A REVIEW OF THE CONTROL OF PHLEBOTOMINE SANDFLIES (DIPTERA: PSYCHODIDAE) AND A SURVEY OF RESPONSES ON MANAGEMENT OF VISCERAL LEISHMANIASIS BY RESIDENTS LIVING IN A FOCUS OF THE DISEASE IN MARIGAT, KENYA.

by

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ii

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A REVIEW OF THE CONTROL OF PHLEBOTOMINE SANDFLIES (DIPTERA:

PSYCHODIDAE) AND A SURVEY OF RESPONSES ON MANAGEMENT OF

VISCERAL LEISHMANIASIS BY RESIDENTS LIVING IN A FOCUS OF THE

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ABSTRACT

Visceral leishmaniasis (**VL**) is a serious disease caused by species of the parasitic protists *Leishmania*. It can affect humans living in parts of the tropics and sub-tropics and is transmitted by *Phlebotomus* sandflies. I review the current knowledge of the disease with emphasis on its occurence in Kenya.

The annual increase of reported cases indicates that a detailed study of vector habitats, animal reservoirs and socio-economic policies on the disease is neccessary. A survey was conducted in a focus of the disease in western Kenya to investigate the control of sandflies. Residents were interviewed on issues related to vector control and observations were made of factors that influence the use of control measures.

Age, life styles and population migrations had a direct effect on the risk of sandfly attack. Children aged 3-14 years appeared more at risk as well as inhabitants who were pastoralists.

Use of permethrin-impregnated screens as barriers or repellants was limited by the cost of materials used, handling and effectiveness of the insecticide against different vector species.

Current treatment of patients with injections of pentavalent antimonials is expensive due to the length of treatment and the distance the patient must travel to receive it.

I conclude that there is need for increased public education, structural development plans that include sandfly management strategies and control methods that would ensure the removal of breeding and resting sites of the vectors within human habitation.

iii

ACKNOWLEDGEMENTS

Dedication

Dedicated to my parents for all their contributions.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

The control of Leishmaniasis especially Kala-azar has been serendipitous, and rarely by direct action.

G.S. Nelson (1978)
In: The Relevance of Parasitology to human welfare today.

INTRODUCTION

Phlebotomine sandflies (Diptera: Psychodidae) are important
vectors of human diseases, transmitting Leishmanial parasites
(Perkins *et al.* 1988, Christensen & Herrer, 1973) phleboviruses
(Minter & Eitrem, 1989) and *Bartonellae* (Adler & Theodor, 1957).

Leishmaniases are major health concerns in the tropics and
sub-tropics. The diseases are complexes caused by parasitic
protozoa of the genus *Leishmania*. It is usually transmitted to
humans from an infected mammalian reservoir host. Depending on the
species of parasite, infection can result in cutaneous,
mucocutaneous *(espundia)* or visceral leishmaniasis *(kala-azar)*
(WHO, 1990). About 60 species of sandflies belonging to 3 genera
are known or suspected as vectors of one form or another of the
disease (Killick-Kendrick, 1989). An estimated 100 animal
species have also been identified or are suspected reservoir
hosts (WHO, 1990).

In 1992, the World Health Organisation estimated that 350
million people throughout 80 countries worldwide were at risk of
acquiring the diseases. About 12 million are already infected
with some 400,000 new cases expected to occur annually (WHO,
1990)

Despite these significant numbers many cases of the disease go
unreported or are undiagonised (WHO, 1990). This may be because
individuals at risk either mistake the disease symptoms for other
tropical diseases such as malaria, or they develop some degree of

immunity and thus innocently act as reservoir of the parasite.

Not only are sandflies important as disease vectors, they are also a major cause of irritation. The continous flight of hundreds of these extremely tiny flies, especially around the face during their peak season, is very annoying. Gianbattista Grassi in 1905 described sandflies as the " New invaders of Rome" in an interview with a local newspaper - *1I Messaggero* (Manzoli, 1991). This was because high populations of sandflies had forced many people to relocate their homes away from the city centre.

Although four descriptive forms of the disease are known, the following study will mainly deal with one - visceral leishmaniasis (**VL**), also called dumdum fever or tropical splenomegaly, with an occasional reference to other forms. The decision to choose **VL** was not only because it is the most lethal of the forms, but also because it has been shown by Mutinga (1986) and other investigators to be the most prevalent in Marigat division of Baringo District, Kenya where the field survey was done.

Sandflies are poor fliers with a range of no more than 2.2 km (Esterre *et al. 1986,* Killick-Kendrick *et al. 1986)*. They are also specific to the habitat in which they occur (Yuval, *1991)*. This habit probably restricts their distribution to discrete foci. Humans entering or residing in these foci where both the vertebrate host reservoir and vector co-exist run the risk of becoming infected. Occupational activities, human habitation and the level of knowledge of the sandfly biology and ecology can

2

greatly influence this risk.

Little work has been done to find out how they affect the occurence of **VL** particularly in Kenya and so this study was carried out with the following objectives in mind;

1.2   OBJECTIVES

1. To review the literature on the ecology and vector biology of sandflies in relation to the management of **VL**

2. to conduct a survey in Marigat area of Baringo district, Kenya, a known focus of **VL**,

    i)   to determine the levels of participation in **VL** management programs in two communities with different occupational activities, pastoralists and non-nomadic residents,

   ii)   to describe demographic factors that predisposed individuals to sandfly attack,

  iii)   to determine the knowledge of the communities of the vector, reservoir, and human victim relationships,

   iv)   to establish the factors that affect the participation of the local communities in disease management,

    v)   to determine factors that cause low acceptance of new technologies introduced for vector control, and

3. based on the results, to propose measures for the control of vectors that residents of Marigat division and other area with similar problems may find sustainable

2.0   BIONOMICS OF SANDFLIES.

Phlebotomine sandflies were first identified and described by Philippo Bonanni in Rome, Italy in 1691 (Manzoli, 1991). The relationship of these insects with disease agents was however not shown until Wenyon in 1911 provided evidence implicating them as vectors of cutaneous leishmaniasis when he found that 6% of sandflies examined in Alleppo were infected with flagellates. Until then, several theories concerning the transmission of the disease were maintained. This included the suspicion that other insects such as mosquitoes, houseflies, fleas, bed bugs and plant-feeding insects were the vectors (Wenyon, 1932).

VL is a rural disease. The majority of victims are usually in the lower socio-economic classes (Hashighushi & Landries, 1991). Though epidemics sometimes occur, the disease is usually pandemic resulting in very high costs in management.

In man, the clinical signs include a progressive enlargement of the spleen, and later the liver. The victims suffer an extended period of debilitation, recurrent wasting and if not treated, death within a few weeks in acute cases and in 2-3 years in chronic cases (WHO, 1990).

The physical symptoms are expressed as recurrent fevers, a distended lower abdomen, and a change in the skin texture.
In children these changes are expressed as a dark colour or a rough appearence on the skin. I noted expressions similar to this, shown in Fig. 1, a photograph I took of a confirmed case in Marigat area

showing the early symptoms, a distended lower abdomen, of a female child of about seven years.

Sandflies occur in areas of substantial economic potential. In these areas, their presence has a direct impact on infrastructural development. In south and central America for example, commercial projects in endemic forests were virtually halted because of labourer's fear of contracting muco-cutaneneous leishmaniasis (WHO, 1984). Similarly, in arid and semi-arid areas of east Africa, irrigation projects have brought together susceptible populations with disease carriers, resulting in an alarming increase in the number of new infections (Mutinga, 1986). This has slowed down the development of the areas, resulting in substantial waste of investment on infrastructure and thus loss of potential returns in terms of job opportunities and increased food supply thus affecting the local economy.

Figure 1:   Photograph of a seven year old female child with
             early symptoms of *kala-azar* taken in Nginyang,
             Baringo focus (March 1994). Note the distended
             abdomen

3.0 DISEASE TRANSMISSION

Figure 2 shows the life-cycle of *Leishmania spp* in the vector and mammalian host.

Like most other blood sucking Nematocera, females of some species of sandflies require a blood meal for egg development (Killick-Kendrick, 1978; Leary & Ready, 1970). During searches for blood meals, sandflies may feed on human or animal hosts infected with *Leishmania spp.* When they do, ingested parasites are deposited in the vector's gut where they attach to the midgut epithelium and transform into rapidly dividing extracellular non-infective promastigotes (Molyneux & Killick-Kendrick, 1987). Sacks and Perkins (1984) noted that the promastigotes undergo differentiation over a period of time into infective forms. They progressively detach and move anteriorly to the cuticular-lined foregut where some stay attached (Molyneux and Killick-Kendrick, 1987), while others remain free for subsesquent transmission. Infection occurs when when blood is being pumped into the vector's gut, parasites are regurgitated in the opposite direction.

The frequency of feeding on another host before oviposition varies from species to species. Gemetchu (1976) noted that *Phlebotomus papatasi* and *P. argentipes* fed several times, while *P. perniciosus* fed only once, laid eggs and died. He also observed that the number of times *P. longipes* re-fed depended on the amount of blood it obtained at the initial ingestion. Partial

feeding the first time led to repeated feeding. It is probable then that hosts such as man that do not tolerate sandflies feeding and continually swat them off before full engorgment, increase the chance of several hosts being bitten over a number of days which in turn increases the efficiency of parasite transmission to a large number of hosts.

Mating in sandflies occurs shortly after the female has fed, or is feeding on a mammalian host (Chaniotis 1967). Though the egg to egg cycle requires seven to ten weeks, several investigators suggest that it may be temperature dependant. Foster *et al.* (1970) noted that *P. longipes* took over twelve weeks from egg to adult when raised at 18-20°C, while at 28-29°C the same species took seven to eight weeks. Similarly Gemetchu, (1976) observed that at 25°C with improved larval feeding, it was possible for the same species to reach adult stage in six to seven weeks. These enviromental conditions also seem to stop growth and subject Phlebotomine to diapause at the larval stage. During cold winters, Degracheva (1972) noted *P. papatasi* and *P. caucasicus* entered diapause lasting seven to nine months. Densities of tropical species such as *P. martini* and *P. dubosqi* decreased considerably during the dry season (Basimike & Mutinga 1992). In the Amazonian focus of Brazil, Lainson *et al.* (1990) indicated that though *Lutzomiya longipalpis* favoured forested habitat to the more open savanna, greater numbers were caught in the wetter season (Jan-April) than the dry season (May-July). If

these enviromental changes have a direct influence on the occurence and densities of sandflies, then the correlation could be used to predict times of increased risk of infection by having vector control measures in place at this time.

Female phlebotomine sandflies lay eggs in small batches (Hertig, 1942). The incubation period ranges from six to seventeen days. The larvae that emerge from these eggs pass through four larval instars before pupation. Although on average, the larvae take two to six weeks, Baretto (1943) noted extremes of upto ten weeks. The larvae feed on organic matter, insect debris, decaying plants, fungi or animal faeces. The naked pupae require microclimatic conditons of 75% to 100% relative humidity to survive.

Susceptible human hosts are exposed to sandfly bites in the the vector's habitat. In all forms of leishmaniases other than **VL**, the contact could be due to victims either entering that habitat or being exposed within a localized area occupied by both vector and host. For **VL** however evidence so far indicates transmission occurs exclusively within domestic or peri-domestic enviroments. This could be from vectors resident within human dwellings or the immediate neighbourhood. In Marigat so far cases of **VL** have been associated with vectors within the houses of victims or in habitat close to residences (Perkins *et al.* 1988).

Figure 2: A diagrammatic representation of the life cycle of the parasitic *Leishmania spp*
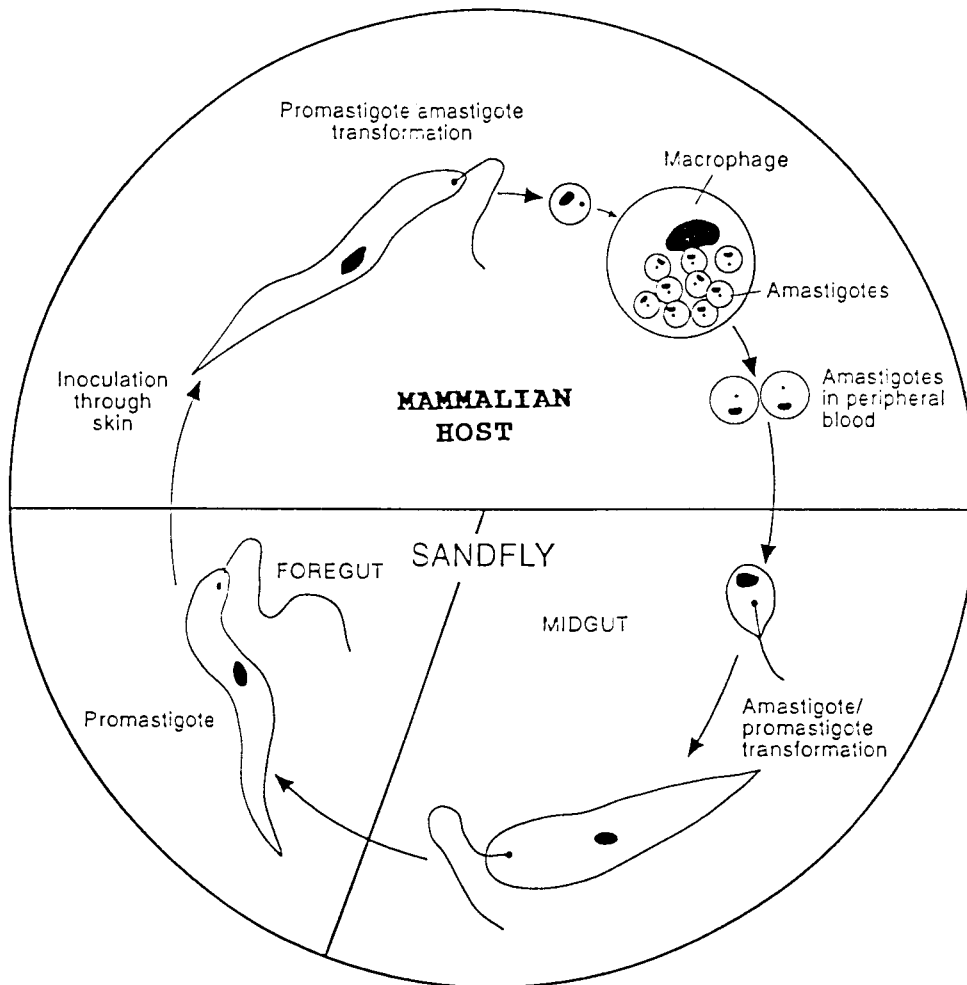
Cycle of visceral leishmaniasis parasites in the Indian sub-continent.

