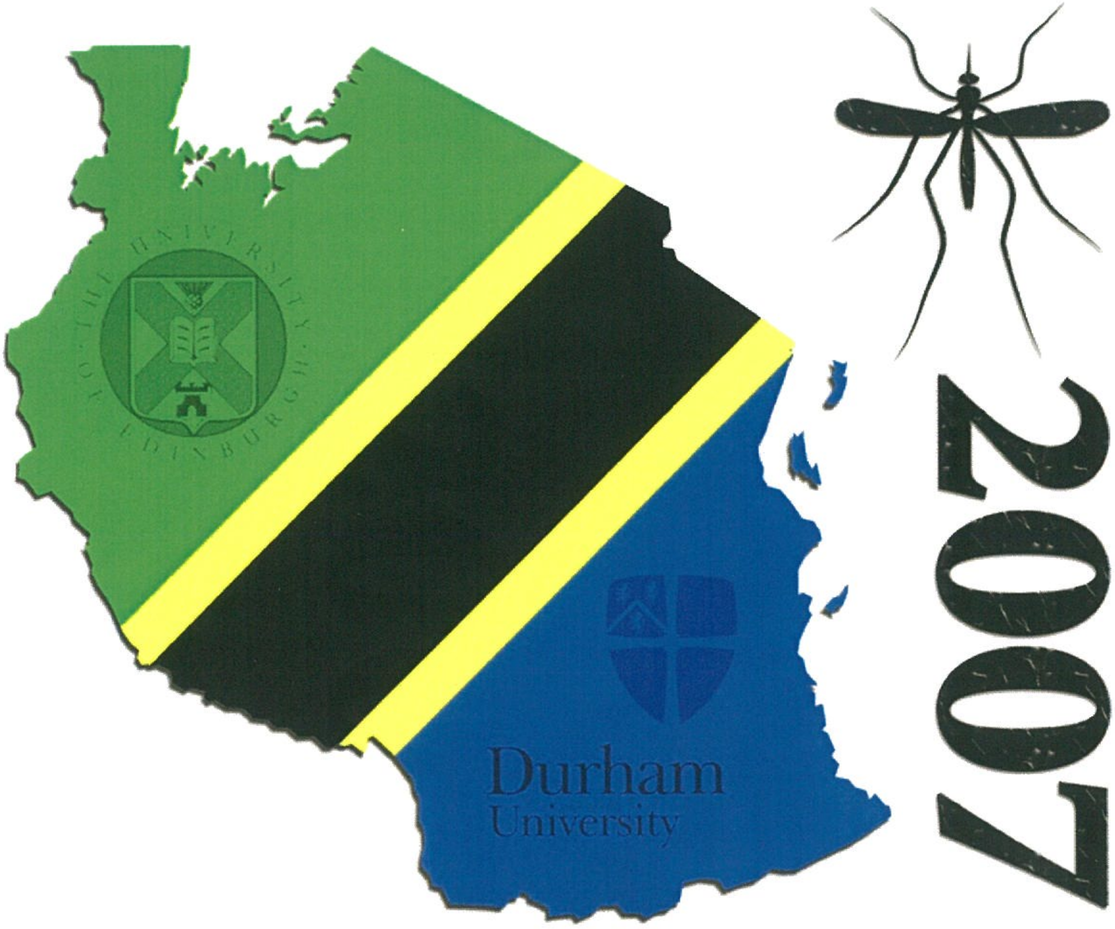
IFAKARA



Project Ifakara 2007

EXECUTIVE SUMMARY

Project Ifakara 2007 was conceived, planned and undertaken by 12 undergraduates from The University of Edinburgh, Durham University and the University of Dar es Salaam. The purpose was to investigate the relationship between malaria prevalence and biodiversity in the Kilombero Valley, in the south of Tanzania. Birds, being good indicator species, were used as a surrogate measure for the overall biodiversity of the area. Research was constrained by two factors: lack of time in the field, and the dry season. Unfortunately, due to insufficient sample sizes, no conclusions of real accuracy could be drawn. However, from the data collected important range extensions were made to certain bird species. It is recommended that future projects to the Kilombero Valley try to survey during both the wet and dry season.

Throughout the planning and execution of the project advice was sought from the University of Dar es Salaam (UDSM). Crucially, six students and an ornithologist from UDSM assisted with the fieldwork. It cannot be emphasised strongly enough that without this support the success of the project would not have been possible.

Project Ifakara was educational in many ways to the team members from Durham and Edinburgh University. The furthering of scientific knowledge and interest forms only one aspect of such an expedition. Each individual also learned much about working hard in difficult conditions and bridging the cultural and lingual gap between foreign countries.

ACKNOWLEDGEMENTS

Firstly, thanks to Gerry for his advice, encouragement and expertise during the process of developing the project during the early stages of planning and throughout our time in Tanzania. Without his counsel and support Project Ifakara would certainly have never left the ground.

Special thanks to Japhet Kihonda and Jasson John for all their assistance with the fieldwork. Without them we would have been clueless.

Thank you to the research assistants, and lab technicians and researchers from IHRDC who supported us while at the centre and out in the field. Particular thanks to Heather Ferguson, Valeliana Mayagaya, Sarah Moore, Tanya Russell, and Edgar Taki who helped with specific aspects of the research.

Thanks to Steve Lindsay from Durham University for all his input and also to Anthony Newton from Edinburgh University for the loan of equipment to make the surveys possible.

Thanks to Jason, Dale, and Mr. Godbole for providing us with food, entertainment and an alternative source of company.

Many thanks to the local villagers for the hospitality and friendliness we were shown throughout the surveying. It was a great privilege for them to allow us into their homes and spend time with them.

Finally, thanks to all the organisations that offered their financial support. Without these awards the expedition would not have been possible.

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The Royal Geographical Society

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INTRODUCTION

Tanzania and the Kilombero Valley

The United Republic of Tanzania is a country of famed natural interest. It is situated on the east coast of sub-Saharan Africa and is bordered by Kenya and Uganda to the north, Rwanda, Democratic Republic of Congo and Burundi to the west, and Zambia, Mozambique and Malawi to the south. Its unique combination of history, politics, geography and wildlife has combined to preserve much of the natural state of the country and much of its original biodiversity remains, 41% in a relatively unchanged state (WRI 1994). In the country there are 322 recorded mammal species and 1038 recorded bird species (Groombridge & Jenkins 1994). Tanzania has some of the highest rates of endemism on the continent, and the Eastern Arc Mountains have the highest rates of endemism in the whole of Africa. Endemic species include the critically endangered Kipunji (*Rungwecebus kipunji)* and the Udzungwa Forest partridge (*Xenoperdix udzungwensis*).

The Kilombero Valley (7°44'-9°26'S/35°33'-36°56'E) is situated at 210-250m above season level between the heavily forested escarpments of the Udzungwa Mountains, which rise to 2,576m above sea level on the northwestern side and the grass covered Mahenge Mountains, which rise to 1,516m on the south-eastern side. The valley is orientated southwest to northeast and the Kilombero and its network of tributaries run through it, creating a seasonally inundated plain 250km long and up to 52km wide (Charlwood *et al.* 2000).

321,611 people inhabit the Kilombero district in predominantly rural settlements. Inhabitants of some villages are subjected to a mean annual Entomological Infection Rate (EIR) of 300 (Charlwood *et al.* 2000). Further, the area holds the highest recorded EIR with an individual receiving an estimated 2,979 infectious bites per annum (Smith *et al.* 1993). For these reasons the area has historically been one of the most important areas in Africa and the world for research associated with malaria.

Ifakara Health Research and Development Centre

Originally founded in 1957 as the Swiss Tropical Institute Field Laboratory it was registered with the Tanzanian Ministry of Health as the Ifakara Health Research and Development Centre (IHRDC) in 1996. It is located in the town of Ifakara in the Kilombero Valley (KV) in the Morogoro region of southern Tanzania (Fig. 1). Its mission is to "develop and sustain district based health research and a resource centre capable of generating new knowledge and relevant information for public policy and actions"[1]

Research at IHRDC includes work on Tuberculosis and Aids, but specialises in malaria reduction techniques. Recent discoveries include a fungus that reduces *Plasmodium* transmission rates between mosquitoes and humans (Scholte *et al.* 2005). IHRDC's international collaborators include the London School of Hygiene and Tropical Medicine, the Centers for Disease Control and Prevention and the Swiss Tropical Institute.

Fig. 1. IHRDC is located in the Kilombero Valley in south-east Tanzania

Physical Environment

The climate of Tanzania is tropical but with large regional climatic variations throughout the country. In the south, winter daytime temperatures are normally between 20°C and 30°C but at night may fall be to between 5°C and 15°C. There are two wet seasons and between July and September rainfall is normally low. The Kilombero area is humid but extreme weather events are rare.

[1] www.ihrdc.org

Flora and Fauna

The valley is home to an extremely diverse flora and fauna. Antelope grass (*Echinochloa pyramidalis)* and perennial reeds (*Oryza* spp.) dominate the main river floodplain which opens up to mixed gallery forests of miombo woodland (*Brachystegia* spp.) towards the south-west. While at the southern end a large papyrus swamp *(Cyperus papyrus)* provides shelter for a variety of arthropods and avifauna.

In 1989 an estimated 995 elephant (*Loxodanta adricanus)*, 20,494 buffalo (*Syncerus caffer*), 8.414 hippopotamus (*Hippopotamus amphibious), 55,769* puku *(Kobus vardonii*) and 2,920 warthog (*Phacochoerus athipiopicus*) lived in the KV (Frankfurt Zoological Society aerial survey 1989). As a result of poaching the numbers of these species is likely to have declined heavily since the 1989 census. The Kilombero area is also home to a huge diversity of birds including several endemics, remarkable for the size of the area, such as the Kilombero weaver (*Ploceus burnieri*) and two species of cisticola that are awaiting formal description; the Kilombero cisticola and the Kilombero melodious cisticola. The nearby Udzungwa Mountains are part of the Eastern Arc Mountains of East Africa, which have the highest rates of endemism and the second highest rate of bird diversity in the whole of the African continent.

Socio-political issues

Shortly after achieving independence from Britain in the early 1960s Tanganyika and Zanzibar merged to form Tanzania in 1964. Following its foundation the country was led by Julius Nyerere as a socialist one-party republic until the first democratic elections took place in 1995. The country is led by an elected president, currently Jakaya Kikwete, who appoints a prime minister, at present Edward Lowassa, to lead the National Assembly. The great majority of the people are of Bantu ethnic origin although some such as the Maasai are Nilotic. The principle language of the country is Swahili which is spoken in schools, although English is common in some areas. The main religions of the country are Christian and Islamic, although indigenous religions such as animism remain important. The economy is heavily dependent on agriculture and tourism and the currency, the Tanzanian Shilling, is stable.

Environmental and Social Impacts

Project Ifakara 2007 was carbon neutral. The certificate was arranged through *Carbon Footprint*[2]. All efforts to reduce environmental impacts were made, including driving and walking on tracks where possible, collecting fire wood from dead wood, and clearing camping areas of waste.

Social impacts of the expedition were reduced by villages being visited in small groups, with the number of UK students never outweighing the number of Tanzanian team members. Local sensitivities were discussed thoroughly throughout each excursion, for example paying attention to the livestock of pastoralists. Female team members wore long trousers or skirts in public, and covered their shoulders.

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[2] www.carbonfootprint.co.uk

BACKGROUND AND JUSTIFICATION

Malaria parasites of humans

Malaria is a disease caused by protozoan parasites of the genus *Plasmodium*. Human malaria parasites are transmitted between their vertebrate hosts by female mosquitoes of the genus *Anopheles*. *Plasmodium* develops in the gut of the mosquito and is passed on in the saliva of an infected insect each time it takes a new blood meal. The parasites are then carried by the blood in the host's liver where they invade the cells and multiply (Molyneux 1998).

Four species of malaria parasite infect humans. *Plasmodium vivax* and *P. falciparum* are the most commonly encountered malaria parasites. Because of the temperature limitations on its transmission by its mosquito vectors, *P. falciparum* remains widely prevalent in the tropical regions of the world (Carter & Mendis 2002).

At least 300 million acute cases of malaria occur worldwide each year, resulting in more than one million deaths annually, over 80% of which are estimated to occur in sub-Saharan Africa, mostly among children under five years old (Lindsay *et al.* 2002). Malaria is now one of the great diseases of poverty. Today no wealthy nation is affected by its endemic presence. The economic ramifications are clear; countries with intense malaria have incomes 33% that of countries without malaria, whether in Africa or not (Snow *et al.* 2005).

Treatment and control have become more difficult with the spread of drug-resistant strains of parasites and insecticide-resistant strains of mosquito vectors (Snow *et al.* 2005). The development of a multistage vaccine, new drugs and insecticides are seen as the strategic goals in the fight against malaria, but little consideration has been given to environmental strategies to control the disease (Lindsay & Birley 2004).

Current approaches for malaria control

The World Health Organisation has specific policies to contribute to the reduction of the public health burden caused by vector-borne diseases[3]. They include 'Integrated Vector Management' (IVM) which emphasises the importance of understanding the

[3] www.who.org

local vector ecology and patterns of disease transmission before choosing appropriate control tools. Strategies available for vector control range from environmental management that can eliminate vector breeding grounds to chemical methods of control like larvicides which help to reduce disease transmission. Complementing this is 'Vector Control and Management' (VEM) which aims to develop and promote strategies based on the principles of IVM by strengthening communication between governmental and non-governmental organisations.

