situations. When the methods are used in combination there is a higher possibility or greatly reducing malaria.

(12) In your activity as member of the Malaria Surveillance Team: Which data do you collect monthly? Give a detailed list.
Kuom tich mitimo kaka achiel kuom n’gatno man’giyo weche mag malaria, en an’go ma inono tiende kendo iketoe andika (Form) dwe ka dwe. GIVE A DETAILED LIST?

- Collecting mosquitoes using the bednet trap and recording their numbers and types
- Mapping and recording all the types and numbers of mosquito larval habitats in my area
- Noting down if the mapped habitats contains water or not.
- Measuring and recording the sizes of the larval habitats
Observing and recording the presence or absence of vegetation
When the vegetation is present, I record the type of the vegetation.
Measuring the water depth when the habitat contains water
Observing and recording the presence of Anopheles and culicine larvae
Observing and recording the density of Anopheles and culicine larvae
Observing and recording the presence of mosquito pupae
In all the above, the habitat name is included in the data sheet.

(13) Explain WHY we collect this data monthly?
Wach ane gima omiyo watimo nonro mar wachni kendo wa kete ei andika dwe ka dwe.

This is because we need to know:
Whether there are malaria mosquitoes in the area and which ones.
How high is the density of the malaria vectors in the area (larvae and adults).
When is the density highest in the year
Which other types of mosquitoes are around that are not malaria mosquitoes.
Where are the different types of mosquitoes breeding
Whether the mosquito breeding places are available throughout the year
How do the breeding places look like, how do they differ
How we can prevent the mosquitoes from breeding in the various sites

PRACTICAL / AYANGA (gima nenore / ratiro)

Name what you see under the points A to F. Explain why.

For example: it is a human being because it can speak and walks on two legs.
Ndik gima inyalo neno e bwo alama mar A nyaka alama mar F.

Wach gima omiyo: Kuom ranyisi – En dhano nikech onyalo wuoyo kendo owuotho gi tiende ariyo.

<table>
<thead>
<tr>
<th>What is it? Ma en an’go?</th>
<th>Describe why? Wach gima omiyo?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Culex larvae</td>
<td>They have their heads facing downwards and siphon( tail) protruding</td>
</tr>
<tr>
<td>B Adults Anopheles mosquitoes</td>
<td>They rest at an angle of 45° to their resting surface</td>
</tr>
<tr>
<td>C Anopheles larvae</td>
<td>They rest with their bodies parallel to the water surface</td>
</tr>
<tr>
<td>D Lake Flies</td>
<td>They have no pointed mouthparts (proboscis)</td>
</tr>
<tr>
<td>E Mosquito pupae</td>
<td>They are comma-shaped/round shaped</td>
</tr>
<tr>
<td>F Adults Culex mosquitoes</td>
<td>They rest parallel to the surface and they have a hump (Enlarged thorax)</td>
</tr>
</tbody>
</table>
APPENDIX 4: TRAINING PROGRAMME FOR COMMUNITY-OWNED MALARIA RESOURCE PERSONS' IN RUSINGA ISLAND

Day 1

What is malaria?
Malaria is one of the most serious diseases in Africa. It is in particular dangerous for children under 5 years old, pregnant women and the unborn child and people who are not grow up in areas with malaria. Malaria is curable and preventable, but it still kills many people. The reason for that is:

- Many people do not come for treatment until they are very, very ill,
- People are living too far from health facilities,
- Many people do not know what causes malaria, how it spreads and how to protect themselves
- Vector (mosquito) control operations are not conducted (neither from the Government nor from the communities themselves)

Most important: Encourage people to seek treatment immediately if they have fever; especially young children and pregnant women should receive treatment latest after 24h!

Symptoms:
The clinical features of malaria vary from very mild to very severe. In areas were malaria is very common, adults might have just a slight fever, however pregnant women and children often have severe illness with many symptoms and signs, and they might even die:

- Shivering, body shaking, Sweating
- Fever up to 40°C, Headache
- Joints pain, Pain in the back
- Loss of appetite, Vomiting
- Diarrhoea, Repeated attacks with phases of recovering
- Long periods of sickness leads to anaemia and general weakness

Malaria parasite
Malaria is caused by the presence of very small organisms (malaria parasites) in the blood. Malaria parasites are so small that they can be only seen under a microscope. They feed on the blood cells, multiply in them and destroy them.