(a)

Infection common
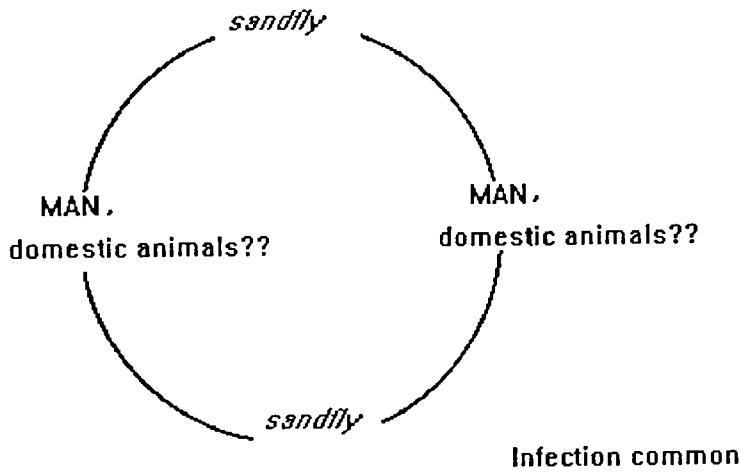
Cycle of visceral leishmaniasis parasites in China, the Mediteranean, and parts of Asia.

(b)

Infection common
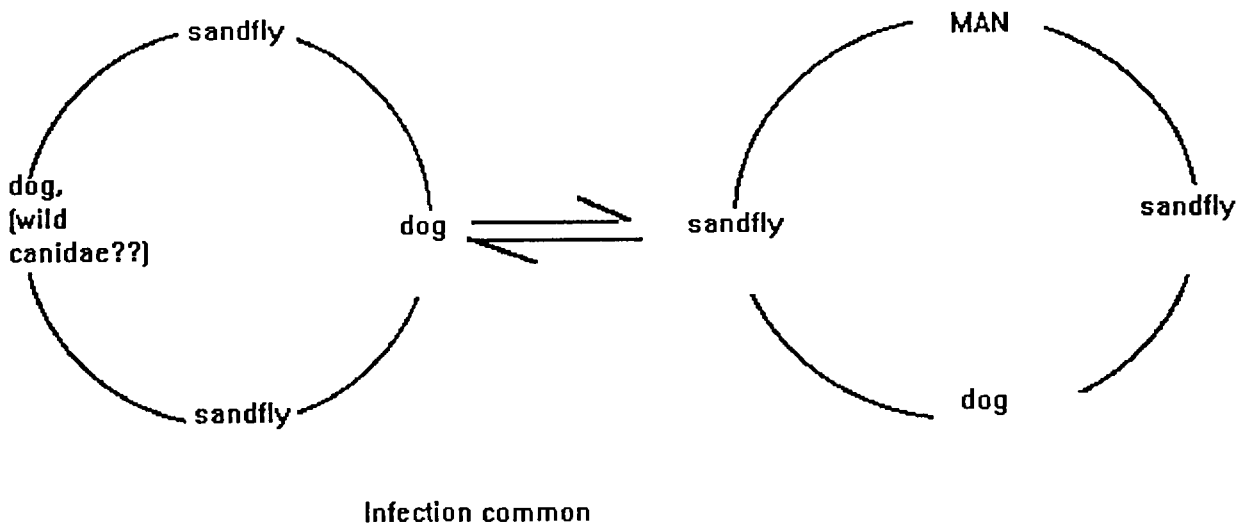
Figure 3. Cycles of *Leishmania spp* in hosts in different foci.
(a) Indian sub-continent, (b) China, parts of the Mediterranean and Asia.

(c)

jackals and
other canidae

sandfly   sandfly ⟶ dog   MAN

jackals and
other canidae   sandfly
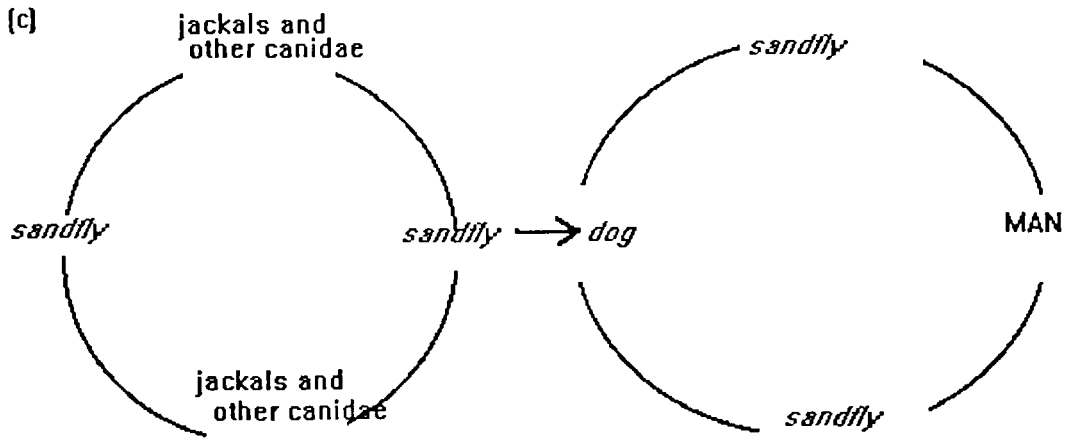
Cycle of visceral leishmaniasis parasites in C. & S. America, and parts of
the Mediteranean.

Cycle of visceral leishmaniasis parasites in east and central Africa.

(d)

rodents, bovids,
some reptiles
dog?

sandfly   sandfly ⟶ MAN

rodents, bovids
some reptiles
dog?
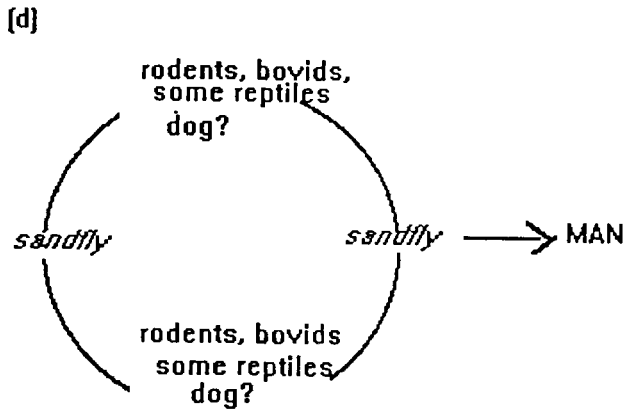
Infection common.

Figure 3 (c & d) : Cycles of *Leishmania spp* in hosts in the
south and central America, and east and
central Africa respectively.

12

4.0   DISTRIBUTION

Visceral leishmaniasis occurs throughout parts of the warm temperate and tropical zones including all the countries along the Mediterranean, southern France, southern Russia, India, Africa, Brazil and parts of tropical America.

In India, Nepal and Bangladesh where more than half of the global population at risk are found, VL is both endemic and epidemic (WHO, 1990). Here sandflies were first suggested as the vectors by Mackie in 1915. It was however not until Swamimath *et al. in* 1952 infected five out of some six volunteers with *L. donovani* using *P. argentipes* as vectors that the vectorial capacity of these species was proven (Adler & Theodor, 1962). In this sub-continent, there are no known animal reservoirs, instead infected humans serve as hosts from whom vectors are infected and can then transmit the parasite to healthy people (Figure 3a).

In Asia, although Lewis (1982) indicated that *P. argentipes* had a geographic range extending from Iran and Afghanistan in the west to Malaysia and Indonesia in the south-east, VL is limited to parts of India, Pakistan, Nepal, and Bangladesh, and is absent in most other areas.

Considering the widespread distribution of the vector, Lane (1986) suggested that it is possible *P. argentipes* had populations that are sufficiently distinct for them to be considered a species complex.

Kamhawi *et al. (1992)* investigated this vector variation

by comparing the cuticular hydrocarbons of the species from the northern and southern range and showed that separate populations of this species had marked differences in cuticular hydrocarbons. The differences in hydrocarbons were similar to two other investigations, one on two related species of *P. ariasi* found in a peridomestic and sylvatic habitat in south America and the other on *P. perfiliwi* Parot from Italy (Phillips *et al. 1990*a, Phillips *et al. 1990*b).

These investigators concluded that the observed differences represented enviromental adaptations. However, considering that the insects used in the investigations were raised in the laboratory for several generations, maintained on the same diet, and within the same enviroment, this seems unlikely.

It might be that among populations of *P. argentipes,* only some sub-species use man as a source of blood thereby transmitting the parasite whereas others are either autogenous or use some other hosts not yet determined.

In the Sudan, cases of **VL** were first diagnosed in 1904. Though sporadic cases occur especially among members of the nomadic communities, a serious outbreak that caused mortalities of more than 50% of infected patients occured in 1956-58. The most recent epidemic occurred in 1988 during which mortalities of more than 6.4% of reported cases were recorded (De Beer *et al. 1991*). Other epidemics have since occurred. During these outbreaks, the disease occur in different regions at different times of the year.

In the Sudan, all age groups are affected though young men seem to be the principal victims. *P. orientalis* is the major vector. A suitable ecology of scattered *Acacia* forest provides a large breeding site for the vector and the mammalian host. Murine rodents such as the black rat *(Rattus rattus)* are probably the major animal reservoir as they have been found infected by the parasite (Hoogstral *et al.* 1963).

In the Mediterranean and neighbouring regions, the disease is more prevelant among children under the age of five years. Dogs are highly susceptible and seem to be the principal animal reservoir (figure 3b).

In China, **VL** is caused by *L. infantum.* The parasite has been isolated in the mountainous north-west of the country where sporadic cases occur. Dogs have been implicated as the major animal reservoir. Prevalence is highest among children under the age of five.In China, *P. chinensis* has been shown as the principal vector (WHO, 1990).In the suburbs of Beijing, isolates of *L. infantum* were obtained from a raccoon-dog *(Nyctereutes procyonides)* which is probably another reservior.

In south and central American, members of the phlebotomine species *Lutzomiya longipalpis* are the primary vectors of *L. chagasi,* the agent of American **VL**. Adult females acquire parasites in the blood meal taken from dogs or foxes and transmit them to humans (Lainson *et al.* 1990; , Ryan *et al.* 1984) (Figure 3c).

In the Amazon forest of Brazil, the natural enviroment of the vector is forests that are not seasonally flooded. However,

adult flies have been caught in abundance in domestic animal pens, particurlarly pig and chicken sheds (Ryan *et al.* 1984,). Although little is known of the ecology of this vector in the Amazon forest, Dye and co-workers (1991) suggested that the vector's anthrophilic characteristic could be the result of difficulty in finding a wild mammalian host in the forest. In addition, enclosured animals provide a large, accessible habitat for the sandfly aggregation.

In Kenya, visceral leishmaniasis is caused by *L. donovani* (Perkins *et al.* 1988). It is thought to have been introduced into the country from Sudan and Ethiopia during the Second World War (Mckinnon & Fendall, 1955). The first major outbreak of epidemic proportions occurred in Kitui District in 1952 (figure 4) (Fendall, 1961). This outbreak lasted until 1954. In 1955, another focus of the disease was recorded from Baringo District by Mckinnon & Fendall. Although the disease in this focus has never reached epidemic proportions, it is estimated that about 100^4 new cases occur annually but I believe this estimate is low as will be shown in the survey later.

Recently, two other endemic foci in west Pokot and Turkana Districts have also been identified. Cases of the disease have also been found elsewhere in the country, but these appear to have been infection that occurred in known foci.

The first identification of phlebotomine sandflies in Kenya was by J.B. Sinton in the coastal areas (Sinton, 1930). Four species were recorded in Kericho area in 1954. Since then, several species of the genera *Synphlebotomus* and *Sergentomyia* have been identified in most parts of the country. The majority of these are not involved in transmission of any known human disease.

Cutaneous leishmaniasis (CL) also occurs in some parts of the country. In western Kenya, especially the area of Mt. Elgon and other high altitude areas, *Leishmania aethiopica* occurs in close

association with cave dwelling species of the vector. *Phlebotomus pedifer* and *P. elgonensis* are suspected to be the vectors. Although both are known to occupy caves, only *P. pedifer* has been shown to be both anthrophilic and zoophilic making it a more likely vector than *P. elgonensis* which seems to be only zoophilic. Mutinga & Odhiambo (1986) collected in a cave, samples of *P. pedifer* that fed on active lesions on two volunteer patients infected with *L aethiopica*. Inoculation of leishmanial isolates from these sandflies into experimental animals resulted in cutaneous lesions similar to those observed from experimental infections induced by promastigotes isolated from an infected man. From these observations they concluded that, *P. pedifer* was the primary vector of the disease. Because *P. pedifer* thrives well in caves and rock cracks which had previously been indicated as potential reservior (Mutinga, 1975), Mutinga & Odhiambo (1986) concluded that hyraxes were probably the main mammalian host and other mammals such as elephants, buffalos, deer and domestic animals that frequent these caves were probably secondary hosts. Hyraxes, are however, widely distributed in mountainous parts of the country and it is curious that the disease is limited to some areas in the 1900M altitude range and is not known in other areas of similar altitude that have the same mammalian host.

Although both species have been found occupying similar niches, Mutinga (1986) noted *P. elgonensis* prefered caves occupied by bushbucks and hyraxes. So far no leishmanial parasites have been isolated from dissections of this potential vector, but their

capability to transmit the disease needs to be investigated.

Leishmania major has also been isolated in the Baringo focus of **VL** (Mutinga & Ngoka, 1983, Chance *et al.* 1978). Several investigations to determine the vector and host (Mutinga *et al.,* 1986, Beach *et al.* 1982) have shown that *P. dubosqii* and *Sergentomyia garhami* can transmit the parasites. Investigations into host preferences revealed that *P. dubosqii* bred in animal burrows and had a distinct preference for rodents in obtaining a blood meal (Mutinga *et al., 1986)*.

Up to now, cutaneous leishmaniasis has not been reported in humans in Baringo focus, but isolates of the parasite have been found in gerbils *(Tatera robusta)*, ground squirrel *(Xerus rutilus),* elephant shrew and nile rat. Should a shift in rodent population occur so that the phlebotomines change hosts, it is possible that man could be at very serious risk.

There has been a recent report by Mebranthu *et al., (1988)* of a focus of *L. tropica* in the Aberdare escarpment in the Mt. Kenya area. Searches for a vector for this parasite resulted in *P. guggisbergi* being found in caves within the dense forest in this area. The few reported cases of **CL** have been limited to people who develpoed symptoms after previous visits to the forest (Mebranthu *et al., 1988)*. Because of this, there is the possibility that a wild reservoir exists in within that maintains the circulation of the parasites together with the suspected vectors. More work is needed to establish this.

