Study of population density of *Culex quinquefasciatus*, (Diptera: Culicidae), vector of filariasis in Bhaktapur District, Nepal

Final Project Report

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Submitted By

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LIST OF ABBREVIATIONS

% : Percentage
An. : *Anopheles*
BR-OVT:
Bti : *Bacillus thuringiensis*
CDC : Centers for Disease Control and Prevention
Cx. : *Culex*
E : East
EGDT : East Godavari District
FF : Full fed
Fig : Figure
G : Gravid
GI : Grass infusion
i : Indoor
Km : Kilometer
LF : Lymphatic filariasis
M : Meter
mph : man per hour
N : North
o : Outdoor
oc : Degree centigrade
PMHD : Per man hour density
UF : Unfed
VDC : Village Development Comitte
WGDT : West Godavari District
WHO : World Health Organization

SUMMARY

The present study was carried out from April- August 2011 in two sites viz Thapa Gaun of Jhaukhel VDC and Lama Tole of Nagarkot VDC, the sites being selected on the basis of altitudinal variation, with an objective of determining the population density of *Culex quinquefasciatus*, the filarial vector. 5 months research lead to the collection of total 3800 mosquitoes of different species (1479 from Thapa Gaun, Jhaukhel and 1196 from Lama Tole, Nagarkot). The laboratory identification resulted altogether **909** *Cx. quinquefasciatus* from indoor and outdoor collection, of which, 508 (**55.89%**) were from Jhaukhel and 401 (**44.11%**) were from Nagarkot. Similarly animal baited net trap collection included 1125 samples i.e. 346 from Jhaukhel and 779 from Nagarkot. On identification of the collected samples, it was found all total of **520** *Cx. quinquefasciatus* viz. 84 and 436 from Jhaukhel and Nagarkot respectively.

Regarding indoor and outdoor collection, the highest density of the filarial vector was observed to be during July for both of the selected sites (26.09 for Nagarkot and 15.75 for Jhaukhel), while the least density was found to be in the month of April(0.165 for Jhaukhel and 0 for Nagarkot). Indoor density of *Cx. quinquefasciatus* was relatively higher than outdoor density which includes 54.75 indoor density and 17.25 outdoor density for Jhaukhel and 44.63 indoor density and 11 outdoor density for Nagarkot collection. Density of the vector in the human residence was lesser than in cattle viz. for Jhaukhel it was 19.25 for human collection and 90.25 for cattle collection and for Nagarkot it was calculated to be 26.75 for human and 62.5 for cattle. The population density of the vector was higher in the morning than in the evening viz. 54.67 for morning and 26.5 for evening of Jhaukhel and 33.5 morning density and 33.34 the evening density. Abdominal status showed increase number of fullfed (670) than unfed (211) and gravid (28) which included 391fullfed, 99 unfed and 18 gravid from Jhaukhel and 279 fullfed, 112 unfed and 10 gravid from Nagarkot which were relatively higher in indoor than in outdoor. Temperature and density were found to be associated with the density of filarial vector. The highest resting density for Jhaukhel and Nagarkot were observed in the month of May (7.73) and June (7.01) respectively while percentage abundance showed the peak value on July for both sites (12.75 for Jhaukhel and 26.17 for Nagarkot). Female *Cx. quinquefasciatus* were found to be relatively higher (875) than male (34).

Out of total samples collected from animal bait net (520) the highest number was obtained during July for both sites(493 for Nagarkot and 60 for Jhaukhel). Unlike on July, no any samples were recorded from animal bait on the month of April.

The present study conclude the presence of *Cx. quinquefasciatus* in both sites(Thapa Gaun of Jhaukhel and Lama Tole of Nagarkot) and the change in density was observed according to month and seasonal variability.

CHAPTER I

INTRODUCTION

Nepal is a landlocked country with the total area of 147181sq.km which lies in between two giant countries of the world, China in the north and India in south, east and west. The country landmass stretches 88km from east to west and has a non-uniform width of 193km north to south. It lies within sub-tropical to the mountainous region at 26° 22'to30° 27'N latitudes and 80° 4' to88° 12' E longitudes with an altitude that ranges from 90m to 8848m from the sea level.

Geographically, Nepal represents a transitional mountainous area between the fertile Gangetic plain of India and the Plateau of China with diversified climate and natural resources. Topographically Nepal is divided into 3 ecological regions, Himalya, Hill and Terai with the Hill/Mountainous region lying between the Himalayan and the Terai region and Kathmandu is the capital city of this country.

