J Vector Borne Dis 46, September 2009, pp. 219–224

Seasonal changes of infectivity rates of Bancroftian filariasis vectors in coast province, Kenya

Sichangi Kasili[a], Florence Oyieke[b], C. Wamae[c] & Charles Mbogo[d]

[a]Department of Zoology, Jomo Kenyatta University of Agriculture and Technology, Nairobi; [b]*School of Biological Sciences, University of Nairobi, Nairobi;* [c]*Centre for Microbiology Research, Kenya Medical Research Institute, Nairobi,* [d]*Centre for Geographic Medical Research-Coast, Kenya Medical Research Institute, Nairobi, Kenya*

Abstract

Background & objectives: Bancroftian filariasis in Kenya is endemic in coastal districts with an estimated number of 2.5 million people at risk of infection. The main mosquito genera involved in transmission of *Wuchereria bancrofti* in these areas are *Anopheles, Culex* and *Mansonia*. The study was envisaged to compare the infectivity rates of Bancroftian filariasis vectors between the high transmission (wet) and the low transmission (dry) seasons.

Methods: Mosquitoes were sampled from houses and compounds from two study sites, Gazi and Madunguni, on the Kenyan coast. Day resting indoor collection (DRI), pyrethrum spray catch (PSC) and CDC light traps were used to collect mosquitoes. After identification, female mosquitoes were dissected to search for *W. bancrofti* III stage larvae.

Results: A total of 1832 female mosquitoes were dissected. Infectivity rates of vectors in Madunguni were 1.49 and 0.21% in wet and dry seasons respectively, whereas in Gazi, these were 1.69 and 0%, respectively. There was a significant difference in the infectivity rates between the two seasons in both Madunguni and Gazi villages ($p < 0.05$). *Anopheles gambiae s.l.* was the main vector in both study sites followed by *Culex quinquefasciatus* and *An. funestus*.

Conclusion: There was a difference in infectivity rates of Bancroftian filariasis vectors between the wet and dry seasons. The abundance of *An. gambiae s.s.* during the transmission season could be responsible for the increased infectivity rates of vectors in this season.

Key words Filariasis – non-transmission season – transmission season – *Wuchereria bancrofti*

Introduction

Lymphatic filariasis, a disease caused by filarial parasites, *Wuchereria bancrofti*, *Brugia malayi* and *Brugia timori,* is a major health problem with nearly 1.2 billion people living in endemic areas (therefore at risk of infection) and 120 million having the clinical disease world wide[1]. *Wuchereria bancrofti*, which causes Bancroftian filariasis, is the most widespread and common species of human filariasis[2]. It is the only known etiologic agent in the African region[3]. Bancroftian filariasis in Kenya is endemic in coastal districts of Lamu, Kilifi, Tana River, Kwale and Malindi[4]. In these foci, it is estimated that at least 2.5 million people are at risk of infection[5]. The main mosquito genera involved in transmission of *W. bancrofti* in these areas are *Anopheles* (Diptera: Culicidae), *Culex* and *Mansonia*[6,7].

Along the Kenyan coast, the prevalence (filariasis index) of the disease in human population was lowest in areas with the highest rainfall and highest population density[8]. However, no explanation was given to these findings especially in the light of vector infec-

tivity or infection rates. In an entomological study in Mambrui and Jaribuni, the peak transmission in the former was during the long rains and after the short rains in the latter[9]. In the same study it was found that during the hot dry season transmission was interrupted in Mambrui and was very low in Jaribuni[9]. Conclusion from another study was that transmission season for Bancroftian filariasis coincides with the long rains during which *Anopheles* vectors were abundant[10], but there were no clear records of comparison between vector infectivity rates in the wet and dry seasons. This study was therefore conducted in Kwale and Malindi districts with the aim of determining the difference in vector infectivity and infection rates between the dry and wet seasons. It is envisaged that the results will provide relevant information which may provide further impetus to the ongoing control efforts, and to support future campaigns aimed at eliminating filariasis. For instance, choice of the environmental settings and time of the year during which vector control should be intensified, coupled with man/vector contact avoidance could very much be guided by these findings.