Though no animal or wild reservoir host has so far been identified in the **VL** focus in Marigat division, the continous incidence of the disease supports the hypothesis that suitable conditions are present to manitain the parasite in this area. Hills of the termites (*Macrotermes subhyalinus*) are a very common ecological feature in all the foci of **VL** in Kenya. In the focus at Kitui, Heisch (1954), observed that during certain periods of the year, these termitaria were teeming with sandflies. He also found that two species, *Sergentomyia rossanae* and *Sergentomyia garhami,* bite humans sitting near these hills during warm, humid and windless days between 7.00 -9.00 PM local time. Unlike other biting insects such as mosquitoes, sandflies bite exclusively on the parts of the body not protected by clothing.

Studies on the correlation between proximity of termite hills to homes of victims of **VL** by Southgate & Oriedo, (1962) were statistically significant. In the focus at west Pokot, Mutinga *et al.* (1984) found that for every home with a **VL** patient termite hills were within ten metres of the homestead. I also noted this in Marigat recently as illustrated by (Figure 5).

These termite hills are raised soil structures with several ventilation shafts built over underground nest of the termites (Fig.6).

As cited earlier, in field collections to determine the seasonal and daily flucuations of probable vectors, Basimike & Mutinga (1992) noted that the relative abundance of *P. martini*

20

and *P. dubosqui* increased with progression of the wet season. During the dry season however, populations of these species varied considerably depending on the habitat they occupied. *P. martini* was found to inhabit termite hills all year while *P. dubosqui* populations was limited to animal burrows and only used the termite hills during the wet season.

In a **VL** focus such as Marigat, where daytime temperatures occassionally reach 34-36° C, it is probable that the interior of these shafts provide the vector with cooler enviroment for breeding and rest. Investigations into the variation of enviromental conditions within these shafts compared to the external enviroment might reveal some of the factors that affect sandfly ecology which could be useful for determining ways to manage them.

Investigations to determine the disease vectors resulted in *P. martini* being found biting humans indoors and outdoors during the rains in and around Marigat market in the Baringo focus. In the focus at Kitui *P. martini* and *P. vansomerinae* were observed in pit latrines, huts and tents. Based on the low rate of leishmanial infections (5%) in *S. garhami* from the focus at Kitui, and the absence of this vector in the focus at Marigat, the most likely vectors appeared to be *P. martini* and/or *P. vansomerinae*. Minter *et al.* (1962) described another *Synphlebotomus* species, *P. celiae* in Kitui focus. He also noted the occurrence of *P. martini* in both foci. By comparing the distribution of all the species, Minter (1963) concluded that *P. martini* was the most probable

vector as it occurred in all foci. Perkins *et al.* (1988) surveyed

for sandflies in four different locations of the focus in Marigat

to determine the validity of this conclusion. Using proximity to

homes of patients diagnosed with **VL** and treated 6 months earlier,

they trapped flies using sticky papers, light traps and direct

aspiration from surfaces. They were able to catch some 2000

flies, all of which were *Phlebotomus martini.* Six females in the

collection had flagellates. When these were characterised

biochemically using cellulose acetate electrophoresis (CAE) two

of the isolates were indistinguishable from isolates obtained

from **VL** patients from the focus. The *P. martini* infected

with the *L. donovani* were caught within 20 metres of the

patient's homes.

Because they collected no other *Synphlebotomus* species near

the patient's homes, they concluded that *P. martini* is the

primary vector of *kala-azar* in Marigat, Baringo district, and

probably all the other foci in the country.

Mutinga & Ngoka (1983) compared the feeding behaviour of

various species of sandflies in the three foci and found that

Sergentomiya spp fed mainly on lizards and some mammals including

bovids and rodents. They also demonstrated that *P. martini* fed

on dogs, and occasionally reptiles (lizard and geckos). From their

observations, they concluded that cross-feeding between mammalian

and reptilian hosts by sandflies probably introduced leishmanial

parasites to hosts that do not commonly act as reservoirs without

showing any disease symptoms. In mammalian hosts this infection

might trigger a response that will render them less susceptible to subsesquent leishmanial innoculations. This could therefore explain why non-target mammalian hosts seem not to show any infections despite being fed on by the vector.

In south and central American foci, sandflies are attracted to enclosed mammalian habitats such as cowsheds, poultry pens and pigpens. In most of the areas in Africa, from east Africa and the Sudan to western Africa and Chad, most of the people living within the known **VL** foci tend to keep large flocks of domestic animals which are often enclosed within a few metres of the human residential homesteads. Encouraging communities with these practices to move their animal enclosures further from the homesteads might reduce the vector density and hence disease occurrence, but this needs to be investigated.

Unlike other vector-borne diseases such as malaria, onchocerciasis and yellow fever, there is ample evidence that the activity and behaviour of the humans affect risk to infection. The activities appear to predispose the individuals to risk of infections. For instance, in the Sudan, E. Africa and other foci where young men are most at risk, such age groups in nomadic communities spend most of their evenings out-doors and near animal enclosures. In the foci along the Mediterrenean, China and parts of south and central America where dogs are the the reservoirs, children up to five years old are most at risk.

This age group is probably exposed more to dogs, the main mammalian host, than are other ages, and therefore have a higher risk of being bitten by vectors searching for a blood meal. In India there is a sex bias with more men than women reported with infection. Brahin & Brahin (1992) suggested that this was probably due to the fact, as observed in Prudah, that women stay indoors more than men, thus reducing their exposure to sandfly attack.

Figure 4: Map of Kenya, showing foci of the parasites of the leishmaniases (the numbers indicate the population living within the focus)[2].

SUDAN

ETHIOPIA

Lake Turkana

UGANDA

West Pokot

158,400

KENYA

SOMALIA

Mt. Elgon

Baringo

70,100

Meru

101,000

Aberdare Range

Mt. Kenya

66,106

Lake Victoria

Kericho

NAIROBI

Kitui

Machakos

257,431

TANZANIA

Lake Natron

L. aethiopica focus

Leishmania donovani Endemic and epidemic foci

L. donovani endemic focus L. major zoonotic focus

- - - - District boundaries

Mombasa

INDIAN OCEAN

0   180

kilometres

Figure 5. A typical location of termite hills near a homestead in Marigat.

Figure 6. Typical ventilation shafts of a termite hill in Marigat focus.

5.0   VECTOR BEHAVIOUR

5.1   BREEDING & HABITAT CHOICE.

" Adult Phlebotomine sandflies are often hard to find,

larvae impossible " (Lewis, 1973)

Oviposition sites of many insects are controlled by chemical factors that direct gravid females to choose breeding sites suitable for their progeny (Bentley & Day, 1989). In Diptera, these factors are mainly due to organic materials in the oviposition site and pheromones associated with the female and immature stages. In sandflies, little is known about the factors that attract and stimulate egg-laying in nature. Schlein *et al.* (1990) report that *P. papatasi* females are attracted to animal faeces in laboratory experiments.

In other work by Elnaiem & Ward in 1990 (cited from Elnaiem *et al.* 1991) the presence of frass, larval rearing medium or rabbit faeces yielded a preferential oviposition by *Lut. longipalpis.*

Several field collections to investigate this aspect of vector behaviour in known sandfly ranges have shown that, despite their ability to inhabit different biotopes ranging from tropical forest to arid and semi-arid areas, eggs are laid in habitats that ensure a high relative humidity without being aquatic. In India, Dhiman *et al.* (1983) found sandfly larvae in decaying organic materials around sheds and troughs of cattle. The larvae were within the top 5 cm of the soil surface which had high relative humidity. Similarly Mukhopadhyay *et al.* (1990) noted that collections in

river beds were mainly centred in alluvial soils that had a high relative humidity.

One other aspect that seems to affect breeding location is shelter from both flooding and desiccation. Thus in India, sandflies were found to avoid desiccation during the dry season by laying eggs in shaded areas near water tanks , while during the wet season more collections were from protected sites closer to homesteads, such as in eaves or even indoors.

There are several other habitats from which sandfly eggs and larvae have been collected. Petrisheva & Izyamkaya (1941), recovered 102 eggs of *P. papatasi* after sifting through 1048 kg of soil obtained from animal burrows and crevices in rocks in Sebastopol. In Spain, Najera (1946) found *Phlebotumus spp* larvae on the rubbish taken along the streets of Madrid while Hanson (1961) working in Panama found larvae in tree buttresses, forest floors, burrows and hollow trees. In Kenya, Mutinga & Kamau (1986) incubated soils from various sites from Marigat and found termite hills and animal burrows were the only sites that yielded *P. martini*. Basimike & Mutinga (1992) sampled sandflies in the same area for a year and found that 81% of *P. martini* caught were from animal burrows, with termite hills yielding only 18 %.

The need to determine the other factors that influence the choice of these habitats is critical. Elnaiem *et al.* (1991) used aqueous extracts of eggs of *Lut. longipalpis* and showed that the choice of the oviposition site of this species was chemically controlled. The concentrations and distances at which this

29

attractant affects choice of a breeding site when applied would be a useful tool in field monitoring and possible control.

Female sandflies lay eggs in small batches. The choice of habitat among the vectorial species has some epidemiological significance. In foci that are well studied, Killick-Kendrick (1989) noted that characteristic features of the landscape are often recognised where vector and parasites circulate. Thus in Sudan, these features are recognised as accacia forest associated with *P. orientalis* transmitting *L. donovani.* In east Africa, termite hills represent a possible location where *L. donovani* are circulated by *P. martini.* Similarly, in Cevenne, France, two species of oak tree at a particular altitude have been identified as markers of VL transmitted by *P. ariasi,* while in Saudi Arabia and other areas where the sandrat *(Psammomys obessus)* is the possible mammalian host of *P. papatasi,* the vector of *L. major,* chenopod plants are the marker feature. These marker features are the consequence of climatic and soil factors. In the old world most are generally recognisable. In the south and central American foci however, habitats are more complex and marker features obscure.

Because breeding of these vectors occurs in micro-habitats, and because they have a short flight range, female sandflies feed on mammalian occupants of the habitat in which they live, such as a burrow-occupying animals or others close by. Transmission of VL is concentrated in localised zones so that a family having an infected individual living with healthy ones in a homestead close to a vector habitat could be considered a sub focus.

30.

6.0   DISEASE MANAGEMENT

Visceral leishmaniasis causes prolonged periods of debilitation, wasting and sometimes death. Its effects on socio-economic activities and community development programmes is substantial. To achieve sustainable management, a successful vector control strategy or a programme that would result in the interruption of the parasite transmission cycle has to be instituted. That intervention has to be intense and be prolonged long enough for the parasite life span to be terminated. I will review and discuss the progress of each of these strategies so far.

6.1   VECTOR CONTROL

Sandfly control programmes in most **VL** foci have advanced slowly when compared to that of other haematophagous arthropods such as mosquitos, ticks and blackflies (Mutinga, 1992). This can be attributed to the fact that in areas where sandflies thrive, malarial mosquitos are also prevalent. Thus, although **VL** is a serious disease, most control programmes have tended to target the mosquito-borne diseases. In India, Pakistan and Bangladesh for instance, during the 1950's and 1960's an anti-malarial control campaign using residual sprays of DDT resulted in a transient disappearence of **VL** That success was believed to be due to the susceptibility of *P. argentpipes* to DDT. Similar sucess was noted in Italy, Greece, Russia and Israel where the control of other

31

forms of leishmaniases was also briefly achieved.

In the Indian sub-continent, because of enviromental and bio-accumulative effects of DDT, cessation of its use led to a progressive resurgence of **VL** including incidences of (Post kala-azar dermal leishmaniasis (PDKL)[3]. In Bangladesh, this progressive spread led to an epidemic in 1980-81 in some districts. Spraying the affected areas with DDT rates of $1gm/m^2$ as part of a malaria control programme dramatically reduced sandfly densities and caused the disappearence of the disease (Elias, *et al.* 1989). In the neotropical forests of south and central America,

because of their vast and complex nature, insecticidal sprays over wide areas are considered impractical, uneconomical, and ecologically unsound, and have therefore never been attempted. Chaniotis, *et al.* (1982) carried out a pilot spray using ultra low volumes of 95% technical malathion in Panama and arrived at a similar conclusion.

In areas where sandflies live within domestic and peri-domestic situations or where people have congregated in a rural area as in construction sites, logging or military camps, regular indoor residual sprays with either DDT, BHC, malathion, fenitrothion, or synthetic pyrethroids[4] have had some sucess in lowering sandfly densities. The application methods used were simple and cost effective and were even more so when active participation of potential human hosts was forthcoming. For example, residual sprays of $1-2gm/m^2$ of DDT gave protection for

up to one year against *Lut. longipalpis* in a logging camp in the Amazon forest (WHO, 1990).

Despite these sucesses, there are few data on the spectrum of susceptibility of sandflies to these residual insecticides. Kaul *et al.* (1994) sprayed human dwellings and cattle sheds with DDT in Uttar Pradesh and observed that timely spraying prevented the build-up of vectors during peak seasons. Quantities used were however not reported. The cases of *P. papatasi* resistance to 4% DDT as was demonstrated in laboratory and field conditions in India (Kaul, 1978) may be widespread, especially when one considers the quantities of DDT and these other insecticides used in agricultural areas within **VL** foci.

In most foci of Africa, south and central America where **VL** vectors are not exclusively domestic but have habitats that spread over domestic to sylvatic enviroments, use of indoor residual sprays offer little chance of success. Similarly, insecticidal sprays on alternate resting sites such as termite hills and animal burrows in east Africa, neotropical forests in south and central America, or even in the acacia forests in the Sudan seem impractical.

In Kenya residual sprays have not been tried, instead use of permethrin-treated bed-nets, repellants such as permethrin-treated mosquito coils and pyrethrin sprays marketed as "DOOM" have been used to reduce man-vector contact. These protection measures were principally for the control of mosquitos, with

sandfly control being secondary. Recommendation for this adaptation was based on the fact that a significant reduction of sandflies entering human houses was observed when permethrin impregnated curtains were hung in exit paths such as windows or on walls within the houses.

The public adoption rate of these recommendations however is still very low and this may be attributed to some of the following factors:

1. Communities in rural semi-arid areas do not prioritize the purchase of the nets and insecticides.

2. Public education programmes are skewed to management of mosquitos and malaria.

3. Effectiveness and protection of permethrin impregnated nets as vector repellants decreases over time due to smoke, dust and poor handling and is therefore insufficient to stop disease transmission.