Map Showing the filarial endemicity district. (Districts found positive are coloured in red, districts found negative in grey.) (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC153485/)

Lymphatic filariasis (LF) is disabling parasitic disease that has been identified by the World Health Organization (WHO) as a major public health and socio economic problem with an increasing prevalence worldwide (WHO, 1992). At present, 1.1 billion people (20% of the world's population) in some 80 endemic countries primarily in Africa, South America, Asia and other tropical and sub-tropical countries. Over one third of the population at risk lives on the Indian sub-continent with an estimated 45 million infected individuals (Michael *et al.*, 1996).

The causative agent for this disease is a nematode parasite *Wuchereria bancrofti* (filarial worm) and vector for its transmission is mosquito i.e. *Culex quinquefasciatus* which is a strong winged domestic species seen all over the tropical and sub-tropical areas in and around human dwellings. Though the disease is thought to be caused primarily by adult worms living in the lymphatic vessels; the microfilariae released by the female worms circulate in the peripheral blood are ingested by female *Culex quinquefasciatus* during the night while taking blood meal from the infected person thus transmitting the

infection from person to person. This species is infective and carry the disease, need not necessarily be infectious if their number is less but their higher density might make them infectious leading to epidemicity of the disease. People with lymphatic filariasis may suffer from swelling of lymphatic vessels(lymphoedema) and elephantiasis, swelling of scrotal sacs(hydrocele) in men, breast enlargement in female, chyluria (milky urine) etc. Though the disease is thought to be caused primarily by adult worms living in the lymphatic vessels; the microfilariae released by the female worms circulate in the peripheral blood and are not harmful, but can be ingested by the presence of *Culex quinquefasciatus*, which transmit the infection from person to person. This species is infective and carry the disease, need not necessarily be infectious if their number is less but their higher density might make them infectious leading to epidemicity of the disease.

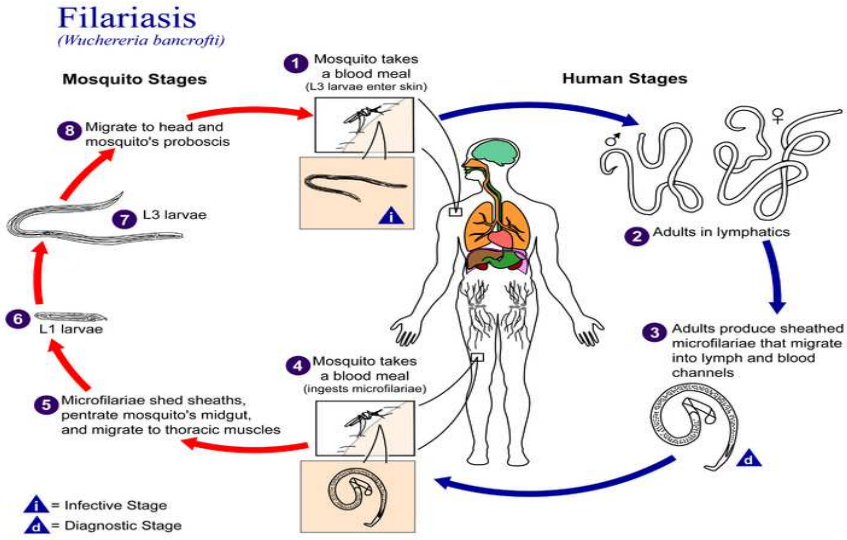


Diagram showing the life cycle of filarial worm Wuchereria bancroti
(http://upload.wikimedia.org/wikipedia/commons/1/19/Filariasis_01.png)

The disease vectors have become an important cause for mortality and morbidity in the developing countries. Nepal, the country with both tropical and sub-tropical climate receives sufficient amount of rainfall during monsoon thus being the favorable breeding place for mosquitoes. *Culex quinquifasciatus* is the primary vector of *Wuchereria bancrofti* in Nepal, which is within the endemic zone of lymphatic filariasis (Jung, 1973). Various researches on this disease have been conducted on its epidemiological survey (Sherchand *et al.,* 2003). In Nepal, out of total population (approximately 23.2 million), 13.9 million (60%) are estimated to be at the risk of filarial infection. It is endemic in different regions of Nepal. Studies on this disease were carried out by Sherchand *et al,*. (2003), Ghimire *et al.,* (2002), Manandhar (2001) and Pradhan *et al.,* (1997). At present the disease is endemic in 33 districts including Bhaktapur (Ministry of Health, Government of Nepal 2004).