Transmission of malaria parasites
The malaria parasites enter and leave the body through mosquito bites:

- Mosquito bites a person and sucks blood
- If the person has malaria some of the parasites that live in the persons blood will be sucked into the mosquito
- The parasites multiply and develop in the mosquito for 2 weeks
- When the mosquito bites a healthy person after that time, the malaria parasite will enter the body of the healthy person and this person will become ill

The mosquito
Malaria is given from one person to the other (transmitted) via mosquitoes. There are no other possibilities to get malaria. BUT not ALL mosquitoes are transmitting malaria. Only the female mosquito of a special species – so-called *Anopheles* mosquito, is responsible for transmitting the malaria parasite. *Anopheles* mosquitoes have a very distinct appearance and can be recognised easily with a little bit of practice (see below). There are many other species biting man, those can be a nuisance or they can sometimes transmit other infectious diseases. Male mosquitoes do not bite, they live from sugar sources only.

**Recognition a malaria mosquito**

Working in malaria research and focusing on malaria control, you have to know your enemy exactly. Therefore you have to be able to distinguish between a mosquito and a lake fly, between malaria mosquitoes and other mosquito species, between a male and a female mosquito and you have to know the life cycle of a mosquito.

**Recognition of adult mosquitoes**

Mosquitoes are rather small and fragile insects and have like all flies two wings only. The three pairs of legs are comparatively long. From other flies they can be easily distinguished by the long tubular mouthpart, called proboscis. This mouthpart is for sucking blood (female) or sucking sugar solution (male and female). Non experienced persons can mistake lake flies for mosquitoes. The appearance of body and legs can be very similar, but they have never long tubular mouthparts.

*See on life objects: Comparison of lake flies and mosquito*

**Recognition of female and male mosquitoes**

Male mosquitoes have very long hairs on the antennae, which consequently have a bushy appearance, rather like a moustache.

On the antennae of the female the hairs are few in number and short

The same is true for lake flies males and females, and is therefore not special for mosquitoes only.

*See on life objects!*

**Distinguishing Anopheline (malaria mosquitoes) from Culicine (non-malaria mosquitoes)**

Malaria mosquitoes can be recognised observing their wings. All malaria mosquitoes in the area have spotted wings. Most of the culicine mosquitoes do not have spotted wings. Live mosquitoes can be distinguished by observing their resting posture. Malaria mosquitoes rest in an angle between 50° and 90° to the surface whereas non-malaria mosquitoes (culicine mosquitoes) rest more or less parallel to the surface they sit on. These resting postures are shown in fig. 4.

*See on life objects!*

**Mosquito life cycle**

Adult mosquito lays eggs on the water surface (*Anopheles* lay single eggs, most culicine clusters (rafts) of eggs). Small larvae are hatching from the egg; they are so tiny that they can be hardly seen larvae develop through 4 larval stages, each stage is bigger than the
other, each larval stage takes approximately 1-2 days, the larvae are feeding tiny particles that they are “brushing” out of the water, they breath air through a siphon at the end of the larval body, with this siphon they stick on the water surface, the way this siphon is built and the way the larva lies in the water tells you whether it is a malaria mosquito or not

Out of the biggest larval stage a so-called pupa develops, the pupal stage doesn’t feed anymore, the pupal stage is very short and can take only a few hours Out of the pupa the adult insect emerges and flies away to seek for blood or sugar meals After the female mated with a male and has taken a blood meal it lays eggs, after oviposition it seeks a new blood meal and lays eggs again With each blood meal the mosquito can pick the malaria parasite or transmit it to a person An adult mosquito can life up to 3 weeks, the aquatic life takes in average 6-8 days only

