Chapter 1: INTRODUCTION
Human health is affected by several diseases. The magnitude of these diseases is further influenced by several factors like needs of routine life, socio-economic status, human habits/life style, place of living and its geographic location and the local ecology which is influenced by meteorological variables such as rainfall, temperature, humidity etc. There are plethora of communicable diseases prevalent in the tropics and subtropics between 40° North and 40° South of Equator. Among communicable diseases, the vector borne rickettsial, viral, protozoan or helminthic diseases are of high public health concern and cause significant economic loss.

These diseases are transmitted either from man to man or animals to man (zoonosis). Mosquitoes, sandflies, houseflies, tsetseflies, blackflies, lice, ratfleas, reduviid bugs, ticks, mites and cyclops are the arthropod vectors involved in the transmission of several vector borne diseases in humans. Among these vectors, mosquitoes are the most important insects of medical importance.

Mosquito borne diseases are now resurgent as global health problem (Gubler, 1998). Malaria, lymphatic filariasis, Japanese encephalitis, dengue fever / dengue haemorrhagic fever and chikungunya fever are the most important mosquito borne diseases prevalent in India. The steep decline of malaria in almost all the countries during the early years of eradication and the collateral benefits achieved in the control/total disappearance of plague and kala azar raised great hope for elimination of many of the vector borne diseases. Unfortunately, these hopes were belied and soon there was wide spread resurgence of malaria (Sharma, 1995). This was followed by large scale resurgence of Kala azar in Bihar with the cessation of DDT indoor residual spraying in the areas cleared of malaria (Rehman, 1989). These were the pointers to the
potential of vectors which have the inherent capacity to build up rapidly and strike in the absence of insecticidal cover.

Presently, Southeast Asia contributes 2.5 million cases to the global burden of malaria. Of this, India alone contributed 76% of the cases (Kumar et al., 2007). In addition to this problem, there has been an increasing trend of filariasis during the last three decades and the disease has become the major public health problem in the country (Sharma et al., 1987; Das et al., 2006). The rapid spread of Japanese encephalitis which is often a fatal zoonotic infection of children, to newer area is also of serious concern (Danda et al., 1996; Victor et al., 2000).

Dengue fever is endemic in many parts of India and the epidemics have been reported from different states of the country (Parida et al., 2002). Dengue haemorrhagic fever (DHF) and dengue shock syndrome (DSS) are the serious manifestations of dengue fever and have emerged as important public health problem in Southeast Asia and Western Pacific regions (WHO, 1985). Chikungunya virus which was assumed to have disappeared from India and South East Asia (Pavri, 1986), has re-emerged in many states of India. Microbiologists have postulated that the re-emergence and spread of chikungunya is due to a variety of social, environmental, behavioral and biological changes and their combinations (Ravi, 2006; Laharia and Pradhan, 2006).

The re-emergence and spread of vector borne diseases to newer areas, ecological changes, vector resistance to insecticides coupled with behavioral changes among vectors due to sustained insecticidal pressure and community awareness about environmental pollution caused by large scale use of chemicals, have made vector
control a challenging task. The different diseases, their causative agent/s and the type of mosquito vector genera involved in the transmission are presented in Table 1.

Lymphatic filariasis (LF) is ranked as the second most common cause of physical disability next only to malaria among the debilitating tropical vector borne diseases (WHO, 1995). The unabated population growth, particularly in the developing countries of Asia, Africa and Latin America and the consequent ecological changes having adverse impact on all round deterioration in ecology and environment has also exacerbated the magnitude of Lymphatic Filariasis and other vector borne diseases (Danda, 1995).

Lymphatic filariasis is the common term for a group of diseases that are caused by *Wuchereria bancrofti* Cobbold, *Brugia malayi* Brug and *Brugia timori* Partono. Since, these parasites primarily affect the lymphatic system of man, the disease is commonly termed as Lymphatic filariasis. The disease though not fatal, is associated with social stigma due to deformities, causing human misery and sorrow (Figs.1 & 2). Many recent studies have illustrated the devastating social, psychological, economical and sexual issues due to massive swelling of limbs, groins and breasts. The disease is debilitating as it interferes with day to day activities resulting in severe functional impairment and physical disability thereby reducing the working man hours and earning capacity of the individual. There is strong feeling of shame and embarrassment in patient with hydrocoele associated with sexual disability and dysfunction. The disease also hampers the marriage prospects of young, specially the females.
Table 1: Mosquito borne Diseases, their Causative agent and Vector genera responsible for transmission

