

**INFECTIVITY RATES OF VECTORS OF BANCROFTIAN FILARIASIS
DURING WET AND DRY SEASONS IN MALINDI AND KWALE DISTRICTS
OF COAST PROVINCE, KENYA.**

BY

SICHANGI KASILI B.Sc.(Nairobi).

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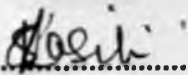
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DEDICATION

To my parents and J. Nyangasi, a dear friend.

DECLARATION.

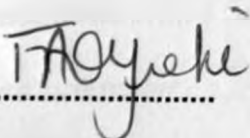
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Dr. F.A. OYIEKE(UoN)

SIGN. .....

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Dr. C.N. WAMAE (KEMRI)

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ABSTRACT

Bancroftian filariasis, a disease caused by *Wuchereria bancrofti*, is on the increase on the Kenyan coast with an estimated 2.5 million people at the risk of infection. Endemic zones on the Kenyan coast are Malindi, Kwale, Lamu, Tana River and Kilifi districts. Control of the disease is possible by chemotherapy, vector control and vector/man contact avoidance. For effective vector control and vector / man avoidance in Kenya, there is need for more environmental and weather specific vector studies in the endemic zones. Such studies include enquiry into the seasonal variation in infectivity rates of important vector species in a specified area so as to know when to protect oneself from infective mosquito bites and when it is most important to control the vector. This was the main issue of concern of this research.

Two study sites on the Kenyan coast known to have bancroftian filariasis were selected. These were Gazi in Kwale district and Madunguni in Malindi district. Houses and compounds from which mosquitoes were to be sampled were selected by simple random sampling. Three methods of mosquito collection were employed; Day resting indoor collection [DRI], Pyrethrum spray catch [PSC] and light traps. The mosquitoes collected were morphologically sorted out into species, females dissected and any *Wuchereria bancrofti* third stage larvae present recorded. A total of 1832 female mosquitoes were dissected in this study in two phases, the transmission [wet] season and the non-transmission [dry] season.

A significant difference [$\chi^2 = 3.05$ in Madunguni and 6.18 in Gazi, $P < 0.05$] was found in the vector infectivity rates between the two seasons. The difference was greater in Gazi whose infectivity rate was zero during the non-transmission period than Madunguni whose infectivity rate was 0.21% during the same period. *Anopheles gambiae s.l* was the main vector in both study sites. The others were *Culex quinquefasciatus* and *Anopheles funestus* in order of importance. It was concluded that there is a difference in infectivity rates of bancroftian filariasis vectors between the transmission season and the non-transmission season. The abundance of *An. gambiae s.s* during the transmission season could be responsible for the increased infectivity rates of vectors in this season.

*The wet and dry seasons in this thesis are specific for the year 1998 due to the El Nino effect. The dry season in this case was in October and September whereas the wet season was in June and July 1998.

CHAPTER ONE

1. INTRODUCTION AND LITERATURE REVIEW.

1.1 INTRODUCTION.

Lymphatic filariasis, a disease caused by filarial parasites, *Wuchereria bancrofti*, *Brugia malayi* and *Brugia timon*, is a major health problem with nearly 1.2 billion people living in endemic areas and 120 million having the clinical disease world wide [Shenoy *et.al*,1998].

A great deal is known about the biology of these filarial parasites and their transmission, their clinical manifestations, their treatment and control but many more people are infected with bancroftian filariasis today than more than 100 years ago when Manson described the first life cycle [Nelson, 1981]. *Wuchereria bancrofti*, which causes bancroftian filariasis, is the most wide spread and common species of human filariasis [Sasa,1976].

It is the only known etiologic agent in the African region [WHO, 1984 ;Wamae, 1994].

Bancroftian filariasis in Kenya is endemic in coastal districts of Lamu, Kilifi, Tana River, Kwale and Malindi [Wijers, 1977a]. In these foci, it is estimated that at least 2.5 million people are at risk of infection [Wamae *et.al*,1998]. The main mosquito genera involved in transmission of *W. bancrofti* in these areas are *Anopheles*, *Culex* and *Mansonia* [Mattingly,1969, Goma, 1966]

Wijers [1977a] identified four main filariasis foci of human microfilaraemia rates of more than 25% on the coast province of Kenya. These are; a focus in the south bordering Tanzania, a focus West of Mombasa, a focus just inland from Kilifi town and a focus along Sabaki River. Whilst the hinterland of Kwale and Malindi districts [focus bordering Tanzania and that along Sabaki river] have been described as being among these foci ,few vector studies have been done in these areas[Wijers,1977a].

Wijers [1977b], working along the Kenya coast found out that the prevalence [filariasis index below 50%] of the disease in human population was lowest in areas with the highest rainfall and highest population density. However no explanation was given to these findings especially in light of vector infectivity or infection rates. In their entomological study, Wijers and Kiilu [1977] working in Mambrui and Jaribuni showed that the peak transmission in the former was during the long rains and after the short rains in the latter. In the same study during the hot dry season transmission was interrupted in Mambrui and very low in Jaribuni. After the studies of Wijers and Kaleli [1984], it was concluded that transmission season of bancroftian filariasis coincides with the long rains within which *Anopheles* vectors are abundant, but there were no clear records of vector infectivity rate relationship with the transmission season and the non-transmission season. Besides, it is now known that *Anopheles* vectors and *Cx. quinquefasciatus* have equal transmission potential [Mwandawiro *et al*, 1997] yet according to the former findings the abundance of the Anopheline vectors in the rainy season was postulated to be the main cause of rise in transmission during the wet season. No efforts were made to study the environmental and

climatic factors , which could affect the abundance and vector infectivity of vectors in general.

This study was conducted in two settings in Kwale and Malindi districts with the aim of determining the vector infectivity and infection rates difference between the dry season and wet season, identifying the environmental and climatic parameters which may affect the abundance and infectivity of bancroftian filariasis vectors. It is envisaged that the results will provide relevant information which may assist in efforts towards the reduction of lymphatic filariasis prevalence in these areas. For instance the environmental settings and time of the year during which vector control should be intensified , coupled with man/vector contact avoidance could very much depend on the results.

1.2 LITERATURE REVIEW

1.2.1 Vectors

Vectors of bancroftian filariasis differ from other disease vectors in that they may include members of entirely different genera not taxonomically related to each other [Sasa, 1976]. So far human mosquito-borne filariasis has been recorded from four main genera worldwide namely, *Anopheles*, *Aedes*, *Culex* and *Mansonia* [Mattingly, 1969]. Transmission of a particular form of the disease i.e whether diurnal or nocturnal is further

limited to certain species within the genera [Sasa, 1976]. In their entomological study in French Polynesia, Lardex *et. al.* (1995), found 2.8 % of the *Aedes polynensiesis* mosquitoes infective. These were therefore considered as better vectors in the transmission of Bancroftian filariasis in this region. *Aedes porcillus* was the best vector of *wuchereria bancrofti* in a Phillipine village (Valeza and Grove, 1979). Hoedojo *et. al.* (1980) carried out a survey on mosquito fauna to determine the vectors of Bancroftian filariasis in West Flores region, Indonesia and found that *Anopheles subpictus* was a potential vector. Elsewhere, *An. punctulatus* in Papua New Guinea, *Culex quinquefasciatus* in a state of Alagoas, Brazil and *Cx. quinquefasciatus* in West Bengal, India were found to be important vectors by Bryan *et. al.* (1995), Das *et. al.* (1997) and Adhikari & Halder (1995) respectively.

Refractory mechanisms against *W. bancrofti* infection reduce the importance of potential vectors in a given ecological setting [Bryan *et al* 1974]. Microfilariae encounter cibarial and pharyngeal armatures in the head capsule of the mosquito which mechanically abrade the sheaths and cuticles of microfilariae as they pass through the fore gut. *Anopheles gambiae* s.s kills about 50% of the ingested *W. bancrofti* microfilariae while *Culex quinquefasciatus* kill only 5% [Bryan *et. al* 1974]. Other refractory mechanisms exist such as blood clotting which trap the microfilariae, peritrophic membrane resistance to passage of microfilariae, putative antifilarial toxins and digestive enzymes among others. Bryan *et al* [1974] gave a detailed review of the effects of different vector refractory mechanisms on *W. bancrofti* microfilariae.