The research effort is now on the areas of the world most in need which includes the entire tropical region of Africa. There are two goals in the management of malaria. These are (i) control of the parasitic protozoan in humans and (ii) to control the vector insect population (Carter & Mendis 2002). Pharmacological application requires skilled personnel who are trained in the use of drugs such as artemisinin-based combination therapies (ACTs). However, the second management goal can be tackled by a broader spectrum of human resources. Indeed, for most countries in sub-Saharan Africa, where humans live in permanent contact with vector mosquitoes, vector control is a realistic management option (Speight *et al.* 1999). Strategies for reducing those at risk include provision of treated mosquito nets and basic education, and environmental management (Panter-Bricka *et al.* 2006). Environmental management has not been traditionally viewed as a long term effective policy (Panter-Bricka *et al.* 2006) but recent evidence has indicated that high species diversity may reduce human exposure to vector-borne diseases (Ezenwa *et al.* 2006).

Malaria and biodiversity

Important research has demonstrated a relationship between high biological diversity and low prevalence of vector-borne human diseases (e.g. Ezenwa *et al.* 2006; LoGiudice *et al.* 2003; Ostfeld & Keesing 2000a). This provides a means of quantifying the value of biodiversity with human health (Ostfeld & Keesing 2000a,b). Providing an economic value for biodiversity is a critical step to ensuring its long-term survival.

The primary mechanism by which biodiversity moderates disease risk is the 'dilution effect'. This has been described for Lyme disease (Schmidt & Ostfeld 2001) and West Nile Virus (Ezenwa *et al.* 2006) and may also operate for a wide range of other vector-borne diseases (Ostfeld & Keesing 2000a; Telfer et al. 2005). The dilution effect predicts that infection rates among vectors, and ultimately human infection risk, will be lower in highly diverse host communities where incompetent reservoir hosts dilute rates of disease transmission between vectors and highly competent hosts. Our understanding of the extent to which patterns of biodiversity affect human disease is still very limited (Ezenwa *et al.* 2006) but it is likely that the 'dilution effect' will be an important factor for malaria control. In addition to reducing the probability of human infection high biodiversity also increases the number of potential mosquito predators.

What is biodiversity?

A contraction of 'biological diversity' or 'biotic diversity', the semantics of biodiversity include political buzz-word and social construct (Gatson 1996). The most widely cited definition is given by the US Congress Office of Technology Assessment (OTA, 1987):

> 'Biological diversity refers to the variety and variability among living organisms and the ecological complexes in which they occur'

This definition essentially encompasses the totality of biological life which is not inherently useful. We were concerned with species richness and used the term biodiversity as a measurable entity. The quantification of diversity is complex and although this is only one measurement of biodiversity it satisfied the requirements for this project.

Mosquito ecology

Mosquitoes are in the family Culicadae which contain 41 genera and over 3500 species. It is only the female of the genus *Anopheles* which carries malaria injecting sporozoites into the host in its saliva during blood meals.

Anopheles mosquitoes can be subdivided into two groups depending on where they feed or rest between meals. *Anopheles albimanus* is termed exophagous as it primarily lives and feeds outdoors. Species like *An. gambiae* are endophagic nocturnal feeders, living mainly inside. The differences in ecology indicate different control methods are required.

An. gambiae, An. funestus and *An. arabiensis* are the most important malaria vectors in sub-Saharan Africa. Approximately 5% of these species carry malaria parasites. All three species are common in the Kilombero valley (Charlwood *et al.* 2000) although their comparative population densities fluctuate with the seasons. In a recent study Killen *et al.* (In Press) found the zoophagic *An. Arabiensis* and the anthropophagic *An. gambiae* to dominate the river valley.

Mosquito biting rate

The human biting rate of mosquitoes is an essential component of vectorial capacity and entomological inoculation rates, the two most important concepts for describing and comparing transmission intensities in entomological terms (Magbity *et al.* 2002; Burkot & Graves, 1995). Measuring the biting rates of mosquitoes, therefore, constitutes an important aspect of entomological monitoring of vector control management, such as insecticide-treated nets. Most studies in sub-Saharan Africa suggest that mosquitoes caught using a light trap (Centers for Disease Control light trap is the 'gold standard') is an efficient and unbiased way of estimating the human biting rate of mosquito populations (Lines *et al.*, 1991; Davis *et al.*, 1995; Costantini *et al.*, 1998).

The current problem with mosquito traps is no design works effectively in both urban and rural environments (Killeen *et al.* In Press). However, a recent PhD project (consult Dr Gerry Killeen for details) has devised a tent trap which is highly efficient in both habitats. The project tested both products to compare their relative efficacy.

Measuring biodiversity

There are two indices commonly used to measure species level biodiversity; alpha and beta (Begon *et al.* 2006). Alpha diversity refers to diversity within a community, usually calculated by the number of taxa within the community or ecosystem. Beta diversity refers to diversity between ecosystems. Two metrics often used to describe these indices are the Simpson index or Shannon-Weiner index.

Avian diversity

Birds are conspicuous members of most ecosystems. They are distributed widely throughout the world and found in most habitat types. Further, their taxonomy is well known, and the geographical distribution of most individual species is sufficiently understood to permit wide-ranging research and analysis. These factors make them suitable for surveys, and have been used as indicators to identify biodiversity hotspots worldwide. Nonetheless, although there is baseline data on the distribution of many species worldwide, quantified knowledge is far from complete for most taxa and regions.

Research has demonstrated that birds are the best indicator taxa for the presence of other endangered species and the representative biodiversity of a region (e.g. Dobson *et al.* 1997; Bibby *et al.* 1992). Thus, data on species richness of avifauna can also be considered as a surrogate for the general species richness of the area.

Birds are relatively easier to count than most other wildlife and the data gathered will also be of use in updating the status of endangered species. Measurements of population size and range were used to contribute to the existing ecological database at IHRDC.

Kilombero Valley

The Kilombero Valley and Rufiji Delta are recognised by Birdlife International as Important Bird Areas (IBAs). Both areas are category A1, regularly holding significant numbers of globally threatened species. The species are recognised on the IUCN Red List as Critically Endangered, Endangered or Vulnerable. Table 1 gives the current listings of bird species found in the area.

Table 1. Bird species found in the Kilombero and Ulanga districts

Scientific name	Common name	IUCN status
Acrocephalus griseldis	Basra Reed-Warbler	Endangered
Anthreptes pallidigaster	Amani Sunbird	Endangered
Anthus sokokensis	Sokoke Pipit	Endangered
Apalis argentea	Kungwe Apalis	Endangered
Ardeola idae	Madagascar Pond-Heron	Endangered
Falco cherrug	Saker Falcon	Endangered
Hyliota usambara	Usambara Hyliota	Endangered
Nectarinia loveridgei	Loveridge's Sunbird	Endangered
Otus ireneae	Sokoke Scops-Owl	Endangered

Ploceus nicolli	Usambara Weaver	Endangered
Sheppardia montana	Usambara Akalat	Endangered
Xenoperdix udzungwensis	Udzungwa Forest-Partridge	Endangered
Zoothera guttata	Spotted Ground-Thrush	Endangered

Demographic Surveillance System

The IHRDC carries out a census of the local population Kilombero, Ulanga and Rufiji districts three times per annum. This technique is referred to as a Demographic Surveillance System (DSS). The scheme has been active since 1998 in Kilombero, Ulanga and Rufiji districts. An interviewer (one of about 40 full-time IHRDC staff) visits each household every four months to collect information on pregnancies, births, deaths, and migrations. Extensive quality control measures include repeat interviews in a randomly selected 10% of households. In addition supervisors visit a random sample of households to verify entries on the census forms and to check that all households visited have been included in the census. Data from each week's work are used to update the household registration system database before a weekly field meeting.

The figure below shows the DSS sampling frame (Fig. 2)

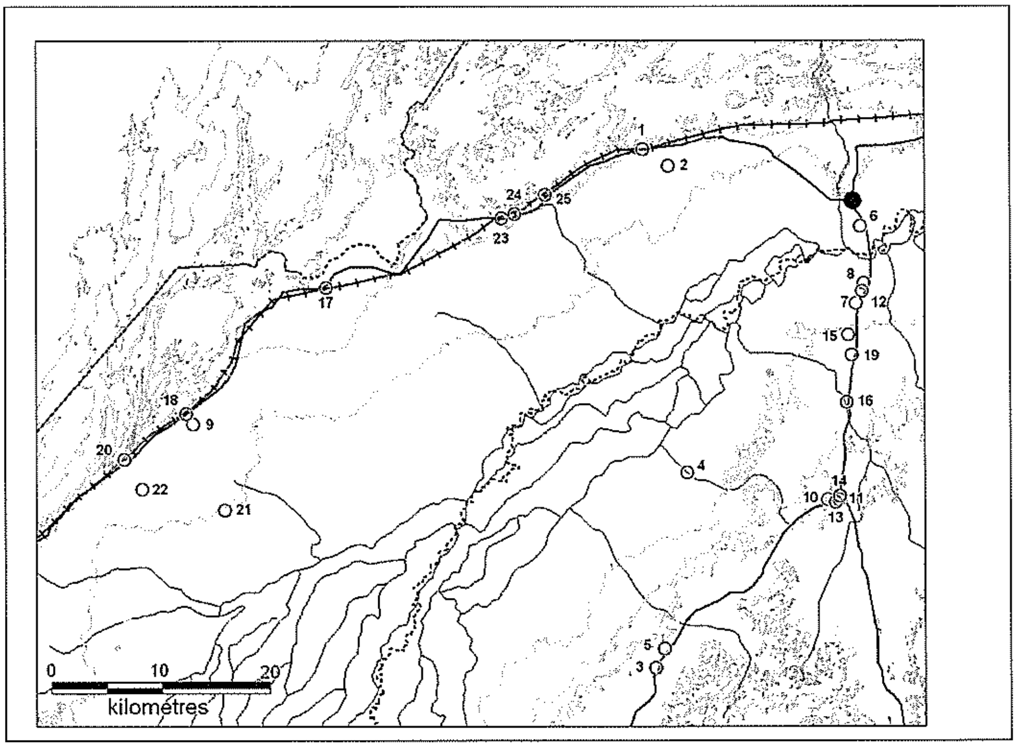


Fig. 2. DSS sampling scheme in Kilombero and Ulanga districts. Each number corresponds to a census point.

Pilot study

Prior to sampling, a three-week pilot survey was conducted in the Selous Game Reserve (Fig. 3) in order to familiarise the team members with the identification of local bird and mosquito species. In addition, this allowed time to locate suitable census stations and helped determine the number of samples required for bird and mosquito surveys.

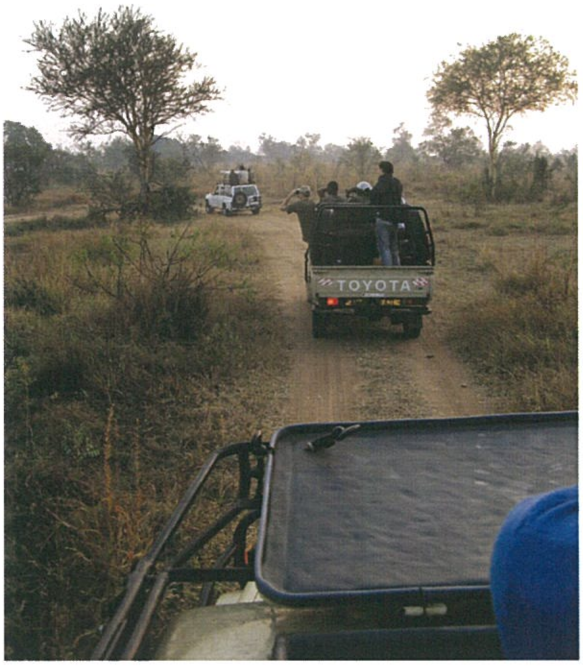


Fig 3. Early morning bird survey in the Selous Game Reserve

METHODS AND MATERIALS

Study Area

Sampling was conducted throughout Kilombero and Ulanga districts in the Kilombero valley. Sampling effort was divided into seven week blocks. Each week a different village was visited from within the DSS sampling area between July 14th – September 7th. Transport to each of the villages was with 4x4, hired from IHRDC. A driver was also needed for both safety and logistical reasons

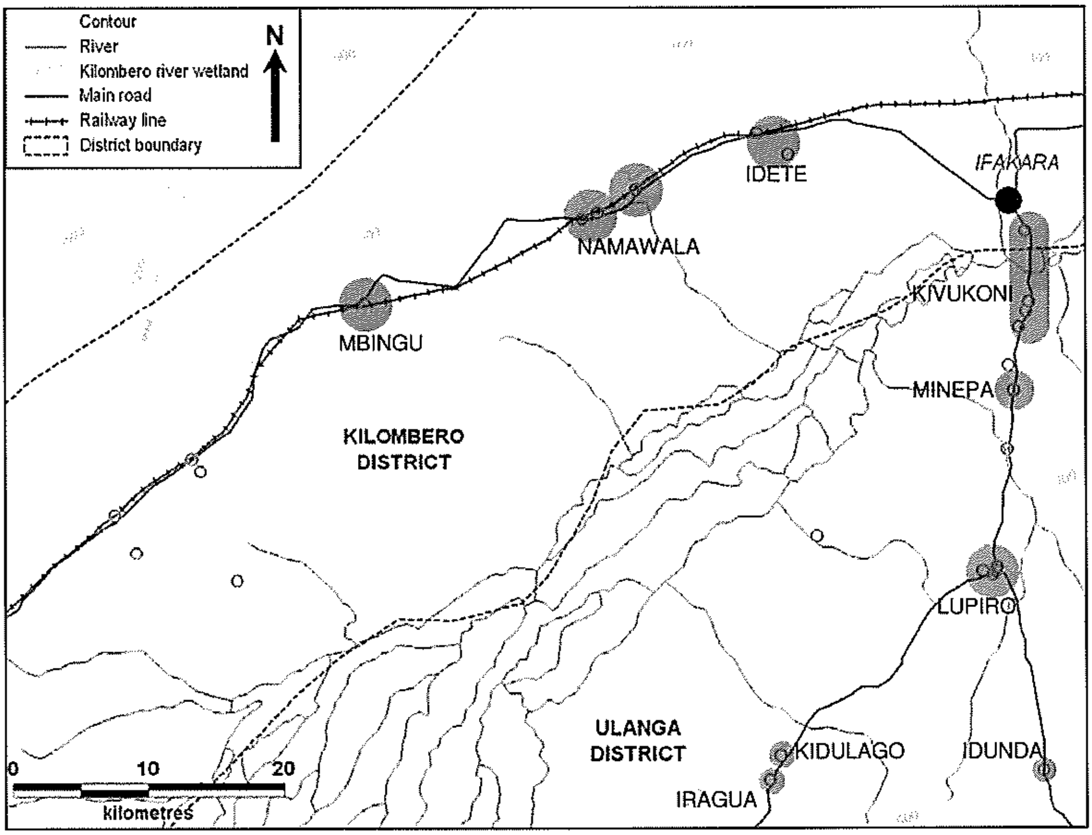


Fig 4. Villages sampled from the DSS

Randomly selected household owners from the DSS were selected (Fig 4) which at the time included approximately 65,000 individuals in circa 16,000 households, distributed into 25 villages (*Vijiji*) and 105 subvillages (*Vitongoji*) in the two districts of Kilombero and Ulanga (Schellenberg et al., 2001). Selected households were visited at the start of each week to ask for permission to search within their property. This was a time consuming process and depending on the number of properties and how widely they were distributed could take most of the first day.