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Name of Disease</th>
<th>Causative organism</th>
<th>Vector genera</th>
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<tbody>
<tr>
<td>1.</td>
<td>Malaria</td>
<td>Protozoa</td>
<td>Anopheles spp.</td>
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<tr>
<td></td>
<td></td>
<td><em>Plasmodium vivax,</em> <em>P.falciparum</em></td>
<td>(About 50 species)</td>
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<tr>
<td></td>
<td></td>
<td><em>P.malariae &amp; P.ovale</em></td>
<td></td>
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<tr>
<td>2.</td>
<td>Lymphatic Filariasis</td>
<td>Nematodes</td>
<td>Culex, Mansonia, Anopheles &amp; Aedes spp.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Wuchereria bancrofti,</em> <em>Brugia malayi</em> &amp; <em>Brugia timori</em></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>DEN Group B, serotypes 1,2,3 &amp; 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Family-<em>Flaviviridae</em>)</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Chikungunya Fever</td>
<td>CHIKV- Group A</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(Family-<em>Togoviridae</em>)</td>
<td></td>
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<tr>
<td>5.</td>
<td>Yellow Fever</td>
<td>Yellow Fever virus – Group B</td>
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<td></td>
<td></td>
<td>(Family-<em>Flaviviridae</em>)</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>(Family-<em>Flaviviridae</em>)</td>
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<tr>
<td>7.</td>
<td>California encephalitis</td>
<td>California virus- Group C</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(Family-<em>Bonyaviridae</em>)</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Eastern equine encephalitis</td>
<td>Alphavirus- Group A</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(Family-<em>Togoviridae</em>)</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Western equine encephalitis</td>
<td>Alphavirus-WEE virus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Family-<em>Bonyaviridae</em>)</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>West Nile encephalitis</td>
<td>West Nile virus-Group B</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Family-<em>Flaviviridae</em>)</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>St. Luis encephalitis</td>
<td>St. Luis virus- Group B</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(Family-<em>Flaviviridae</em>)</td>
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Fig. 1(A&B) : Persons suffering with Lymphatic Filariasis
Besides disfigurement with lymphoedema, elephantiasis, hydrocoele, etc., the chronic cases of LF are unable to care for self and suffer isolation from the community. Loss of social support, family stress, shame and stigma due to sexual disability- all together complicate the matters. Overall, Lymphatic filariasis is a disease of the poor and it is prevalent in urban, periurban and rural areas.

**Life Cycle of *Wuchereria Bancrofti* Cobbold**

Man is the definitive host for filarial worms wherein adult male and female matured filarial parasites mate and produce microfilariae. Mosquito is the intermediate host. The adult parasites are usually found in lymphatic system of man. They produce as many as 50,000 microfilariae per day, which find their way into the blood circulation. The life span of microfilariae is not exactly known which may survive up to a couple of months. The parasite cycle (Fig. 3) inside the mosquito body begins when the microfilariae are picked up by the vector mosquitoes during their blood feeding from an infected person. Once inside the mosquito host, the development of microfilariae begins, they undergo two moults transforming to I and II stage (L1 & L2) and finally growing into infective third stage larvae (L3). Under optimum conditions of temperature and humidity, the duration of the parasite cycle inside mosquito (extrinsic incubation period) is about 10-14 days. When the infective mosquito harbouring L-3 stage larvae feeds on a healthy human host, the infective larvae are deposited at the site of mosquito bite, from where they gain entry into the lymphatic system through the wounds on the skin. A large number of infective bites may be necessary for patent microfilaraemia. In the human host, the infective larvae develop into adult male and female worms and lodge themselves in lymphatics.
Fig. 2(A&B) : Persons suffering with Lymphatic Filariasis
Fig. 3: Life Cycle of *Wuchereria bancrofti* in Mosquito and Man.
The adult worm survives for about 5-8 years or sometimes up to 15 years or even more. Adult males live for a short period compared to females which can survive for longer periods up to 40-50 years. The duration between the infective bite and production of microfilariae is about one and half year for *W. bancrofti* and nine months to one year for *B. malayi* (VCRC, 1988).