Material & Methods

Study sites: Two sites, Madunguni in Malindi district and Gazi in Kwale district were chosen for the study. Madunguni is a rural village which is 20 km northwest of Malindi town, on the valley of the River Sabaki. The terrain in most of the region is flat and sometimes covered by the floods of the River Sabaki. The inhabitants are the Giriama, a sub-tribe of the Miji-Kenda group of the coastal people. The Giriama mainly live in mud-walled and makuti-thatched houses which are sparsely spaced. Houses with stone walls and or iron-sheet roofing are extremely rare. The Giriama are peasants, growing mainly cassava and coconuts. Livestock kept include cattle and goats with some of the animals tethered inside human dwellings. This site was selected because it lies within the main filariasis foci along the Kenyan coast[4].

Gazi is a small village town near the sea, about 60 km south of Mombasa town whose terrain gently slopes towards the sea. The village is inhabited by the Digo, another ethnic group of the Miji-Kenda, who grow coconuts and cashew-nuts but keep very few livestock. They live in clustered Swahili type of houses, a few of which have latrines inside. Gazi was chosen due to its easy accessibility and also being within the main filariasis foci[4].

Mosquito sampling technique: Mosquito collection was done twice, during the wet season (June/July 1998) and the dry season (September/October 1998). In all, 32 houses from Madunguni and 17 from Gazi were randomly selected from where mosquitoes were collected both indoors and outdoors. Fewer houses were selected in Gazi because of its small size.

Three methods were used for mosquito collection concurrently in order to increase the catch in terms of mosquito physiological status, i.e. gravid, blood fed and unfed as well as catering for the difference in feeding and resting behaviour of various species of filariasis vectors. For example, day resting indoor collection (DRI) and pyrethrum spray catch (PSC) were applied in all the houses whereas light traps were set up in only four compounds randomly selected. The first method was the DRI which was done twice a week between 0700 and 0900 hrs. PSC was done from 0700–0830 hrs and each house was sprayed twice a week. Each study site was arbitrarily divided into two zones such that a zone sampled using PSC one week would be sampled with DRI the following week. Lastly, CDC light traps were set under eves of houses or trees in the compound at 1900 hrs and collected the following day at 0700 hrs. Traps were set in a given compound only once a week. Collected mosquitoes were stored in paper cups inside the cool box and transported back to the laboratory for further processing.

Laboratory processing: In the laboratory, mosquitoes that were still alive (caught by DRI and light traps) in the paper cups were killed by chloroform. Dead mosquitoes were then sorted out into different species based on their morphological characteristics[11]. During dissection, the three parts of the female mos-

quito (the head, thorax and abdomen) were dissected separately on the same slide to search for *Wuchereria bancrofti* Larval stages (L_1, L_2 and L_3). Parasite identification was done on observation[12]. Infection and infectivity rates were calculated as follows:

$$\text{Infectivity rate} = \frac{\text{No. of mosquitoes carrying } L_3}{\text{No. dissected}} \times 100$$

$$\text{Infection rate} = \frac{\text{No. of mosquitoes carrying } L_1, L_2 \& L_3}{\text{No. dissected}} \times 100$$

Data analysis: Data were analyzed by chi-square using Epi Info 6 computer software statistical analysis programme to compare the infectivity rates of mosquito vectors between the wet and dry seasons, the two study sites and the mosquito vectors species.

Results

A total of 1832 female mosquitoes were dissected in this study. Table 1 shows the infection and infectivity rates of mosquito vectors in Madunguni. Infection rates were 3.99 and 1.04% in the wet and dry seasons respectively. Infectivity rates were 1.49% for the wet season and 0.21% for dry season. Table 2 shows the infection and infectivity rates of mosquito vectors in Gazi. Infection rates were 3.16 and 0.42% in the wet and dry seasons respectively. Infectivity rates were 1.69% for wet season and nil for dry season. Fig. 1 shows the mean monthly rainfall levels in Gazi and Madunguni indicating the wet and dry seasons.