Trapping methods

CDC light traps were placed as close as possible to occupied nets (Fig 5) at a height of approximately 50 cm, as previously described (Lines et al., 1991; Mboera et al., 1998). They were started by the household owners at 7pm and left running for 12 hours.

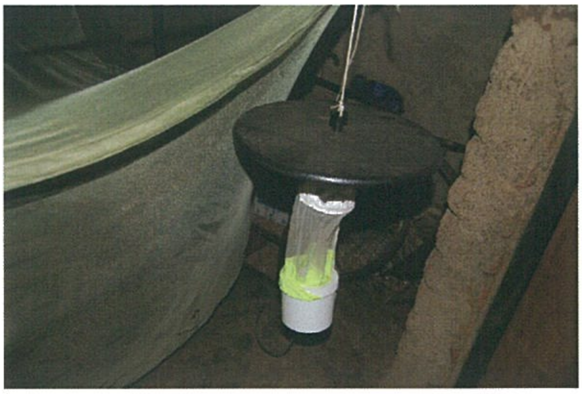


Fig 5. CDC light traps were placed by bed-nets

Specially designed traps, 'resting boxes', were placed strategically around houses to catch mosquitoes outdoors. Between four and six boxes were used per building depending on its size. These were a simple construction of a black material tailored to fit inside a cardboard box of 100cm x 40cm x 60cm laid on its side facing towards the house (Fig 6). To prevent their movement by children, animals or wind, rocks were placed in the bottom of the box as it lay on its side. Mosquitoes were collected from them daily using an aspirator.

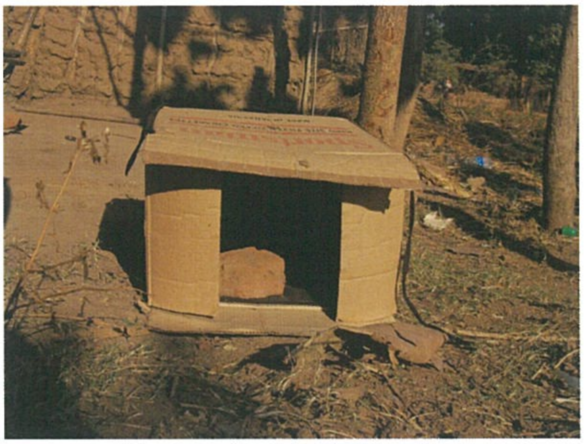


Fig 6. Resting boxes were placed around the perimeter of households

Tent traps (Figs. 7 & 8) were used where possible in the field. They were placed in the same location as the rest of the tents. Because of their relative bulk only one was taken out on location for each village.

Fig 7. Tent trap

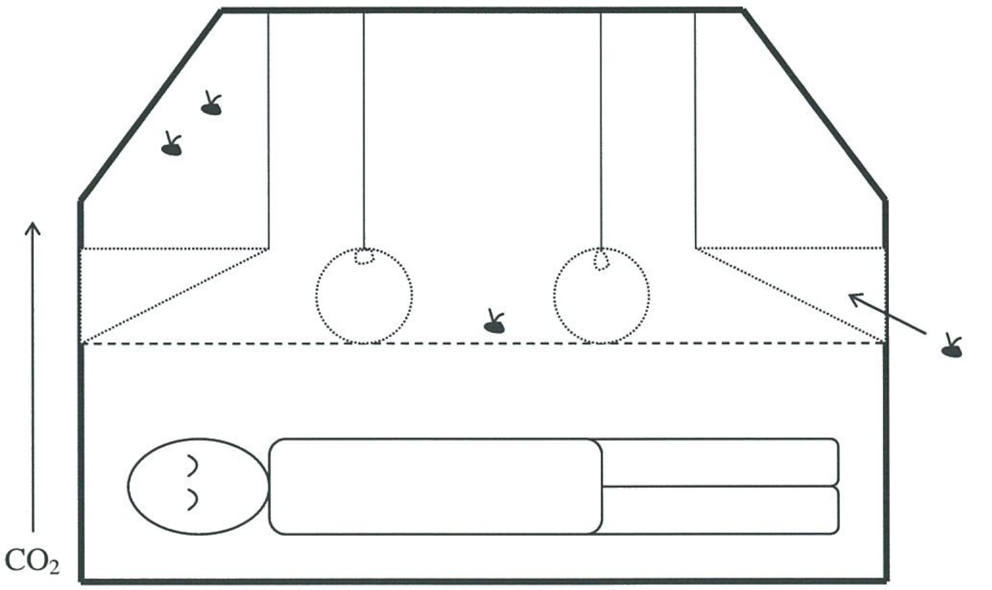


Fig 8. Interior of Tent trap

Aspirators (Fig 9) were used in conjunction with a torch within buildings and households (including mosquito nets) and to collect specimens from resting boxes. It is a skilful technique and requires time to perfect. It is a simple tool with a flexible tube at one end and a collecting chamber at the other. A gentle sucking motion is used to collect specimens – this requires speed and accuracy.

Fig 9. Collecting mosquitoes with an aspirator

Mosquito collection and processing

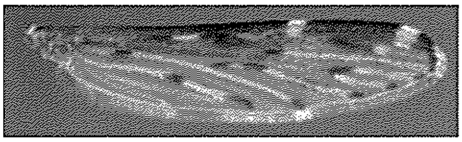
Either four or eight properties were visited each week. Sampling started at 7am and continued until each house had been visited. This was repeated daily giving a total of four repetitions per house. Collected mosquitoes were sorted into species and placed in specimen tubes with a wad of cotton wool and desiccating agent (silica granules). They were then labelled according to collection site, date and trap method. These were analysed at IHRDC. Samples were divided by visual identification using a dissecting microscope into one of four species type: *Anopheles gambiae, An. funestus,* other *Anopheles* species, and *Culicine* species. Sex and feeding status of the mosquitoes were also recorded. In order to determine sporozoite rates, and therefore the prevalence of *Plasmodium falciparum* within the sample population, samples were subjected to a sandwich-*ELISA* to detect *P. falciparum* circumsporozoite proteins. Generalized linear modelling was used to test significance of differences in species richness and abundance between sites.

In the field

Anopheline mosquitoes were simple to distinguish from the Culicine tribe because the palps are as long as the proboscis and they are often dark in colour. This can be seen with the naked eye so samples could be sorted accurately and rapidly in the field.

Some *Anopheline* mosquitoes could then also be sorted to species level. For example, two of the most important malaria vectors in this region can be distinguished simply by examining them with the naked eye. *Anopheles gambiae* (the primary malaria vector in the Kilombero Valley) has three pale bands on the palps, speckled legs, dark tarsi and a pale interruption on the third dark patch of the wing costa. *An. funestus* is smaller than *An. gambiae* with no speckling of the legs. The apex of the palps is pale and the third dark patch of the wing costa has no interruption.

Wing of Anopheles spp.



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An. gambiae is part of a species complex. This means that the species in the complex are morphologically indistinguishable but exhibit behavioural differences. These species can be distinguished from one another through molecular methods such as PCR.

Under the microscope

Using the samples collected in the field a specimen library was being complied for use in teaching of mosquito taxonomy at IHRDC. In order to distinguish between genera in the *Culicine* tribe and other *Anopheline* species for the library, specimens were examined under the microscope and a number of different keys used in identification (see reference list).

The genera present in the Kilombero Region are:
Culex
Aedes
Mansonia
Coquillettidia
Eretmapodites
Uranotaenia
Toxorhynchites
Mimomyia

There are around 140 species of mosquito in this region.

Mosquito taxonomy is a complicated discipline. The use of numerous keys and anatomical diagrams facilitated the identification process. This was helped by the fact that many of the mosquitoes caught were of the same species. Also, Anopheles mosquitoes are quite distinct from the *Culicine* tribe so they could be separated easily but team members were still required to spend a great deal of time on sorting and identifying the samples that were collected. By assessing the distribution of mosquito genera in the Kilombero Valley the team hoped to relate the findings to the results of the biodiversity surveys and further understand the pattern of malaria in the human population.

Mosquitoes that were trapped on other fieldwork projects were identified to genus level, sometimes to species in *Anopheles* mosquitoes, and the data was compiled at IRHDC.

Mosquitoes were sorted at the end of each day into species. Following this specimens were placed in labeled vials each of which contained a wad of cotton wool and dessicating agent (silica granules). This was for transport back to the laboratory at TTCIH for analysis by ELISA or PCR.

Apparatus

- CDC light trap
- Torch
- Aspirator
- Tent trap
- Vial
- Desiccating agent

Results

Twelve DSS villages in the KV were sampled for a total of 51 days during the dry season, June – September, of 2007 (see appendix). A total of 8,149 mosquitoes were collected (Table 2); 1,913 were identified as *An. gambiae* and 583 were identified as *An. funestus*.

Table 2: Abundance and distribution of all mosquito sampling in KV dry season of 2007.

Village	No. Days Sampled	All Mosquitoes	*Anopheles funestus*	*Anopheles gambiae*	Other *Anopheles*	*Culicine* spp.
Kidulago	4	198	40	46	0	112
Idete	4	4	0	4	-	-
Namawala	4	447	152	10	36	249
Idunda	4	273	264	1	0	8
Mbingu	4	2669	4	2	4	2659
Kivukoni	2	33	0	4	0	29
Ifakara/TTCIH	9	966	0	0	1	965
Minepa	4	1700	84	319	128	1169
Iragua	2	269	20	9	2	238
Sagamaganga	5	147	3	143	1	-

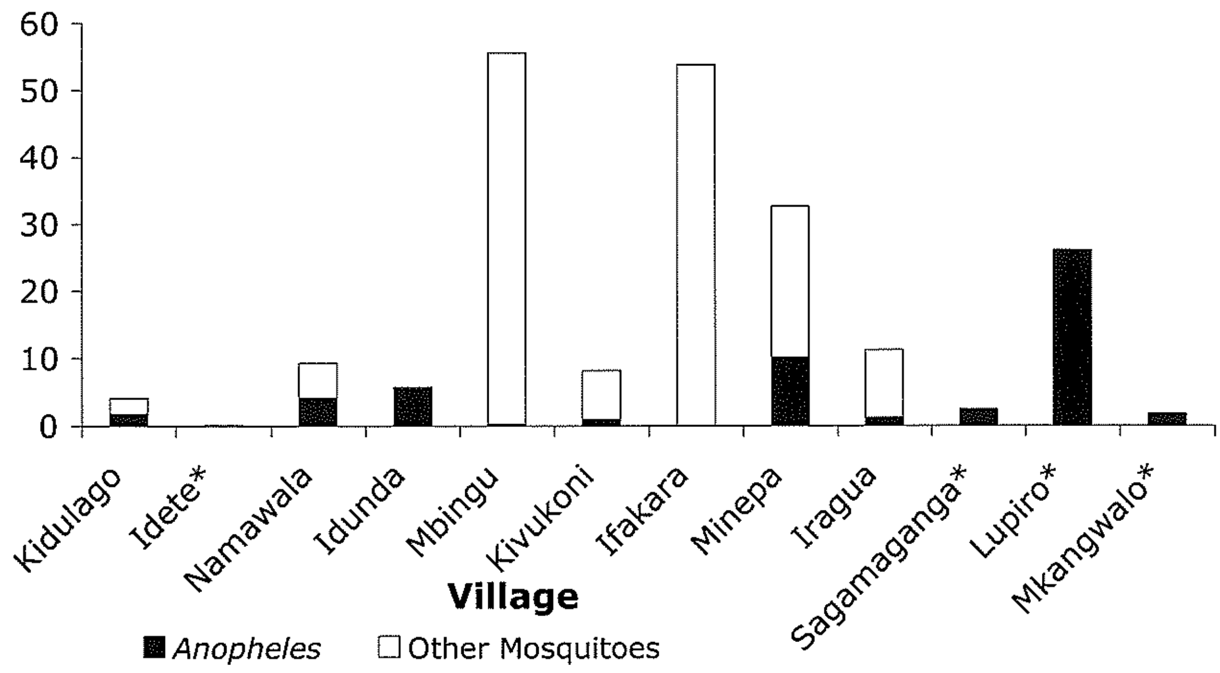

Fig 10. Relative mosquito densities in the KV dry season of 007. (*) denotes villages where non-An. gambiae/funestus mosquitoes were not recorded.