**Epidemiological Situation of Lymphatic Filariasis**

At present, world wide 1.3 billion people are at the risk of lymphatic filariasis infection and about 120 million people are affected in 83 countries (WHO, 2006). Of the estimated 128 million lymphatic filariasis cases, 91% are caused by *Wuchereria bancrofti* (Michael and Bundy, 1997). The magnitude of the lymphatic filariasis problem in the world (Fig. 4) is presented below (CD Alert, 2001).

<table>
<thead>
<tr>
<th>Total Population afflicted</th>
<th>1.2 billion</th>
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<tbody>
<tr>
<td>People with Lymphoedema/Elephantiasis</td>
<td>15 million</td>
</tr>
<tr>
<td>People with Hydrocoele</td>
<td>25 million</td>
</tr>
<tr>
<td>People with Acute Inflammatory Attacks</td>
<td>15 million</td>
</tr>
<tr>
<td>People with Chyluria</td>
<td>2 million</td>
</tr>
<tr>
<td>People with other conditions (often hidden)</td>
<td>63 million</td>
</tr>
</tbody>
</table>

In India, the disease was recorded in as early as 6th century B.C. by the famous Indian Physician ‘Susruta’ in his book, ‘Susruta Samhita.’ In 7th century A.D. Madhavkara described the signs and symptoms of the disease in his treatise, ‘Madhavnidhan’ which hold good even today. In 1709, Clarke called elephantoid legs as ‘Malabar legs’ in Cochin.
Fig. 4: Countries including India with the problem of lymphatic filariasis.
The discovery of microfilaria (mf) in the peripheral blood was first made by Levis in 1872 in Kolkata and the developmental forms of filarial parasites of man in *Culex quinquefasciatus* were discovered by Mansion in 1878 (Anonymous, 2004).

Forty percent of world’s filariasis disease burden is contributed by India alone wherein 450 million people are exposed to the risk of this infection with 31.26 million people with microfilaremia, 7.44 million people with lymphoedema (elephantiasis) and 12.88 million people with hydrocoele and the estimates of health burden due to filariasis disease suggests that 2.06 million disability adjusted life years (DALYs) are lost in India and annual wage loss at current prices is estimated at 811 million US dollars (Shenoy, 2002).

Indigenous LF cases are reported from 20 states/UTs namely, Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh, West Bengal, Pondichery, Andaman Nicobar Islands, Daman & Div, Lakshwadeep and Dadra & Nagar Haveli (Anonymous, 2004).

In main land of India, the bancroftion filariasis caused by *Wuchereria bancrofti* and transmitted by the ubiquitous vector *Culex quinquefasciatus* has been the most predominant infection contributing to 99.4% of the filariasis disease burden of the country and malayan filariasis caused by *Brugia malayi* and transmitted by *Mansonia* mosquitoes is mainly restricted to rural pockets and contributes the remaining 0.6% of filariasis disease burden (Anonymous, 2004). The largest endemic tract of malayan filariasis presently exists along the central part of Kerala and other localized foci are in Assam, Orissa, Madhya Pradesh and West Bengal. Both *W. bancrofti* and *B. malayi*
infections in main land India exhibit nocturnal periodicity of microfilariae coinciding with vector feeding behaviour.

In 1974, diurnal sub-periodic *W. bancrofti* infection was discovered among aborigines inhabiting Nicobar group of Andaman & Nicobar Islands (Kalra, 1974). Diurnal *Ochlerotatus (Finlaya) niveus* group of mosquitoes were incriminated as the vectors of this infection, which were formerly classified as *Aedes (Finlaya) niveus* (Shriram et. al., 2005).

WHO in its World Health Organization Assembly in 1997 has targeted the elimination of LF by 2020, through annual mass drug administration to all the people at risk. The mass drug administration strategy was based on the hypothesis that if majority of the people in a community consume single dose of DEC annually once, it will reduce the parasite load and if continued for sufficiently long period, may eliminate filariasis. Elimination efforts primarily rely on reduction in lymphatic filariasis transmission till elimination is achieved through annual mass drug administration, appropriate management of individual patients both in acute and chronic stages to prevent disability and improving quality of life, community participation, IEC (Information, Education, Communication), manpower development, monitoring and evaluation (CD Alert, 2001).