The malaria vectors, *Anopheles gambiae* s.l. Giles and *Anopheles funestus* s.l. Giles have been incriminated as major vectors of bancroftian filariasis together with *Culex quinquefasciatus* Say in East Africa [Nelson et al., 1962; White, 1971; Wijers and Kiilu, 1977]. Exhaustive investigation by several authors on the Kenya coastal strip reported infections of infective stage *W. bancrofti* larvae in these mosquitoes [White, 1971; Nelson et al., 1962; Hawking, 1974; Mosha and Mutero, 1982; Mwandawiro et al. 1997].

On the Kenyan coast, Nelson et al. [1962] demonstrated that *Anopheles* are the most important vectors in lymphatic filariasis transmission. That malaria vectors, *An. gambiae* and *An. funestus* are principle vectors of filariasis throughout much of Africa is supported by findings of Gelfand [1955b], Muirehead-Thomson [1954] and Taylor [1930] in West Africa.

White [1971] working in the North Eastern Tanzania showed that *Cx. quinquefasciatus* was the commonest man biting mosquito although it was by far the least involved in the transmission of *W. bancrofti*. He therefore concluded that the risk of infection from bites of infective mosquitoes was due to *An. funestus* and *An. gambiae*. *Culex quinquefasciatus* was however recorded by Magayuka and White [1972] as an efficient laboratory vector.

During experimental infections of mosquitoes with *W. bancrofti*, it was found out that 54% of *Cx. quinquefasciatus* contained infective larvae after 14 days compared with 9% of *An. gambiae* [Wayne, 1973]. In the same experiment, *An. gambiae* s.l. had very low mortality compared to *Cx. quiquefasciatus*. Filarial nematodes are pathogenic to mosquitoes and

mortality depends on the intensity of microfilariae ingested in the blood meal [Sasa, 1976]. Mosquitoes which do not ingest a large number of microfilariae may be better vectors in areas where microfilarial density is high [Wayne, 1973].

In their studies on Kenyan coast, Nelson *et. al.* [1962], Wijers & Kiilu [1977] and Wijers & Kinyanjui [1977] reported that *Cx. quinquefasciatus* was the main vector for bancroftian filariasis in coastal towns and villages but in the rural hinterland villages of coast province *An. gambiae s.l* and *An. funestus* were more important. All three vectors were found active in rural districts around Muheza, Tanzania with infectivity rates of 6.1%, 2.4% and 0.54% for *Anopheles funestus*, *An. gambiae* and *Cx. quinquefasciatus* respectively [White, 1977]. In Mamburi and Jaribuni of the Kenyan coast, of the *Cx. quinquefasciatus* dissected the proportion infected was 5.7% and the proportion infective was 0.97%. For *An. funestus* the proportion infected was 3.5% and those infective was 0.99% [Wijers and Kiilu, 1977]. Their results, recorded as infectivity rates against each month for a year, generally showed low transmission during the dry season as compared to the rainy season.

Other studies on the south coast of Kenya demonstrated high rates of infective larvae of *W. bancrofti* of 11.8% in *An. gambiae s.s.* and 1.1% in *An. merus* [Moshia and Mutero ,1982]. Studies on filarial infection in Lamu and Tana River districts showed no infection in mosquitoes [Mwandawiro, 1990]. In a more recent study in Lutsangani, Dzivani and Gandini in Kwale district infectivity rates of dominant mosquito vectors varied with the method of collection, For instance *An. gambiae* and *An. funestus* were found to be infective from catches by three methods, that is ,pyrethrum spray catch, human bait

technique and indoor resting collection but *Cx. quinquefasciatus* mosquitoes were only found to be infective from those collected by human bait technique [Mwandawiro *et. al.*, 1997]. The results of this study indicated that all the three dominant mosquito species appear to be significant vectors for bancroftian filariasis in the rural hinterland though the order of importance changed from place to place in response to certain local ecological factors and individual species requirements yet to be elucidated.

1.2.2. Vector infectivity and abundance in relation to climatic and environmental factors

The vectorial capacities of incriminated vectors vary with ecological zones depending on the suitability of the vector to the environment and climate [Sasa, 1976]. For example the distribution and population oscillations of *An.gambiae* complex sibling species within the tropics were found to be critically regulated by rainfall [Horsfall, 1972]. The environment influences the breeding places of mosquito vector species i.e *An. funestus* characteristically breeds in clear water bodies that are either large or more less permanent e.g swamps [near edges if deep], weedy sides of streams, furrows and ponds [Horsfall, 1972]. Horsfall [1972] also reported *An. gambiae s.l.* breeding on surfaces of rain pools during rainy seasons and along rivers during the dry season. On the other hand, *Cx. quinquefasciatus* breed in almost all sorts of water surfaces especially in discarded domestic containers and ground pools where sewage disposal is inadequate [Horsfall, 1972]. Samarawickrema *et. al* [1982] found coconut husk pits important as breeding places for *Cx. quinquefasciatus* mosquitoes on the coastal belt of Sri Lanka.

The most important vectors of bancroftian filariasis in the African region are *An. gambiae*, *An. funestus* and *Cx. quinquefasciatus* [Wijers and Kiilu, 1977; Colluzi *et al*, 1979]. There are six sibling species of *An. gambiae* complex namely, *An. arabiensis*, *An. gambiae* s.s, *An. merus*, *An. melas*, *An. quadriannulatus* and *An. bwabwae* [White, 1974]. Of the six, only three have been identified on the East African coast i.e, the salt breeding *An. merus* and the fresh water breeding *An. gambiae* s.s and *An. arabiensis* [Mosha and Petrarca, 1983]. Of the three, *An. gambiae* s.s was found to be the best vector of bancroftian filariasis on the Kenyan coast [Mosha and Petrarca, 1983]. The distribution of *An. gambiae* s.s and *An. arabiensis* [which are most closely associated with man and are major vectors of malaria and filariasis] overlaps extensively and were found to occur sympatrically in East Africa [Rishikesh *et al*, 1985]

In general *Anopheles gambiae* s.s was found by White [1974] to predominate in the humid situations where as *An. arabiensis* was successful in drier situations. White *et al* [1972] reported an abrupt replacement of *An. gambiae* s.s. by *An. arabiensis* as a dominant species of *An. gambiae* complex due to change from rainy season to the dry season. The adaptation to various seasons seemed to have a genetic bearing. The polytene chromosome differences found among species of *An. gambiae* complex consisted essentially of change in band sequences due to paracentric inversions [Colluzi, *et al* 1979; Colluzi *et al* 1985]. The expected number of fixed inversions was in this study found on chromosome 2. The distribution of the 29 polymorphic inversions differed and were non-random. Chromosome 2R represented 30% of the polytene complement and it carried

more than 60% of the polymorphic inversions [Colluzi *et al*, 1979]. Marked geographical variations in distribution and frequency of polymorphic inversions were observed in *An. gambiae s.s* and *An. arabiensis*. According to Colluzi *et al* [1979], the frequencies were correlated with climate and vegetational patterns. In particular the frequencies of chromosomal inversions 2Ra in *An. gambiae s.s* and the inversions 2Rbc, 2Rd and 2La in *An. arabiensis* increased gradually in progressively more arid areas [Rishikesh *et al* 1985]. The carriers of chromosomal arrangement 2Rbc, 2Rd and 2La showed advantage in terms of drought tolerance over carriers of other arrangements during the dry months in Northern Nigeria [Rishikesh *et al.*, 1985]. The proportion of the two *An. gambiae s.l.* species were also observed to vary seasonally and from area to area [Service, 1989]