<table>
<thead>
<tr>
<th>Anophelines</th>
<th>Aede</th>
<th>Culix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs</td>
<td>Laid singly</td>
<td>Laid singly</td>
</tr>
<tr>
<td></td>
<td>Hes floats</td>
<td>No floats</td>
</tr>
<tr>
<td>Larvae</td>
<td>Rest parallel to water surface</td>
<td>Rest at an angle to the water surface</td>
</tr>
<tr>
<td></td>
<td>Rudimentary breathing tube</td>
<td>Air tube</td>
</tr>
<tr>
<td></td>
<td>Short, stout breathing tube with one pair of hair tubes</td>
<td>Long, slender breathing tube with several pairs of hair tubes</td>
</tr>
<tr>
<td>Pupae (differ only slightly)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>Proboscis and body in same straight line</td>
<td>Proboscis and body at an angle to one another</td>
</tr>
<tr>
<td></td>
<td>Maxillary palps</td>
<td>Maxillary palps</td>
</tr>
<tr>
<td></td>
<td>as long as proboscis</td>
<td>Maxillary palps shorter than proboscis</td>
</tr>
<tr>
<td></td>
<td>Wings spotted</td>
<td>Wings generally uniform</td>
</tr>
<tr>
<td></td>
<td>Tip of female abdomen usually pointed</td>
<td>Tip of female abdomen usually pointed</td>
</tr>
</tbody>
</table>

Distinguishing characteristics of Anopheline and Culicine (Rozendaal, 1997)
Malaria control aims to reduce the man–mosquito and the man–parasite contact. There are two major ways of targeting malaria control:

- Target the malaria parasite through treatment and prophylaxes with drugs
- Target the malaria mosquito through mosquito control methods

Both have to go together to secure a successful malaria control!

Vector control (=mosquito control)
Mosquitoes have a complex life cycle and develop in different stages. Parts of their early life as larvae, they spend in water, out of these larvae an adult fly is emerging, flying around to look for a host to feed on.

To reduce mosquitoes or the contact with mosquitoes you can target:

- The adult fly
- The aquatic larval stage

Adult mosquito control

- Spraying houses with insecticides that have a long lasting effect, mosquitoes die when sitting on the wall
- Mosquito proof house construction to prevent mosquitoes from entering the house through screens/curtains/nettings in the windows, doors, eaves etc.; smooth walls inside the house prevent mosquitoes from resting there
- Use of insecticide treated bednets to prevent mosquito contact and bite at night time and to kill those approaching the net
- Use of repellents: burning repellent plants, mosquito coils (insecticide) etc.; using skin lotions etc., wearing protective cloth

Larval mosquito control

- Eliminating or changing the breeding places to make it unsuitable for development of larvae (remove litter that could hold water, fill holes in the ground, and have a good drainage)
- Making the breeding places inaccessible for adult mosquitoes to lay their eggs (cover water storage containers with netting, even the smallest hole, cover hole in pit latrines etc.)
- Releasing fish or other natural enemies of mosquito larvae into the water
- Applying larvicides (insecticide that kills mosquito larvae in the breeding places)

Which method to choose?
Mosquito control is most successful if you combine as many different methods as possible because all methods have their advantages and disadvantages. Nobody can say one single method is the best and has therefore be used and others can be neglected.

Some mosquito control methods can and have to be conducted by individuals e.g.:
• Use of bed nets and the care of impregnation with insecticides
• Use of repellents
• House improvement
• Removal of artificial breeding sites around the house, like tyres, tins and any water collecting container, holes in the ground

It is very important that you act as a community and work all together. Everybody in the community should help to improve the situation. If your neighbouring household is taking care of mosquito control measures and you not, your neighbours will still get mosquito bites and you will be responsible for that!

Some mosquito control methods have to be organised and implemented by a trained group of field workers, e.g.:
• Large scale insecticide spraying
• Large scale larval mosquito control

Larval control activities can be community based organised and implemented. The requirements for insecticide spraying are usually too high and therefore these operations are mainly implemented through the national health institutions.

Larval mosquito control in addition to your personal precautions has several advantages:
• Mosquitoes are destroyed before they disperse to human habitations
• The operation can be carried out in very short time
• Very effective and safe larvicides are available
• Applications of these larvicides don’t need expensive equipment and is easy to be implemented by trained lay persons

But there are also disadvantages you have to be aware of:
• Control is temporary and has to be repeated frequently
• Application of larvicides has to be done in a certain time because development of larvae is fast, therefore field workers have to be reliable and highly motivated
• ALL breeding sites have to be covered by larvicide application, otherwise there will be no major impact on the malaria situation in the area
• A larval control programme has to be maintained properly throughout years, as soon as control stops mosquitoes and disease will come back