Achieving the target of elimination by 2020 would however need a strong political commitment, concerted efforts by the public health administrators, public health professionals, clinicians and community at large from all the member countries. Government of India being the signatory to the resolution, envisages eliminating the disease by 2015 (CD Alert, 2001).
The Global Programme to eliminate lymphatic filariasis (GPELF) was launched in the year 2000 (Sunish et al., 2007). Although, significant progress in initiating MDA programmes in endemic countries has been made, the emerging challenges to this approach have raised questions regarding the effectiveness of MDA alone to eliminate LF without the inclusion of supplementary vector control (Bockarie et al., 2009).

**Lymphatic Filariasis Problem in Goa**

Goa is one of the filariasis endemic states of the country. The endemicity of Goa for banroftian filariasis has been known since many years (Wagh, 1976). In a recent survey conducted in 2008, 191 disease cases of lymphatic filariasis have been reported from all the Health Centres (PHCs/UHCs/CHCs) from Goa. Out of 191 cases, 107 cases are reported from North Goa district and 84 cases from South Goa district (Source: NVBDCP- Goa). The number of female persons affected is 113 and males- 78. The number of persons whose legs were affected was 145 and in 46 patients the other organs such as scrotal sacs in males, breasts in females and upper arm were affected. More cases of filariasis are reported from the coastal plains of Goa, having humid and warm climate without drastic variations in temperature throughout the year, favoring density build up and increasing the longevity of the vector mosquitoes in the areas. Mass drug administration with single dose of 6 mg/Kg body weight Diethyl car bamazine tablets annually is being carried out since 2004 in Goa. During 2005 to 2008, 22 new microfilariae carriers have been detected through limited sentinel night time parasitic surveillance in Goa.

Reservoir or source of infection is the person with circulating microfilariae in his peripheral blood. mf carriers are usually without any recognizable symptoms or
illness. A person may continue to be a mf carrier without any disease manifestation for a prolonged period. The period for which the person will be microfilaraemic depends on the fecundic life span (the period for which the adult Wuchereria female produces microfilariae) of the adult worm which is about 5.4 years for W. bancrofti and 3.4 years for B. malayi. (VCRC, 1997). The individuals with chronic disease on the other hand are usually negative for mf. In chronic lymphoedema, the night blood examination to detect microfilariae, ICT Card Test for filarial antigenaemia and ultrasonography for locating the adult worms are usually negative (Weil et al., 1996).

All age groups of people are susceptible to infection in endemic areas. Filarial infection has been recorded even in infants of six month age, but the infection has been found to rise with age upto 20-30 years and not consistently thereafter (Anonymous, 2004). There is plenty of evidence now, which suggests that LF infection is first acquired in childhood in several instances, even though the clinical manifestations start appearing much later, mostly in adult life (Shenoy, 2006).

The methods currently in use to detect the filarial parasites include- 1. Thick blood smear by wet film or stained blood smear examination; 2. Membrane filtration; 3. Detection of adult worms by ultrasound 4. Immunodiagnostics. Of all the methods, the wet film examination can be easily done. For this, a sixty cubic millimeter thick blood smear is taken after 8 P.M. The wet smear can be examined directly under microscope for microfilariae or can be dried overnight, dehaemoglobinised next day, stained with JSB stain and examined under microscope. This is the standard method adopted to detect the microfilariae.
Clinical Manifestations of Lymphatic Filariasis

Clinical manifestations of LF depend upon the different stages in the course of infection in the human host and the load of the adult worms. The following manifestations may be encountered.

A. Stage of Invasion: The infective larva gains its entry into the human host and starts undergoing further development. Diagnosis at this stage rests on the triad of eosinophilia, lymphadenopathy and a positive intradermal test with the supporting evidence of history of residence in the endemic area.

B. Asymptomatic or Carrier Stage: This stage is usually with no clinical manifestation. The carriers are usually detected by night blood examination.

C. Stage of Acute Manifestation: These cover filarial fever, lymphangitis, lymphadenitis and lymphoedema of various parts of the body and epididymo-orchitis in the male.