Work done in humid zones showed that *An. gambiae s.s* were predominantly anthropophilic and endophilic [White, 1974 ; Colluzi, *et. al.*, 1979 ; Highton *et. al.* 1979]. Coupled with high human blood index [HBI], *An. gambiae s.s* had the highest vectorial capacity as opposed to other sibling species [White, 1974]. *An. arabiensis* females were found to be predominantly exophilic [White, 1974]. Among populations of *An. arabiensis* caught in Nigeria, Colluzi *et al* [1979] found chromosome inversions 2Ra. *Anopheles funestus* frequent human quarters but houses where smoking fires are maintained yield few or no mosquitoes and they were observed to feed preferably on man but also fed on other animals [Horsfall, 1972]. *Anopheles funestus* breeding sites as recorded by Wijers and Kiilu, [1977] are clear water, river marginal vegetation among others. During the hot and dry season, these mosquitoes had reduced infectivity due to the

decreased lifespan [Wijers and Kiilu, 1977]. Adult *Cx. quinquefasciatus* mosquitoes occupy houses inhabited by man but they were also found by Horsfall [1972] in livestock houses and barns, the resting conditions being mainly the dark and overcrowded houses. They are indiscriminate in their host choice [Horsfall, 1972]. A difference in the longevity or lifespan of *Cx. quinquefasciatus* between the wet and dry seasons i.e. high during wet season and low during the dry season is known to exist. Peak transmission during the long rains and the interruption of transmission during hot dry season was linked to these factors by Wijers and Kiilu [1977]. *Aedes aegypti* was found to be an occasional transmitter of *W. bancrofti* larvae. Since its biting was observed to be primarily diurnal [Wijers and Kiilu 1977], it was regarded as being of no medical importance under natural conditions in nocturnally transmitted filariasis.

1.2.3. *Wuchereria bancrofti* [Cobbold, 1887] and transmission of infective larvae.

Wuchereria bancrofti is the etiological agent of bancroftian filariasis [Sasa, 1976]. Its development was for the first time demonstrated in the mosquito *Cx. quinquefasciatus* by Manson in 1887 [Mattingly, 1969]. Since then the parasite has been isolated from three other genera, that is, *Anopheles*, *Aedes* and *Mansonia* [Cheng, 1986].

The adult worms found in lymphatic systems of vertebrate hosts are slender, thread-like and measure up to 10 cm. and 5 cm. long in females and in males respectively. The female on mating releases numerous microfilariae in the vertebrate host which escape into the host's blood stream. Microfilariae measure 150-350 μ . It is from here that they are

picked by mosquitoes while feeding. In the mosquito, the development of the sheathed microfilariae take place. They pass through the fore gut, penetrate the stomach wall to the thoracic muscles where they develop to third larval stage which is also the infective stage. The life cycle of *W.bancrofti* was given by Sasa, [1976] and Mattingly [1969]. The infective stage of larvae spreads evenly in the body of the mosquito unlike those of *Brugia malayi* which concentrate mainly in head and proboscis [Mwandawiro, 1990]. Transmission to the human host occurs when the infected mosquito takes another blood meal. The microfilariae of *W. bancrofti* are differentiated from other species of microfilariae by the presence of a sheath, staining properties, size, shape of the tail and the arrangement of the body nuclei [Denham and McGreevy,1977]. In *W.bancrofti* three races have been recognized: the nocturnally periodic race, diurnally subperiodic race and the nocturnally subperiodic race [Sasa, 1976]. The nocturnally periodic race is spread throughout tropical and subtropical zones and is transmitted by *Culex* and *Anopheles* mosquitoes [Mattingly, 1969]. The transmission event is favored by environmental temperatures of 26-32⁰ C and high humidity of 40-90% [Wijers, 1977b]. This is because larvae escape from the proboscis into a drop of fluid and have to find their way in this medium into the puncture wound before the fluid evaporates. Temperatures and humidity were regarded important for transmission of larvae in to the human hosts as well as their development in mosquitoes [Wijers and Kiilu,1977].

1.2.4 Pathology, symptomatology and prevalence of Bancroftian filariasis .

Though not considered to be a major cause of mortality, bancroftian filariasis morbidity

is devastating and is a crippling affliction that can cause social and economic hardships at both individual and community levels [Wamae, 1994]. In many individuals host responses to host/parasite interactions cause episodic bouts of incapacitating fever and lymphatic abscess [Sasa,1976]. Repeated and prolonged infections result in the development of chronic manifestations such as oedema fibrosis and finally an irreversible state of elephantiasis [Goma, 1966]. Elephantiasis is a consequence of enormous enlargements of external genitalia, breast and limbs. This is, in part, as a result of an obliterative endolymphangitis caused by an allergic reaction to the adult worms [Wijers, 1977a], mechanical damage to the endothelium and secondary fungal and bacterial infections [Dreyer *et al* 1992].

The presence of living worms in the lymphatics leads to the dilation of the afferent lymphatic vessels and leakage of lymph into the tissue[causing lymphoedema] with an increase in the tissue fluid content. Hydrocele or lymph scrotum is a result of rupture of varicose lymph vessels which leads to the accumulation of lymph in the scrotum[Wijers, 1977a]. It has been suggested by Jordan [1955], Nasah [1978], Nwafo *et al*,[1981] and Ekwere [1989] that there is a link between infection and male sterility. Chyluria is caused by rupture of lymph varices in to any part of the of the urinary tract [Wijers,1977a]. A minority of infected subjects may also have gross hematuria [WHO,1992 ;Dreyer *et al* 1992]]. This is due to the blockage of retroperitoneal lymph nodes below the cisterna chyli with consequent reflux and flow of intestinal lymph directly in to the renal lymphatics, which may rupture and permit flow of chyle in to the urinary tract. In Kenya Kwale district, hematuria was found to be linked to *Schistosoma haematobium* infections [Wamae and

Lammie, 1998]. Renal reports of glomerulonephritis in patients with bancroftian filariasis exist in literature [WHO, 1992]. Body systems most frequently found to manifest filarial disease is the genitalia in males leading to hydrocele and epididymitis [Dondero *et al.*, 1976]. These develop primarily after puberty and the prevalence appear to be age dependant [Wijers, 1977a].

Bancroftian filariasis occurs in endemic areas throughout the tropical parts of the world with a predilection for developing countries where socioeconomic conditions are favorable for mosquito vector breeding [Cunningham, 1997]. This is mainly because of poor environmental maintenance. Bancroftian filariasis in Kenya is endemic in Malindi, Lamu, Tana River, Kilifi and Kwale districts of the Coast Province [Wijers, 1977b]. On Pate island bancroftian filariasis has been known since 1910 [Heisch *et al.*, 1959].

Wijers, [1977a] did a filarial survey in coastal districts known to have *W. bancrofti* and the infection rates for the male population examined ranged from 28.4% to 56% while the sign rate was 32%. Microfilarial densities were twice as high in the Northern part of Kilifi as in the Southern part of Kwale. Out of 5004 men examined, 100 had leg elephantiasis and 32 scrotal elephantiasis. In the two Northern districts of Lamu and Tana River there were low microfilarial densities and moderately high sign rates [23.3%], the sign rates mainly occurring in the older men. A sign rate is the proportion of the human population carrying microfilariae together with those presenting clinical manifestations. Hydroceles and elephantiasis rates increased with age [Wijers, 1977a].

Nelson *et al.* [1962] carried out a survey on the 10 km. Coastal strip area and areas along

Tana and Sabaki rivers in which microfilarial rates among human population ranged from 10% in the South to 25% in North.

Later studies indicated that the microfilarial prevalence in Maili Nane, Kinango, in Kwale district was 22.4% [Wamae *et al.*, 1989]. In more recent studies the microfilaremia rates in Mvurmoni and Kilore, two adjacent communities in Muhaka, Kwale district, was 6.3% and 24% respectively [Wamae *et al.*, 1998] thus emphasizing the focal nature of the disease prevalence.

1.2.5. JUSTIFICATION

Bancroftian filariasis is major cause of morbidity in endemic areas. Besides, it has also been incriminated as a cause of male infertility, thus being of social and economic concern. With an estimated 2.5 million people at risk of infection with the disease on the Kenyan Coast, there is need for control. Man/ vector contact avoidance, chemotherapeutic intervention and vector control are the options available. For application of any of these options, factors influencing the vector abundance and infectivity rates need to be clearly understood. Many workers have carried out studies on vector population dynamics, drug trials and vector control strategies. None addressed the reason for increased human infection of the disease during the rainy seasons in relation to vector infectivity on the Kenyan coast. The current study addresses this problem and attempts to explain why this is so.