Rapid urbanization and industrialization without adequate drainage facilities are responsible for its increased dispersal. The species is highly anthropophlic preferring human blood. They enter the houses at dusk and reaches maximum density by midnight which is their peak biting time. Legs, particularly below the knee are the preferred biting sites. During day, it may be seen resting indoors on walls, underneath furniture, hanging cloths and in dark corners. It breeds profusely in dirty water collections, viz. stagnant

drains, cesspools, septic tanks with leak, burrow pits, and in fact all organic polluted water collection. The distribution of this vector has been reported from different parts of Nepal (Peters and Dewar 1956) including Bagmati, Koshi, Narayani and Dhanusha district. Recently an entomological study carried out by Neupane V.D., 2009 in Chitwan, Nepal reported a total species of 17 *Culex* species with *Cx. quinquefasciatus* the most abundant one.

Patterns of disease transmission are influenced by the vector population abundance. In order to understand adequately the dynamics of vector-borne disease, one must understand how and why vector populations change over time and environmental factors. It is often hypothesized that the abundance of mosquitoes in a house is associated with the distribution of livestock and humans. Previous study on seasonal distribution of *Culex tritaeniorhynchus*, the vector of Japanese encephalitis in Kathmandu valley has been done by Tamrakar in 2009. In her study, *Culex quinquefasciatus* was reported from Bhaktapur district, but no detail study on the seasonal population density, resting habit and age structure study so far has been carried out. So, this study has been carried out in two different localities of Bhaktapur district, Nepal so as to obtain baseline data on the population density, as a preliminary step for developing a control operation strategy to control vector and eliminate lymphatic filariasis from in different geographical areas of Nepal.

Statement of the problem and Justification

Lymphatic filariasis, the most important disease of human in terms of morbidity and mortality and a leading cause of permanent disability worldwide is considered globally as a Neglected Tropical Disease. It a parasitic disease caused by microscopic, thread-like worms. The adult worms only live in the human lymph system. The lymph system maintains the body's fluid balance and fights infections. Lymphatic filariasis spreads from person to person by the bite of mosquitoes *Culex quinquefasciatus. Culex quinquefasciatus* is the most important vector, a domestic mosquito that feed on man at night indoors and outdoors. This species is abundant in human dwellings and animal shelters. Fresh and clear to brackish, turbid and polluted waters are favorable habitats for immature stages and is common in ground pools, ditches, drains, sewage, latrines, septic tanks and artificial containers. People with the disease can suffer from lymphedema and elephantiasis and in men, swelling of the scrotum, called hydrocele.

Three factors are primarily responsible for increasing disease transmission: urbanization, some urban centers making conditions ideal for transmission of domestic mosquito borne disease and consistent increase in air travel by man. Due to these conditions chances of spread different vector borne diseases, including filariasis is high. This felt to be watchful in those areas where there high population movement in terms of possible increase of vector borne diseases. Rapid urbanization often results in the proliferation of such breeding sites. However, in Nepal many studies have been carried out to find out the distribution of the different species of mosquitos of Nepal (Darsie and Pradhan, 1996; Richard et al., 1990) and other many workers but when the patterns of disease transmission are influenced by the vector density, understanding of the seasonal population density, resting habit and age structure of the vector adequately in light of change in vector populations over time and environmental factors are most important. As mentioned earlier, since no detail study on the seasonal population density, resting habit and age structure of *Culex quinquefasciatus,* the vector of lymphatic filariasis has been previously attempted, apart from a limited entomological survey in Bhaktapur district by Tamrakar in 2009, which established the existence of *Culex quinquefasciatus* in this district and also the host-vector contact is an important parameter in

disease epidemiology, the present study was carried out in two different localities of Bhaktapur district namely Lama Tole of Nagarkot VDC and Thapa Gaun of Jhaukhel VDC so as to obtain baseline data on the population density, as a preliminary step for developing a control operation strategy to eliminate lymphatic filariasis from Nepal. Nevertheless, the one year detail study is essential to confirm the real situation of the vectors which are responsible for causing disease in the country. The present study may fulfill the requirement to some extent. Overall, this study included the aggregated nature of habits, habitats and age structures ought to enhance feasibility of controlling the adult *Culex quinquefasciatus.*

CHAPTER II

OBJECTIVES

General

- To report observation on the seasonal density of *Culex quinquefasciatus* in Bhaktapur district

Specific

- To observe seasonal population density of *Culex quinquefasciatus* in Bhaktapur district,
- To determine the resting density of *Culex quinquefasciatus* in the study areas, and
- To assess the abdominal condition of *Culex quinquefasciatus* collected from study areas.