4. Permethrin has a very low vapour pressure. It may therefore not produce a sufficient barrier around the individual or within the household.

5. Concentration of insecticides sufficient to control different vectors has been shown to be species-specific. For example $0.5gm/m^2$ of permethrin controlled *Anophles gambiae* for six months, *Culex quinquefaciatus* for four months and *Aedes aegypti* for 10 months in Marigat (Mutinga *et al.*, 1992). Similarly Sandfly trials, using nets impregnated with dosages of $0.5gm/m^2$ of permethrin EC 20 caused reduction of 52-73% of non vectorial

phlebotomines, and 76-85% of *P. papatasi* and *P. dubosqui,* yet all these species do occur in the same habitat, and all are a nuisance.

Despite limited community participation, use of permethrin impregnated nets or curtains called "Mbu" cloth in Kenya when used and properly stored have been experimentally shown to be effective for sandfly control (Mutinga *et al.,* 1992).

6.2   HABITAT CHANGE AND RESERVOIR HOST CONTROL.

Physical enviromental change for the management of *Visceral leishmaniasis* can be done in two ways:

1. Removal of the animal reservoir by destruction of its habitat.

2. Altering sandfly breeding and resting sites thus reducing their contact with humans.

While this approach has had some sucesses in some areas, there appears to be factors that limit its use as a long term strategy.

In southern Russia, destruction of burrows of *Rhombomys opimus* and ploughing the vegetation to remove its habitat eliminated VL. In south and central America, the range of the disease appeared to extend with the clearing of tropical forests. Walsh *et al.* (1993) attributed this extension to the fact that vectors and mammalian hosts could adapt to secondary vegetation once primary forests were removed. Thus the fox *(Lycolopex vetulus)* and *(Cerdocyon thous)* the

35

mammalian hosts of *Lut. longipalpis* can adapt to the changed ecology. By maintaining close attachment to dogs and other domesticated animals man has complicated the possibility of breaking the cycle of transmission as these animals attract vectors from the wild hosts to the domestic enviroment. Habitat destruction in the neotropical forest therefore may not reduce the incidence of leishmaniasis, but will most probably result in an increase.

Despite these limitations, a delay of several months before humans enter and occupy houses in cleared forests has been observed to lower transmission. Similarly a clear area around primary forest, or the establishmnent of a forest-free zone of about 400m around human settlement, prevented peri-domestic transmission by *Lut. umbratilis* as the belt was possibly wider than the flight range of sandflies.

These approaches are however not easily applicable in the **VL** foci of south and central America, where cleared areas are occupied immediately because of human population pressures.

In some areas of Kenya, particularly where irrgation schemes for farms are being established in **VL** foci, destruction of termite hills and animal burrows have taken place. However no studies have been done to determine the effect of this vegetional change on mammmalian and vector densities and eventual disease transmission. Basimike and Mutinga (1992) suggested that destruction of such habitats could lead to invasion of human dwellings by the vectors. Mutinga (1990) noted that the recent upsurge of the disease in newly established irrigation

schemes was probably the result of both the movement of non-immune people into these endemic areas and the absence of alternate animal

hosts hence diversion to man as primary host.

Similar reasons may also apply in the Sudan where establishment of irrigation schemes within VL foci, and the migration of people appears to be causing increasing incidence of the disease.

In Ethiopia, *P. argentipes* has been observed to feed on cattle in the countryside, however in the city of Addis Ababa, it instead attacked man. This may probably due to population dependent factors that led to the choice of man as an alternate host.

Change of habitat due to construction of human settlements in sandfly zones seem to have little impact on vector densities. Kamhawi *et al.* (1991) investigated the effect of building activities on phlebotomine species of epidemiological importance in the Jordan and observed that habitat change temporarily eliminated them, but sandflies were able to recover in man-made habitats and in fact exceeded original densities found in the natural enviroments. From this observation they concluded that the vectors possibly entered human dwelling for shelter against wind and desiccation or for mating and breeding purposes. This may explain the existence of the disease in urban areas and because of increasing urbanisation, an increased risk to more people now concentrated in one area. Habitat changes, especially where the mammalian host would not be completely eliminated or where there

are alternate hosts seem to offer a very low probability of achieving control of the vector. In developing countries such as Kenya therefore unless measures are taken, new risks in urban centres or areas where infrastructural developments are being undertaken may militate against improved health often associated with developmental projects.

6.3   DISEASE TREATMENT

Patients afflicted with **VL,** are often wasted, anemic and malnourished. Because the disease greatly reduces productivity of the individuals, treatments need to aim not only at removing the intracellular parasitic infections, but should also prevent relapse due to development of unresponsiveness (whether it be due to drug resistance or intermittent drug use). This has to be achieved with minimum hospitalisation and treatment costs.

In most cases, the predominant complaints and symptoms of **VL** such as the abrupt onset of fever, rapid loss of weight, profound malaise *etc,* are very similar to and often confused with malaria. Treatment therefore requires accurate diagnosis. Seriological examination or demonstration of parasites in the spleen, bone marrow or lymph glands is commonly used. This requires specialised equipment and experienced medical personnel. In areas where these limited, treatment may be delayed.

WHO (1990) recommends the use of pentavalent antimonials of which these two (meglumine antimoniate and sodium stibogluconate) are availiable as standard first line drugs. Efficacy against **VL** is thought to be related to the content of pentavalent antimony (Sb^{5+}). Meglumine antimoniate solution contains 8.5% Sb^{5+} (85 mg/ml) and sodium stibogluconate 10% Sb^{5+} (100mg/ml).

I will not discuss the drug adminstration here, save to mention that a 20 mg/kg body weight to a maximum of 850mg of Sb^{5+} as a daily dose is the recommendation (WHO, 1990).

In Kenya, use of pentostum[5] (sodium stibogluconate) was first introduced in 1988. In Baringo District Hospital daily injection of 6ml/day for 7-10 days for adults and 0.1mg/kg of body weight up to 21 days for children is the recommended dose (Hospital records). In India, best results were obtained with a 40-day regime, while a 6-day course in China had a cure rate of 90% (WHO, 1990). The daily dose in both cases was not indicated.

Amionsidine sulphate (50mg vials) administered as injections of 500mg/dose were also used in Baringo, but were discontinued in 1990. No information as to why it was discontinued was availiable.

The performance of patients on pentostum was reported to be varied depending on the seriousness at admission (Medical staff). I did not investigate the effect of other drugs further, but pentostum was noted by the medical personel as being effective.

I similarly did not investigate other chemotheraphies used before 1988, both in Kenya and other parts of world.

In Kenya, the diagnosis and treatment of VL patients from the various health centres spread over the disease focus is done in the referal hospital within a district.

Occasionally, teams of the vector-borne division of the Ministry of Health carried out field surveys notably within the pastoral communities and recommended to suspected individuals they seek hospital diagnosis and treatment. Reaction to and effects of these recommendation are varied and will be discussed in the next chapter.

Control of vectors for management of vector-borne diseases such as the Leishmaniases, in most parts of the tropics and sub-tropics have generally been imposed by goverments and their agencies (WHO 1990, Elias *et al.,* 1989). Because resulting benefits tend to come indirectly through better health, most populations at risk often do not recognise nor do they understand the extent of the participation expected of them. Those who do often resort individual vector control. Those who don't go for treatment only when they have the disease, and even then a significant number do not follow recommendations given to them, despite VL being recognised by the people and communities as a serious disease. The next chapter covers some of the issues that I noted among residents of Marigat as causing this differences.

7.0   SURVEY OF PARTICIPATION.

7.1   THE STUDY AREA

The Marigat focus of **VL** population 70,000 (National population census report, 1993)[6] in the District of Baringo is a semi-arid area, situated at an altitude of about 1067m above sea level on the floor of the Kenyan rift valley 240 km west of Nairobi (Fig.4).

The area has a mean air temperature of 32.8 C$\pm$1.6 C with a total annual rainfall of about 512 mm that fall in two seasons from March to August and from November to December.

Conspicious ranges that vary in altitude from 300-1000m, rise on either side of this valley, which leads North to the vast plains of west Pokot and Turkana. Major rivers such as the Perkera, Molo and others drain into lakes Baringo and Bogoria and the latter has several hot springs.

The area close to these lakes has been brought under crop farming with irrigation. Immediately beside the lakes are tourist attractions and pre-historic sites which together with the farming, fishing and commercial activites, have attracted many immigrants into the area leading to a large population concentrated within a small area. The people here make up the settled communities involved in the survey.

The part North of lake Baringo (fig.7) is occupied by the pastoral communities. Here seasonal stormy rivers form the basic drainage patterns. Though the population density is low, the wide expanse of the total area and the fact that new irrigation schemes

Figure 7: Map of Baringo District showing the area where the survey was conducted. (Numbers in circles represent distribution of patients admitted into hospital with **VL** in 1993)

Kapedo

Chemolingot △
(10)   □ Nginyang

(16)

Loruk ⚪
(12)   *Lake Baringo*

Karbarnet ⚪   (19) △ Marigat

Perkeia R.

Loboi □ *Lake Bogoria*
(4)

N

0   20
kilometres

⚪   Urban Centre

△   Market Centre

□   Rural Centre

▨   High Altitude (1300-2500 m)

▢   Marginal & Semi-Arid (below 1200 m)

━━   National Trunk Roads

▪▪▪▪   Secondary Roads

43
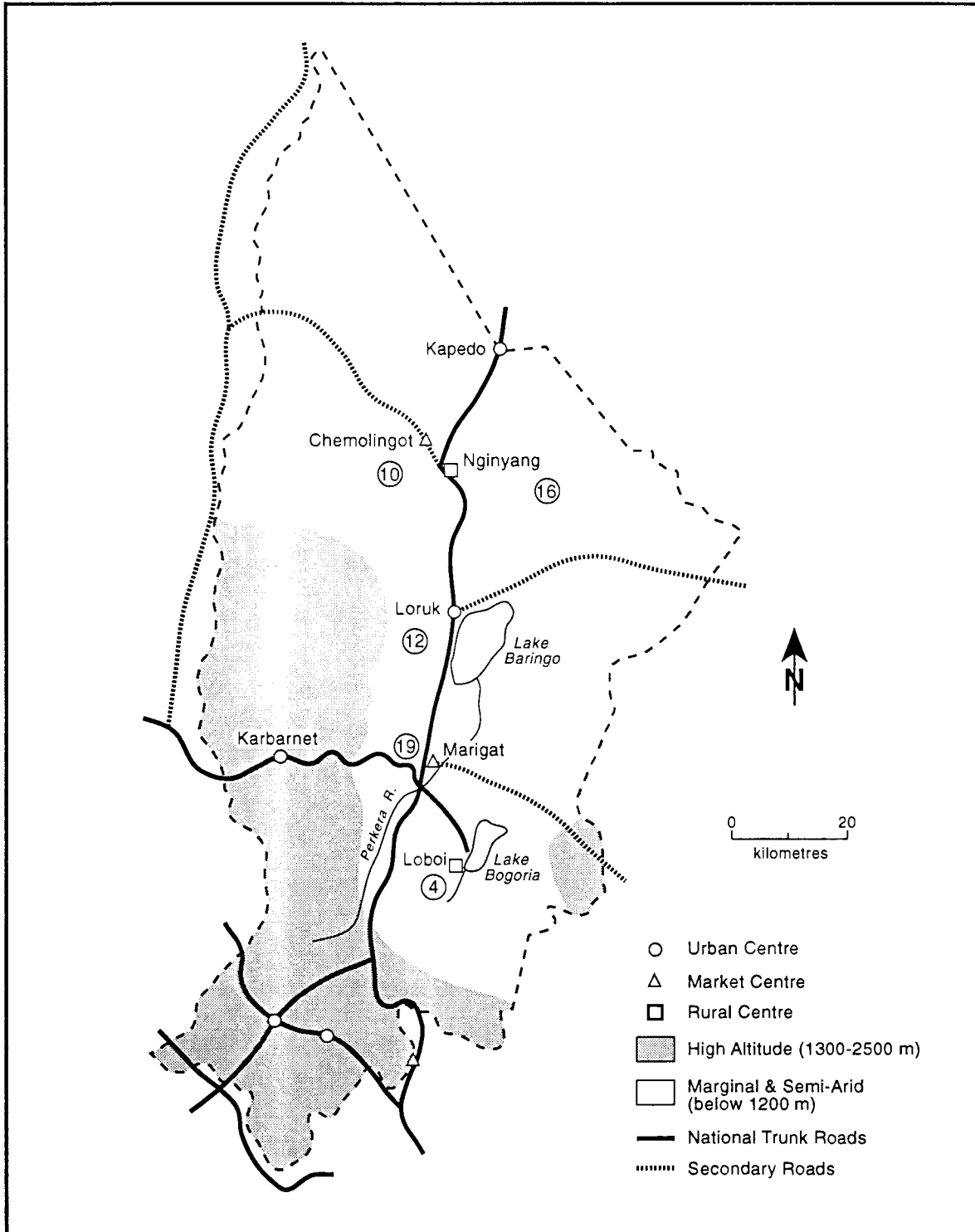
similar to the one described earlier are being developed make the
total exposed population large. The pastoral communities live in
small groups that move from place to place with their livestock
in search of pasture.

7.2 METHODS AND MATERIALS

Two questionnaires were prepared and were used as a guide in
obtaining information. One (Appendix II) was used during interviews
with local communities, the other (Appendix III) was given to
Goverment health providers in the area.

The survey was carried out between Jan.-Mar. 1994. A total of
51 residents were interviewed. Twenty three were nomadic
pastoralists (Pokots) and the rest were settled non-nomadic
residents. During the interviews specimens of adult sandflies and
mosquitos obtained from ICIPE[7] were used for confirmation of
identification.

In order to avoid bias in selection of respondents, each
section within the the four local centres- (Marigat and Loboi -in
the settled area and Nginyang and Chemolingot -in the
pastoral area) were randomly allocated a minimum of five home
interviews, two with respondents at schools within that village,
and one with a resident of the local market in that village. For
the home interviews, a respondent was randomly chosen in a family
for interview. Although it was possible to obtain information from
the respondents independently, within the pastoral communities in
a few cases family members joined in irrespective of whether it

44

was desired or not and contributed in some way in arriving at some answers.

Respondents aged 12-65 years were interviewed. The questionnaire requested information on such subjects as age, how long the resident has lived in the **VL** focus, occupational activities, factors considered to lead to risk of infection with VL and malaria, action taken to stop vector attack and why there was poor acceptance and use of vector control strategies. They were also tested on their ability to recognise sandflies and mosquitos and to relate the two vectors to the disease they cause. Each interview took a minimum of one hour to complete. The information from the communities were compared.