1.2.6. Objectives.

1. To compare the infectivity rates of bancroftian filariasis vectors between the wet and dry seasons.
2. To determine the effect of rainfall and relative humidity on the infectivity and infection rates in mosquito vectors.
3. To assess the effect of house type and its environs on the mosquito vector abundance and infectivity rates.

CHAPTER TWO

2. MATERIALS AND METHODS

2.1 selection of study sites

Two sites, Madunguni in Malindi district and Gazi in Kwale district were chosen for the study. Madunguni is a rural setting which is 20 km. North-West of Malindi town, on the valley of Sabaki River. The terrain in most of the region is flat and sometimes covered by the floods of River Sabaki. The inhabitants are the Giriama, a sub-tribe of the Miji-Kenda group of the coastal people. They live in Giriama type of houses, mud walled and makuti thatched, [plate 1] which are sparsely spaced. Stone walled and iron sheet roofed houses are extremely rare. Makuti walled and thatched are substantial in number. Goats and cattle are the common livestock whereas coconuts and cassava are the main crops. Goats and calves are kept in residential houses. This area was selected because it lies within the main filariasis foci along the Kenyan coast [Wijers 1977a].

Gazi is a small village town a few metres from the sea, about 60 km. to the North of Mombasa town. The terrain gently slopes towards the sea. The main crops of the Digo, the

inhabitants who are also the Miji-Kenda, are coconuts and cashewnuts. Very few livestock are kept. These people live in swahili type of houses which are close together. There are a few latrines which are normally part of the houses. Bushes forms better part of the town periphery. Gazi was chosen for it's easy accessibility and being within the main filariasis foci [Wijers 1977a].

Fig.1. Map showing the study sites locations

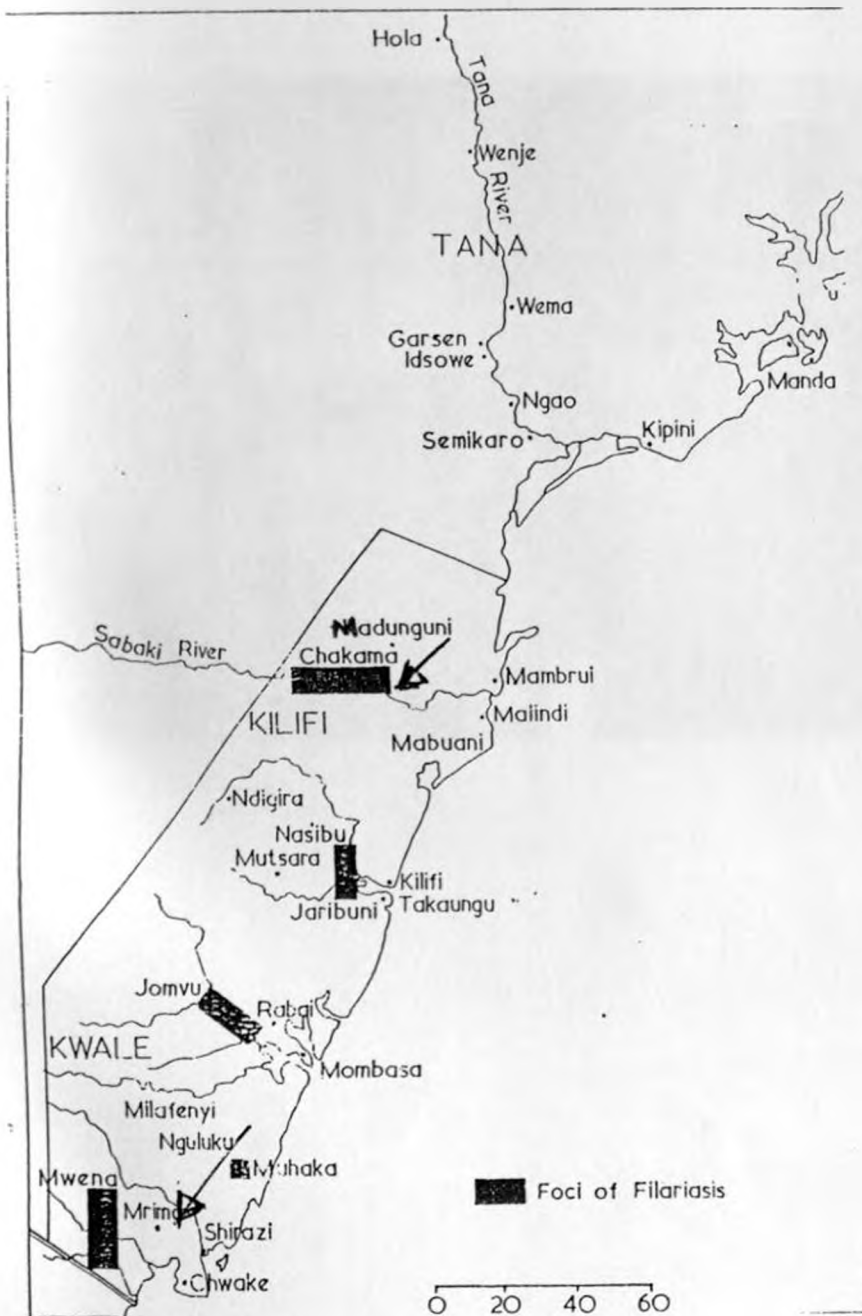


Plate 1. Mud walled and makuti thatched house common in Madunguni.



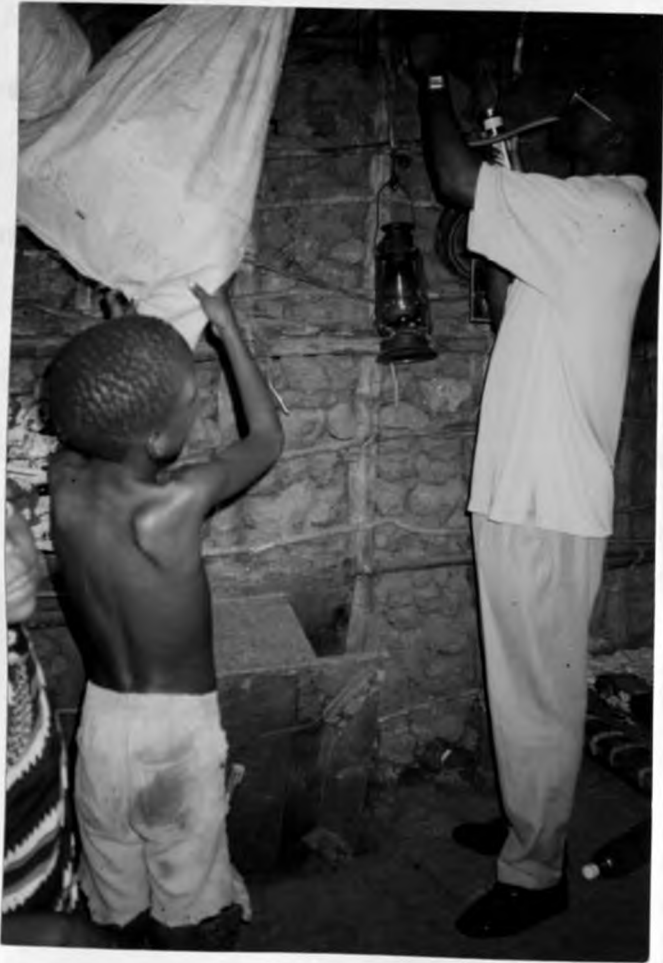
2. 2. Mosquito sampling technique

Collection of mosquitoes was done at two time points, the wet season [June/July 1998] and dry season [September/ October 1998]. Thirty-two houses from Madunguni and seven-teen from Gazi were randomly selected from or around which mosquitoes were sampled by simple random sampling method. Due to the small size of Gazi fewer houses were selected because not everyone will accept to have his house sampled. Secondly, it would not be a sample if all the houses in this small region are selected. These houses were categorized into different groups depending on the material which they are made of i.e makuti-thatched mud-walled, makuli walled and thatched, stone-walled and makuti-thatched, stone-walled and ironsheet roofed and grass thatched and mud-walled. Due to the small size of Gazi few houses were selected compared to Madunguni rather than sampling from every house.