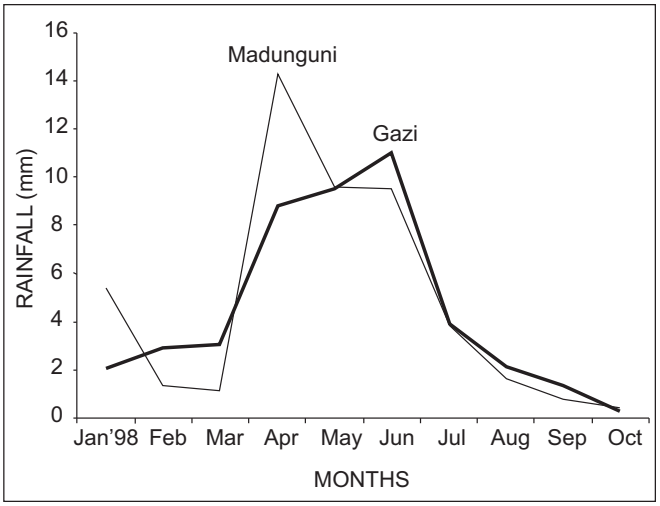

Fig. 1: Mean monthly rainfall levels in Gazi and Madunguni indicating the wet and dry seasons

Table 1. Infection and infectivity rates of mosquito vectors in Madunguni during the transmission (June/July 1998) and non-transmission (September/October 1998) seasons

Mosquito species	No. dissected	No. containing L_1	No. containing L_2	No. containing L_3	Infection rates (%)	Infectivity rates (%)
Wet season						
Cx. quinquefasciatus	241	2	3	1	2.49	0.41
An. gambiae s.l.	90	2	3	5	11.1	5.6
An. funestus	36	0	0	0	0	0
M. africana	19	0	0	0	0	0
M. uniformis	13	0	0	0	0	0
An. squamosus	2	0	0	0	0	0
Total	401	4	6	6	3.99	1.49
Dry season						
An. gambiae s.l.	175	2	1	1	2.3	0.6
An. funestus	121	0	0	0	0	0
Cx. quinquefasciatus	136	1	0	0	0.7	0
M. uniformis	43	0	0	0	0	0
An. squamosus	4	0	0	0	0	0
Ae. furfurea	1	0	0	0	0	0
Total	480	3	1	1	1.04	0.21

Table 2. Infection and infectivity rates of mosquito vectors in Gazi during transmission (June/July 1998) and non-transmission (September/October 1998) seasons

Mosquito species	No. dissected	No. containing L_1	No. containing L_2	No. containing L_3	Infection rates (%)	Infectivity rates (%)
Wet season						
Cx. quinquefasciatus	186	4	1	5	4.37	2.68
An. gambiae s.l.	12	0	0	2	16.6	16.6
An. funestus	266	3	1	1	1.87	0.38
M. africana	2	0	0	0	0	0
Ae. aegypti	4	0	0	0	0	0
An. nili	1	0	0	0	0	0
Total	471	7	2	8	3.16	1.69
Dry season						
Cx. quinquefasciatus	371	2	0	0	0.54	0
An. funestus	101	0	0	0	0	0
An. gambiae s.l.	4	0	0	0	0	0
Ae. aegypti	3	0	0	0	0	0
Total	479	2	0	0	0.42	0

The infectivity rates differed significantly between the wet and dry seasons in both Madunguni ($\chi^2 = 4.60$, $p = 0.0320$) and Gazi ($\chi^2 = 8.20$, $p = 0.0041$). There was no significant difference in the overall vector infectivity rates between the two study sites in both the wet ($\chi^2 = 0.06$, $p = 8.279$) and dry ($\chi^2 = 1.00$, $p = 0.3175$) seasons.

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* (Tables 1 and 2). This was the same trend in both the wet and dry seasons. Statistically significant differences in infectivity rates were found between *An. gambiae* and *Cx. quinquefasciatus* ($\chi^2 = 9.22$, $p = 0.0230$) and also between *An. gambiae* and *An. funestus* (χ^2=11.67, $p = 0.0063$). However, there was no significant difference between the infectivity rates of *An. funestus* and *Cx. quinquefasciatus* ($\chi^2 = 1.43$, $p = 0.2313$). *Culex quinquefasciatus* was abundant in dry season but *An. funestus* was dominant in Gazi during the wet season (Table 2). In Madunguni, *Cx. quinquefasciatus* was predominant in wet season whereas *An. gambiae s.l.* was predominant in the non-transmission season (Table 1). The highest number of infective larvae per mosquito in Madunguni was 3 with an average of 2 which occurred in wet season. There was only one infective mosquito (*An. gambiae)* in dry season with one L_3 recovered. In Gazi, the highest number of infective larvae per mosquito was 2, with an average of 1.12 during wet season. During dry season there was no infective larvae found.