Absolute densities were normalised according to total number of days and traps in each village to give relative mosquito densities (Fig 10). While Mbingu and Ifakara/TTCIH had the highest relative densities of mosquitoes (>50/trap/day), there were low relative densities of *Anopheles* (<0.5/trap/day) at both places. Lupiro had the highest relative density of *Anopheles* mosquitoes (26/trap/day) in line with its highly rural location, and was the only village with enough suitable specimens (>200) for *P. falciparum* detection by ELISA to allow an EIR to be calculated as follows:

$$\text{EIR} = 1.605 \times \frac{(\text{no. positive ELISA tests})}{(\text{no. mosquitoes tested})} \times \frac{(\text{no. mosquitoes collected})}{(\text{no. catches})} \times 365$$

$$\text{Lupiro EIR} = 1.605 \times (1/1300) \times (1356/20) \times 365$$
$$= 30.3$$

where 1.605 is a conversion factor that accounts for the number of catches that bite man (Lines et al. 1991) and the number of catches is (no. traps x no. days). Overall mosquito recorded mosquito densities were low, most likely due to the harsher breeding environment of the dry season.

The trends in *Anopheles* species distribution varied between villages in the KV during the dry season of 2007 (Fig 11). For example, Namawala and Idunda *Anopheles* were primarily *An. funestus*, while the *Anopheles* of Lupiro and Minepa were predominantly *An. gambiae*. There is no trend towards an overall precedence of a particular *Anopheles* species throughout the villages sampled in the KV, and it is unclear why particular *Anopheles* species predominated in some villages but not others.

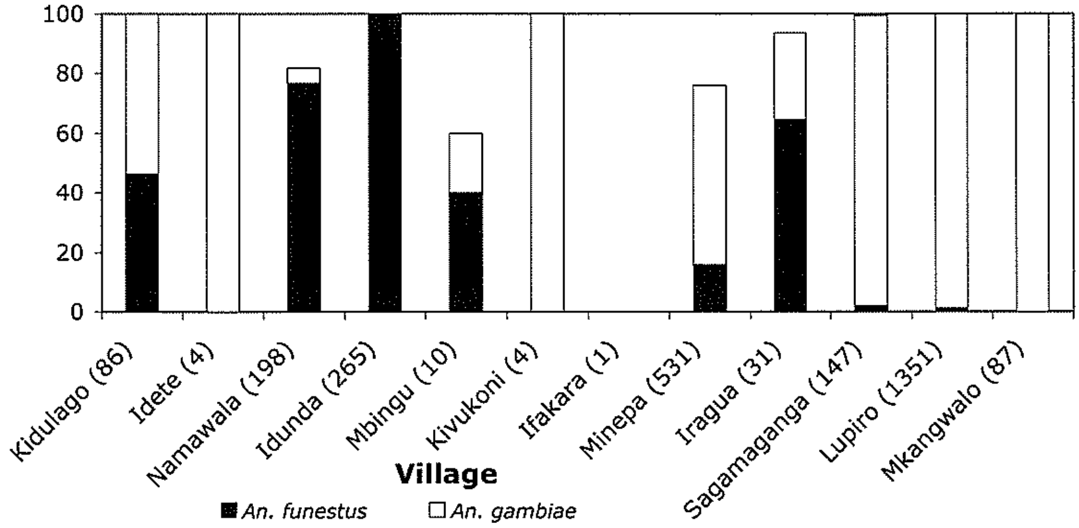

Fig 11. Malarial vector species distribution in the KV dry season of 2007. (n) = total *Anopheles* caught in village.

Four trapping methods were used to obtain dry season mosquito densities, and their relative performances were compared (Fig 12). Interestingly, the CDC light trap appears to be most successful, with the total number of *Anopheles* and total number of *An. gambiae* caught being approximately double that of any of the other trapping methods. Tent trapping appears to catch equivalent numbers of *An. gambiae* compared to resting catches and boxes. However, like the resting box, the tent trap catches a lot less *An. funestus* in comparison with CDC light trap and resting catch methods.

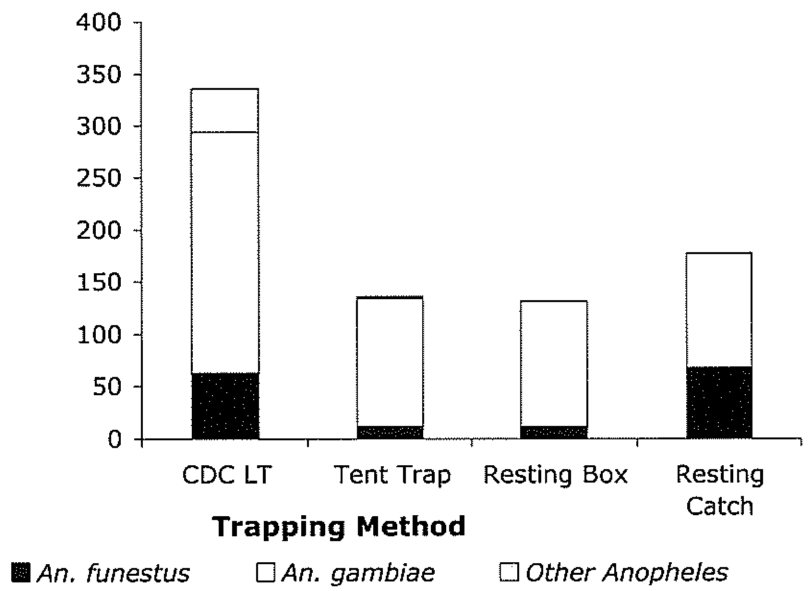

Fig 12. Relative efficacies of different field trapping methods in catching *Anopheles* species in the KV dry season of 2007.

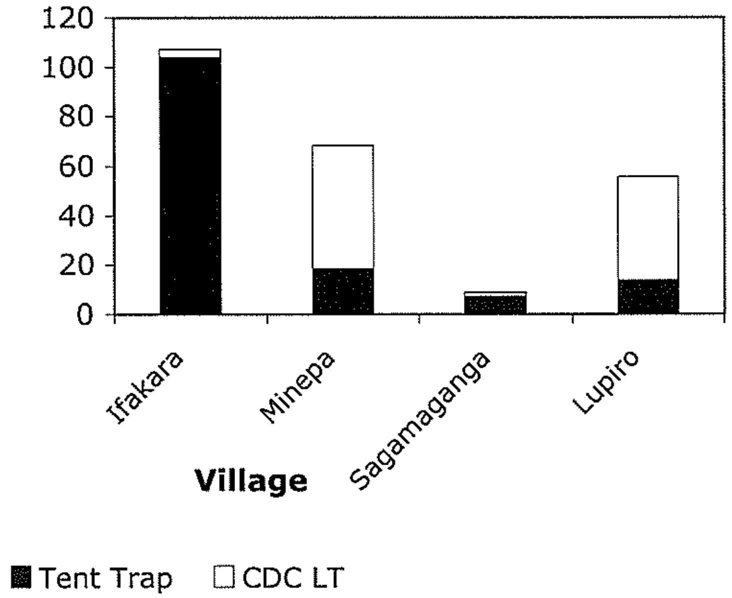

Fig 13. Direct comparison of CDC light trap and tent trap relative mosquito densities in the KV dry season of 2007.

In particular, the efficacy of the new tent trap design was compared with that of the standard CDC light trap (Fig 13). In concurrence with the higher efficacy of the light trap compared to the tent trap, the light trap is responsible for the majority of mosquitoes caught per trap, per day, in Minepa and Lupiro. However, the tent trap is more effective than the light trap in Ifakara, perhaps due to sub-optimum positioning of the light trap. It is also possible that the tent trap is more effective than the CDC light trap in an urban setting, but in any case, the relative densities of potential malarial vectors were comparatively minimal. Interestingly, the tent trap was more efficacious than the light trap in rural Sagamaganga. However, this result may be skewed by mathematical manipulation as the number of tent traps was much less than the number of light traps used in this location.

BIRD SURVEY

Kilombero valley is a globally important wetland afforded protection as a RAMSAR site and is home to large and important populations of ungulates, plants and birds. The valley consists of a number of different habitat types including swamp, forest and farmland and the habitats link with larger neighbouring areas such as the Selous and the Udzungwa Mountains which are also important areas of biodiversity at a regional and international scale respectively.

The valley is an important area for large concentrations of wetland bird species examples of which include the African Skimmer (*Rynchops falvirostris*) and the Madagascar Squacco Heron (*Ardeola idae*). It provides habitat for three species of locally endemic and restricted range bird species: The Kilombero Weaver (*Ploceus burnieri*), the White-tailed Cisticola (undescribed) and the Kilombero Cisticola (undescribed). Birdlife International also notes that the area houses unusually large concentrations of raptors.

Expanding settlements, population growth and agricultural development are threatening many important avian habitats in East Africa. The Kilombero Valley is faces all of these threats. During the last 10 years there have been high levels of immigration into the area as people have sought to secure the remaining available expanses of land. Much of this land has been given over for the purposes of rice and sugar cane cultivation while in other areas overgrazing is becoming an increasing problem. Large amounts of deforestation have and continue to occur as wood is harvested for fuel or felled to clear land for agricultural purposes. Homogenous teak plantations have replaced some areas of indigenous woodland. Legislation does exist to prevent some of these environmental problems but it is largely ignored or poorly enforced.

Aims

The purpose of the study was to investigate a possible correlation between spatial patterns of biodiversity and malaria prevalence rates in human populations.

Methods

Surveys to record bird diversity and abundance were conducted in the environs of seven settlements in the Kilombero Valley during July and August 2007. Six of the settlements were small villages or rural communities and the other a small town. The sites were chosen for their accessibility and to correspond with existing malaria prevalence and mosquito diversity data from the IHRDC DSS. Four days were spent at each site and surveys were conducted on foot in the early mornings (approx. 7-11am) and late afternoons (approx 4-6.30pm). At each site bird diversity and abundance were sampled along transects starting out from points at the edges of the settlements and proceeding in a radial direction. The direction and start point of each transect were chosen haphazardly to follow existing walkways and to avoid the houses of local residents while maintaining every effort to sample the variety of habitats surrounding each settlement and in every direction. Point counts (Bibby et al., 2000) were made at 200m intervals along each transect each for duration of 15 minutes starting immediately after arrival with no 'cooling off' period. Species were identified by sight and call. Their distance from the point and the number of individuals in a grouping were also recorded. Two spotters who faced in opposite directions while scanning the vicinity made sightings and a scribe recorded sightings as they were made. Each of the spotters was equipped with a pair of binoculars and the scribe with a laser range finder to measure distance. Jasson John, Bahati Mmary Emmanuel and Mark Boyd undertook the majority of survey work with additional aid at some sites by Ed Minards, Alex Scott-Tonge, Laurel Bennett and Eliza Wolfson.

As part of our cultural considerations to the local villagers we liaised with the elected Village Leaders at each site before commencing with any survey work. We had been advised that previous failures to do this had caused problems for future researchers and it was paramount that this should not happen again. We also asked the Village Leaders if we might hire a guide to accompany us at all times who might act as a guide and ambassador. At six of the seven sites the Village Leaders elected to take on this role themselves.

Species diversity at each site was calculated using the Shannon-Weiner Index of Diversity to obtain alpha values.

All species names follow Stevenson & Fanshawe, The Birds of East Africa, 2002.

Results

The presences of 180 bird species from 56 families were recorded in the survey area at the 6 sites (Table 3).

Table 2. Observed numbers of bird species

Village	Species	Families	Alpha Diversity
Idunda	59	34	2.1
Mbingu	68	31	2.7
Minepa	75	34	3.7
Iragua	70	32	2.3
Kidulago	58	29	2.8
Ifakara	80	39	2.3
Total	**180**	**56**	

For a full list of species and families observed see appendix A.

Range extensions

The Yellowbill (*Ceuthmochares aereus*) was detected at Mbingu and its presence represents a small easterly extension from its normal range found closer to the eastern coast where individuals are normally migrants from the south of the race australis. The race of this individual was not noted.

Southern Brown-throated Weaver (*Ploceus xanthopterus*) was detected in Idunda and Iragua. In Idunda, 10 individuals of mixed sex were seen perching among banana plants on arable land where they were clearly observed in a mixed group with Black-headed Weavers (*Ploceus cucullatus*). At Iragua only one individual was observed, also in a farmland environment. This species is known to associate with marshes or extensive wetlands and is know to be locally common at three others sites, all in southern Tanzania.

The alien and invasive Indian House Crow (*Corvus splendens*) was not observed at any of the survey sites but was seen on several occasions in the localities of Iragua and Ifakara, and throughout Ifakara town to the Kilombero River crossing at Kivukoni. These records are beyond the current recorded range of this species and it is likely that these sighting represent the current advancing edge of this species' range. The spread of the House Crow is associated with the replacement of the indigenous Pied Crow (*Corvus albus*) and it is known to be a voracious predator of many small native bird species. The detection of this species in this region indicates that it may be spreading more rapidly than previously thought with important implications for the attempted control of its spread in East Africa.

Endemic and restricted range species

The Kilombero Valley is situated close to several areas of endemism such as the Mahenge range and the Udzungwa Mountains. The Valley itself is also the primary location of three species of restricted range birds endemic to Tanzania: The Kilombero weaver (Ploceus burnieri), the Kilombero Cisticola (undescribed) and the White-tailed Cisticola (undescribed). Of these only the White-tailed Cisticola was seen, at Minepa, on three occasions close to the main Kilombero River. The Kilombero Weaver was seen at Kivukoni close to the Kilombero River on several occasions but not on a survey.

No other restricted range, Tanzanian or East African endemic species were observed during the surveys.

Species of Conservation Importance

Of the 49 species of birds red-listed in East Africa by Birdlife International in 2000 only two were observed by our surveys in the Kilombero Valley.