Three methods were used for mosquito collection. Firstly, was the day resting indoor collection [DRI],-plate 2. This involved searching of the indoor resting mosquitoes from the walls ,thatch and other objects in the house. By the help of a torch light seen mosquitoes were aspirated by an aspirator between 0700- 0900hrs for a period of 15 minutes by two people per house. The aspirated mosquitoes were stored in paper cups,placed in a cool box and transported back to the laboratory. Secondly was the pyrethrum spray catch [PSC] which involved spreading of white sheets on the beds and floors of houses in which

people had slept the previous night. Pyrethrum spraying was done by hobra sprayer in the eaves first to restrain the mosquitoes from escaping to the outside and then inside of houses. The doors were closed and after 5-10 minutes the knocked down mosquitoes were collected by the help of a pair of forceps, placed in labelled petri dishes and put in a cool box for transportation to the laboratory. Spraying was done from 0700-0830 hrs and each house was sprayed twice a week. Lastly, light traps were set up at 1900 hrs and collected the following day at 0700hrs. Traps were hung under eaves of houses or trees in the compound. Mosquitoes were aspirated from the collection net of the trap into the paper cups which were put in the cool box for transportation. Two methods of mosquito collection [DRI &PSC] were used in all houses within the study areas. Light traps were set only in four compounds randomly selected at each trapping in both study areas.

Plate 2. Mosquito collection by day resting indoor collection method



2.3 Laboratory processing

In the laboratory some mosquitoes transported while still alive [caught by DRI and light traps] in paper cups were killed by chloroform. The dead mosquitoes were sorted out into respective species by their morphological characteristics according to Gillet [1972]. The other feature examined was the abdominal status i.e whether gravid, half-gravid, blood-fed or unfed. The female mosquitoes were then dissected, first by separating the three parts of the mosquito into head, thorax and abdomen and later each part dissected separately, but on the same slide. *Wuchereria bancrofti* larvae were sought in the abdomens, thoraxes and heads. Identification was done according to Chandler and Read [1969]. The L3 (third larval stage) were identified mainly by the caudal papillae after staining with giemsa stain. The much slender L1 (first larval stage) stage were identified by their possession of a sheath and lack of nuclei in their tapering tails and the L2 (second larval stage) by the thickened sausage- shape

CHAPTER THREE

3. RESULTS

3.1 Rainfall and relative humidity of study areas .

The weather data for study sites are shown in tables 1a and 1b below from October 1997 to October 1998 and they indicate low rainfall means in September and October 1998. This was taken to be the non-transmission period because they were the driest months. Table 2a and 2b show the average R H and rainfall means for five years before study period in the study areas. Both tables indicate drier months as January, February and September. In both Table 1a and 1b, the high rainfall means in October and November 1997 were as a consequence of the El Nino weather phenomenon and therefore not the normal levels in the study area. The same applies to the relatively high rainfall rates in January and February 1998. Mosquitoes for this study were collected during the last two months of the rainy season [June and July] because during the peak of the long rains [April and May] in Madunguni, flooding occurs hence rendering the place inaccessible. Besides mosquito larvae are washed away when flooding occurs. This season was then taken to be the transmission [wet] season. The average R H and rainfall means for five years before the study period in study sites indicate that these months are always wet. The dry season (non transmission) for this study was taken to be September and October 1998.

Both Tables 1a and 1b show highest R.H means in October 1997 and lowest in March 1998. They also show that the RH means were higher in the transmission season than in the non transmission season.

Table 1a. Mean monthly relative humidity and rainfall for Malindi district . [Meteorological data from Kenya Agricultural Research Institute(KARI), Musabaha sub regional centre.]

MONTH	R. H MEANS(%)	RAINFALL MEANS (mm)
Oct. 1997	82	20.28
Nov.	81.2	11.1
Dec.	78.5	5.1
Jan. '98	81	5.4
Feb.	76	1.3
Mar.	72	1.1
Apr.	77.5	14.3
May	78	9.6
Jun.	79	9.5
Jul.	80	3.8
Aug.	77.5	1.6
Sept.	74	0.76
Oct.	69	0.4

Table 1b. Mean monthly relative humidity and rainfall monthly for Kwale district. [Meteorological data from Msambweni divisional Headquarters-Agriculture department.

Oct.'97	84.5	12.03
Nov.	81.5	186.5
Dec.	79	6.4
Jan.'98	80.5	2.04
Feb.	78	2.9
Mar.	76	3
Apr.	79.5	8.8
May	77.5	9.5
Jun.	79.5	11
Jul.	80.5	3.9
Aug.	76.5	2.1
Sep.	76.5	1.3
Oct.	69	0.3

Table 2a. Average R.H. means (%) and rainfall means (mm) for five years(1993 – 1997) before study period in Madunguni. – Data from Musabaha Agricultural Sub regional centre (KARI).

Jan.	70.7	0.72
Feb.	68.2	0.11
Mar.	67.3	0.99
Apr.	75	6.36
May	76	12.8
Jun.	77.7	4.6
Jul.	77.3	4.9
Aug.	76.4	1.4
Sep.	75.5	1.2
Oct.	75.4	5.1
Nov.	75.3	4.7
Dec.	72.1	3.2

Fig.2b. Average R.H. means (%) and rainfall means (mm) for five years(1993 – 1997) before study period in Gazi. – Data from Msambweni Agricultural Divisional Office.

Jan.	67.5	0.12
Feb.	67.5	0.14
Mar.	67	0.8
Apr.	76	8.5
May	80	12.5
Jun.	83.5	2.3
Jul.	81.5	3.7
Aug.	74	1.4
Sep.	72	1.4
Oct.	82	2.7
Nov.	81.5	4
Dec.	78.5	1.4

3. 2 Infection and infectivity rates of mosquito vectors.

A total of 1832 female mosquitoes were dissected in this study and infection and infectivity rates were calculated for the two study sites, Gazi and Madunguni as follows:

Infectivity rate= no. of mosquitoes carrying L3/ no. dissected multiplied by 100.

Infection rate=no. of mosquitoes carrying L1,L2,& L3/ no. dissected multiplied by 100.

Table 3a and table 3b below show the infection and infectivity rates of mosquito vectors in Madunguni. Infection rates were 3.99% and 1.04% in the transmission season [June/July 1998] and non transmission season [September 1998] respectively. Infectivity rates were 1.49 for the transmission season and 0.21 for non-transmission season.

Table 3a. The infectivity and infection rates of mosquito vectors in Madunguni during the transmission season-June / July, 1998.

Mosquito species	No. dissected	No. Containing L1	No. Containing L2	No. containing L3	Infection rates %	Infectivity rates %
Cx. q	241	2	3	1	2.49	0.41
An.g	90	2	3	5	11.1	5.6
An .f	36	0	0	0	0	0
M. a	19	0	0	0	0	0
M. u	13	0	0	0	0	0
An.s	2	0	0	0	0	0
Total	401	4	6	6	3.99	1.49

Table 3b The infectivity and infection rates of mosquito vectors in Madunguni during the non-transmission season-September/ October, 1998.

Mosquito species	No. dissected.	No. Containing L1	No. Containing L2	No. Containing L3	Infection rates %	Infectivity rates %
An. g	175	2	1	1	2.3	0.6
An. f	121	0	0	0	0	0
Cx. q	136	1	0	0	0.7	0
M. u	43	0	0	0	0	0
An. s	4	0	0	0	0	0
Ae. f	1	0	0	0	0	0
Total	480	3	1	1	1.04	0.21

Tables 4a and 4b below show the infection and infectivity rates of mosquito vectors in Gazi. Infection rates were 3.16% and 0.42% in the transmission and non transmission seasons respectively. The infectivity rates were 1.69% and 0% respectively for the transmission and non transmission seasons.