Discussion

Mosquito behaviour and population dynamics vary temporally and spatially as well as according to the mosquito species. The results of the study have shown that the mosquito infectivity rates are low during the dry season and high in the wet season. This was observed for both study sites; Madunguni, a rural village on the north coast and Gazi, a village town on the south coast. Similar results were found along the Kenyan coast[9] and Philippines[13].

The only significant difference in the infectivity rates of vectors was between *An. gambiae* and the rest of the vectors in both the wet and dry seasons. These results depicted *An. gambiae* as the most important vector of Bancroftian filariasis in terms of infectivity

rates. Similar findings were found at other sites of the Kenyan coast[14] and in Tanzania[15,16]. The increase in number of *An. gambiae* in Madunguni did not however necessarily increase the infectivity rates in the dry season. In Gazi, there was no appreciable difference in their numbers.

Previous work has shown that *An. gambiae s.s.* mosquitoes are known to predominate the wet season whereas *An. arabiensis* are mainly found in the dry season[16]. The high infectivity rates in the wet season can be explained by the fact that polymorphic inversions 2Rbc, 2Rd and 2La on chromosome-2 do confer tolerance to dryness in *An. arabiensis*[17,18]. The frequencies of these inversions are low in *An. gambiae*. The frequencies are correlated to climatic and vegetation patterns. The carriers of 2Rbc, 2Rd and 2La polymorphic inversions therefore have an advantage over carriers of other inversions during the dry season. *Anopheles gambiae s.s.* is also endophagic and anthropophagic[16]. Many of the *An. gambiae s.s.* female mosquitoes therefore become infected with 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. Therefore, the reduced tolerance to dryness of *An. gambiae* (most important vector) immensely reduces the overall vector infectivity rates during the dry season.

Culex quinquefasciatus and *An. funestus* have been known to have a reduced longevity in the dry seasons[9]. Therefore, even if their numbers could be high, they may not live long enough to support *W. bancrofti* infective larvae. In the current study, *Cx. quinquefasciatus* was abundant but with low infectivity rates. These mosquitoes ingest more microfilariae of *W. bancrofti* when feeding on blood of infected persons than *An. gambiae* and *An. funestus* because they take larger volumes of blood. Since microfilariae are pathogenic to the vectors, high mortality is expected in endemic areas with high microfilarial rates in the human populations[19]. So even though *Cx. quinquefasciatus* mosquitoes could be many in number, very few may live to be infective. This is why these mosquitoes are likely to have a lower contribution to infectivity rates. None of *Cx. quinquefasciatus* mosquitoes was found to be infective during the dry season in this study.

In Madunguni, *Cx. quinquefasciatus* mosquitoes were more abundant in the rainy season than in the dry season whereas in Gazi *An. funestus* dominated in the wet season but *Cx. quinquefasciatus* in the dry season. The number of *An. funestus* in Gazi declined during the dry season probably 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 not surprising because it is a rural area without open polluted water trenches and also lacks bathrooms in or around the houses, leaving very few breeding sites for this species. Apparently, 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. In both study areas, *Cx. quinquefasciatus* was abundant although not the most important in the transmission of *W. bancrofti*. Therefore, it appears that the great risk of infection from infective mosquitoes in both Madunguni and Gazi is due to the bites of *An. gambiae s.l.* Though it has been reported that *Cx. quinquefasciatus* was the main vector in the coastal towns[9], results of this study indicate that even in Gazi, a village town, *An. gambiae s.l.* is a superior vector, though a few of them were caught for dissection.

Conclusion

The difference in the infectivity rates of Bancroftian filariasis vectors between the wet and dry seasons is not dependant on the general abundance of mosquito vectors as it is the case with malaria transmission[20] 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 wet and dry seasons and the abundance of *An.gambiae s.l.* during the rainy season could be

the main reason for this. This knowledge is important in vector control, a potential component of the global alliance to eliminate lymphatic filariasis.

Acknowledgement

The authors wish to thank communities of the study areas for their cooperation.