Effective larval control is most feasible where breeding places are:
• Limited in number
• Easy recognizable
• Easy accessible
• Well mapped and monitored throughout the year

What is the use of data collections on mosquitoes in malaria control?
To control the malaria mosquito I have to know it! We need basic information for planning our intervention. We need to know WHO we are going to target, WHEN we are going to target, WHERE are we going to target and HOW are we going to target.
Therefore we need to identify:

- If there are malaria mosquitoes in the area and which ones?
- How high is the density of the malaria vectors in the area (larvae and adults)?
- When is the density highest in the year?
- Which other mosquitoes are around that are not malaria mosquitoes and how many?
- Where are the different mosquitoes breeding?
- Are the breeding places available throughout the year?
- How do the breeding places look like, how do they differ?
- How can we prevent mosquitoes breeding in the various sites?

All this information is necessary to design a powerful larval mosquito control operation and to see in the following years whether we have success with our control. We should be able to compare the mosquito densities before and after insecticide treatments and see a reduction in the number of mosquitoes.

Furthermore, data on malaria cases will be collected by CCF and ICIPE in the preparation phase as well as during the larval control operations to show if we have an impact on malaria with our control operation.

A good preparation period is most important if a control operation shall be successful in future. Therefore all people involved have to have great interest, motivation, responsibility and enthusiasm to make the programme work!

Where mosquitoes breed

- Mosquitoes breed only in water! The larvae can not survive somewhere else, they DO NOT breed in grass or bushes. But the adult flying mosquitoes are resting in bushes, in grass and in houses because they are protected there from the sun, and that is the reason why you find them there and you get bitten there.
- Mosquitoes can breed in any kind of water and therefore all water bodies have to be checked for mosquitoes.
- Mosquitoes do not breed in the open lake (only lake flies do), but they can breed in the swamp areas where water hyacinth or other floating plants or any reed is growing and protecting from the waves.
- Mosquitoes do not breed in fast running water of rivers, but at the edges where the water is not moving fast they can breed, e.g. in cattle hoof prints along a river, or along the lake shore.
- Anopheline larvae prefer water that is sun exposed, culicine larvae breed everywhere.

How to distinguish between different habitat types?

In our survey we try to characterise the breeding sites (water bodies) we find, to get an idea which sites are the most attractive ones for Anopheles to breed in:

**Swamp**: areas along the lake shore, that has floating vegetation, or reed (high grass) growing.

Areas inland that show the same characteristics...
Rock pool: rocks that form the ground of stagnant water, rocks can be on the lake shore, getting water from the waves, or can be the natural ground in the area and collecting water after rain

Puddle: puddles are small to medium sized areas where water stands on the ground after rain, they are always natural

Footprints: footprints from hippos and cattle can form small holes in the wet ground where water can collect, that water can come from rain or can be groundwater, or can be lake or river water

Tyretrack: vehicles leave often tracks in the ground that get filled with water after rains

Artificial hole: man-made holes in any ground (for taking soil, for getting stones, for building a pit latrine etc.), that can collect water

Concrete hole: are artificial holes, but made out of concrete, in front of newly built stone houses

Artificial container: any container collecting water e.g. plastic cups and blue band containers, buckets, clay pots, tyres, tins, water storage containers etc.

How to find possible breeding sites
To find the mosquito breeding areas you have to observe your environment closely. In all homes you have to check for possible artificial containers and man-made holes, concrete holes, any puddles etc.

Ask people if they know any standing water around their compound and if they store water in any way.

Check the lake shore in the area of your responsibility and remember man-made holes for getting soil and stones.

Check the run off areas where water flows from the hills down to the lake.

Check the rocky areas, where water after rain can easily stand for some days or weeks.

Check open grassland and tyretracks for any puddles from rain.

Always talk to people to get more information about possible breeding sites. Try to get as many community members involved in the monitoring of habitats as possible.

Always visit the sites closely, so that you can observe and take water samples.

If the site is not accessible at all (too deep) note it!

Check your area for possible breeding sites once a week because the situation can change quickly after rainfall or activities from man like house building, farming (irrigation) etc.