Table 4a. The infection and infectivity rates of mosquito vectors in Gazi during the transmission season-June/July, 1998.

Mosquito species	No. dissected	No. Containing L1	No. Containing L2	No. Containing L3	Infection rates	Infectivity rates
Cx. q	186	4	1	5	4.37	2.68
An. g	12	0	0	2	16.6	16.6
An. f	266	3	1	1	1.87	0.38
M. a	2	0	0	0	0	0
Ae. a	4	0	0	0	0	0
An. n	1	0	0	0	0	0
Total	471	7	2	8	3.16	1.69

Table 4b. The infection and infectivity rates of mosquito vectors in Gazi during the non-transmission season-September and October 1998.

Mosquito species	No. dissected	No. Containing L1	No. Containing L2	No. Containing L3	Infection rates %	Infectivity rates %
Cx. q	371	2	0	0	0.54	0
An. f	101	0	0	0	0	0
An. g	4	0	0	0	0	0
Ae. a	3	0	0	0	0	0
Total	479	2	0	0	0.42	0

Key

Cx. q = *Culex quinquefasciatus*

An. g = *Anopheles gambiae*

An. f = *Anopheles funestus*

An. s = *Anopheles squamosus*

An. n = *Anopheles nili*

M. a = *Mansonia africana*

M. u = *Mansonia uniformis*

Ae. f = *Aedeomyia furfurea*

Ae. a = *Aedes aegypti*

Fig.2 Graph showing the infectivity rates of mosquito vectors in Gazi and Madunguni during the transmission period.

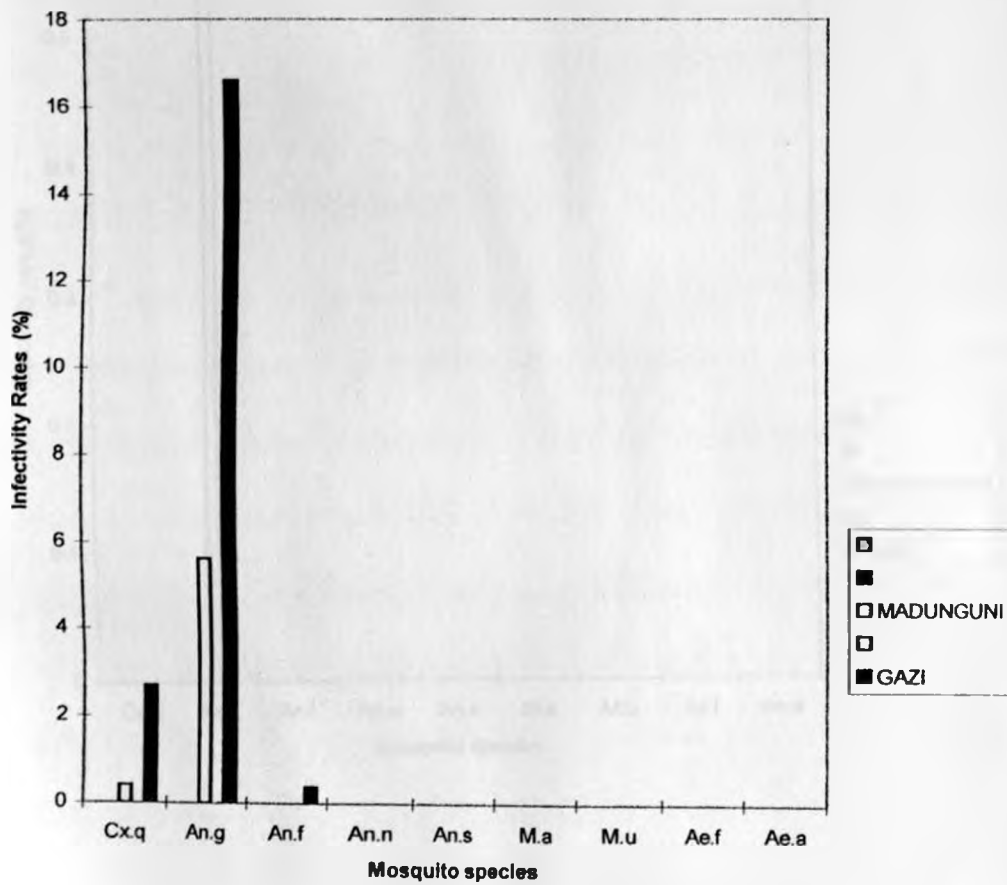
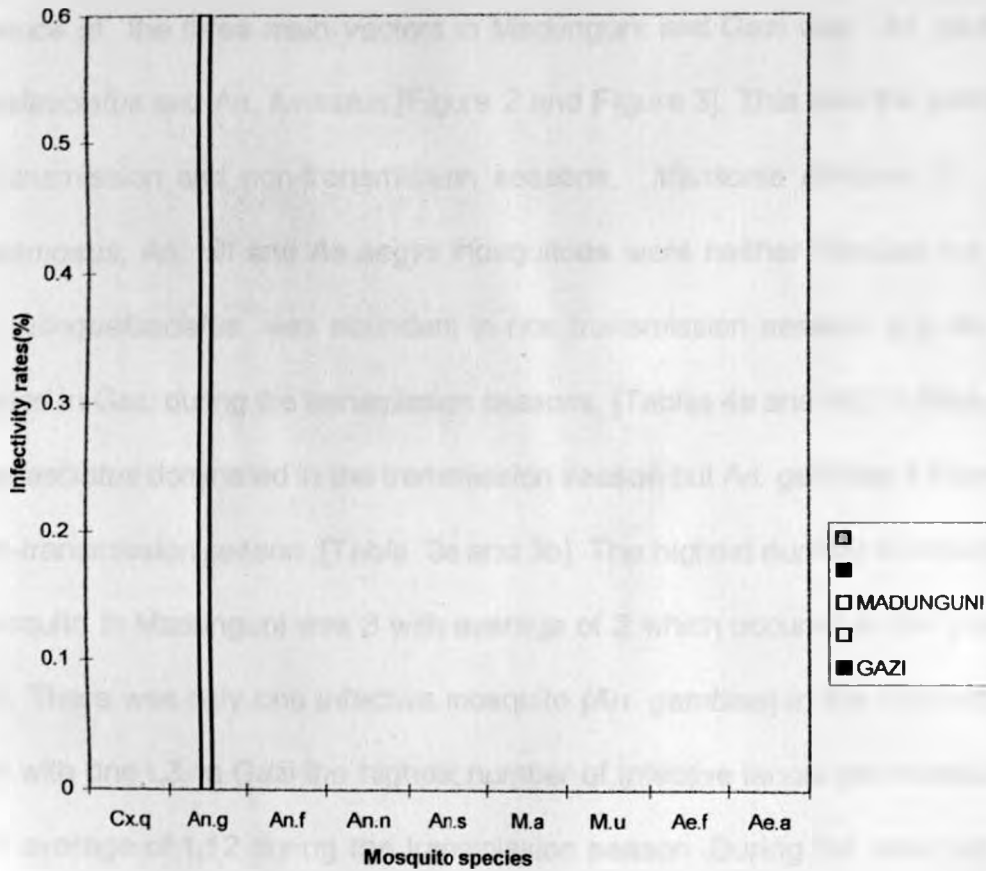


Fig. 3. Graph showing infectivity rates of mosquito vectors in Madunguni and Gazi during the non transmission period.



Data for infectivity rates of mosquito vectors were analyzed by Epi Info 6 computer software statistical analysis program. The infectivity rates in Madunguni differed

significantly [$\chi^2 = 3.05, P < 0.05$] between the transmission and non-transmission seasons. The infectivity rates in Gazi also differed significantly [$\chi^2 = 6.18, P < 0.05$] between the transmission and non-transmission seasons.