CHAPTER III

LITERATURE REVIEW

Rosângela and Lêda (2011) monitored the temporal fluctuation of *Culex quinquefasciatus* using oviposition traps containing attractant and larvicide. They used the combination of *Bacillus thuringiensis var. israelensis* (Bti) and grass infusion (GI) vs. GI alone were tested for their ability to attract in paired BR-OVT traps in the backyards of 10 houses in Recife, Brazil, for a period of 45 days. Results showed that females prefer to oviposit in traps containing Bti (363 compared with 251 egg rafts over 45 days). Results from a one-year trial on the efficacy of BR-OVT traps loaded with GI and Bti as a sampling tool to monitor temporal fluctuations in the population densities of *Culex quinquefasciatus* in an urban environment were also reported. It was also found that BR-OVT loaded with GI and Bti is sensitive enough to demonstrate continuous reproductive activity of *Cx. quinquefasciatus* in the study area throughout the year and to monitor temporal fluctuations in population density.

Kaliwal *et al.,* in 2010 showed the perennial prevalence of *Cx. quinquefasciatus* in Panji, Goa with the highest per man hour density of females (48.6) in February and the lowest density (6.6) in September. Monthly variations in the densities between different months was significant ($F=15.3$; $P<0.05$) and rainfall significantly influenced the population of *Cx. quinquefasciatus* ($t=2.63$; $P<0.05$) with strong correlation of fed group and semi-gravid group with the relative humidity ($P<0.05$), rain fall ($P<0.05$) and number of rainy days ($P<0.05$). It was also reported that 62.4 per cent of females and 65.1 per cent of males preferred to rest on hanging objects.

Kent *et al.,* in 2010 concluded that the blood feeding pattern of *Culex quinquefasciatus* may vary according to collection method. Mosquitoes were trapped by light traps, gravid traps, and aspirator from plastic pots and vegetation. The study concluded that the array of vertebrate hosts supplying blood to *Cx. quinquefasciatus* did not differ significantly by method of collection. The density of engorged *Cx. quinquefasciatus* per trap-night was not significantly different between CDC light traps, gravid traps, and plastic pots; however, there was a significantly higher proportion of total mosquitoes that were engorged collected from pots than from either CDC light traps or gravid traps.

Dixit *et al.,* in 2009 studied the impact of season on density and infection of filarial vector in Raipur city of Chhattisgarh India and found high vector infection and infectivity during rainy seasons followed by summer and winter. There was a gradual increase in *Culex* infection rate from June onwards with maximum (22.1%) in August and minimum (2.38%) in February.

Tamrakar in 2009 studied seasonal distribution of *Culex tritaeniorhynchus*, the vector of Japanese encephalitis in Kathmandu valley, which established the extistence of *Culex quinquefasciatus* in Bhaktapur district.

A study conducted by Neupane in 2009 to determine the distribution of different *Culex* mosquitoes species in 10 villages (5 VDCs) of Chitwan district found out a total of 17 reported species i.e. 12 in post monsoon and 5 in Pre monsoon. *Culex quinquefasciatus* was the most abundant species (26.90% in post monsoon and 18.71% in pre monsoon and September was found to be the most favorable month for the distribution of *Culex* species. Positive correlation was reported between numbers of mosquitoes with temperature.

A 12-month entomological survey was conducted to determine the diversity of riceland mosquitoes and factors affecting their occurrence and distribution at 3 sites targeted for malaria vector control in Mwea, Kenya and found the dominancy of Common species included *Anopheles arabiensis* (53.5%), *Culex quinquefasciatus* (35.5%), *An. pharoensis* (4.7%), *An. coustani* (2.5%), and *An. funestus* (1.6%). (Muturi *et al.,* 2008)

Sathantriphop *et al.,* (2006) studied the susceptibility and avoidance behavior of three colonized *Culex quinquifasciatus* to three different residual insecticides viz. deltamethrin (0.02 g/m2), propoxur (0.2 g/m2), and fenitrothion (0.2 g/m2) using and excite repellency escape chamber system and observed striking differences in behavioral response and excito-repellency between mosquito strains and test compounds.

Mahanta *et al.,* (2006) conducted a study for two consecutive years on transmission of bancroftian filariasis among tea garden workers which revealed that among the host seeking *Culex quinquifasciatus* average infection rate was 4.6% and with 2.1 larvae per mosquito. The overall prevalence of infective mosquitos was 0.8% with average L3 load of 2.0 per mosquito. The probability of infected mosquitos surviving to have complete development of filarial larvae (13 days) was 0.17. The expectation of infective life was 1.416 days for man biting *Cx. quinquefasciatus* and the estimated adult survival rate of was 87.6%. Mosquito bites/man/year in tea garden and the infective bites as well as transmission index was also recorded.