D. Stage of Chronic Manifestation: The clinical manifestations comprise of elephantiasis of genitals, legs or arms, hydrocoele, chyluria etc. Hydrocoele is the commonest manifestation of bancroftian filariasis in the male population.

The adult worms cause the dilation of lymphatic vessels resulting in their damage and dysfunction. This leads to slow flow of lymph which may cause lymphoedema, kidney damage and chyluria from rupture of dilated lymphatics into urinary system. Typical acute inflammatory attacks of LF occur due to the entry of bacteria through breaks in lymphoedemous skin. Stasis of lymph provides conditions for rapid growth of these bacteria. Damage to small lymphatic vessels results in fibrosis and progression of elephantiasis.
Mosquitoes and Vectors of Lymphatic Filariasis

Mosquitoes are small and delicate insects with three segmented body consisting of head, thorax and abdomen. They have three pairs of long and slender legs and a pair of membranous wings for flight. The second pair of wings are reduced to small knob like structures called halteres which are used for equilibrium. The mosquitoes may be distinguished by their long and slender proboscis extending forward with the palps. Mosquito life cycle includes four distinct stages viz., egg, larva, pupa and adults. The females excepting to those belonging to genus *Toxorhynchites* are haemotophagous and require a blood meal for the development and maturation of eggs. The first stage of larva hatch out from the egg and grow to fourth stage larva and further to pupa. Finally, adult female and male mosquitoes emerge out from the pupae (Fig. 5).

In addition to disease transmission, the mosquitoes often cause much discomfort and possess great nuisance potential. Though, the amount of trauma produced by the bite is negligible, the injection of saliva in the body may produce a reaction. The pruritus with which it is associated, often results into scratching and may be followed by secondary infection (Gordon and Lavoipierre, 1962).

Mosquitoes are found all over the world. They are found at a height of 14000 feet in Kashmir and as low as 3760 feet below sea level in gold mines in South India (Russel et al., 1943). About 3200 species of mosquitoes are reported worldwide with several sub-species (Dixit et al., 2002).
Fig. 5: Life cycle of *Culex quinquefasciatus*
The systematic position of mosquitoes in the classification of animal kingdom is as follows.

Phylum: Arthropoda
Class: Insecta
Sub-Class: Pterygota
Division: Endopterygota
Order: Diptera (two winged insects)
Subdivision: Nematocera
Superfamily: Culicoidea
Family: Culicidae (Mosquitoes)

Family- Culicidae is further classified into Subfamily- Anophelini and Subfamily- Culicinae. The important genera under Culicinae are Culex, Aedes and Mansonia.

Each group of mosquitoes differ in their breeding, feeding, biting and resting habits from one region to the other as a function of climatic change. The knowledge of mosquito habits, their distribution and abundance is essential from the point of view of proper understanding the role they play in disease transmission as well as for controlling the mosquito vectors. A number of mosquito species are known to be the vectors of parasitic and viral diseases. Nine species of mosquitoes belonging to genus Anopheles act as vectors of malaria in different geographical regions of India (Kumar et al., 2007). Two species of genus Aedes act as the vectors of dengue fever/DHF and chikungunya fever. Japanese encephalitis virus has been isolated from six species of genus Culex, three species of genus Anopheles and one species of genus Mansonia (Banarjee, 1987).
Different species of mosquitoes prevalent in an ecological set up differ in their susceptibility to disease pathogens. The same species may exhibit significant difference in vectorial efficiency in different ecological conditions. There is ample evidence of this phenomenon in malaria and certain other mosquito borne infections including filariasis (Das, 1976). *Mansonia* mosquitoes are generally refractory to *W. bancrofti* infection, but *Mansonia (Mansonoides) uniformis* is found to naturally transmit *W. bancrofti* in New Guinea (Rook, 1957). *Culex quinquefasciatus* an efficient vector of periodic *W. bancrofti*, has been reported to be the poor vector of *W. bancrofti* in tropical Africa (Hammon et al., 1967).