7.3   **RESULTS AND DISCUSSION**

Table 1 shows some demographic features of the population living in the area where the survey was done. The ratio of male to female individuals was (1: 1.06), while that of pastoral to settled populations was (1: 1.04).

Among the pastoral Pokots, Visceral leishmaniasis is called *"termes"*. Sandflies, the disease vectors, are refered to as *"kaliany"*. These terms are used by both adults and children. For the other communities involved in this study, the disease is commonly called *"nuag"*, and sandflies are *"soriek"*. During the

interviews these terms were used to ensure that there were no errors in comprehension of what was being discussed with the respondents.

In 1993, 61 patients admitted into the District hospital at Kabarnet (Fig. 7) were satisfactorily diagnosed and treated for VL. Figure 8 is an illustration of the monthly distribution of these patients when admitted the first time. Sandflies have their peak activity during wet seasons. In Marigat this falls in March to April followed by a shorter wet period in July-August (Basimike *et al.* 1992). The disease incidence peaks approximately six months after the rainy season suggesting an incubation period of about six months similar to that observed in Iran (Soleimanzadeh, 1993).

The distribution of the patients by age and gender is shown in Figure 9. Forty of 61 (70.5%) were 20 years old or younger. From the pastoral community, 21 of 38 (55.3%) were aged 0-15 years while from the settled residents 11 of 23 (48%) were in this same age group. The prevalence of the disease appears to be higher in the age group (0-15). This can be attributed in part to the virtual absence of vector protective measures among the pastoral communities and the low priority given to children aged 3-14 years when it comes to use of protective measures such as permethrin impregnated nets within the the settled communities. It could also be possible that at this age, immune response to leishmanial infection is inadequate (Fig 9).

The frequency of disease occurence appeared to be higher for men than women (59% compared to 41%). This may be the result of either occupational activities such as spending more time near livestock enclosures or community lifestyles in which boys use different sleeping quarters which may not be as protected as those of the parents. They would therefore be more prediposed to sandfly attack.

Figure 10 shows the distribution in relation to the main occupational activity of the location in which the patient resided. The frequency of disease occurence seemed higher for individuals from the pastoral than those from settled communities (62% compared to 38%) despite the fact that the two communities lived in close association sharing several services such as schools, health services, commercial centres and many others. Some of the factors that predisposed the former to higher disease risk will be discussed later.

There were no patients from the nomadic area older than forty. This may be due to a higher tolerance, the result of being exposed to the disease for a longer time. Most of those from the settled communities were recent immigrants into that area and may not have previous exposure to VL.

Table 1: Distribution of the population living in Marigat, Baringo District where the survey was done. The ratio of male to female and pastoral to settled is indicated (source: population census report of 1993)

		distance to hosp.	male individuals	Female "	TOTAL population	Ratio of men: women	predominant occupation *
LOCATIONS							
Marigat							
and		30-60km	14,692	15,392	30,084	1: 1.05	Agricultural/
Loboi							commercial
Nginyany							
and		60-120km	13,831	15,040	28,871	1: 1.09	Pastoral/
Chemolingot							nomadic
TOTAL			28,523	30,432	58,955	1: 1.07	

Figure 8: Distribution of VL patients from Marigat at first month of admission into hospital for treatment in 1993 (source: Kabarnet hospital records)

kala-azar patients 1993
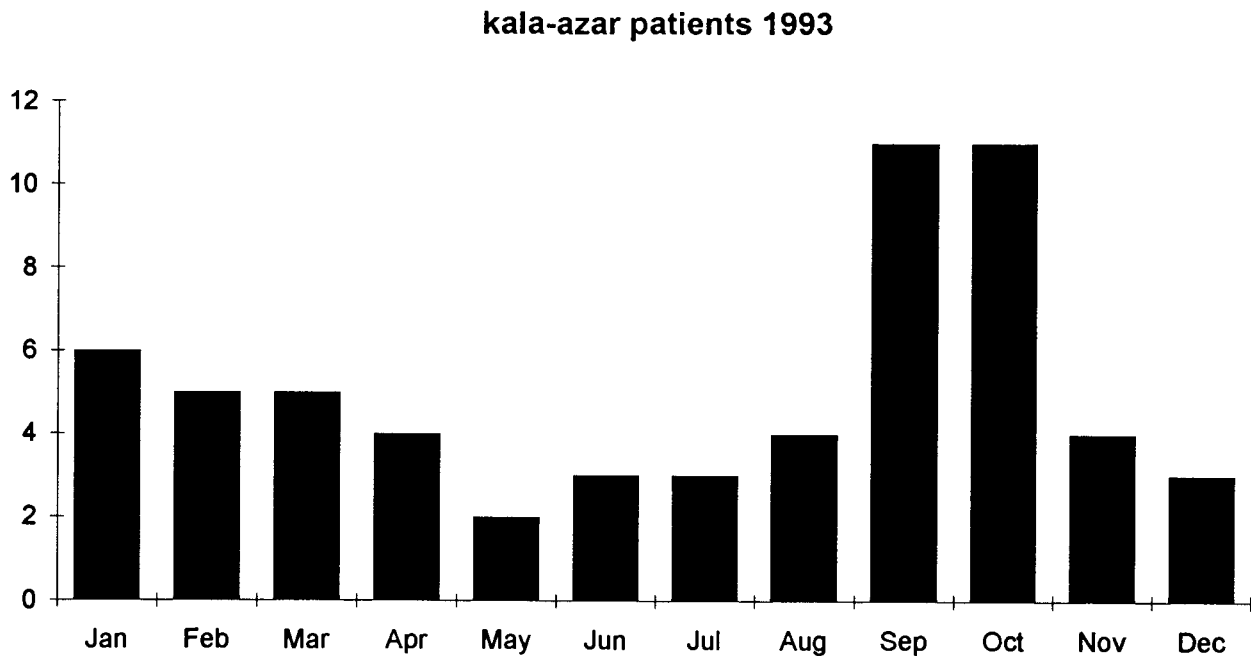
Figure 9: Distribution of VL patients admitted to Kabarnet hospital according to age and gender (source: Kabarnet hospital records).

black represent female patients, white male.
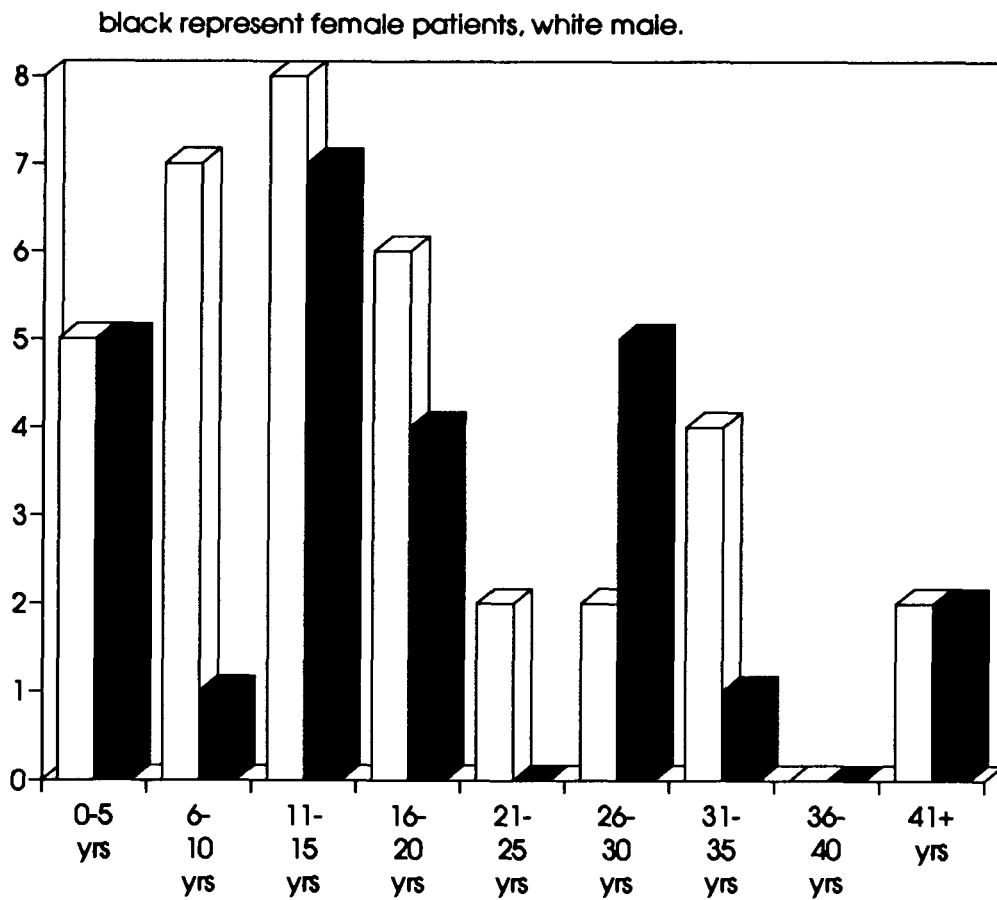
Figure 10: V L patients admitted to Kabamet hospital according to their age and main way of life of residents of the location they were resident of.

way of life: black represent patients from settled area, white the pastoralists.
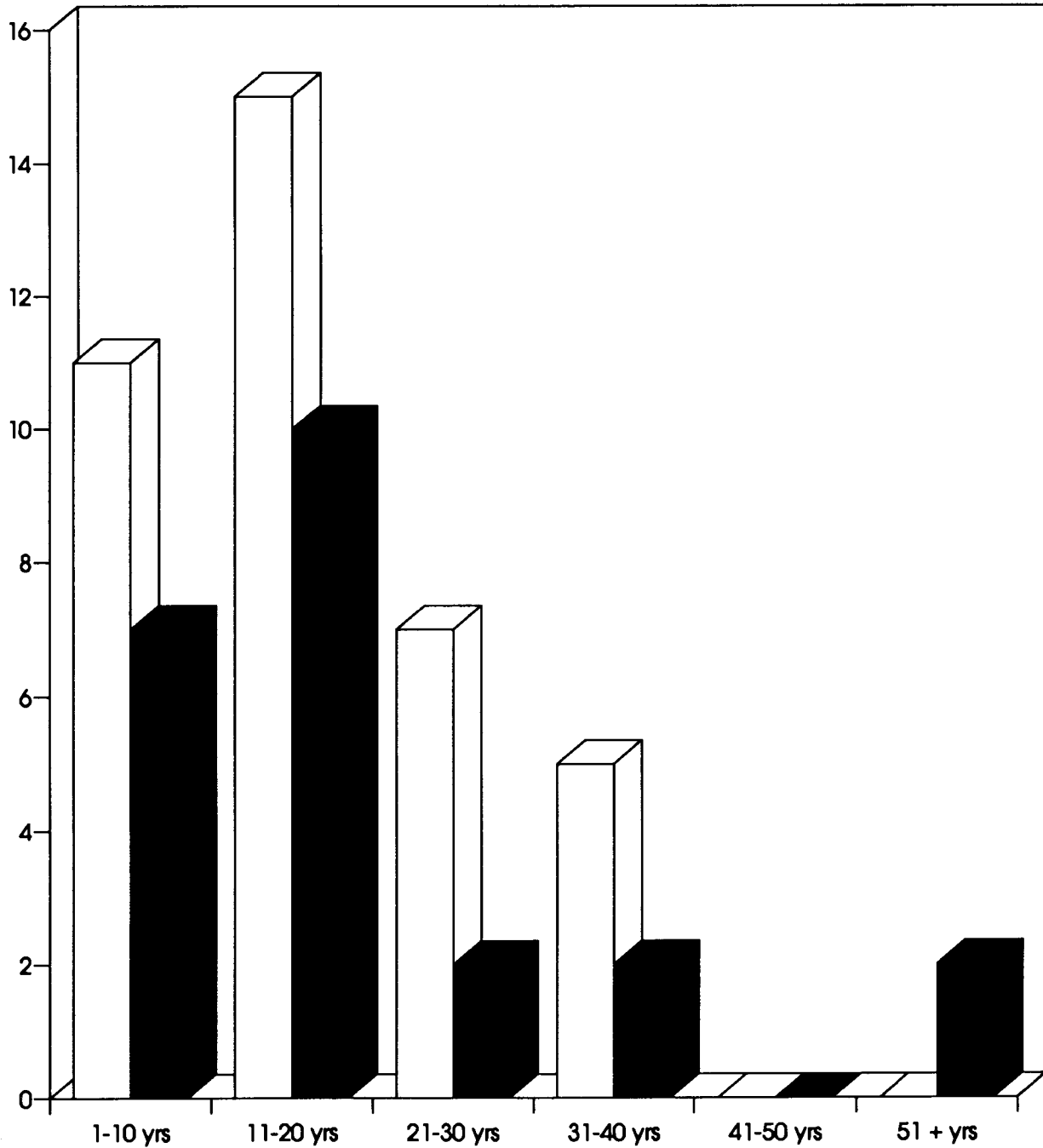
Results of the survey

A total of 51 respondents were interviewed during the survey. 35 were male, 16 female. Table 2 shows their distribution according to their predominant occupation, approximate number of households within the village and approximate distance of that village to the hospital at Kabarnet where diagnosis and treatment of the **VL** was done.

All 21 respondents (14 males, 7 females) from the pastoral community indicated they had lived in that area all their lives. 26 of the 30 respondents from the settled communities had lived for more than ten years with 4 (13%) having immigrated into Marigat in the last four years. Of those from the settled community, 21 were males and 9 females.

Table 2: Distribution of respondents, approximate distance of village to hospital and predominant lifesytle in location.

		populatio est. **	# of inter viewees	approx. distance to hosp. (km)	predominant occupation		
LOCATIONS							
Marigat*		22,000	15	25km	agricultural/commercial		
Loboi		8,084	15	40km	"	"	
Nginyany		16,000	13	75km	nomadic/pastoralists		
Chemolingot		12,841	8	85km	"	"	
	TOTAL	58,955	51				
	** population of divisions were available, that of locations						
	estimated from the observed physical distribution.						

52

Twenty six respondents were 25 years or younger. Of this 24 (47% of the survey), had at least six years of primary school education. Of the 25 who were 26 years or older, 14 (29% of 51) had no education and could not read. A much higher proportion (18% compared to 10%) of those aged 26 or older were from the pastoral community.

There was no obvious difference in the proportion[8] of men to women who had not been to school within both communities However between communities the settled had higher proportion of the literate compared to the pastoralists (Table 3).