Mwangangi et al., (2006) reported that *Culex quinquifasciatus* was the non-anopheline species. Culicine and Aedine species densities were significantly higher during the post harvesting period.

Muturi *et al.,* (2006) reported that *Cx. quinquefasciatus, Anopheles arabiensis* and *Anopheles pharoensis* were more abundant in rice agroecosystem and in planned tan in the unplanned rice agro-ecosystem.

Kumar *et al.*, (2004) conducted a study on mosquito diversity in Rajiv Gandi National Park, Karnataka State, India and recorded a total of 60 species belonging to 10 genera in which *Culex* species were predominant. Maximum number of species was found to breed in ponds of the total number of species recorded. It was reported that 14 species were the known vectors of different mosquito borne diseases in India.

Gomes *et al.,* (2003) found out wide host range for *Aedes aegypti* and *Culex quiquefasciatus* with the similar feeding habit but humans and dogs were most common.

Oliveira *et al.,* (2003) found *Culex quinquifasciatus* to be highly resistance to *Bacillus sphaericus* strain 2362. The effect of B. sphaericus on the fitness of *Cx. quinquefasciatus* was determined in terms of fecundity, fertility, and development time.

Dixit *et al.,* (2002) researched on the population dynamics of *Culex quiquefasciatus* filarial vector in Raipur city of Chhattisgarh state and reported the species throughout the year with highest density during March (44.29pmh), February (41.29mph), August (38.58mph) and April (37.17mph) and lower during July (17.05mph), September (16.82mph) and November (16.64mph).

Murty *et al.,* (2002) studied the relative seasonal abundance of *Culex quinquefasciatus* in the rural and urban areas of the East and West Godavari districts (EGDT and WGDT) of Andhra Pradesh, India. They

reported the highest infection and infectivity rates in the rural areas of Rajahmundry (43.6%) and Amalapuram (13.2%) respectively. In urban areas, the highest infection and infectivity rates were found in Rajahmundry: 7.5% and 3.6% respectively. It was reported that there was considerable difference in the infection rate and infectivity rates between the rural areas and urban areas in each unit.

Apperson *et al.,* (2002) studied on host feeding habits of Culex and other mosquitoes in the Brough of Queens in New York City and reported *Culex pipens L*. and *Cx. restuans Theobald* fed primarily on birds and their feeding habits support their implication as enzootic vectors of West Nile Virus. *Cx. Salinarius coquilletl* and *Coquilletlidia perturbans* (walker) fed mainly on mammals with fewer blood meals taken from birds and these two species are potential bridge vectors of West Nile Virus.

Pramanik and Raut (2002) reported *Culex quinquefasciatus* was dominanat (62.96%) on average of $92 mosquitoes in Kolkata.

An extensive epidemiological mapping on filariasis covering 37 districts performed by Sherchand *et al.,* in 2001 reported 33 districts of Nepal to be filarial endemic and the overall prevalence of lymphatic filariasis from a 4,488-sample population was found to be 13% (Sherchand *et al.,* 2003).

Lai *et al.,* (2000) found no significant difference in microfilarial development in *Aedes albopictus* and *Culex quinquifasciatus* after feeding them with canine blood with different microfilarial density of *Dirofilaria immitis.*

Pipitgool *et al.,* (1998) while studying on biting density and biting cycle of *Culex quiquefasciatus* in Khon city of Thailand found out the biting density ranging from 1.6/man/hour in December to 9.2/man/hour in March with the average of 5/man/hr. lowest biting density was observed in winter, higher in summer and rainy season. It was mentioned that temperature was the most important variable that influenced the biting density in each month of the year ($P<0.05$). Biting cycle showed that the mosquitoes were active throughout the night with the peak activity during 22-23:00 hour.

Brito *et al.,* (1998) observed microfilariae on laboratory reared *Cx quinuefasciatus* after blood meal on individuals with different densities of mocrofilaria in the peripheral blood stream and found that the number of microfilariae ingested by mosquitoes was proportional to the density of microfilariae in the peripheral blood of the human subjects, but with a concentration factor of up to 6.5 times the expected number. Survival of mosquitoes was not influenced by the density of microfilariae in the peripheral blood of infected individuals. Infectivity indices were proportional to microfilaremia in human subjects. The number of L3 larvae/female (intensity of infection) was not influenced by individual microfilaremia. The highest vector efficiency and the best experimental infection index were recorded in mosquitoes that blood fed on individuals with moderate microfilaremia. The results are discussed in relation to the transmission on bancroftian filariasis in the study area.