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Considering the infectivity rates of vector species independently, the order of vector importance of the three main vectors in Madunguni and Gazi was *An. gambiae*, *Cx. quinquefasciatus* and *An. funestus*, [Figure 2 and Figure 3]. This was the same trend in both transmission and non-transmission seasons. *Mansonia africana*, *M. uniformis*, *An. squamosus*, *An. nili* and *Ae. aegypti* mosquitoes were neither infected nor infective. *Culex. quinquefasciatus* was abundant in non transmission season but *An. funestus* dominated in Gazi during the transmission seasons, [Tables 4a and 4b]. In Madunguni *Cx. quinquefasciatus* dominated in the transmission season but *An. gambiae s.l.* dominated in the non-transmission season, [Table 3a and 3b]. The highest number of infective larvae per mosquito in Madunguni was 3 with average of 2 which occurred in the transmission season. There was only one infective mosquito [*An. gambiae*] in the non-transmission season with one L3. In Gazi the highest number of infective larvae per mosquito was 2, with an average of 1.12 during the transmission season. During the non-transmission season there was no infective larvae found [Data not shown].

Table 5. Mosquito collection techniques and the respective number of mosquitoes

collected and those found infective in Madunguni and Gazi in both seasons.

Collection technique	Number collected.	Number infective.
DRIC	275	6
PSC	1432	7
Light traps	125	2

Day resting indoor collection (DRIC) harvested six infective mosquitoes out of 275 dissected. By Pyrethrum spray catch (PSC) out of 1432 dissected 7 were infective. Two infective mosquitoes were collected by light traps out of 125 dissected during the whole study.

In Gazi, many mosquitoes dissected were the bloodfed in both seasons, [Table 6a]. During the transmission season, out of 288 bloodfed mosquitoes only three were infective. This was the same number found in gravid mosquitoes although only 84 were dissected. Out of the 471 mosquitoes, only 8 were infective. There was no infective mosquito during the non-transmission period. In Madunguni the situation was different in that the bloodfed mosquitoes dissected were more abundant in the non-transmission season as opposed to gravid ones in transmission season, [Table 6b].

The total number of infective mosquitoes was 6 out of 401. Only one infective mosquito was found during the non-transmission season. Empty [unfed] mosquitoes were the least

of those infective during both seasons in Gazi and Madunguni.

Table 6a. Proportions of different abdominal status of mosquito vectors dissected and their respective number of infective mosquitoes during the transmission and the non-transmission seasons in Gazi

Abdominal status	Transmission season	No. of mosquitoes infective	Non-transmission season	No. of mosquitoes infective
Bloodfed	288	3	372	0
Gravid	84	3	54	0
1/2 gravid	59	1	22	0
Empty	40	1	39	0
Total	471	8	479	0

Table 6b. Proportions of different abdominal status of mosquito vectors dissected and their respective number of those infective during the transmission and the non-transmission season in Madunguni.

Abdominal status	Transmission season	No. of mosquitoes infective	Non-transmission season	No. of mosquitoes infective
Bloodfed	147	1	336	1
Gravid	207	4	71	0
1/2 gravid	41	1	12	0
Empty	6	0	61	0
Total	401	6	480	1

3.3 Environmental factors affecting abundance and infectivity rates of mosquito vectors..

Generally, both *Culex* and *Anopheles* mosquitoes were abundant in only certain areas in Madunguni. *Culex quinquefasciatus* mosquitoes were found within or around houses whose surrounding was of vegetation of about 1-3ft tall. Dirty water trenches which form part of their breeding areas were not found in the study area. The type of house did not affect the abundance and infectivity rates of *Culex* mosquitoes. All the houses from which infective *Culex* mosquitoes were collected were either mud walled and makuti thatched or ,makuti thatched and walled. On the other hand, *Anopheles* mosquitoes were strictly found within or around houses which were close to the slow moving rivers and larger water bodies with vegetation on the periphery [Plate 3] or trenches which contained water during the rainy season.

Plate 3. A large water body with vegetation on the peryphery in Madunguni forming breeding sites for *An.gambiae* and *An. funestus* mosquitoes.



However *Anopheles funestus* mosquitoes were found in fringes of the town close to the forested areas in Gazi while *Cx. quinquefasciatus* mosquitoes were restricted to the center of the town where houses had wet pit latrines and bathrooms inside. Also open trenches with polluted water was in the vicinity of the houses. Both *Anopheles* and *Culex*

mosquitoes were found around or within different house types without special preferences to any one of them. Even houses with ceilings but without mosquito screens had mosquitoes. There seemed to be no difference in the infectivity rates of mosquito vectors from different house types. Instead the rates were almost constant in specific houses in rainy season but these decreased in the dry season. In Gazi, there was no appreciable change in the surrounding of the residential houses in both seasons. However in Madunguni the tall grass, the surrounding of most houses was dry with no moisture covering even in the mornings of the dry season as opposed to the wet season. Since there was no uniformity in the number different house types and house environs, it was impossible to statistically analyze the data found on the effect of house type and house environs on the infectivity rates and abundance of mosquito vectors.

CHAPTER FOUR

4. DISCUSSION AND CONCLUSION

4.1. Discussion

Mosquito behavior and population dynamics vary temporary and spatially as well as according to the mosquito species. The results found from this study conform with those found on Kenyan Coast by Wijers and Kiilu [1977] who reported that the mosquito infectivity rates were low during the dry season and high in the wet season, though in the latter study particular rates for each month over a period of one year were given rather than the overall rates for each season as in the current study. Valeza and Grove [1979] working in the Philippines also found the same results even though they made indoor collections twice a week for five weeks each season.

The climatic and ecological conditions significantly favor survival and relative abundance of different vector species. For example an environment with open trenches containing polluted water, as in Gazi in the current study, encourages the breeding of *Culex quinquefasciatus* mosquitoes but discourages the buildup of *An gambiae* and *An.funestus* mosquito populations. The latter two species breed only in clean water bodies such as sides of slow moving rivers or large water bodies with vegetation on the periphery. Even within the same genera of mosquito vectors, there are differences in specific climatic and environmental preferences. For instance within the *Culex* mosquitoes, *Cx. quinquefasciatus* breed relatively in higher numbers in husk pits than *Cx. gelidus* [Samarawickrema *et al*, 1982].

The dominant mosquito vector species in the study areas in order of vectorial capacity

importance are *An.gambiae s.l.*, *Cx. quinquefasciatus* and *An. funestus* . These are the same vectors reported to be important in bancroftian filariasis transmission by Wijers and Kiilu [1977], White [1977] , Mwandawiro *et al* [1997] in Kenya and Bushrod [1979] in Tanzania. In the current study, these mosquito species showed ecological and seasonal pattern of prevalence . In Madunguni, *Cx. quinquefasciatus* was more abundant in the rainy season than in the dry season where as in Gazi *An. funestus* dominated in the wet season but *Cx. quinquefasciatus* in the dry season. The observation in Gazi is contrary to what Mwandawiro *et al* [1997] found in Kwale district where *Cx. quinquefasciatus* mosquitoes were abundant in the rainy season. In another coastal town, Mambui in Malindi, Wijers and Kiilu [1977] found both *Cx. quinquefasciatus* and *An. funestus* abundant in the rainy season. The difference in this study could have been due to the lack of incorporation of the human bait technique in mosquito collection methods and the relatively short time in which the current study was done. *Anopheles funestus* in Gazi reduced during the dry season because their breeding sites were mainly clear water and vegetation near the water sources which were rare in dry season. The decrease of *Cx. quinquefasciatus* in Madunguni during the dry season was expected because it is a rural area with no open polluted water trenches and lack bathrooms in or around the houses which leaves very few breeding sites. In general the abundance of *An. gambiae s.l* and *Cx. quinquefasciatus* was highly influenced by the rains with large numbers appearing during the long rains and very few during the drier months. Relative humidity quoted by Wijers [1977b] as important in the maintenance of the parasite in the vector was above 40% in both seasons and therefore relative humidity was not considered to be important in affecting either abundance or vector infectivity rates.