The Madagascar Squacco Heron (*Ardeola idae*), an endangered intra-African migrant, was observed at three sites (Idunda, Kidulago and Ifakara), where it was seen in close association with marshes and rice paddies.

The Kilombero Weaver is listed as globally threatened.

The White-tailed Cisticola, which has yet to be described, has been observed only from a small area and, if granted species status, is likely to be listed as at risk.

IBA/EBA/Ramsar Key Species

The Kilombero is recognised as an internationally important RAMSAR wetland site and as an IBA by birdlife international. Birdlife list 18 species as key to the designation of this site. 9 of these were recorded at the 6 sites: Madagascar Squacco Heron (*Ardeola idae*); White-headed Lapwing (*Vanellus albiceps*); African Skimmer (*Rynchops flavirostris*); Racket-tailed Roller (*Coracias spatulatus*); Rufous-bellied Tit (*Parus rufiventris*); Kurrichane Thrush (*Turdus libonyanus*); Shelley's Sunbird (*Nectarinia shelleyi*); Broad-tailed Paradise Whydah (*Vidua obtusa*).

The Kilombero Weaver (*Ploceus burnieri*) and the Southern-banded Snake-Eagle (*Circaetus fasciolatus*) were also observed at other times.

A flock of approximately 150 Skimmers were observed on a sand bank on the Kilombero River approximately 5km north of the Kivukoni Ferry. This flock represents approximately 40% of the population of the Kilombero Valley IBA as estimated by Birdlife International in 2008. A nesting pair was observed twice at a nearby site, in the first instance with a small chick, and secondly incubating one egg.

Migrant Species

The Common Sandpiper (*Actitis hypoleucos*) was the only Afro-Palaearctic species recorded during the surveys. Individuals of this species are known to reside throughout the year and this most likely applied to individuals seen this far south at this time of year.

Site Diversity

Alpha diversity (H) values were calculated for each of the 6 sites using the Shannon-Wiener Diversity Index. H values ranged between 2.1 for Idunda and 3.7 for Minepa. These values indicate an average level of diversity.

Limitations

The Kilombero Valley is a highly seasonally variable environment. In the dry season the river retreats to its channel but during the wet season it can expand dramatically, inundating its entire floodplain to create huge areas of wetland. Many of the bird species present in Tanzania are intra-African migrants moving within the continent to take advantage of seasonal changes in food abundance. As the survey was conducted during July and August at the height of the dry season the results are not representative for the rest of the year. It is likely that many other species arrive during the wet season while other may move to other areas and a more comprehensive survey would have to encompass an entire annual cycle.

Another problem with the survey – and any other conducted in Africa during the Palaearctic winter – is that it was unlikely to detect Palaearctic migrant bird species, which would have departed for their Northern Hemisphere breeding grounds. Such species may represent a large assemblage within the avifaunal community of the Kilombero Valley during the wet season but the only species observed was the Common Sandpiper (*Actitis hypoleucos*), individuals of which are known to be present all year round.

Our sample locations were chosen in correspondence with the other aims of this project and not with the sole aim of calculation avifauna diversity and the duration of survey was limited by time and funding. A more thorough and extensive survey would have been better and this might explain the lack of observations for some species that otherwise might have been expected and that are known to exist in the Kilombero Valley. Locations were also chosen for their accessibility, something that can be a huge problem in the Kilombero where vast areas are accessible only by canoe during the wet season and on foot at other times during the year. As a result it should be taken into account that the sites may not have been representative of the more remote areas of the Kilombero Valley and the survey area as a whole.

Abundances of the species observed have not been calculated due to a lack of data. Very few species were seen on enough occasions to make calculations of their abundance at each site possible and it would have been much more difficult and inaccurate to further extrapolate from site densities the abundances and densities of species throughout the Valley. Given the diverse nature of the habitat a more extensive survey would be required for this.

DISCUSSION

Sampling considerations

General

The fieldwork conducted by Project Ifakara was subject to a number of limitations that had direct impact upon the scope of the project. The timing was necessarily restricted to fit within university holidays, resulting in only ten weeks in the field. Due to this limited time period visits to villages were restricted to single visits with no repeats giving limited accuracy to the data.

The timing (June – September) also coincided with the dry season. Mosquito populations vary seasonally and are far higher in the wet season (October – January) when the habitats for breeding are far more abundant. Thus to get a true picture of abundance fieldwork would have to extend throughout the year to account for this periodicity in seasons. As is the case for other areas of Africa, dry season numbers of mosquitoes can fall below levels detectable from conventional trapping methods (Charlwood et al. 2000).

The benefits of dry season work are ease of movement between villages. In the wet season the valley is predominantly flooded necessitating forms of other transport such as canoe, precluding significant movement between villages. It is important to note that the work could not be carried out without 4x4 and assistance from IHRDC including a driver and a trained entomologist for navigation and identification. Equally vital to the fieldwork were our Tanzanian counterparts, without their bi-lingual skills we would certainly not have been able to successfully complete the project.

Trapping

The four different trapping methods were designed to complement each other in terms of their respective designs. Prior to departure a significant aim of the project was to test the new design of a tent trap in a multitude of different environments. This proved a less easy task than expected. The tent trap itself was a bulky piece of apparatus. It could not be easily handled by one person and certainly not over any great distance. Its construction and design meant it required a vehicle for transportation. The design was an evolution, part of a PhD project and as such had some minor teething problems such as a loose fitting net and leaking seams allowing water in. Based on the data gathered the tent trap was less effective than the light trap during the dry season. From the results obtained it can be said that the tent trap was the least effective trapping method in a rural environment. That the tent trap was so effective in TTCIH may be due to the more artificial set-up and inappropriate positioning of the light trap.

The original purpose of the tent trap is its ability to be used in rural and urban environments. Unfortunately we were limited to testing in only rural situations. In these conditions it performed moderately well compared to other tried and tested methods. Its relatively high price and logistical difficulties mean in its current design it is not as suitable as the other simpler methods used.

In terms of price the resting box is an ingenious method of catching mosquitoes overnight compared with the light trap. The specimens caught were generally blood-fed or gravid. However, overall for absolute numbers the light trap was still the most effective. The aspirator was effective because of its ease of use and ability to catch specimens during daylight hours. The tent trap, along with the other methods is likely to have better trapping success in the wet season.

Mosquito diversity and abundance

The sample size was too small too infer any statistically significant differences regarding species distribution, malaria prevalence and relationship between biodiversity. This is primarily due to the small sampling timeframe. It is also important to remember that these results refer to trapping success in the dry season only which resulted in densities which were too low to give accurate sporozoite rates and EIR for particular villages. This precludes the possibility of using our data to compare with biodiversity values. It is possible to use past calculations from previous papers (Drakeley et al 2003, MTIMBA estimates) but this is far less accurate. This would require consistent sampling throughout the year in the KV.

Mosquito numbers varied considerably between villages. There were a number of variables which contributed to this. The most important being micro-climatic differences. The most *An. gambiae* were caught in Lupiro which has the wettest climate throughout the year and the highest known ever recorded EIR (Killeen *et al.* 2006). Other possible factors included the lifestyles of the villagers. This is predominantly related to pastoral or non-pastoral habitats. Species like *An. gambiae* are endophagic nocturnal feeders, living mainly inside. Accordingly, most individuals were caught with the light trap and by resting catch (aspirator). PCR would have determined the number of *An. gambiae* and *An. arabiensis* caught. These are part of the same species complex and indistinguishable by eye. In pastoral habitats the more zoophilic *An. arabiensis* is likely to be more prevalent. In the relatively more densely populated areas *An. gambiae* was more widely found. More *An. gambiae* were caught compared to *An. funestus*. This may relate to behaviour differences or to local ecological variables. Generally it will continue to be difficult to gain accurate estimations of dry season relative densities, sporozoite rates and EIRs with current sensitivities of sampling methods. There is therefore a need to develop more sensitive trapping methods for direct observation of dry season phenomena.

CONCLUSION

The research conducted by Project Ifakara aimed at an integrated understanding of the relationship between malaria prevalence and biodiversity. In order to answer this question further work is required to bulk out the dataset. Additionally, analysis of the relationship between malaria prevalence and biodiversity requires fieldwork further afield than just the Kilombero Valley. There are a number of ecological factors which contribute to habitat range and abundance which would require more detailed study to identify those factors with greatest influence. However, the bird study made valuable contributions towards adding a substantial body of data concerning avifauna species diversity and distribution.

There is certainly room for improvement in the tent trap design. The net protecting the sleeper from the captive mosquitoes generally needs to be tighter as it was often too loose resting on the inhabitant. The canvas design was also heavy and only moderately watertight. In addition the heavy metal poles used to construct it were too cumbersome for fieldwork without a vehicle. These also resulted in gaps in the eaves which needed to be filled with cotton wool to keep captive mosquitoes in. More testing needed to see which is more effective in urban areas (especially during the wet season) as we only had 1-2 really urban locations.

Aside from the specifics of the research, Project Ifakara was educational in many ways. One of the primary motivations was to expand fieldwork experience. The wide range of disciplines presented an opportunity for the team to improve methodological, processing and analytical skills in a field setting. The use of recognised ecological population methods, such as bird and insect surveys gave further practical experience in the fields of zoology and entomology. The challenges of this project, from learning Swahili in the UK before departure to demanding fieldwork, required every team member to be suitably motivated to achieve the research objectives. This challenging situation helped to build the skills required for teamwork; such as effective communication, problem solving, use of initiative, and the ability to make and learn from constructive criticism.

The contacts that have been set up with IHRDC and UDSM are perhaps the most important outcome of the project. The chance to conduct research in Kilombero would certainly not have been possible without there their help. The effects of the project are still being felt with two of the students having successfully competed for MSc Fellowships from the Wellcome Trust for British Universities. The project has therefore directly helped launch the careers of at least two Tanzanian scientists.

LOGISTICS

Food and accommodation

Accommodation at IHRDC was provided in the form of double rooms and shared bathrooms at a cost of US$ 16/person/night. The rooms were clean, with bed nets, bed linen and towels provided (Fig 14). Each room was provided with a bottle of water daily, which could be refilled at the IHRDC canteen. Breakfast was provided at a cost of 1000 Tanzanian shillings, but further, cheaper, meals were sourced in town. Local food was eaten where possible which usually consisted of a combination of rice, beans, chicken, chapattis and spinach.

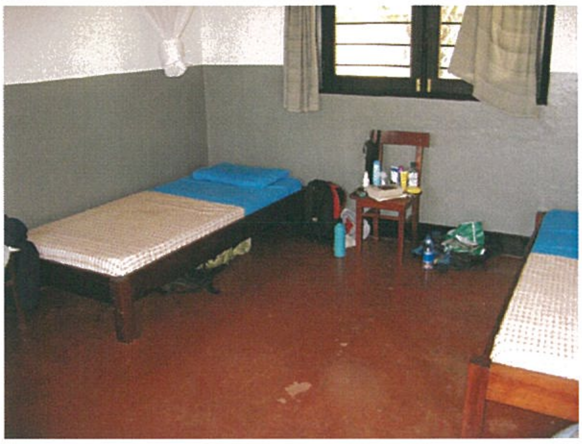

Fig 14. Accommodation at IHRDC was clean with bed-nets provided

Fieldwork was conducted near villages or in remote areas. For the latter, food was bought at markets prior to departure from built up areas, and stored in plastic bins. Transport was by 4x4 or canoe. Food and water were transported in bulk in the expedition vehicles for periods of up to a week. Where necessary water for cooking was taken from streams, boiled, and iodine added before use. Travelling during the dry season meant dry fire wood for cooking was plentiful.

In villages food and water were available from local restaurants. Tents were used for accommodation in the majority of survey sites but where there were not suitable places to camp, local guesthouses were used. Village representatives were consulted on the suitability areas to pitch our tents to ensure that we were on public ground and that there were suitable facilities available nearby and we would no disrupt the local village community.

Communication

The sabbatical to Durham University of Dr Gerry Killeen, Unit Leader at IHRDC, during the planning of the expedition meant that communications with IHRDC and the University of Dar es Salaam were excellent.

Each team member carried a mobile phone, with a Celtel sim card, which has good coverage throughout East Africa. IHRDC has six computers with intermittent internet, and we were provided part time with a dedicated lap top. Ifakara has a post office, and IHRDC has a post box for receiving post.

The six Tanzanian team members provided a wealth of in-country knowledge, which was particularly important as the bulk of the fieldwork was carried out in rural areas. The UK team learnt basic Swahili, but with only three months in the country it was essential for the success of the expedition to have the fluent Swahili of the Tanzanians and their strong grip of English.

Twinning Process

The comprehensive funding of the expedition allowed for the inclusion of six Tanzanian counterpart team members. IHRDC placed a full page advert in the national newspaper, which attracted over 500 applications. Applicants were interviewed and selected by Dr Gerry Killeen and colleagues. Tanzanian team members and UK team members were then 'twinned' together, based on similar interests, with the aim of fostering close relationships. For details of team members, please see p47.

The Tanzanian team members were selected by IHRDC with a view to future employment and the expedition was, in effect, an internship for the Tanzanian team members.

This expedition highlighted the importance of in country collaboration and local knowledge. It proved a great benefit to logistical organisation and the awareness of cultural sensitivities that at least half of the team were Tanzanian nationals.

Specialist Equipment

Two Stereomicroscopes were purchased in the UK for use in mosquito identification. These were then donated to IHRDC at the end of the project. The expedition team bought 4 tent traps designed by Nico Govella, PhD student, from IHRDC. Repairs were done at the IHRDC work shop. Aspirators and CDC Light Traps used for mosquito collection were also loaned to the team by IHRDC.

For Avifauna surveys, binoculars[4], range finders[5], and bird books[6] were used. These were purchased both in the UK and Tanzania and were donated to the University of Dar es Salaam after the project. The GPS used was lent to the team by the University of Edinburgh Geography Department.