An entomological survey carried out in 19 rural and urban localities of Grande Comore. Anjouan and Moheli Islands from October 1988-January 1989 as a part of a malaria and filariasis control programme, found out maximum number of *Culex quinquefasciatus (*94.5%). Along with it *Anopheles gambiae, A. funestus* and other anopheline species were also reported (Sabatinelli *et al.,* 1994).

A nine month entomological and parasitological study conducted on *Cx. quinquefasciatus* at Kanchrapara, West Bengal showed it to be endemic for bancroftian filariasis with microfilaria rate among the human

population being 1.9 per cent (35 of 1200 persons), average man hour density to be considerably high (31.10) and higher vector prevalence was seen in summer. The infection and infectivity rates of the natural population of the vector were 2.3 and 0.28 per cent respectively. 9.2 and 1.7 per cent of the human habitations were found to contain infected and infective *Cx. quinquefasciatus*. Both infection and infectivity rates were higher during the rainy season than the other seasons. (De and Chandra 1994)

Gowda and Vijayan in 1993 studied the biting density, behavior and age distribution of *Cx. quiquefasciatus* and investigated the seasonal abundance, night indoor biting behavior and parity of this species for the period of 1 year which revealed that *Culex quiquefasciatus* to be active through out the night with peak activity at 22.00-23.00hr.

Gowda and Vijayan in 1992 studied on the indoor resting density, survival rate and host preference of *Culex quiquefasciatus* in Mysore city. It was reported that the annual per man hour density was 104.5. The Nulliparous and Parous (1-parous and 2-parous) mosquitoes were collected through out the year while 3-parous and 4- parous were recorded during cold and rainy seasons. Human blood was the most preferred host (94.1%) while with bovine and aves; it was mentioned to be 1.4% and 3% respectively.

Gingrich *et al.*, 1992 states that vector abundance was high in monsoon (May-October), moderate in transition (March- April and November-December) and very low in dry (January-February) seasons in Bangkok while the risk of human infection appeared greatest at the site with moderate vector abundance because of its greatest population density.

Seasonal variations in biting *Cx quinquefasciatus* and transmission of bancroftian filariasis were investigated in Pondicherry, South India. The biting density of *Cx. quinquefasciatus*, was found to be lowest in the summer months and higher during the monsoon and winter months. The survival of the vectors as indicated by the proportion of parous mosquitoes was found to be less in the summer season. Biting mosquitoes with infective stage larvae were not encountered during the hottest months of May, June and July and the early monsoon month of August indicating seasonality of transmission. Maximum transmission took place between November and March (Ramaiah and Das, 1992).

A study carried out by Jayasekera *et al.*, 1991 suggest that there was a good correlation between the number of mf ingested and the number of infective larvae per mosquito and low density carriers could be a source of infection. This study revealed that the examination of recently fed house-resting populations of *Cx quinquefasciatus* could be a sensitive method for measuring the prevalence of mf in the human population.

Barr in 1957 studied the detail distribution of *Culex p. pipens* and *Culex pipens quinquefasciatus* in North America.

CHAPTER IV

MATERIAL AND METHODS

Study Area

The study areas Thapa Gaun and Lama Tole were selected on the basis of atitudinal variation. Thapa Gaun of Jhaukhel VDC located at latitude of 24°41'32''N and a longitude of 85° 25'50''E is situated at an altitude of 1314m above the mean sea level. The other study area Lama Tole of Nagarkot VDC located at an altitude of 1669m above the mean sea level in Bhaktapur district with a latitude of 27°42.725'and a longitude of 85°29.703'.

House Structure

Both sites comprise the human dwellings made by bricks with mud, the roof being made by zinc and hedge. Few cemented houses were also observed in the Thapa Gaun but absent in Lama Tole. The kitchen was built at the ground floor and was of traditional type with a smoky stove. Also use of smoke and mosquito coil was observed. Bushy vegetation, stagnant water, outdoor resting places for the cattle and accumulated kitchen waste, vegetable waste along with cattle dung were observed in the front and behind the houses which are the perfect breeding sites for the mosquitoes.

Cattle Shed

Majority of cattle shed were made up of wooden blocks with hedge roof (open type) and also by brick with wooden blocks with Zinc roof (closed type).