To determine levels of participation in vector control, respondents were asked whether they were aware VL and malaria were transmitted by insects. All respondents answered in the affirmative for malaria. On *kala-azar* however, 12 of 21 (57%) and 22 of 30 (73%) of pastoral and settled communities respectively indicated they knew the disease was transmitted by an insect. The remaining respondents in the pastoral community thought the disease was caused by; use of unclean drinking water (3 respondents), floods during the rains (2 respondents), bodily contact with a sick dog (3 respondents) and drinking tea with milk (1 respondent). The settled communities gave alternate causes as; being the result of progressively untreated malaria (5 respondents) and parental transfer of VL within a family (3 respondents).

The association of the disease with floods and unclean water may be due to the the occurrence of disease shortly

after the rainy season, when only flood water represent that availiable for use especially within the area the pastoral communities live.

Families with one **VL** patient risk having more individuals infected. The belief that **VL** is inherited may therefore be wrong but is a reasonable conclusion.

All the respondents knew mosquitos transmitted malaria. Similarly, 19 of 21 (90%) of the pastoral and all the settled communities respectively could identify specimens of adult mosquitos. For visceral leishmaniasis however, results indicated that 11 of 21 (52%) and 19 of 30 (63%) of the pastoral and settled residents knew sandflies transmitted the disease, but only nine (42%) and 14 of 30 (47%) respectively could identify specimens of this vector despite the relatively high densities and wide distribution of the insect within the survey area during the wet season. All the respondents knew the local name of the insect but few recognised it. The main reason given was because it is extremely small unlike other vector such as mosquitos, ticks or other biting insects.

Among the pastoralists those that did not know transmission was by insect thought the disease was caused by associating with dogs and cattle (5), or entering unoccupied houses and cattle sheds when livestock was out for pasture (2) or were not sure how the disease occurred (2).

Among the settled communities in the survey, 17 of 30 (57%) knew sandflies transmitted the disease while humans were asleep

at night, (2) in the morning when performing such chores as milking, and (3) in the evening when one was resting or walking.

There were no clear difference in the proportion of men to women within and between both communities on the recognition of sandflies, (table 3).

No wild or domestic mammalian reservoir has so far been incriminated in the **VL** cycle in Marigat focus. These responses in addition to that of cases of dog sickness point to the possibility of dogs being reservoirs. This needs to be investigated

Seventeen of 21 (81%) and 71% of the pastoralist and settled communituies knew where sandflies bred and rested respectively. Six (29%) of the pastoralists reported the day resting sites as termite-hills. With the settled communities, 21 of 30 (71%) responded that termite-hills, cracks and tree holes served as both breeding and rest sites during the day and 14 (47%) among these noted vectors used human houses at night. Kamhawi *et al.* (1991) showed that sandflies invaded and rested in houses during the day and night. In light of the responses, investigation need to be conducted to determine if the same occurs in Marigat so the practice of blocking shutters with screens during the night to eliminate vectors (a practise common among some residents) could be replaced with more efficient methods that can ensure vector resting indoors are excluded by repellant or be killed.

The low level of **VL** knowledge by pastoral communities could be due either to low levels of literacy or low public health education programmmes, or occupational activities that hamper

education. Despite these limitations, all respondents were anxious for choices that would result in change in the attitude that the disease was inevitable and that nothing could be done about it.

On vector control among the settled communities, the respondents used combination of the following methods: smoke from burning of livestock dung or some specific plants to repel vectors (26), destruction or blocking of termite hills and their ventilators (11), clearing bushes and rocks near homesteads (7), using permethrin sprays such as "DOOM" as a repellant (5), using permethin-impregnated nets (9), and moving livestock enclosures further away from the homestead combined with insecticidal control of ticks (1). There was an overlap of methods used, as individuals said they used more than one control strategy. Only four residents said they had not attempted to control the vectors. Use of smoke as a repellant represented the method used by most. Despite the sucesses attributed to the use of permethrin-impregnated nets, only 9 of 30 (30%) had used them.

In the region smoke was identified as a traditional method of vector control among the local residents. People grew up using it. For using permethrin-impregnated nets however, 6 of 30 (20%) got their information from public health workers, 1 (3%) from goverment research institute (KEMRI)[9], 2 (7%) from public broadcasting systems. All nine also indicated they obtained more information from neighbours. There was an overlap on the source of information.

Among the pastoral community, only 4 of 21 (19%) said they had used smoke as a repellant, 2 (10%) had used permethrin-impregnated nets and 2 (10%) cleared termite hills as a control measure. The low use of vector control was probably because they had no permanent housing. Those who used nets said they got information from public health workers, 2 (10%).

A larger proportion of women (37.5%) used permethrin-treated nets than men (14%). The major source of information for women were women groups and community health workers.

Similarly, a higher proportion of the settled community used at least one form of the vector control measures when compared to the pastoralists (table 3).

Various types of insecticides including pyrethriods are widely used by residents living within the survey area for agricultural activities. Asked about health risks associated with handling, use and storage of these insecticides, mosquito nets and insecticidal repellants, 28 (54%) responded there were none. The rest indicated they had not handled the insecticides on a regular basis as they were involved in agricultural activities. This response eliminates lack of adoption from being due to perceived risks from insecticides or nets. It can therefore be assumed that there maybe a poor link between the sources of the vector control strategies and receipients.

On the comparison of seriousness between *kala-azar* and malaria, or other diseases, 14 of 21 (67%) of the pastoral

community responded **VL** was the most serious disease and gave the following reasons why; the disease caused infected individuals to contribute very little in terms of daily chores and were therefore a burden during migration, **VL** did not respond to traditional medicine mainly from medicinal plants. Drugs availiable from the local health centres and shops in the local markets were for anti-malarial, pain relief and similar ailments. These had no effect on **VL** patients. Infected individuals had to travel to the District Hospital 30-100 km away. To **VL** patients, costs incurred in travel and hospitalization were exhorbitant, affecting the choice for treatment. This may explain the increasing number of **VL** cases as the distance from the District hospital increased.

Among the settled inhabitants, only 11 of 30 (37%) said **VL** was more serious than malaria. Seriousness of **VL** was due loss of productive time as patients took a long time to recover. There a clearly higher proportion of the pastoral community who considered **VL** a more serious disease than the settled inhabitants This, considered in conjunction with the frequency of the disease prevelance appear to lend credence to the perception of the pastoral community that **VL** was a more important disease to them. Their low level of participation of vector control might be a contributing factor to the disparity.

On how long and who made the decision to seek treatment, reponses showed that both parents in a family made that decision but this depended on the seriousness of the sickness, and the availiability of money.

Table 3: Comparison of responses of the two communities of Marigat on vector control participation

|		Nomadic community		Settled residents		Av. of all residents	
RESPONSES		n=21		n=30		n=51	
		# of resp.!	expr. %**	# of resp.	expr.%	expr. %	
1.Resident in							
Marigat (>4yrs)		21	100%	26	87%	93%	
2.Literacy (>6yrs) or							
still in school		11	52%	24	80%	69%	
3.Recognition of:							
(i) mosquitos		19	90%	30	100%	96%	
(ii) sandflies		9	42%	14	47%	45%	
4.Kala-azar the							
most serious dse		14	67%	11	37%	52%	
5.Vector control							
(i) smoke		4	19%	26	87%	53%	
(ii) permethrin net		2	10%	9	30%	22%	
(iii) permethrin							
sprays		0	0%	5	17%	9%	
(iv) termite hill							
removal		2	10%	11	37%	23%	
(v) no control		15	71%	4	13%	42%	
6.Source of strat-							
egies on control:							
(i) neighbour		4	14%	9	30%	22%	
(ii) public health		2	10%	8	27%	19%	
(iii) public media		0	0%	3	10%	5%	
(Iv)Research KEMRI		0	0%	2	7%	4%	
(v) others*		3	14%	5	17%	16%	
	* include women groups, church leaders etc						
	** expressed as a percentage						
	! number of responses						

Clinical officers, public health technicians, private practitioners within the focus and the Medical Doctor in the referal Hospital responded to the survey.

A seasonal rise and decline in the number of patients affected with **VL** was reported (Fig 8). The clinical officers in the health centres noted a difficulty in differientiating **VL** from malaria especially among children and adolescents. No reason was given for this observation.

Patients suspected with **VL** were referred to the District hospital. It was however noted that some patients failed to adhere to this recommendation. Instead they used pallative drugs such as folic acid and ferous sulphate from health centres given for alleviation of anemic conditions and/or anti-malarials from the either the health centre or local markets. Other patients preferred use of traditional herbs that often had no specific dosages. Improvements were temporary and in all cases symptoms especially with children recurred almost immediately.

The unavailiabilty of pentostum within the health centres was a major concern of the medical staff. Figure 11 shows the quantities of this drug used at the hospital from 1988. Considering the dosages neccessary for cure, this quantity were insufficient for the number of reported cases of the disease, more so because the drug was regulated and was only availed through goverment hospitals.

Figure 11: Quantities of 100 ml bottles of pentostum (sodium stibogluconate), the drug received and used to treat VL used at Kabarnet Hopital 1988-1993 (source: Kabarnet hospital records)
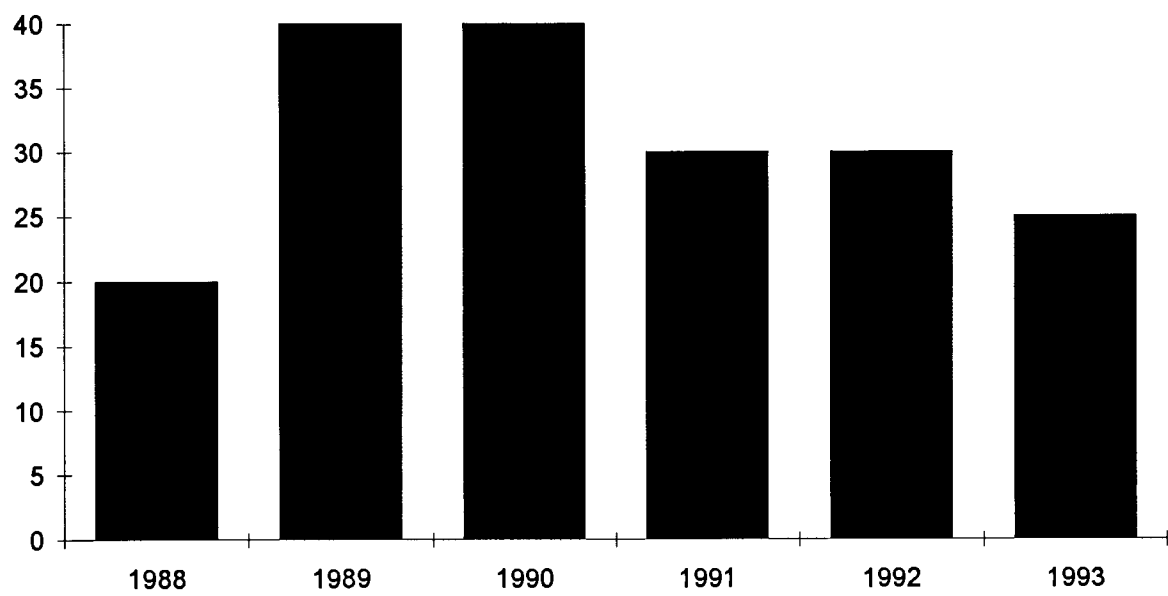
Very litle was done in public education programmes on sandfly control. Public health emphasized control of mosquitos, an extension of the mosquito control programmes within the country. Thus permethrin treated nets were termed "Mbu" (local name of a mosquito). The public media, posters at hospitals and other areas for public consumption detailed only mosquito and malarial control. Repellants were also labelled "mosquito coils" and in school education vector control prioritized mosquitos.

The number of field surveillances for **VL** cases carried out within pastoral areas by the vector borne division for the detection of **VL** was reported to be very few. In 1993, the interval between surveillances were also far apart. It is doubtful whether this had any impact on the disease management.

Unlike most other infectious diseases, **VL** does not appear homogeneously distributed within human populations, instead it occurs in clusters within communities or households. In Marigat, in addition to the predisposing factors already discussed, management was also observed to be influenced by the following factors.

Housing

I did not investigate the housing type of the **VL** patients admitted to hospital in 1993. However, among those interviewed, 13 of 51 (25%) had a member of their family with **VL** in the last two years. Nine of 13 (69%) had a house that was either incomplete

(thatched roofs with incomplete walls) or had open ventilation. All nine had between one and three members of their family with **VL** patients in the last two years. The remaining 38 all had homes that were complete with ventilations that could be opened and shut at night. Twelve of 38 did not use vector control measure, 26 did. Two of the 12 (17%) not using vector control measures had a **VL** patient in the preceeding two year while only one of 26 (4%) who used vector control had a **VL** patients during the same period. It is probable to infer from this that poor housing increased the risk of infection.

The location of the houses also seemed to increase the risk of **VL**. For instance, eight of 13 (62%) of those with incomplete houses and six of 38 (16%) with completed homes lived close to seasonally flooding rivers. All eight and three of those whose homes were incomplete and completed respectively reported having a **VL** patient in the last two years. It appears possible that such sites increased risk to sandfly attack.

Cost of vector control

In the control of mosquitos, Shaw (1989) estimated the cost of using $0.5gm/m^2$ of permethrin in impregnated screens in Cote d'Ivoire to be about US$ 2.40 /person /year. In Marigat, most of the respondents belonged to large families (> 5 persons). The cost of mosquito nets at approximately Ksh 170 (US$ 4.85) and permethrin at Ksh 360 (US$ 10.30) per litre (1993 prices) was

beyond the price range of most families if each family member

had to be protected. Among those who used permethrin-treated nets

for vector control, concentration that were less than the

recommended 165ml/dose for five nets to achieve $0.5gm/m^2$

concentration was noted. Such treated nets were also exposed to

smoke and dust which probably lowered the efficacy to less than the

six month re-treatment period.

Priority on health improvement

Except for the control of mosquitos, most vector control

programmes in Marigat did not emphasize other health benefits.

Because of this, most of the residents who used control measures

did so only during the season when mosquitos were at their peak

which coincided with the rainy season. During the non-malarious

months, use of vector control measures was suspended or was

sparingly used. Education programmes target control of mosquitos

as the primary health concern and all other vectorial diseases

including VL given less priority leading to the disparity observed.

Way of life

As previously discussed, among the pastoral communities,

vector control were observed to be limiting due to their way of

life. Different approaches are neccessary to achieve active participation.