In case of lymphatic filariasis, there are many reports on human filarial infections detected in mosquitoes in different endemic areas of the world. In India, natural and experimental infections of the periodic *W. bancrofti* have been detected in 17 species of mosquitoes, of which 5 are culicines and 12 are anophelines (Das, 1976). To incriminate a species of mosquito as a vector of LF, it is necessary to obtain the infective larvae (L-3 stage) which can be identified with certainty. The infective larvae of LF have been detected in ten species of mosquitoes and of which, 9 are anophelines and one is *Culex*. Owing to its abundance, anthropophilism and feeding activity, *Culex quinquefasciatus* is the principal vector of bancroftian filariasis in India (Das, 1976; Samuel et al., 2004). Globally, the majority of the lymphatic filariasis caused by *W. bancrofti* is transmitted by *Cx. quinquefasciatus* (Sunish et al., 2007). Similarly, *Mansonia (Mansonoides) annulifera* is the principal vector of brugian filariasis, while *M. (M). uniformis* is the secondary vector of this infection. The vectorial role of *M. (M). indiana* is very limited due to its very low density.
At the time when the third expert committee on filariasis met in 1973, the tropical urban mosquito was designated as *Culex quinquefasciatus* in North America and as *Culex pipiens fatigans* in the rest of the world. Subsequently, the work done by two groups of authors led the international scientific committee to adopt *Culex quinquefasciatus* and this change simplified the former situation where a same species was designated under two different names (Subra, 1983).

*Cx. quinquefasciatus* is also the vector of West Nile virus (Godsey et al., 2005), Japanese encephalitis virus (Nitapattana et al., 2005), Saint Louis encephalitis virus (Jones et al., 2002) and secondary vector of Western equine encephalitis (Aviles et al., 1990). Chikungunya virus also has been isolated from the adults of *Cx. quinquefasciatus* collected from field in Southeast Asia (Halstead et al., 1969).

*Cx. quinquefasciatus* is the predominant species in the urban areas, especially in those areas having inadequate or faulty drainage system. The pace at which the unplanned urbanization is observed, increased industrialization, consequent increase in human population and movement and also the involvement of various segments of the society in the creation of man-made mosquitogenic conditions, all of which are responsible for increased prevalence of *Cx. quinquefasciatus*.

The density of vector population is subjected to seasonal prevalence and also on its reproductive potential and survival/mortality rate at different stages of development from egg laying to adult emergence due to different biotic or abiotic factors. The study on life table of the vector species can elucidate the survival/mortality rate of the species. Resting habits (endophily or exophily) and resting habitats may also vary in different areas. Biting activity of vector species is an important parameter in understanding the
vectorial potency and transmission dynamics of filariasis. Feeding behavior (endophagic or exophagic) of the mosquito species and the feeding preference for human blood (anthrophilic) or animal blood (zoophilic) may vary subject to the availability and accessibility of host in the immediate environment of the vectors (Lee et al., 1954; Kaul and Wattal, 1968a; Samuel et al., 2004).

The completion of extrinsic incubation period of the disease pathogen to complete its growth inside the mosquito body is dependent on the longevity of the vector species. Therefore, the longevity of the vector species interalia determines the disease transmission. The potential risk of transmission also depends upon infection/infectivity rate of vector in time and space, the reservoir of infection and environmental factors. Temperature and humidity play an important role not only in the survival of the vector species and development of filarial parasites in the mosquito host, but also in the survival of infective larvae deposited on the skin of the vertebrate host (Das, 1976). As such, the climatic conditions in different endemic areas determine the active transmission period.

The longitudinal observations of the density pattern, breeding habitats, biting activity, longevity, infection/infectivity rate are essential to understand variations in the transmission potential during different periods of the year which could help to undertake the vector management/disease management operations to reduce the potential risk of lymphatic filariasis transmission.

The antivector measures are undertaken both against immature stages and the adult mosquitoes. The antilarval measures comprise of physical, biological and chemical methods. Insecticides belonging to organochlorine, organophosphate,
carbamate and synthetic pyrethroid are being used in health and agriculture sectors and indiscriminate use of these chemicals has resulted in the resistance to several insecticides by the vector mosquitoes (WHO, 1992; Sunaiyana et al., 2006; Mukhopadhay et al., 2007). The relevant information on various potential breeding habitats, helps to selectively apply suitable antilarval measures to prevent/control mosquito breeding and to judiciously use the chemical methods. This reduces the chances of development of resistance against insecticides being sprayed and also limit the health hazard posed by the toxic chemicals. The anti-adult measures are done mainly by the spraying of insecticides. As the chemicals are used/being used both against the larval and adult stages, it is imperative to generate information on the susceptibility/resistance status of vector species to the sprayed insecticide/s prior to and during the use. This information is vital for effective vector management.