Risks and hazards

A full project risk assessment was carried out before departure. Thankfully, none of the identified risks presented real problems in the field.

The largest hazard to the team was on the roads. During fieldwork in the Kilombero Valley, only IHRDC vehicles were used. These were well maintained, well equipped, and driven by Driver Technicians. During the safari between Dar es Salaam and Ifakara through the Selous Game Reserve, 4x4s hired from *Waterbuck Safaris* were used. The vehicles were badly maintained, poorly equipped, and the drivers were extremely poorly trained and dishonest. We would strongly advise against anyone using this company again.

Malaria (primarily *Plasmodium falciparum*) was a concern. The Kilombero Valley has the highest recorded Entomological Infection Rate (EIR) rate in the world, though the risk was reduced because it was the dry season. Team members wore long sleeved shirts and trousers and applied DEET at dawn and dusk. The team also slept under permetherin impregnated bed nets, or in tents which did not allow insects to enter. All UK team members took *Malarone* prophylactics daily. In case malaria was contracted, rapid diagnostic kits and coartem were carried with the team at all times.

Insect bites and cuts were kept clean to prevent infection.

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[4] Bushnell, Tasco
[5] Bushnell
[6] Stevenson & Fanshawe (2001), Birds of East Africa

Risk from wildlife was taken very seriously. In Game Reserves, people were not permitted to leave the vehicles during travel. If it was deemed absolutely necessary to leave the vehicle (e.g. to repair a puncture) other team members stood on the other two vehicles using binoculars to keep watch for approaching danger. Camps were set up in open areas during day light, fires lit, and the camp boundaries lit by kerosene lamps. Everyone was required to sleep in tents, and not in the open, as animals would often pass through the camps at night.

Whilst on the Kilombero River, fishermen and their canoes were used for transport, so that the team could safely navigate around hippopotamus and crocodiles. Camps were set up in open areas recommended by the fishermen, with location of hippopotamus and their nightly grazing taken into consideration.

Working in sun made heat illness a risk. Team members hydrated regularly, covered up, and used sun cream in exposed areas. A mild case of heat illness was experienced. Work for the day was stopped, the individual placed in the shade created by erecting a tent, given fluids, and covered in a wet cloth. No further medical assistance was needed.

Medical arrangements

A short while before the team left the UK all team members attended a two-day wilderness first aid course, run by *Adventure Lifesigns*. This excellent course covered all basic first aid and then moved on to real-life situations that can occur in the field and was an excellent opportunity for team bonding. All necessary inoculations were obtained before departure. These included Tuberculosis, Hepatitis A and B, Rabies, Typhoid, Tetanus, Polio, and Yellow Fever.

At all times, a comprehensive first aid kit was available to all team members. This was ensured by having three, divided between different day sacks. The nearest medical centre is St Francis hospital, right next to IHRDC, which could deal with minor injuries. In case of more serious injury, all team members were members of AMREF Flying Doctors. AMREF are able to fly the casualty from any airstrip within 1000km of Nairobi which covers most of Kenya and Tanzania. Highly qualified medical staff and aircrew are on standby to respond to emergencies 24 hours a day.

The nearest airfield to IHRDC is Kibanoni Airfield, located 11km away by road. The team were never further than a days travel from the nearest airstrip.

Itinerary

Date	Details
17th – 18th March	Life Sciences Wilderness First Aid Course, Edinburgh
18th June	Edinburgh Team Arrive in Tanzania
20th June - 2nd July	Edinburgh community work and Swahili study
3rd July	Durham Team Arrive
4th July - 8th July	Preparation for Selous transect
9th July - 15th July	Leave Dar es Salaam, Selous Transect and arrive IHRDC
16th July - 22nd July	Introduction to IHRDC
23rd July – 8th September	Field work at IHRDC
10th September	Edinburgh Team leave Tanzania for UK
20th September	Durham Team leave Tanzania for UK

Training and equipment

Before departure from the UK, each team member undertook a two-day wilderness first aid course, run by *Adventure Lifesigns*. The real life situation training was an excellent opportunity for team bonding between a team from two different universities.

An eight day transect was covered between Dar es Salaam and IHRDC. This included the Rifuji Valley, Selous Game Reserve, and Mikumi National Park. The aim was to train team members in field skills and living in the bush, whilst away from sensitive communities. Bird experts, Dr Steve Willis from Durham University and Jasson John from the University of Dar es Salaam, instructed on avifauna identification and survey techniques. Dr Gerry Killeen and Nico Govella instructed on mosquito surveying and identification. This was also taken as an opportunity for team bonding between the newly formed team comprising of six British and six Tanzanian students.

Photography

A Nikon D50 digital SLR was taken with a telephoto 170-500mm lens and three memory cards. The equipment performed well and no major problems were encountered. Individual team members also took smaller digital cameras and a standard 35mm SLR. Silica gel sachets were obtained prior to leaving to keep film and SD cards dry and free from mould.

Permission and Permits

On discussion with regional Immigration Officers, IHRDC staff recommended applying to the Tanzanian consulate in London for Business Visas. These were obtained before departure, and were valid for the standard 60 days. On entry to Tanzania, visas were signed 'HV', designating 'Holiday Visa'. Unknown at the time, this negates the validity of the Business Visa and on arrival at IHRDC the local Immigration Officers declared that another Business Visa must be applied for each team member, and the fee paid again.

Permission to work at IHRDC was granted by Dr Gerry Killeen and Hassan Mshinda, the director.

Fundraising

Fundraising was very successful. The nature of Project Ifakara 2007 made for an ambitious budget. This was exceeded, and the number of Tanzanian team members could be increased from four to six.

Finances

An expedition bank account was set up which allowed international access through two VISA cards. For a full summary of the accounts see the budget.

Insurance

Insurance was sort from *Worldwide Travel Insurance Services Limited.* Three months Super cover was taken for all team members, costing £79.80 each including a 5% group discount. Microscopes, cameras, and lenses were also covered at a cost of £18 a month.

Travel and transport

Travel to Dar es Salaam, Tanzania from the UK was by aeroplane. Each team member carried a large rucksack and daypack, with a single hold-all for group equipment. The team flew with Qatar Airways

During fieldwork in the Kilombero River Valley, only IHRDC vehicles were used. These were well maintained, well equipped, and driven by Driver Technicians.

During the transect between Dar es Salaam and Ifakara through the Selous, hired 4x4s were used.

When surveys were conducted up the Kilombero River, dug out canoes were used. These were expertly navigated up the valley by the local fishermen who owned them. The risk of heat illness due to exposure, and hippopotamus in the water should be noted.

In the local area, bicycles could be hired for 100 TZ Shillings an hour. Bicycles provided an excellent way to travel around the immediate vicinity, and had the advantage over a vehicle of not being intimidating to the community.

Public transport was also utilised in order to travel between villages when not doing survey work. Coaches were used for long distance travel but the majority of trips were taken using dala dalas (small minibuses) which provide basic but cheap transport.

Team Members

Durham University

Edward Gaylord Minards, British, 24, Zoology (BSc)

Durham Expedition Leader

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In summer 2006 Ed was a member of a Durham University expedition to Sabah, Borneo. The research involved investigating the hydrology of the rainforest canopy and he is a self confessed monkey lover. He gained valuable experience of working with different cultures when he spent six months as a hairdresser in central China. He has just graduated from Sandhurst as second fiddler for the army music brigade.

Laurel Bennett, British, 25, Zoology (BSc)

Medical officer

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Laurel has a keen interest in conservation biology and has travelled widely participating in various research projects. In 2002 she was involved in voluntary conservation and community work in Kenya. As an undergraduate, she participated in a bird monitoring expedition to Cape Verde in 2004 and the following year led a marine conservation expedition to the Philippines. Last summer, Laurel worked as a research assistant at a field centre in Borneo. During the third year of her degree, Laurel was employed at the Central Science Laboratories to work in bird management and gained valuable experience in various field survey techniques. Laurel has now completed an MSc in Conservation Management at University College London, and plans to develop a career in this area in the future.

Mark Boyd, British, 25, Ecology (BSc)

Equipment officer

markboyd@hotmail.co.uk

Mark graduated with Honours from Durham University on the summer of departure. He has previous experience of working in East Africa and in 2005 spent six months working in the bush in Southern Tanzania as part of a self-funded year out. In 2006 he received training as a field ecologist in South Africa as part of his studies and whilst there specialised in bird surveying. Mark spent the past summer working for Oxford University Conservation Research Unit where he developed his analytical and fieldwork skills. He is an accomplished wildlife photographer and has exhibited his work successfully several times.

University of Edinburgh

Alex Scott-Tonge, British, 25, Ecology with Conservation and Management (BSc)

Edinburgh Expedition leader

ascotttonge@gmail.com

Alex graduated with Honours from The University of Edinburgh on the summer of departure. In 2006 he led a student expedition to study the canopy and terrestrial small mammals of Borneo. In the summer 2005 he was involved in an undergraduate expedition to the Amazon basin in Bolivia studying biomass regeneration under different forms of forest management. In 2002 he spent three months with Coral Cay in Fiji mapping coral reefs and becoming a PADI rescue diver. In his final year of study, Alex was treasurer of the University of Edinburgh Expeditions Society.

Zafer Ozveren, British, 25, Electrical and Mechanical engineering (MEng)

Webmaster, Treasurer

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During his time at university, Zafer developed a good understanding and appreciation of the scientific method as well as benefiting from much expeditionary and fieldwork experience with the Edinburgh OTC, where he gained a COMEC leadership certificate. In 2005 he was a founding member of the Edinburgh branch for 'Engineers Without Borders, UK.' Zafer has contributed to conservation activities in Angus County as part of his DoE Gold Award scheme and has enjoyed several extended white-water rafting excursions to Konya province, Turkey. Laboratory work and industrial experience during his degree have provided both electrical and mechanical competencies. Zafer is now using the skills learnt from the expedition and his degree to begin a career with Scottish Power.

Eliza Wolfson, British, 24, Microbiology (Bsc)

Secretary

lizafish@gmail.com

Eliza has previous experience of working with people of varying needs, from educating children through illustration, to drug and alcohol rehabilitation. She has a broad base of disciplines including photography, editing and design as well as familiarity with ecological methodology and data analysis. During her gap year Eliza worked in a primary care trust implementing new government policies, essentially epidemiology of chronic and preventable diseases. Eliza is now doing a PhD at Edinburgh University in Microbiology and Epidemiology.

University of Dar es Salaam

Lilian Mulamula, Tanzanian, 26, Wildlife Science and Conservation (BSc)

Lilian has an interest in natural resource conservation and management and their influence on human health and the economy. Participating in the expedition has given her an important opportunity to explore the Kilombero valley, an area with an overwhelming health risk from malaria, influenced largely by its seasonally flooding wetlands. This has challenged her to think more about how to contribute her natural resource management knowledge to improving human health. She expects to involve herself more in research concerning management of natural resources and health.

Deodatus Fadhili Maliti, Tanzanian, 27, Molecular Biology and Biotechnology (BSc)

Deodatus' interests lie in Molecular biology, especially in processes that determine patterns of inheritance, DNA manipulation and biotechnology. The expedition has left him with long lasting positive experience in areas pertaining to malaria control programmes, and has also posed a great challenge to him as a young researcher. Through interaction with the UK students, Deodatus has learned to live in a multicultural world. He has found the experience fantastic, as it revealed to him a lot of values humans share across geographic and ethnic backgrounds. The cultural and social disparities helped Deodatus with appreciating the meaningful differences between people. In the future, he hopes to work at IHRDC as a malaria research scientist on investigating the use of molecular processes and theories as malaria intervention strategies.

Abissay Ndaki Hussein, Tanzanian, 37, Applied Statistics (BSc)

Abissay's interests lie in applied statistics used in human health. His original career path of choice was as a teacher in the Morogoro region. After four years of teaching, he realised his dream by enrolling in Mzumbe University for higher education. On graduating, Abissay saw the advert for the expedition whilst reading the newspaper, and decided it would be a good opportunity. The expedition has helped him decide on a future in research, and Abissay hopes to stay with IHRDC as a research scientist, with the aim of one day enrolling for a PhD.

Lubandwa Sebastian Biswaro, Tanzanian, 26, Molecular biology and biotechnology (BSc)

Biswaro has interests in a variety of fields within public health including epidemiology, the molecular aspect of disease, viruses and protozoans. In 2005 he participated in practical training at Amani Biomedical Research Centre on determining efficacy of antimalarial drugs and completed a detailed project on point mutation detection. Creating a mosquito specimen library for Project Ifakara has served to increase his interest in malaria research and he hopes to be involved in the research of entomological diseases in the future.

Maganga Sambo, Tanzanian, 28, Geography and Environmental Studies (BSc)

Maganga has experiences in geographical research methods; he spent two months in early 2006 doing fieldwork in Tanga region on water resources management, land use, agricultural innovation and the outcomes of rural-urban migration. In summer 2006, he worked with IHRDC as a researcher and facilitator during community sensitization meetings and conducted a review of social marketing strategies on issues relating to malaria in the Ulanga and Kilombero Districts. Maganga found the expedition very exciting, and the insight and experience of research on biodiversity and malaria transmission extremely interesting. He hopes to develop his career in research activities focusing on environmental resources and public health.

Mmary Bahati Emmanuel, Tanzanian 27, Political science and Public Administration (BA)

Mmary's interests lies in human resource management and public administration. He enjoys participating in activities which involve interaction with people. He has worked as Human Resource Officer with VI-Agro forestry working on the conservation issues surrounding the Lake Victoria Basin. This expedition has made him realize the importance of involving the grass root community in different aspects of disease control in particular. He hopes to use his career to fight poverty in Tanzania especially amongst rural communities.