References

1. Shenoy RK, Varghese J, Kuttikkal VV, Kumaraswami V. The efficacy tolerability and safety of diethylcarbamazine-fortified salt in the treatment of microfilariaemias of Brugian filariasis: an open hospital based study. *Ann Trop Med Parasitol* 1998; *92:* 285–93.
2. Sasa M. *Human filariasis.* Tokyo: University of Tokyo Press 1976; p. 1–140.
3. *Fourth report of the WHO Expert Committee on Filariasis*. *WHO Tech Rep Ser* No. 702. Geneva: World Health Organization 1984.
4. Wijers DJB. Bancroftian filariasis in Kenya. Pt. 1: Prevalence survey among adult males in Coast Province. *Ann Trop Med Parasitol* 1977; *71:* 313–31.
5. Wamae CN, Gatika SM, Roberts JM, Lammie PJ. *Wuchereria bancrofti in* Kwale district, Coastal Kenya. Patterns of focal distribution of infection, clinical manifestation and antifilarial IgG responsiveness. *Parasitology* 1998; *116:* 173.
6. Goma HRL. The mosquito. In: Hutchinson *Tropical Monographs* London: Hutchinson & Co. (Publishers) Ltd. 1966; p. 95–9.
7. Mattingly PF. *Mosquitoes.* London: George Allien and Unwin Ltd. 1969; p. 13.
8. Wijers DJB. Bancroftian filariasis in Kenya. Pt. 4: Disease distribution and dynamics. *Ann Trop Med Parasitol* 1977; *71:* 451–63.
9. Wijers DJB, Kiilu G. Bancroftian filariasis in Kenya. Pt. 3: Entomological investigation in Mambrui, a small coastal town, Jaribuni, a rural area more inland (Coast Province). *Ann Trop Med Parasitol* 1977; *71:* 347–60.
10. Wijers DJB, Kaleli N. Bancroftian filariasis in Kenya. Pt. 5: Mass treatment given to the local community. *Ann Trop Med Parasitol* 1984; *78:* 57–63.
11. Gillet JD. Common African mosquitoes and their medical importance. London: William Heinemann Medical Books Ltd. 1972; p. 8–33.
12. Chandler AC, Read CP. *Introduction to parasitology*. Tokyo, Japan: Tapan Company Ltd. 1969; p. 473–9.
13. Valeza FS, Grove DI. Bancroftian filariasis in a Philippines village: entomological findings. *Southeast Asian J Trop Med Public Health* 1979; *10:* 51–6.
14. Mwandawiro CS, Fujimaki Y, Katsivo M. Mosquito vectors of Bancroftian filariasis in Kwale district, Kenya. *East Afr Med J* 1997; *74:* 288–93.
15. Mosha FW, Petrarca V. Ecological studies on *Anopheles gambiae* complex sibling species on Kenya coast. *Trans R Soc Trop Med Hyg* 1983; *77:* 344–5.
16. White GB. *Anopheles gambiae* complex and disease transmission in Africa. *Trans R Soc Trop Med Hyg* 1974; *68:* 278–301.
17. Rishikesh N, Di Deco MA, Petrarca V, Colluzi M. Seasonal variations in indoor *Anopheles gambiae* and *Anopheles arabiensis* in Kaduna, Nigeria. *Acta Trop* 1985; *42:*165–70.
18. Colluzi M, Sabatani A, Petrarca V, Di Deco MA. Chromosomal differentiation and adaptation to human environments in the *Anopheles gambiae* complex. *Trans R Soc Trop Med Hyg* 1979; *73:* 483–97.
19. Bryan JH, McGreevy PB, Oothuman P, Andrews BJ. Effects of pharyngeal and ciberial armature of mosquitoes on microfilariae. *Parasitology* 1974; *2:* 610–1.
20. Mutero CM, Ouma JA, Agak PK, Wanderi JA, Copeland RS. Malaria prevalence and use of self protection measures against mosquitoes in Suba district, Kenya. *East Afr Med J* 1998; *75:* 11–5.

Corresponding author: Dr Sichangi Kasili, Jomo Kenyatta University of Agriculture and Technology, Department of Zoology, P.O. Box 62000-00200 Nairobi, Kenya.
E-mail: skasili@yahoo.co.uk

Received: 29 April 2009 *Accepted in revised form:* 20 July 2009