The low acceptance of introduced vector control strategies due among other things to the following.

Delivery systems

During the demonstration of new control strategies such as use of permethrin nets, the participation of local residents was limited to that of spectators. Investigators, researchers and/or public health workers often used households or homesteads to obtain data on various aspects such as vector dynamic, control measure effectiveness *etc*. The residents were not aware of what the reasons were for the investigation, the direct effect if successful and what their role would be. Later delivery of recommendation was treated as foreign by the local residents and were neglected once trials were complete and/or no govermental insistency. Adoption was therefore very low.

Materials and equipment

Most new control strategies, such as use of wire screens in houses were introduced with the supply of materials limited to the time of introduction. After the initial stage, residents attributed the low level of adoption to lack of re-supply of these materials

within distance that could be easily reached, such as a local market. As a result the control strategies were often discarded after the initial phase, leading to a low sustainability.

Target groups

Though men were the major decision makers within families, I observed in this survey that women and men with young children were more likely to accept new vector control strategies. Public education need to be tailored to target such groups instead of the present general approach.

Policy

While medical treatment is important, a policy should be established that will de-link residents from the idea that the solution of every disease is hospital treatment. Instead community based control programmes such as vector control should be given some priority.

CONCLUSION

This survey was conducted in order to evaluate the approach and limitations a population living in a **VL** focus faced in their approach to disease control. From this survey, it can be hyphothesized that it is not just an individual's perception that affects vector control but other factors such as family sizes and ages of all members, individual or family economic status, the perception of development of immunity to **VL**, the effect of sandflies as a nuisance, alternate vector control strategies, and the occurence and frequency of the disease over several years. Each of these factors influences the way individuals perceive problems and make decisions, and hence affect disease control one way or another. Additional data on these factors need to be investigated in order to identify the priorities and importance of each.

It can be concluded that individuals settled and pastoral communities differ with respect to their knowledge of **VL** and use of **VL**-control practises. Similarly, though **VL** is perceived to be a serious disease, few effective public health programmes are implemented in the region. However, public health programs for malaria were more common and as a result, the public was more informed about malarial control. It is possible then that improved public health programs on **VL** would increase awareness and use of **VL**-vector control measures.

Because there is a majority of diseases in young children,

school based programs for children and home-based programs for adults are needed. These control measures need to be designed so that they may be effectively used by each age group.

In the survey, I noted several limiting factors. There appeared to be a poor acceptability and adoption of vector control strategies. The 22% usage of permethrin-treated nets was seems low. However, unless monitoring and evaluation are carried out, it may not be possible at this stage to confidently conclude that these observations agree with the general conditons.

Visceral leishmanisis is a seriously debilitating disease. It is also potentially one vector-borne disease that can be managed. One option that offers this choice is the control of sandflies. Despite investigations and recommendations on various control measures, there appears to be little success as evidenced by the annual increase of reported cases.

Although investigations report sucess with the use of permethrin-impregnated nets ("Mbu cloth"), in Marigat it was noted that its application was limited by the high cost and unavailabilty of the materials within local centres, use during mosquito peak seasons only and the exposure to substances that could shorten the effective period. The distinct discomfort caused by mosquitos during attack is absent in sandflies leading to a "silent attack" and this might have led to the tendecy to keep nets away when mosquitos were not at peak flight. Public health education programmes aimed at rectifying this may be neccessary.

The type of houses and way of life of the residents influenced risk to **VL**. Pastoral inhabitants appeared more at risk. Different approaches on vector control, disease management and eduation programmes that can appropriately suit their way of life need to be designed.

As population increases, immigration into areas not previously occupied will continue to occur. This will be bring people closer to focus of diseases such as **VL**. Development

programmes such as irrigation schemes in such areas should be designed to ensure vector-borne diseases can be managed. By planning the locations of homesteads relative to sandfly breeding and resting habitats, the exclusion of this vector from houses of could be achieved.

Community education programmes using the media (radios, TVs) and use of billboards that displays catch phrases could be introduced to enhance public awareness of the role of the vector, thus empowering individuals to relate disease occurence to vector control more readily. This may increase acceptance and adoption of effective vector control measures. At the same time women groups and schools could be used as channels of education as more individuals in these groups used control measures. Their involvement during investigations, and trials may lead to longer sustainability of these measures.

The destruction of termite hills, the habitat suspected to be main breeding site of sandflies is costly and almost impossible as the termites rebuilt the mounds as they were remove. Insecticides such as Aldrin (restricted for use on residential houses termite control) or alternatives that can ensure a more permanent removal within homesteads could be investigated.

Similarly an investigation into the effect of vegetation and enviromental changes due to agricultural practises and human population concentrations in urban settings on the densities and effectivity of the vectors of VL need to be determined in order to predict the effect of similar changes in other areas.

Government initiatives through the vector borne division and community health workers need to develop and promote programmes that will increase the knowledge of the role of vectors in disease transmission. In order to eliminate inappropriate and inefficient communication, the target population should be sensitized about the disease transmission. Promotion of literacy is a neccessary ingredient in this aspect.

There is also the need for sufficient availability of the drugs needed for treatment. Simple procedures for early detection of **VL** in the health centres in the disease focus are also neccessary.

Appropriate, cheap and sustainable vector control measures developed with active participation of the population may increase adoption of strategies ensuring a lowered risk to the disease.

REFERENCES

Adler, S. & Theodor, D., 1957. Transmission of disease agents by *Phlebotomus* sandflies. Ann. Rev. Entomol. 2 : 203-226

Baretto, M.P., 1943. Observaciones sobre la biologia em condicoes matturais do *flebotuomus* do Estado de Sao Paulo. Fac. Med. Univ. Sao. Paulo. Tex.de Concurso a Docencia-Livre Cadeira de Parasitologia 162 pp

Basimike, M. & Mutinga, M. J. 1992. The relative abundance of *Phlebotomus martini* Parrot and *P. dubosqui* Neveu-Lemainre (Diptera: Psychodidae) in animal burrows and termite mounds in Marigat location, Baringo District, Kenya. Insect Sci. Appl. 13 (2): 173-176

Basimike, M., Mutinga, M.J., Kumar, R.1992. Habitat preference and seasonal variations of *Phlebotomine* sandflies (Diptera:Psychodidae) in Marigat area Baringo District, Kenya. Insect Sci. Appl. 13 (3): 307-314

Beach, R., Young, D.G., & Mutinga, M.J. 1982. *Phlebotomus dubosqui* from Kenya. Trans. R. Soc. Trop. Med. Hyg. 69 (5): 707-708

Bentley, M.D & Day, J.F. 1989. Chemical ecology and behavioural aspects of mosquito oviposition. Ann. Rev. Entomol. 34: 402- 424

Brahin, I. & Brahin, B.J. 1992. Parasitic infections in women and their consequences. Advances in Parasitology 31: 1-18

Chance, M.L., Schnur, L.F., Thomas, S.C. & Peters, W. 1978. The biochemical and seriological taxanomy of *Leishmania* from *Aethiopian* zoogeographical region in Africa. Ann. Trop. Med. Parasit. 72: 533-542.

Chaniotis, B.N., Parsons, R.E, Harlan, H.J, Correa M.A. 1982. A pilot study to control Phlebotomine sandflies (Diptera: Psychodidae) in a neotropical rainforest. J. Med. Entomol. 19 (1): 1-5.

Chaniotis, B.N. 1967. The biology of Californian *Phlebotomines* (Diptera: Psychodidae) under laboratory conditions. J. Med. Entomol. 4 (2): 221-233

Christensen, H.A. & Herrer, A. 1973. Attractiveness of sentinel animals to vectors of *Leishmaniasis* in Panama. Amer. J. Trop. Med. Hyg., 22: 578-584

De Beer, P., Harith, A., Deng, L.L., Semiao-Santos, S.J., Chantal, B., Groothest, M.V. 1991. A killing disease epidemic among displaced Sudanese population identified as *Visceral Leishmaniasis*. Amer. Soc. Trop. Med. Hyg., 44 (3) 283-289.

Degracheva, T.I. 1972. The duration of development of pre-imaginal stages of some species of sandflies (Diptera: Phlebotominae) as observed in the laboratory. Meditsinskaya parazitologia i parazitarnye Boleznii, 41: 536-542.

Dhiman, R.C.,Shetty. P.S., & Dhanda, V. 1983. Breeding habits of *Phlebotumus* sandflies in Bihar, India. Indian Journal of Med. Research, 77: 29-32

Dye, C., Davies, C.R., Lainson, R. 1991. Communication among *Phlebotomus* sandflies, a field study of domesticated *Lutzomyia longipalpis* population in the Amazonian Brazil. Anim Behaviour, 42: 183-192.

Elias, M., Mizanur Rahman, A.J.M., Khan.N.I, 1989. Visceral leishmaniasis and it's control in Bangladesh. Bulletin of the World Health Organisation, 89 (1): 43-49.

Esterre, P., 1986. Evaluation d'un programme de lutte centre la leishamniose cutan'ee dans un village forestier de Guyane francaise. Bulletin of the World Health Organistatio, 64: 559-565.

Elnaiem, D.A., Ward,R.A., Rees, H.H. 1991. Chemical factors controlling oviposition of *Lutzomyia longipalpis* (Diptera: Psychodidae). Parasitologia, 33 (suppl): 217-224

Fendall, N.R.E. 1961. The spread of *Kala-azar* in Kenya. East African Med. J. 38: 417

Foster, W.A., Testa-Yohannes, T.M., Tecle, T. 1970. Studies on *Leishmaniasis* in Ethiopia-II. Laboratory culture and biology of *Phleobtomine longipes* (Diptera: Psychodidae). Ann. Trop. Med. Parasitology, 64: 403-439

Gemetchu, T. 1976. The biology of a laboratory colony of *Phlebotomus longipes* Parrot and Martin (Diptera: Phlebotominae). J. Med. Entomol. 12 (5): 661-671

Hanson, W.J. 1961. The breeding of Phlebotomus in Panama (Diptera: Psychodidae). Ann. Entomol. Soc. Amer. 54: 317-322

Hashighushi, Y. & Laundries, E.G. 1991. A review of *Leishmaniasis* in Equador. Bulletin of PAHO, 25 (1): 64-76

Heisch, R.B. & Guggisberg, C.A.W. 1954. Studies on *Leishmaniasis* of East Africa -I- The epidemiology of an outbreak of *Kala-azar* in Kenya. Trans. R. Soc. Trop. Med. Hyg. 48: 449.

Hertig, M. 1942; *Phlebotomus* and Carrion's disease. Amer. J. Trop. Med. 22 (suppl): 1-81.

Hoogstraal, H., Heyneman, D., Dietlein, D.R., Brown, H.G., Reid, T.P., Van peenan, P.F.D., Saber, A.H., & Rohrs, L.C. 1963. *Leishmaniases* in the Sudan Republic. Epidemiological findings. Bull. WHO, 28: 263-265.

Kamhawi, S., Lane, R.P., Cameroon, M., Philiphs, A., Milligan, P. & Molyneux, D.H. 1992. The cuticular hydrocarbons of *Phlebotomus argentipes* (Diptera: Phlebotominae) from field populations in Northern India and Sri Lanka and their change with laboratory colonization. Bull. Entomol. Res. 82: 209-212

Kamhawi, S., Abdel-Hafez, S.K, Molyneux, D.H. 1991. Urbanisation:- How does it affect the behaviour of sandflies? Parassitologia, 33 (Suppl): 299-306.

Kaul, S.M., Sharma, R.S., Ray, K.P., Rai, R.N., Verghese, T. 1994. Impact of DDT indoor residual spraying on *Phlebotomus argentipes* in a *kala-azar* endemic village in eastern Uttar Pradesh. Bull. of the WHO, 72 (1): 79-81.

Kaul, S.M., 1978. Preliminiary observations on the susceptibility status of *Phelbotmus argentipes* and *P. papatasi* in North Bihar (India). J. Communicable diseases. 10: 208-209.

Kettle, D.S. 1990. Medical and Veterinary Entomology. Published by CAB International, Worthington, U.K pp159-172

Killick-Kendrick, R. 1978. Recent advances and outstanding problems in the biology of Phlebotomine sandflies. Acta Tropica 35: 297-313

Killick-Kendrick, R., Wilkes, T.J., Bailly, I., & Righton, A. 1986. Preliminary observation on the flight speed of *Phlebotomine* sandfly. Trans. R. Soc. Trop. Hyg. 80: 138-142.

Killick-Kendrick, R. 1989. The ecology and entomolgy of *Leishmaniases*. NATO-ASI-Ser-SerA- Life Sciences: 175-179

Lainson, R., Dye, C., Shaw, C., Macdonald, D., Courtenay, O., Souza, A.A.A., & Silveira, F.T. 1990. Amazonian *Visceral leishmaniasis*: Distribution of the vector *Lutzomiya logipalpis* (Lutz & Neiva) in relation to the fox (*Cerdocyton thous* (L),and efficiency of this reservoir host as a source of infection. Mem.Inst.Oswaldo.Cruz, 85: 135-137

Lane, R.P. 1986. Recent advances in the systematics of sandflies. Insect Sci. Appli. 7: 225-230

Leary, A.J.& Ready, P.D. 1970. The establishment, maintenance and productivity of a laboratory colony of *Lutzomiya logipalpis* (Diptera: Psychodidae). J. Med. Entomol. 13: 429-440

Lewis, D.J., Mutinga, M.J., Parrot, A., Ashford, R.W., 1972. *Phlebotomus longipes* (Parrot and Martin) (Diptera: Phlebotominae) and a new related species. J. Med. Entomol. 41: 119-124

Lewis, D.J., 1982. A taxonomic review of the genus *Phlebtomus* (Diptera: Psychodidae). Bull. of the British Museum of (Natural History), Entomology Series; 31: 217-343

Majori, G., Maroli, M., Sabatineli, G., Fausto, A.M. (1989). Efficacy of permethrin- impregnated curtains against endophilic phlebotomine sandflies in Burkina Faso. Short communication. Medical Veterinary Entomology, 3: 441-444

Manzoli, F.A., 1991. Opening address of the 1st international symposium on Phlebomine sandflies, Rome Italy. Parasitologia, 33 (suppl): 3-4.

Mckinnon, J.A., Fendall, N.R.E. 1955. *Kala-azar* in Baringo District of Kenya. J. Trop. Med. Hyg., 59: 208-212

Mebrahthu, Y., Lawyer, P., Githure, J.I., Kager, P., Leewernberg, J., Perkins, P., Oster, C., Hendricks, C.D. 1988. Indigeneous human cutaneous Leishmaniasis caused by *Leishmania tropica* in Kenya. Ann. Trop. Med. Hyg. 39: 267- 273.