Although, mass drug administration (MDA) is being carried out with the annual dose of Diethyl carbamazine tablets- a drug effective against the circulating microfilariae in the blood of infected persons, the effect of the drug is doubtful against adult filarial worms since in many filariasis cases, microfilaria reappear after certain period (VCRC, 1988). A high coverage of population and compliance of drug intake at mass scale in the endemic areas is essential under MDA.

It seems unlikely that MDA alone would be able to interrupt LF transmission in area of Culex transmission of LF due to their high vectorial efficiency (Jayasekera et al., 1991). The implementation of mass chaemotherapy with annual single dose of DEC (6 mg/ Kg body weight) combined with vector control may yield better results in reducing the mf rate in the population (Manoharan et al., 1997).
Therefore, vector control is essential for sustained interruption of LF transmission (Burkot et al., 2006). Accordingly, incorporation of vector control in the global LF elimination programme has been advocated as it potentially decreases the time required for elimination of LF (Sunish et al., 2007). It has also been reported that at lower level of community microfilaria load (CMFL) and higher level of vector density, vector control would be more cost effective (Das and Vanamail, 2008). In such a situation, dual strategy of vector control and treatment of mf carriers is being followed by National Filaria Control Programme in the country.

Therefore, besides treating patients, achieving reduction in the vector population with appropriate and timely vector control measures and prevention of mosquito bites through personal protection are of great significance to reduce the risk of LF transmission. For formulating an effective vector management strategy, sound knowledge on bio-ecology of the principal vector *Cx. quinquefasciatus* is essential. In Goa, such information is scarce, fragmentary and outdated (Bounsulo, 1968; Thavaselvam et al., 1993). Goa has undergone significant ecological changes due to increased urbanization and industrialization over the years, coupled with increase in human population and large inflow of migrant population from different filarial endemic states of the country, leading to the creation of increased number of man-made mosquito-generating conditions and also making available the reservoir of infection from different areas. However, *Culex quinquefasciatus*, the principal vector of lymphatic filariasis has never been subjected to systematic and thorough scientific investigation in Goa.
Transmission of infection through vectors is considered to be a density dependant phenomenon. The density pattern depicted by the vector species in any area is influenced by gross ecology of the terrain and meteorological variables (Kaul and Wattal, 1968b). The weather has been considered as a predominant cause of variations encountered in insect population and to a great extent sets the stage for the process of population regulation. As such, findings on vector populations of one geographic region cannot be fully applied to the other. Therefore, the present study with the following aims and objectives has been undertaken in Panaji, Goa which is the known filarial endemic area in the state of Goa.

Aims and Objectives of the Study

1. To carry out literature search and collect the information on vector species *Cx. quinquefasciatus*, pertaining to various entomological and epidemiological studies, meteorological / weather data, physical features and developmental activities.

2. Detection and collection of immatures (eggs, larvae and pupae) from different habitats in the field to determine the larval and pupal indices viz. per dip density and container index of *Cx. quinquefasciatus* immature stages.

3. To study the development from egg to adult emergence to assess the survival rate under life table of *Cx. quinquefasciatus* in the laboratory at ambient temperature and relative humidity.

4. Collection of adult mosquitoes from the field to study adult density of *Cx. quinquefasciatus*, resting habits and habitats covering all the seasons of the
year to know the seasonal prevalence/variations in population density of vector species.

5. Whole night hourly collection of mosquitoes landing on man to find out man-biting activity, man-mosquito contact rates, preferential human body parts for vector biting and seasonal variations in biting rate of *Cx. quinquefasciatus*.

6. Blood meal analysis of field population of *Cx. quinquefasciatus* to find out the feeding preference of vectors to determine the anthropophilic index.

7. Dissection of field collected female *Cx. quinquefasciatus* mosquitoes to find out longevity of mosquitoes (Parity rate) and filarial parasites in different regions of the body for determining vector infection and infectivity rates.

8. To carry out tests to find out current susceptibility status/resistance level of both larval and adult populations of *Cx. quinquefasciatus* to different insecticides.