How to identify mosquito larvae in a breeding place?
The identification of larvae in a breeding site is not easy in the beginning, but you will see that after a while of practice you will become an expert.

If you enter a mosquito breeding site be aware that every movement you make the larvae can see. Larvae tend to dive and disappear from the surface. Then you hardly see any larvae.

Therefore enter a breeding site and observe it carefully for a few minutes. In bigger sites larvae tend to be only on the edges.

After observation you take some dips of water with a plastic bowl. Wait here too for a while, because larvae are diving in your bowl as well. Be always aware that very young larvae are very small, you have to look closely. Can you see anopheles larvae
horizontally swimming on the water surface? Can you see culicine larvae hanging down from the water surface?

Dip always on the edges of water bodies and/or near vegetation (like grass), there is the highest possibility to find larvae.

Did you see the Anopheline larvae already without dipping?
Do you have Anopheline larvae nearly in every dip you take (up to 10 dips)?
Than you can say the density of Anopheline larvae was high!

Did you see no Anopheline larvae without dipping?
Do you have Anopheline larvae in only one or two dips from a number (up to 10 dips)?
Than you can say the density of Anopheline larvae was low!

Did you see culicine larvae already without dipping?
Do you have culicine larvae nearly in every dip you take (up to 10 dips)?
Than you can say the density of culicine larvae was high!

Did you see no culicine larvae without dipping?
Do you have culicine larvae in only one or two dips from a number (up to 10 dips)?
Than you can say the density of culicine larvae was low!

If you don’t find one of the species or no larvae at all note absent.
Try to take as many dips as possible to make your result most reliable!

DAY 3
Field trip to the various possible breeding sites in your zone
How to keep records? Which data need to be collected; how and when?
The data projection form

1 Habitat Name: write in any name you associate with the breeding place you found, this name should help you to remember the area where you found the site. The name should be the same always, so that we can follow the development of the site.

2 Habitat Type: We have characterised a number of different habitat types, note to which every single site of yours belongs. If none of the given ones fit, write down your own definition!
Swamp: areas along the lake shore, that has floating vegetation, or reed (high grass) growing.
Areas inland that show the same characteristics
Rock pool: rocks that form the ground of stagnant water, rocks can be on the lake shore, getting water from the waves, or can be the natural ground in the area and collecting water after rain
Puddle: puddles are small to medium sized areas where water stands on the ground after rain, they are always natural
Footprints: footprints from hippos and cattle can form small holes in the wet ground where water can collect, that water can come from rain or can be groundwater, or can be lake or river water

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Concrete hole: are artificial holes, but made out of concrete, in front of newly built stone houses

Artificial container: any container collecting water e.g. plastic cups and blue band containers, buckets, clay pots, tyres, tins, water storage containers etc.

3 Water Content: Is the habitat at the date of visit dry or does it contain water

4 Habitat Size: If you walk around the habitat, is the perimeter smaller 1 m, 1-10 m or larger than 10 m in perimeter (you might then not be possible to walk around)

5 Plants: Are there any plants growing in the habitat or floating on top? Are there green algae in the water? Or does the habitat just contain the soil or concrete as ground?

6 Water depths: With help of a stick you can see if the water in your habitat is deep (approximately more than ½ m) or shallow.

7 & 8 Densities: Observe water surface for mosquito larvae and pupae.
Take between 5 and 10 dips of water with a plastic bowl (1litre) on the edges on the habitat and near vegetation. If you have footprints, get your information mainly through observation and one dip per footprint.

Did you see the Anopheline larvae already without dipping?
Do you have Anopheline larvae nearly in every dip you take (up to 10 dips)?
Than you can say the density of Anopheline larvae was high!

Did you see no Anopheline larvae without dipping?
Do you have Anopheline larvae in only one or two dips from a number (up to 10 dips)?
Than you can say the density of Anopheline larvae was low!

Did you see culicine larvae already without dipping?
Do you have culicine larvae nearly in every dip you take (up to 10 dips)?
Than you can say the density of culicine larvae was high!

Did you see no culicine larvae without dipping?
Do you have culicine larvae in only one or two dips from a number (up to 10 dips)?
Than you can say the density of culicine larvae was low!

If you don’t find one of the species or no larvae at all note absent.
Try to take as many dips as possible to make your result most reliable!