Minter, D.M. & Eitrem, U.R. 1989. Sandflies and disease in Cyprus 1944-1985. NATO-ASI-SER-SerA- Life Sciences: 207-216

Minter, D.M. 1963. Studies on the vectors of *Kala-azar* in Kenya III. Distribution evidence. Ann. Trop. Med. Parasit., 57: 19-21

Minter, D.M., Wijers,D.J.B., Heisch, R.B. & Manson-Bahr, P.E.C. 1962. *Phlebotomus martini,* a probable vector of *Kala-azar* in Kenya. Brit. Med. J., 2: 835.

Molyneux, D. & Killick-Kendrick, R. 1987. The leishmaniases in biology and medicine. W. Peters and Killick-Kendrick (eds) Academic Press, London Vol 1 pp 121-176

Mukhopadhyay, A.K., Rahaman, S.J., Chakravarty, A.K. 1990. Effects of flood control on immature stages of sandflies in flood prone *Kala-azar* endemic villages of North Bihar, India. WHO/VBC.90. 986.

Mutinga, M.J., 1986. Leishmaniases. Insect Sci. Appl., 7: 421-427

Mutinga, M.J., 1975. Phlebotomine fauna in the cutaneous leishmaniasis focus of Mt. Elgon, Kenya. East African Med. J., 52:340-347

Mutinga, M.J., Basimike, M., Mutero, C.M., Ngindu, A.M., 1992. The use of permethrin -impregnated wall clothe ("mbu" cloth) for the control of malaria and leishmaniases in Kenya.-II. Effects on the Phlebotomine sandflies population. Insect Sci. Appl., 13 (2): 163-172.

Mutinga, M.J., Basimike, M., Kamau, C.C., and Mutero, C.M. 1990. Epidemiology of the leishamniases in Kenya. Natural host preference of wild caught Phlebotomine sandflies in Baringo District, Kenya. East Afrian Med, J., 67 (5): 319- 327.

Mutinga, M.J.& Kamau, C.C. 1986. Investigation on the epidiemiology of Leishmaniasis in Kenya. The breeding sites of Phlebotomines in Marigat, Baringo District, Kenya. Insect Sci. Appl., 7: 37-44

Mutinga, M.J, Kamau, C.C, Kyai,F.F., 1986. Investigations on the epidiemiology of leishmaniases in Kenya. The breeding habitat of *Phlebotomus dubosqui* (Diptera: Psychodidae), the vector of *Leishmania major* in Marigat, Baringo District, Kenya. Insect Sci. Appl., 7: 727-729

Mutinga, M.J., Ngoka, J.M., 1983. Investigations of the animal reserviors of visceral leishmaniasis and the isolation of *Leishmania major* in Marigat, Baringo District, Kenya. Insect Sci. Appl. 4: 237-240

Mutinga, M.J.& Odhiambo, T.R.1986. Cutaneous Leishmanisis in Kenya III. The breeding and resting sites of *Phlebotmus pedifer* (Diptera: Phlebotominae) in Mt Elgon focus, Kenya. Insect Sci. Appl., 7: 175-180.

Mutinga, M.J., Renaprukar, D.M, Wachira, D.W., Mutero, C.M., Basimike, M., 1992. Evaluation of residential efficacy of permethrin-impregnated screen used against mosquitos in Marigat, Baringo District, Kenya. Trop. Med. Parasitol., 43: 277-281.

Najera A.L.1946. Observaciones Sobre la ecologia de los Phlebotomes en su face larvoria principalmente. Rev. Iber. Parasit. 6: 139-158.

Perkins P.V., Githure, J.I., Mebrathu, Y. Kiilu, G., Anjili, C., Ngumbi,P.S., Nzovu, J., Oster, N., Whitmine, R.E., Leeuwenberg, J., Hendricks, C.D., & Koech, D.K. 1988. Isolation of *Leishmania donovani* from *Phlebotomus martini* in Baringo District, Kenya. Trans. R. Soc. Trop. Med. Hyg. 82: 695-700.

Petricheva, A.& Izyumskaya, N.G. 1941. On the breeding places of Phlebotomines in Sebastopol. Rev. Appl. Entomol. (B) 21: 98- 101.

Phillips, A., Le Pont, F., Pesjeux, P., Mulligan, P., Broomfield, G. & Molyneux,D.H. 1990a. Seperation of *Psychodopygus carrerai* and *P.yucumensis* by liquid chromatography of cuticular hydrocarbons. Acta Tropica, 47: 145-149

Phillips, A., Mulligan, P., Maroli, M., Lane, R.P., Kamhawi, S. & Molyneux, D.H. 1990b. Interspecific variation in the cuticular hydrocarbons of *Phlebotomus perfiliewi* Parrot (Diptera: Psychodidae) from Italy. Med. Vet. Entomol., 4: 451-457.

Ryan, L., Silveira, F.T., Lainson, R.& Shaw, J.J. 1984. Leishmanial infections in *Lutzomiya longipalpis* and *Lut. cutenesi* (Diptera: Psychodidae) on the Island of Marajao, Para State, Brazil. Trans. R. Soc. Trop. Med. Hyg. 78: 547-548

Sacks, D.L. & Perkins, P.V. 1984. Identification of an infective stage of Leishmania promastigote. Science, 223: 1417-1419.

Schlien, Y., Bonat, S., Jacobson, R.C. 1990. Oviposition, diapause and other factors affecting the egg-laying of *Phlebotomus papatasi* in the laboratory. Med. Vet. Entomol., 4: 76-78.

Schlein, Y., Jacobson, R.C., Messer, G.1992. Leishmania infections damage the feeding mechanism of sandfly vector and implement transmission by bite. Proc. Natl. Acad. Sci. (USA) 89: 9944- 9948

Shaw, A.P.M., 1989. Comparative analysis of the cost and benefits of alternative disease control strategies: Vector control versus human case finding and treatment. Ann. Soc. belge Med. trop., 69, Suppl. 1:237-253

Sinton , J.A.1930. Some new species and records of Phlebotomus from Africa. Indian J. Med. Res., 18: 171-172.

Southgate, R.A.& Oriedo, B.V.E. 1962. Studies in the epidemiology of east African Leishmaniases I- The circumstantial epidemiology of *Kala-azar* in Kitui District, Kenya. Trans. R. Soc. Trop. Med. Hyg., 56: 30-47.

Walsh, J.F., Molyneux, D.H., Birley, M.H., 1993. Deforestation:-effects on vector-borne diseases. Parasitology, 106: S55-S75

Wenyon, C.M. 1932; Trans. R. Soc. Trop. Med. Hyg. Vol 25, 315

WHO, 1990. Control of Leishmaniases. Report of a WHO expert committee. WHO Technical series, 793.

WHO, 1984. The Leishmaniases. Report of a WHO expert committee. WHO Technical series, 701

Yuval, B. 1991. Populations of *Phlebtomus papatasi* (Diptera: Psychodidae) and the risks of *Leishmania major*. Transmissions in three Jordan valley habitats. J. Med. Entomol., 28 (1): 192-195

FOOTNOTES

1   Unpublished estimate of **VL** cases by Leeuwenberg cited
from (Perkins *et al, 1988)*

2   Except for the population of the Marigat focus, the
populations living in the other leishmaniases foci was
obtained from (Mutinga, 1985)

3.   PDKL- commonly occuring in the Indian sub-continent
is a condition caused by *L. donovani* characterised by
skin lesions that occur 6 months to several years after
the apparent treatment of **VL.** In some cases patients may
not develop **VL** symptoms, but later develop PDKL

4.   Except for DDT, the concentrations, quantities and
interval of application of the other insecticides were
not indicated

5.   Pentostum- packaged in 100ml bottles containing
100mg/ml of antimony

6.   Report of the population census of 1993 (population
statistics, District office, Kabarnet)

7.   ICIPE- International Centre of Insect Physiology and
Ecology, Nairobi

8.   Proportion= <u>illiterate number in the group</u>
          ratio   Total number in that group

9.   KEMRI- Kenya Medical Research Institute

APPENDIX I.

(The reasons for this interview were first explained to the respondents before conducting the exercise).

<u>SURVEY OF RESPONSES TO THE CONTROL OF SANDFLIES</u>

<u>(DIPTERA: Psychodidae) FOR THE MANAGEMENT OF VISCERAL</u>

<u>LEISHMANIASIS IN MARIGAT, KENYA.</u>

Part I - QUESTIONAIRE

VILLAGE NAME _____ . VILLAGE # ___ . INTERVIEWEE # ___ .

I PERSONAL INFORMATION (INTERVIEWEE).

1. Sex   male __ female __

2. Age (years) <10 __ , 10-20, ____ 20-45 ___ ,   >45 ___ .
3. How long have you lived here? _____

4. When did you move to Marigat? _____

5. From where did you come from? _____

6. What is your level of education? <u>PRY</u> , <u>2DRY</u>   <u>TER</u>___

II. OCCUPATIONAL INFORMAION.

7. What is your major occupation ? _____

8. How many days in a week are you likely to be out of your house

   by 8.00 pm?

   <2 days/week __ , 2-4 days __ , >4 days _____ .

9. What will you be doing at this time (rank priority

   with major occupation being # 1,2,3,*,* etc)

        herding _____

        farming _____

        trading _____

        in school _____

        fuelwood collection ___

        drawing water _____

        chatting with friends __

        other _____ (what _____)

III KNOWLEDGE OF THE DISEASE.

10. What do you consider as the most serious disease here?

        Malaria   _____

        Leishmania _____

other _____

(name of this diseases _____(local name where

neccessary _____

11. Can you recognise a sick person who has

malaria? (yes/no) _____

leishmaniases? (yes/no) _____

12. What symptoms do you recognise when a sick person has

malaria ? _____

leishmaniases? _____

_____.

13. Which do you consider a most serious diseases?

malaria/leishmaniases? _____.

14. Why do you consider it a more serious diseases?

Kills _____

loss of productive time _____ how ?------------

expensive to treat _____ explain ?-------

other reasons (give reason) _____

_____.

15. Have you or any member of your family been treated for this

diseases in the last one year?

malaria (yes/no) _____

leishmanaises (yes/no) _____

16. Who was? <u>(tick all affected)</u>

self (interviwee) _____

father _____

mother _____

children (approx. ages) _____

children's gender (male/female) _____

17. Do you have any history of sickness due to leishmaniases in

your family? (yes/no) _____

18. How many members of your family in this age group were

affected by leishmaniases in the last 5 years?

children (<10 years) (i) boys _____

(ii) girls _____

the young (10-20 yrs) (i) boys _____

(ii) girls _____

adults (i) males _____

(ii) females _____

IV KNOWLEDGE OF INSECTS VECTORS. (here specimens of adults
___ Sandflies and mosquitoes will be used where neccessary to ___
___ confirm identification).

19. Are you aware that this diseases are transmitted by insects?

      malaria -   (yes/no)   ____.

      leishmaniases- (yes/no)   ____.

20. What insect transmitts (local name will do).

      malaria-   _____

      leishmaniases   _____

21. Can you recognise the insect you've said transmit's the

diseases above? (yes/no)   _____

22. Which insect is this? (specimens from ICIPE will be used)

      recognised sandflies (yes/no) _____

      recognised mosquitoes (yes/no) _____

23. How ** DO ** these insects (sandflies) transmit the

leishmaniases? _____

_____

24. How do they come into contact with the person they infect?

_____

_____

25. Do you know where they live during the

      day (yes/no) _____ where? _____

      night (yes/no) _____ where? _____

Where do they breed (lay eggs)? _____

26. What season of the year are they most serious?

      rainy season/dry season _____

      what month?   _____

27. Have you associated this insects with living in your

      house? (yes/no)? _____

      chicken coop (yes/no)? _____

      cattle/goat pen (yes/no)? _____

      cracks on trees/rocks on your compound

          (yes/no)? _____

      termite hills/holes of arboreal animals? (yes/no) _

28.***- Where do these insects get the parasites that cause ___
___ leishmaniases?   _____

  Are you aware that they get the parasites from

      (i) infected (sick) dogs? (yes/no)   _____

      (ii) infected (sick) people? (yes/no) _____

82

(iii) wild animals such as hyraxes,squirrels

(yes/no)? _____

29. Do you understand that infected people can act as agents of

spreading the leishmaniases? (yes/no) _____

30. What treatments do you or the affected persons in your family

use?   _____

_____.

V   INSECT CONTROL STRATEGIES AND ADAPTABILTY

31. Do you know of methods by which to control these insects?

sandflies   (yes/no) _____

which are they?   (i) _____
                  (ii) _____

iii) _____ iv) _____, etc

32. Have you used this methods for controlling the sandflies in or

around your homestead? (yes/no) _____

which have used?   _____

have you used this method in the last six months? (yes/no)__

33. How or where did you get this information on the control of

sandflies?

public health workers   _____

neighbours?   _____

others? _____ who? _____

34.   Which method have you found most sutainable? _____

_____

35. If new methods were introduced how would you like to be

involved in order to use and adapt them sustainable?

_____

36. What traditional methods **DID YOU/ DO YOU** in use in

treatment of diseases? _____

control of sandflies? _____

37. Is there any comments you would like to make on this subject? _

_____

_____

END

APPENDIX II.

Questionaire sent to goverment health provider in the survey area.(An introductory letter stating reason for the information was attached)

1. Are there any incidences of Leishmaniases treated in Marigat or any other parts of the District in the

    (i) last 6 months? (yes/no)   _____

       If yes how many cases?   _____

    (ii) the last 2 years? (yes/no)   _____

       If yes how many cases?   _____

  In both cases if NO please answer all the same.

2. For those individuals treated in the last 6 months please fill out this table (this is just a guide to discrimnate those villages where to carry out the survey i.e- suspected incidence areas against non suspected).

Treated individuals.

      1 2 3 4 5 6 7

Village or location

Age

Sex

Occupation if known

Visceral or cutaneous
(leishmaniases)

No of times treated
for the same disease

3. What drugs do you reccommend for treatment?

    Drugs used 1. _____ 2. _____

           3. _____ 4. _____ etc

4. How much of these drugs were used for treatment during these years?

  (please indicate the quantities in units)

    name of   drug 1   drug 2   drug 3   drug 4

         (___) (___) (___) (___)

  1993

  1992

  1991

  1990

  1989.

5 Are there any particular trends that you think may asssist me
   in determining the areas of disease prevelance and where
   sandfly control has been or has not been carried out?

_____

6. If you have any comments to make please write them here.

_____

Thank you in advance.