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APPENDIX A

Species observed

African Darter	*Anhinga rufa*
Abdim's Stork	*Ciconia abdimii*
African Citril	*Serinus citrinelloides*
African Cuckoo-Hawk	*Aviceda cuculoides*
African Firefinch	*Lagonosticta rubricata*
African Golden Oriole	*Oriolus auratus*
African Golden Weaver	*Ploceus subaureus*
African Green-Pigeon	*Treron calvus*
African Grey Hornbill	*Tockus nasutus*
African Hobby	*Falco cuvierii*
African Jacana	*Actophilornis africana*
African Marsh Harrier	*Circus ranivorus*
African Moustached Warbler	*Melocichla mentalis*
African Palm Swift	*Cypsiurus parvus*
African Paradise-flycatcher	*Terpsiphone viridis*
African Pied Wagtail	*Motacilla aguimp*
African Skimmer	*Rynchops flavirostris*
Amethyst Sunbird	*Chalcomitra amethystina*
Arrow-marked Babbler	*Turdoides jardineii*
Ayre's Hawk-Eagle	*Hieraaetus ayresii*
Bateleur	*Terathopius ecaudatus*
Bearded Woodpecker	*Thripias namaquus*
Black Coucal	*Centropus grillii*
Black Crake	*Amaurornis flavirostra*
Black Cuckoo-Shrike	*Campephaga flava*
Black Egret	*Egretta ardesiaca*
Black Kite	*Milvus migrans*
Black Saw-wing	*Psalidoprocne pristoptera*
Black-and-white Mannikin	*Lonchura bicolor*
Black-and-white Shrike-flycatcher	*Bias musicus*
Black-backed Puffback	*Dryoscopus cubla*
Black-collared Barbet	*Lybius torquatus*
Black-crowned Tchagra	*Tchagra senegala*
Black-headed Batis	*Batis minor*
Black-headed Heron	*Ardea melanocephala*
Black-headed Oriole	*Oriolus larvatus*
Black-headed Weaver	*Ploceus melanocephalus*
Black-shouldered Kite	*Elanus axillaris*
Blacksmith Lapwing	*Vanellus armatus*

Black-tailed Grey Waxbill	*Estrilda perreini*
Black-winged Red Bishop	*Euplectes hordeaceus*
Blue-mantled Crested-flycathcer	*Trochocercus cyanomelas*
Blue-spotted Wood-Dove	*Turtur afer*
Bohm's Spinetail	*Neafrapus boehmi*
Brimstone Canary	*Serinus sulphuratus*
Broad-tailed Paradise-Whydah	*Vidua obtusa*
Bronze Mannikin	*Lonchura cucullata*
Brown Snake-Eagle	*Circaetus cinereus*
Brown-breasted Barbet	*Lybius melanopterus*
Brown-crowned Tchagra	*Tchagra australis*
Brown-headed Parrot	*Poicephalus cryptoxanthus*
Brown-hooded Kingfisher	*Halcyon albiventris*
Brubru	*Nilaus afer*
Burchell's Coucal	*Centropus burchelli*
Cardinal Woodpecker	*Dendropicos fuscescens*
Cattle Egret	*Bubulcus ibis*
Collared Pratincole	*Glareola pratincola*
Collared Sunbird	*Hedydipna collaris*
Common Bulbul	*Pycnonotus barbatus*
Common Sandpiper	*Actitis hypoleucos*
Common Scimitarbill	*Rhinopomastus cyanomelas*
Common Squacco Heron	*Ardeola ralloides*
Common Stonechat	*Saxicola torquatus*
Common Waxbill	*Estrilda astrild*
Crested Francolin	*Peliperdix sephaena*
Crimson-rumped Waxbill	*Estrilda rhodopyga*
Crowned Hornbill	*Tockus alboterminatus*
Dark-backed Weaver	*Ploceus bicolor*
Dark-capped Yellow Warbler	*Chloropeta natalensis*
Eastern Chanting-Goshawk	*Melierax poliopterus*
Eastern Paradise-Whydah	*Vidua paradisaea*
Emerald-spotted Wood-Dove	*Turtur chalcospilos*
Fan-tailed Widowbird	*Euplectes axillaris*
Fish Eagle	*Haliaeetus vocifer*
Fork-tailed Drongo	*Dicrurus adsimilis*
Grassland Pipit	*Anthus cinnamomeus*
Great Egret	*Ardea alba*
Greater Honeyguide	*Indicator indicator*
Green Wood-hoopoe	*Phoeniculus purpureus*
Green-backed Camaroptera	*Camaroptera brachyura*
Green-capped Eremomela	*Eremomela scotops*
Green-headed Oriole	*Oriolus chlorocephalus*

Grey Crowned Crane	*Balearica regulorum*
Grey Heron	*Ardea cinerea*
Grey-headed Bush-shrike	*Malaconotus blanchoti*
Grey-headed Kingfisher	*Halcyon leucocephala*
Grosbeak Weaver	*Amblyospiza albifrons*
Hadada Ibis	*Bostrychia hagedash*
Half-collared Kingfisher	*Alcedo semitorquata*
Hamerkop	*Scopus umbretta*
Helmeted Guineafowl	*Numida meleagris*
Hooded Vulture	*Necrosyrtes monachus*
House Crow	*Corvus splendens*
Jacana	*Actophilornis africana*
Kurrichane Thrush	*Turdus libonyanus*
Lesser Honeyguide	*Indicator minor*
Lesser Masked Weaver	*Ploceus intermedius*
Lesser-striped Swallow	*Hirundo abyssinica*
Lilac-breasted Roller	*Coracias caudatus*
Little Bee-eater	*Merops pusillus*
Little Egret	*Egretta garzetta*
Little Greenbul	*Andropadus virens*
Little Sparrowhawk	*Accipiter minullus*
Livingstone's Flycatcher	*Erythrocercus livingstonei*
Lizard Buzzard	*Kaupifalco monogrammicus*
Long-crested Eagle	*Lophaetus occipitalis*
Madagascar Squacco Heron	*Ardeola idea*
Malachite Kingfisher	*Alcedo cristata*
Marabou Stork	*Leptoptilos crumeniferus*
Marsh Owl	*Asio capensis*
Marsh Tchagra	*Tchagra minutus*
Mosque Swallow	*Hirundo senegalensis*
Olive Sunbird	*Cyanomitra olivacea*
Open-billed Stork	*Anastomus lamelligerus*
Osprey	*Pandion haliaetus*
Pale Batis	*Batis soror*
Palm-nut Vulture	*Gypohierax angolensis*
Pied Crow	*Corvus albus*
Pied Kingfisher	*Ceryle rudis*
Pink-backed Pelican	*Pelecanus rufescens*
Pin-tailed Whydah	*Vidua macroura*
Piping Cisticola	*Cisticola fulvicapillus*
Plain Martin	*Riparia paludicola*
Purple Heron	*Ardea purpurea*
Purple-banded Sunbird	*Cinnyris bifasciatus*

Purple-crested Turaco	*Tauraco porphyreolophus*
Racket-tailed Roller	*Coracias spatulatus*
Red-billed Firefinch	*Lagonosticta senegala*
Red-billed Quelea	*Quelea quelea*
Red-eyed Dove	*Streptopelia semitorquata*
Red-winged Warbler	*Heliolais erythropterus*
Reed Cormorant	*Phalacrocorax africanus*
Retz's Helmet-Shrike	*Prionops retzii*
Ring-necked Dove	*Streptopelia capicola*
Rufous-bellied Tit	*Parus rufiventris*
Sacred Ibis	*Threskiornis aethiopicus*
Scarlet-chested Sunbird	*Chalcomitra senegalensis*
Shelley's Sunbird	*Cinnyris shelleyi*
Shikra	*Accipiter badius*
Silvery-cheeked Hornbill	*Bycanistes brevis*
Singing Cisticola	*Cisticola cantans*
Southern Blue-eared Starling	*Lamprotornis elisabeth*
Southern Brown-throated Weaver	*Ploceus xanthopterus*
Southern Cordon-bleu	*Uraeginthus angolensis*
Southern Grey-headed Sparrow	*Passer diffusus*
Southern Ground-hornbill	*Bucorvus leadbeateri*
Speckled Mousebird	*Colius striatus*
Spectacled Weaver	*Ploceus ocularis*
Spur-wing Lapwing	*Vanellus spinosus*
Striped Kingfisher	*Halcyon chelicuti*
Sulphur-breasted Bush-shrike	*Malaconotus sulfureopectus*
Tambourine Dove	*Turtur tympanistria*
Tawny Eagle	*Aquila rapax*
Tawny-flanked Prinia	*Prinia subflava*
Tropical Boubou	*Laniarius aethiopicus*
Trumpeter Hornbill	*Bycanistes bucinator,*
Variable Sunbird	*Cinnyris venustus*
Village Indigobird	*Vidua chalybeata*
Violet-backed Starling	*Anthreptes longuemarei*
Wattled Lapwing	*Vanellus senegallus*
Wharlberg's Eagle	*Aquila wahlbergi*
White-backed Vulture	*Gyps africanus*
White-breasted Cuckoo-shrike	*Coracina pectoralis*
White-browed Coucal	*Centropus superciliosus*
White-browed Robin-Chat	*Cossypha heuglini*
White-crowned Lapwing	*Vanellus albiceps*
White-fronted Bee-eater	*Merops bullockoides*
White-headed Saw-wing	*Psalidoprocne albiceps*

White-tailed Cisticola	*undescribed*
White-winged Widowbird	*Euplectes albonotatus*
Wire-tailed Swallow	*Hirundo smithii*
Yellow Bishop	*Euplectes capensis*
Yellow fronted Canary	*Serinus mozambicus*
Yellow-bellied Hyliota	*Hyliota flavigaster*
Yellowbill	*Ceuthmochares aereus*
Yellow-billed Stork	*Mycteria ibis*
Yellow-breasted Apalis	*Apalis flavida*
Yellow-rumped Tinkerbird	*Pogoniulus bilineatus*
Yellow-streaked Greenbul	*Phyllastrephus flavostriatus*
Zebra Waxbill	*Amandava subflava*

Families observed

Accipitridae
Alcedinidae
Anhingidae
Apodidae
Ardeidae
Bucerotidae
Campephagidae
Capitonidae
Charadriidae
Ciconiidae
Coliidae
Columbidae
Coraciidae
Corvidae
Cuculidae
Dicruridae
Estrildidae
Falconidae
Fringillidae
Glareolidae
Gruidae
Hirundinidae
Indicatoridae
Jacanidae
Malaconotidae
Meropidae
Monarchidae
Motacillidae

Musophagidae
Nectariniidae
Numididae
Oriolidae
Pandionidae
Paridae
Passeridae
Pelecanidae
Phalacrocoracidae
Phasianidae
Phoeniculidae
Picidae
Platysteiridae
Plocidae
Prionopidae
Psittacidae
Pycnonotidae
Rallidae
Rynchopidae
Scolopacidae
Scopidae
Strigidae
Sturnidae
Sylviidae
Threskiornithidae
Timaliidae
Turdidae
Viduidae

APPENDIX B

Larvicide study

Background

For the past year, the Dar es Salaam city council has been conducting trials of a brand of Biological larvicide granules known as VectoBac, the aim being to prove the efficacy of a preventative malaria control programme using this product. During these trials, the IHRDC has been acting as a consultancy in the areas of entomological, statistical and administrative analysis, where it has also provided PhD students and academic contacts.

During the tour, it was possible to see how larvicide granules could be applied by hand in most cases, except where mosquito habitats formed in the middle of sewage ponds. As can be seen in sketch A of Fig. 2, when the sewage ponds are flush with surface water, the mosquito lay larvae around the perimeter of the pond, within the 15m range of the diesel powered blowers purchased for the UMCP. However, when the pond is not flush with water (semi-dry) the surface is mostly faecal matter with small puddles of water accumulating throughout. In these cases, the mosquitoes will lay their larvae around the perimeter of the puddles, often beyond the 15m range.

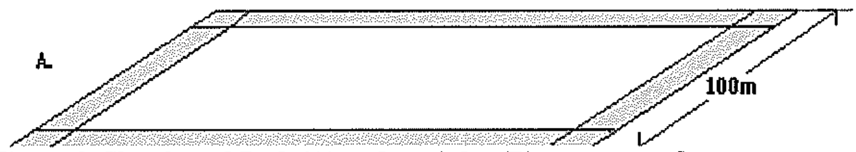
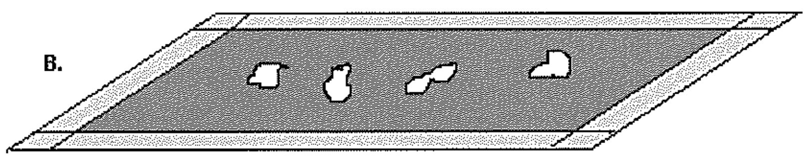


Figure 3: Sketches of flush (A) and semi-dry (B) sewage ponds.



While it is not physically impossible to extend the range of these blowers, cost is the ultimate barrier on a government programme with a limited budget.

Attempts at Solution

Bearing in mind any solution to this problem had to be low tech, low maintenance, and easily operable with little or no additional running costs to the UMCP, the following solution was devised:

- A bag made of mosquito net is filled with the granules.
- Like a salt-seller, when the bag is stationary, the granules do not fall but when it is shaken the granules fall at a steady rate.
- This bag was held over the 100m-wide ponds using three light sisal ropes; one main rope and two separate pull ropes that held it and could move it along the width of the pond if needed

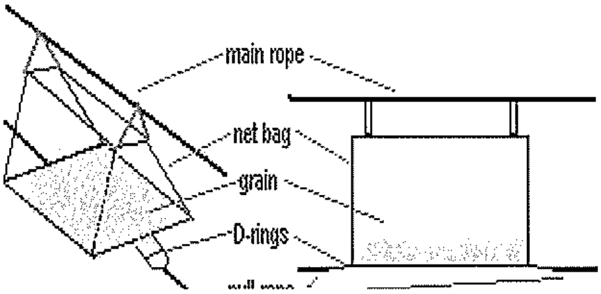


Figure 4: Sketch of the device used.