Ethical clearance

Ethical clearance was obtained from community leaders and the household owners before starting the study especially for indoor hand collection and animal baited net trap collection. The participants were informed in clear, comprehensible terms in the local language about the objectives, study protocol, and advantages and inconveniences. Community people were told they have complete liberty to accept or refuse to give permission.

Entomological surveys

Two VDCs Jhaukhel and Nagarkot were selected for the present study conducted from April- August 2011. Most of the collection villages/localities were selected randomly as far as possible. However, emphasis was given to select the villages located on the agro-field ecosystem areas and present of cattle on the areas. In addition, the localities were selected on the basis of accessibility as well. Households were surveyed in sequence along the block from the start house between 7:00 PM to 9:30 PM and 7:00 AM to 9:30 AM. 15 minutes were spent in each catching station (human dwelling and cattle sheds) by 4 collectors to collect the mosquitoes resting inside the households and cattle sheds, while 30 minutes were spent by each collector for the outdoor collection. Unoccupied or closed houses and houses where residents did not provide permission for the survey, businesses, offices, and schools were not sampled. Prior to continuing surveys of unsampled households, an attempt was made to inspect houses that were

previously closed or where access had been refused. Access to houses of each area were attempted a minimum of three times. This process was carried out until all the houses in each neighborhood had been surveyed or repeated attempts to gain access failed. All the mosquitoes were also recorded and brought in the laboratory to identify adequately. Mosquitoes trapped in the animal baited net trap fixed in the villages were also recorded. Altogether four man hours were spent searching mosquitoes in and around 16 houses of four locations by mosquito collectors in indoor and outdoor hand collection to collect adult mosquitoes resting inside and outside the houses. Households were surveyed with the use of aspirator and torch.

Different collection tools were used to collect *Culex quinquefasciatus* and other possible vectors of filariasis. The different methods used were as stated below;

Indoor hand collection:

Indoor hand collections were carried out inside different shelters in the evening 7:00 to 9:30 and in the morning 7:00 to 9:30 starting from in human and animal dwelling spending 15 minutes in each house by one collector. All the collected samples of mosquitoes were brought to the laboratory and properly identified using the identification key prepared by Darsie and Pradhan (1991).

Outdoor hand collection

Outdoor collections was similarly attempted outside the house from outside walls, under eaves, vegetation and bushes around cattle sheds, and in and around outdoor stored materials etc., for two hours by 4 collectors and transported to the laboratory for identification and enumeration.

Animal baited net trap collection

One animal baited net trap, the bed net measuring 5m x 5m x 5m was used to collect mosquitoes in animal baits tied inside the net whole night. In the morning the mosquitoes trapped in the net trap were collected and brought to the laboratory. All the mosquitoed collected were identified with the help of a mosquito key developed by Darsei and pradhan (1991).

Altogether 12 man hours were spent in each location for the collection purpose. All collected mosquitoes were recorded and brought to the laboratory for the identification. Mosquitoes were identified morphologically following the key guide given by Darsie and Pradhan, 1991. Also the abdominal

condition (fed, unfed and gravid) of were observed. Temperature and relative humidity of the collection time of each month was also recorded.

Data analysis

After identifying the collected mosquitoes, the raw data obtained were compiled. The analysis was made more effective with the help of tables, bar diagrams, graphs wherever necessary and all necessary data relevant to the species of the different study areas of the country were analyzed

Limitation of the study

Only *Culex quinquefasciatus* were focused during the study period. Since this study describes the vector population density in 2 VDCs (Jhaukhel and Nagarkot VDCs) of Bhaktapur district, five months (April to August 2011) data do not reflect a complete figure regarding the diversity, population density and seasonal abundance of *Culex quinquefasciatus.* For the detail information, a detail investigation should be a target. Furthermore, district wise detail survey is needed for determining the distribution, breeding habitat, population density and vector abundance of the species before deciding the most appropriate means of control. It must be noted that continuity of this study is necessary. Since lymphatic filariasis is one of the life threatening diseases causing permanent disability of the organ involved, the control on the vector might be a useful attempt in the control of transmission of the disease so a nation wise survey on the abundance and distribution of filarial vector should be a priority.