Infection rates which were higher than infectivity rates in both seasons and sites confirmed the fact that not all infected mosquitoes lived to be infective and therefore only infectivity rates were considered in this section. In both wet and dry seasons, *An. gambiae s.l.* had the highest infection and infectivity rates as compared to the rest of the dominant vectors of filariasis. Thus this agrees with the findings of Mwandawiro *et al.*, [1997] and Mosha & Petrarca [1983] working on the Kenyan coast and White [1974] in Tanzania. The increase in number in Madunguni did not however necessarily increase the infectivity rates in the dry season. In Gazi there was no appreciable difference. In both study areas *Cx. quinquefasciatus* mosquitoes were abundant and therefore the common man biting mosquitoes though not the most important in transmission of *W. bancrofti*. Therefore it appears like the great risk of infection from infective mosquitoes in both Madunguni and Gazi is due to the bites of *An. gambiae s.l.* Though Wijers and Kiilu [1977] reported *Cx. quinquefasciatus* as the main vector in the coastal towns, results of this research indicate that even in Gazi, a town, *An. gambiae s.l.* is a superior vector.

From the literature, *An. gambiae s.s.* predominates the wet season where as *An. arabiensis* the dry season [White, 1974]. The high infectivity rates in the wet season can be explained. Polymorphic inversions 2Rbc, 2Rd and 2La on chromosome 2 confer dryness tolerance to *An. arabiensis* [Rishikesh *et al.*, 1985 & Colluzi *et al.*, 1979], but the frequencies of these inversions are low in *An. gambiae*. The frequencies are correlated to climatic and vegetational patterns. The carriers of 2Rbc, 2Rd and 2La polymorphic inversions show advantage over carriers of other inversions during the dry season. Most

likely the advantage lies in the larval adaptation to the restricted atypical breeding sites and or adult adaptation to dryness. *Anopheles gambiae* s.s is also endophagic and anthropophagic [White, 1974]. Many of the *An. gambiae* s.s female mosquitoes therefore become infected to filarial parasites compared with other *An. gambiae* complex species. This and the high human blood index [HBI] give *An. gambiae* s.s a higher vectorial capacity than any other member of the *An. gambiae* complex.

The next important vector species in this study *Cx. quinquefasciatus* has been known to have reduced longevity in the dry seasons. In the current study it was common but with low infectivity rates. *Culex quinquefasciatus* mosquitoes are also known to ingest more microfilariae of *W. bancrofti* when feeding on blood of infected persons than *An. gambiae* and *An. funestus*. This is because the pharyngeal and cibarial armatures in their head capsule kill the least number of microfilariae as they pass through the fore gut (Bryan *et al*,1974). Also, because *Cx.quinquefasciatus* has got a relatively large size it takes larger volumes of blood thus taking in more microfilariae. Since microfilariae are pathogenic to the vectors, high mortality is expected in endemic areas with high microfilarial rates in the human populations [Bryan *et al*,1974]. This is why it is likely to have a lower contribution to infectivity rates in dry season

This is why it is likely to have a lower contribution to infectivity rates in dry season as observed by Wijers& Kiilu, [1977]. None of *Cx. qunquefasciatus* mosquitoes was found to be infective during the dry season in this study. Few were infected during the dry season but not as high as *An. gambiae*. Further studies on the microfilarial rates in the human population should be done to assess the incompetence of *Cx. quinquefasciatus* as a vector

even in the town setting due to this factor.

Since *An. funestus* breeds characteristically in clear water bodies, the numbers of these mosquitoes are expected to decrease during the dry season especially in areas in which there are no permanent slow moving rivers. Moreover, few of *An. funestus* become infective in the dry season because of the shortened lifespan.

Other common mosquito species in these settings such as *An. squamosus*, *An. nili*, *Mansonia uniformis*, *M. africana*, *Aedes aegypti* and *Aedeomyia furfurea* are not important and even in this study none were found infected nor infective .

Most of the mosquitoes infective were either gravid or bloodfed. In both seasons the percentage of infective gravid mosquitoes was consistently high in Gazi and Madunguni.

This implies that gravid mosquitoes were not coming to feed for the first time but they were probably caught while seeking another blood meal. Infective bloodfed mosquitoes must have gone through the gonotrophic cycle at least once. Empty or unfed mosquitoes had not taken a blood meal or could be seeking another meal but then the chances of survival after going through the first gonotrophic cycle are low. The PSC method of mosquito collection used as one of the collection methods was aimed at obtaining a more representative sample of mosquitoes at all stages of the gonotrophic cycle that is, gravid, half gravid, blood fed and unfed mosquitoes. However during feeding infective larvae are lost so that fewer infective mosquitoes would be expected from resting catches [such as PSC and DRI] than from human bait catches.

Apart from some environmental issues like the presence or absence of breeding sites already discussed, the other features such as house types and house environs did not appreciably affect the abundance of vector mosquito species and had no contribution to infectivity or infection rates. Houses from which infective mosquitoes were found were probably occupied by microfilaraemic persons. Therefore the climatic and environmental factors were most important to filariasis transmission in this study.

Bancroftian filariasis can therefore be easily controlled through proper environmental management alongside vector control, chemotherapy of infected persons and vector avoidance during the transmission period. Control measures can however only be successful if there is active cooperation by the affected communities [Nelson, 1981]. There is also need to research on human behavior in relation to transmission of the disease so as to avoid contact with the vector. For instance Chandra [1995], by collecting and dissecting mosquitoes at different times of the night found out that biting density, natural infection and infectivity rates of *Cx. quinquefasciatus* were significantly higher in the third quadrad of the night [from midnight to 0300 hours] than other times. Since this was true in both urban and rural environment, avoidance of mosquito during this time period could reduce and limit filarial transmission. One other way through which bancroftian filariasis can be controlled as given by Sasa [1976] is by chemotherapy of human parasite carriers to treat or prevent clinical attacks and infection of mosquitoes. Though drug trials have been done by McMahon [1979], Ottesen and Compbell [1994], Carme and Laigret [1979], Ottesen [1985], Balakrishnan *et al*, [1992] among others and now suitable drugs are

available, the challenge is to deliver them to the affected communities and identification of high risk communities for mass chemotherapy as selective chemotherapy is no longer desirable.

This study was however limited by time and the logistical problems encountered such refusal of some of the people to have their houses sampled and resistance of people to be used as human baits. In as much as the result agree with most other findings of different people, the few seeming diversions could be due to the shorter time period that this research took and the sampling methods. For example the low numbers of *Cx. quinquefasciatus* in this study were contrary to what Wijers and Kiilu [1977] found in Mambui and Mwandawiro *et al* [1997] in Kwale. The reason could be because the latter studies were done throughout the whole year. Also the human bait technique though the most suitable [Service, 1976] was not used in the current study. This could have affected the infectivity rates of some mosquito species such as *Cx. quinquefasciatus*. Furthermore, such a method which does not interfere with the inhabitants of the house from which mosquitoes are collected can also be used as primary surveillance method for identification of filariasis endemic villages by detection of *W.bancrofti* microfilariae in mosquitoes [Gad *et al*, 1995]. Results of this study show that *An.gambiae s.i* is the most important vector in the two study sites. Although according to the available literature, *Anopheles gambiae s.s* is the most abundant during the rainy season from the literature, further work in these areas is required to characterize the sibling species of *An. gambiae* complex during the rainy and dry seasons by use of genetic markers such as chromosomal inversions and electrophoretically detectable variants at the enzyme protein structural loci

[Kitzmilller and Kanda, 1981] Such information can shed light on the observed difference in the infectivity rates of mosquito vectors in the study sites between the dry and the wet seasons (non transmission and transmission seasons) i.e due to the abundance of *An. gambiae s s* during the wet season

4.2. Conclusion

It seems therefore that the difference in the infectivity rates of bancroftian filariasis vectors between the transmission and non-transmission seasons is not dependant on the general abundance of mosquito vectors as it is the case with malaria transmission [Mutero et al, 1998] but the actual species of the mosquito vector. Based on infectivity rates of vectors of bancroftian filariasis, results of this study indicate that there is a difference between the transmission and the non-transmission season and the abundance of *An.gambiae s s*. during the rainy season could be the main reason for this

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