Proof of concept:

Samples of mosquito net were obtained and a grain sample to demonstrate the salt-seller principle to the UMCP department head. This was necessary to get the staff time and expenses needed to implement the idea.

Manufacturing

A local uniforms manufacturer agreed to make sample net bags for testing. This was due to the perceived interest other city councils would take in such a project, as well as the owner's personal obligation to such endeavours through membership of the local rotary club chapter. The manufacturer was Elastic Product Industries of Bibititi-Mohammed Road, Das es Salaam.

Operation

After the ropes have been attached and the net bag has been loaded, a worker stands on either side and just in front of the pond, holding both the main rope and one of the pull ropes. (1) The bag is then manoeuvred over the target area (2) and then agitated to dispense the granules (3).

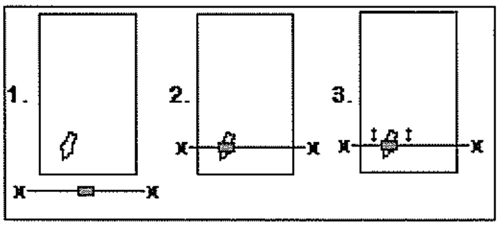


Figure 5: Plan view sketch of how the device was used.

When there are many targets, there is a compromise to be made between lightly filling the bag, which requires frequent reloads, and heavily filling the bag, meaning less manoeuvrability due to sagging.

In order for the bag to be positioned over any area of the pond, the sum of the pull rope lengths (see Fig 3.) should be 1 ½ times the width of the pond.

The base of the prototype net bag measured 10cm by 20cm. The ratio of mesh to grain diameters was approximately 1.3 and the net fabric was polyester, as it was expected cotton would not be as robust in this situation due to biodegradation, abrasion etc. Sewn into the base of the net bag is a 5mm diameter low-grade steel brace, to which a thin strip of material was looped around and sewn on either side to attach it to the D-rings (see Fig 3.). The purpose of this was to ensure that no tension from the ropes was exerted on the net fabric as this was found to cause tearing during the first attempt. For reference the device will be referred to as the ShakeBag.

Quantitative Testing

While the larviciding field officers were satisfied that the ShakeBag was fit for the purpose of targeting individual puddles, it was suggested by Dr Killeen that some quantitative tests should be carried out for any future reference or duplication of results that may be needed.

Data Type

Only one type of data was gathered for analysis, namely how many grains fell within a randomly chosen area within a simulated "puddle".

Heuristically, the measures of how effective the device was were decided to be the:

- Closeness of the mean to the recommended 4 grains per 10cm by 10cm area.
- Peakiness of the distribution curve about the mean (i.e. low standard deviation).

Below is a sketch of what we would have hoped the data to look like; a mean value of 4 with a low standard deviation.

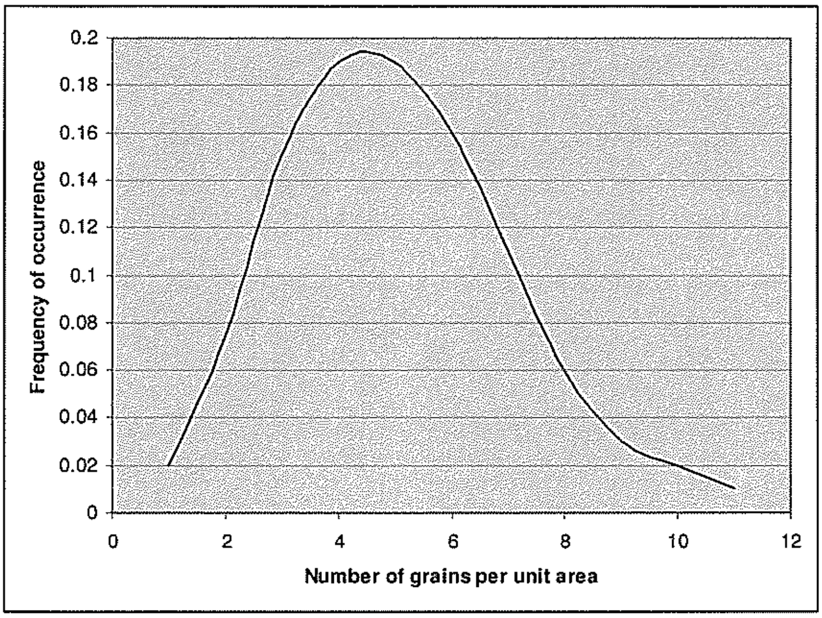


Figure 6: An ideal distribution.

Testing Method

The ideal testing scenario is one where the whole area of a completely dry, unused pond is available As well as allowing a large number of samples to be taken safely, it also represents the environment of intended use (i.e a wet or semi-dry sewage pond) as closely as possible. The main factors that were able to be represented were wind conditions as well as the relative heights of operators, bag and target.

The sketch below shows how plastic wash basins were filled with polystyrene cups in random positions (right) and then and then placed along the ground of the empty sewage pond in as straight a line as possible (left).

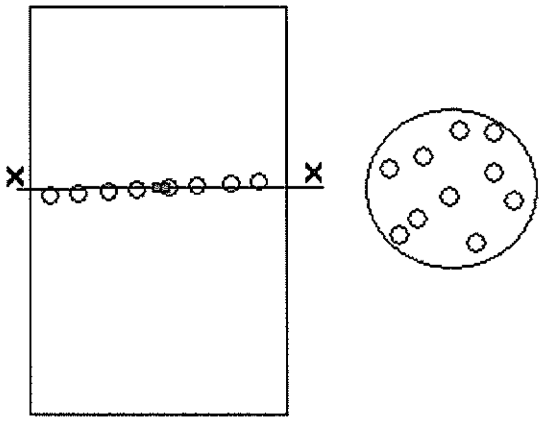


Figure 7: Sketch of Test Setup

The ShakeBag was then used to target each of these basins as if they were individual puddles. Afterwards, the average number of grains per cup and number of grains in each basin was recorded. There were 10 cups per basin.

Analysis and Summary

The standard measure for adequate treatment of an area was that there should be no fewer than 4 grains per 10cm x10 cm area ($0.01m^2$) of water. The aim of the analysis was to obtain a frequency distribution of grains per 10cm x 10cm area, on an integer scale of 1 to 10 (See Fig. 5).

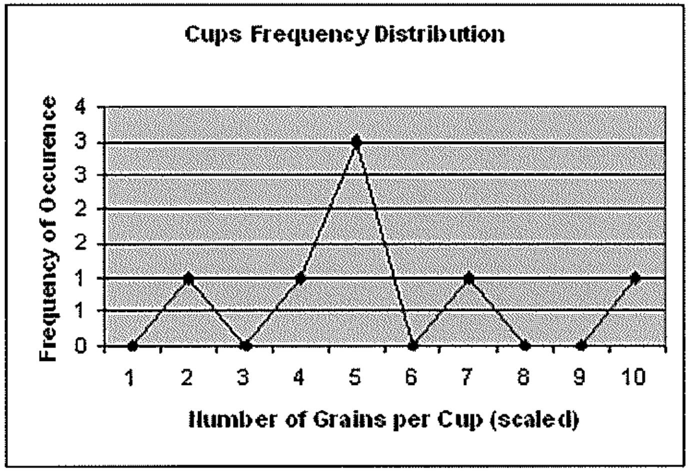
As there was no practical way of measuring out and randomly sampling 10cm x 10cm areas, basins were used to simulate puddles and cups were used as random samplers within the basins (See Fig 6.). For each simulated puddle, the number of grains per cup and grains per basin were scaled relative to a 10cm x 10 cm area.

Separate analyses were done for basins and cups. The primary data were:

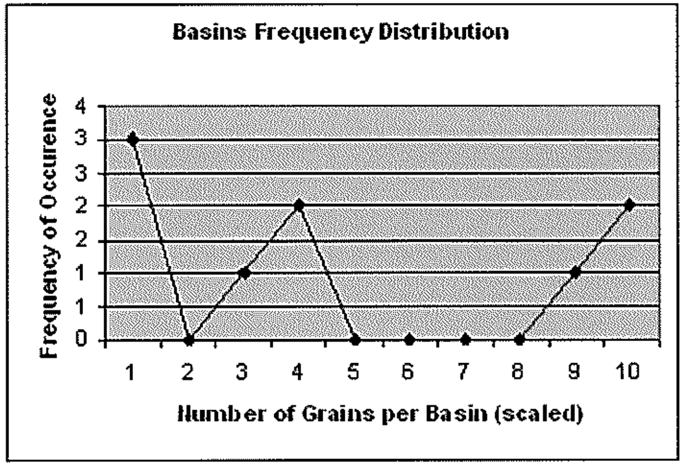
- Number of grains in each basin [integer]
- Total number of grains in all the cups of each basin [integer]
- Basin and Cup diameters [m]
- The results are summarised overleaf

Standard unit [m^2]	Basin Diameter [m]	Basin Area [m^2]	Basin Scale Factor	Cup Diameter [m]	Cup area [m^2]	Cup Scale Factor
0.010	0.530	0.221	0.045	0.065	0.003318307	0.331830724

Basin	Cups	Scaled Basin	Scaled Cup
56	307	2.538	10.187
200	600	9.065	19.910
30	60	1.360	1.991
100	220	4.533	7.300
40	125	1.813	4.148
20	150	0.907	4.977
225	150	10.199	4.977
225	400	10.199	13.273
90	165	4.079	5.475



Cup Bins	Cup Frequencies	Basin Bins	Basin Frequencies
1	0	1	3
2	1	2	0
3	0	3	1
4	1	4	2
5	3	5	0
6	0	6	0
7	1	7	0
8	0	8	0
9	0	9	1
10	1	10	2



Data on grains per cup above the 4 grain threshold could be further summarised as follows

Cups Overdosing

Grains Per cup	Overdose [% of 4 grains]	Frequency [%]	Weighted Overdose [%]
10	150	26	39
7	75	18	13.5
5	25	39	9.75
		Total Weighted Overdose [%]	62.25

Cups Underdosing

Grains Per cup	Underdose [% of 4 grains]	Frequency [%]	Weighted Underdose [%]
1	75	7.8	5.85
3	25	7.8	1.95
		Total Weighted Overdose [%]	7.8

Conclusions

Although the plotted distributions vary significantly from the ideal distribution described in 3.3.5, the following features were observed:

- Both plots have a significant peak in the target region of 4 to 5 grains
- The majority of the distribution is above the minimum 4 grains limit – there is only a 5% under dosing as measured from cups and a 14% under dosing as measured from basins.
- The maximum excess of the 4 grains threshold is 6 grains (10 grains per unit area).
- The final conclusions that could be drawn from this trial alone are:
- The ShakeBag under dosed 5% of the random cups.
- The amount of grain in cups above the minimum threshold was 62.25% more than what would be needed for all cups to have exactly the minimum number of grains
- The amount of grain in cups below the minimum threshold was 7.8% less than what would be needed for all cups to have exactly the minimum number of grains.
- In total therefore, the data indicates that the system used 62.25 – 7.8 = 54.45% more grain than needed, 5% of which did not go where it was needed.

Discussion

It could be argued that the final conclusion is a good reason not to adopt this system, as it seems to over use grains by a factor of 1 ½ and underdoses a statistically significant area However, the following counter arguments could be made:

- Assuming the cost of extra grain could be absorbed by the UMCP (especially seen as the sewage ponds are by far a minority area in the treated areas of the city), then the only issue would be the 5% of area under dosed.
- Even if cost is nonetheless an issue, the data may not be a fair representation of the system's effectiveness.
- More data would be more representative. It was not possible to obtain more data due to time and logistical difficulties.
- Overdosing is easier to remedy than overdosing. It could be argued that the over-dosing is attributable to the over-enthusiasm of the persons operating the system and that trimming the dose down would simply be a case of moving the ShakeBag more swiftly across the width of the pond while also making a conscious effort to not dispense as much grain (i.e more practice is needed).

APPENDIX C

Budget

			£
INCOME		Davis Fund	5000
		James Rennie Bequest	1710
		Weir Fund	4500
		Peter Marsh Prize	1000
		British Association Travel Fund	400
		Gilchrist Educational Trust	1500
		Royal Geographical Society	1250
		Royal Scottish Geographical Society	250
		Sir Leonard Rogers Fund	1000
		Frederick Soddy Trust	850
		Durham University	1200
		Edinburgh Trust No 2	750
		Personal Contribution	3600
		TOTAL	**23010**
EXPENDITURE	**Preparation**	Website	87.7
		Postage	89.5
		Membership Fees	60
		T-shirts	279.99
		Carbon neutral certification	115
		Brochures	81.5
		Travel	70.44
	Health & Safety	First Aid Courses	336
		First Aid Kit	187.6
		Insurance	891
		Prophylactics	1994
		Vaccinations	323.3
	Equipment	Satellite Phone	250
		Stereo Microscope	600
		Camera Lens	505
		GPS	89.99
		Binoculars	204
		Range Finder	69.95
		Memory card	66
		Batteries	33.7
		Mosquito Nets	119.9
		Mosquito Tent Traps	600
		Recharger	24.99
		Radios	70
	Travel	London - Dar es Salaam	3600
		Visas	300
		Dar es Salaam - Ifakara	60
		Ifakara - Dar es Salaam	60
	Accommodation	Dar es Salaam	294
		IHRDC	4200

	Villages	531
IHRDC	Internet	93
	4x4 hire	2400
	Laboratory Hire	320
Personnel	Research Assistants	1500
	Driver	1200
	Lab assistant	700
Post-project	Report printing	600
	Postage	40
	TOTAL	**23047.56**