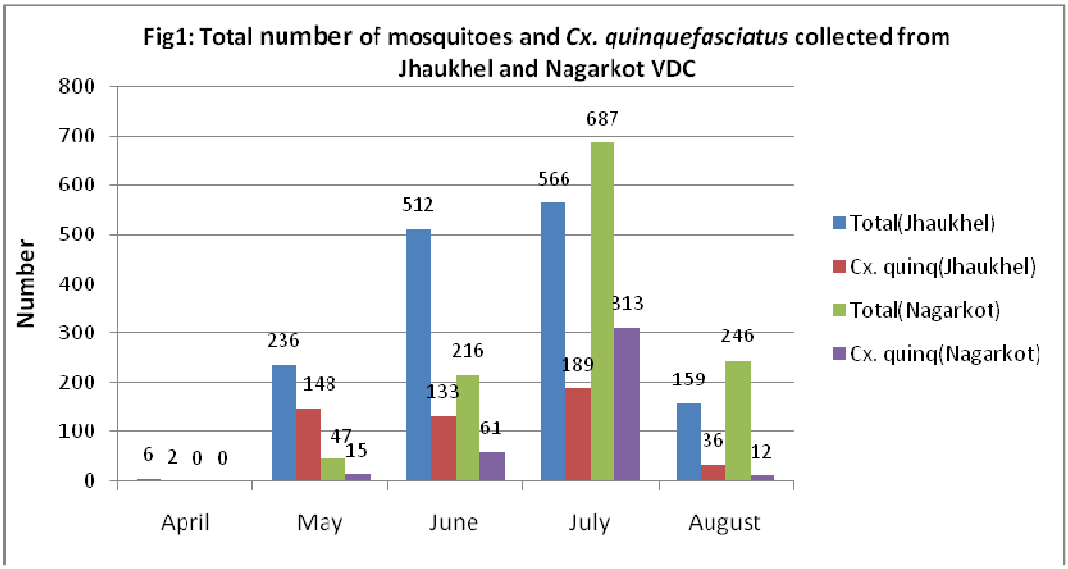
CHAPTER V

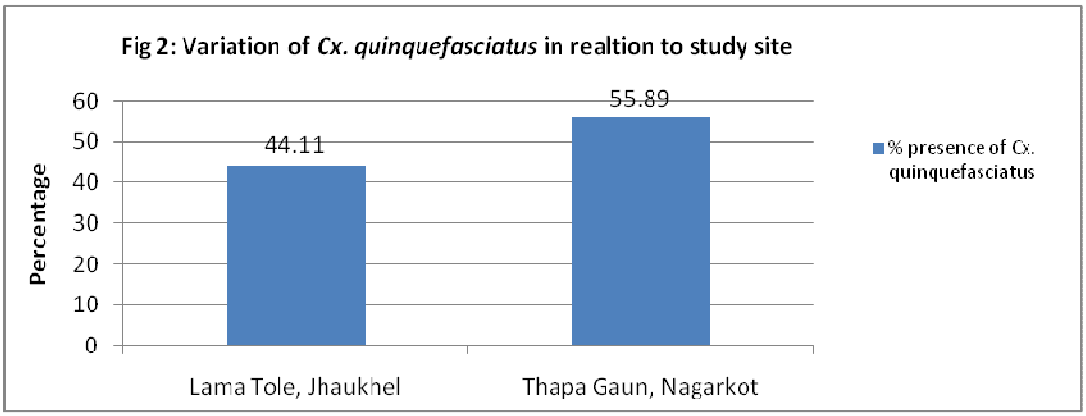
RESULT

Results obtained from this study are tabulated and figured in table 1-13 & figure 1-16. A total of 3800 mosquitoes (1479 from Thapa Gaun, Jhaukhel and 1196 from Lama Tole, Nagarkot) (Table 1 & figure 1,2,3) were collected in five months survey conducted from April to August 2011. Of the total, 508 (**55.89%**) *Culex quinquefasciatus* were from Jhaukhel and 401 (**44.11%**) were from Nagarkot (Table1, fig1). Animal baited net trap collection comprised 1125 samples i.e. 346 from Jhaukhel and 779 from Nagarkot. Identification on animal bait net collection resulted 84 and 436 *Culex quinquefasciatus* from Jhaukhel and Nagarkot respectively (Tab2, Fig 3).

Table 1: Total number of mosquitoes and *Culex quinquefasciatus* collected from Jhaukhel and Nagarkot VD

S.N.	Month	Thapa Gaun, Jhaukhel		Lama Tole, Nagarkot	
		Total number of mosquitoes	Total number of *Culex quinquefasciatus* (%)	Total number of mosquitoes	Total number of *Cx. quinquefasciatus* (%)
1	April	6	2(0.39)	-	-(0.00)
2	May	236	148(29.13)	47	15(3.74)
3	June	512	133(26.18)	216	61(15.21)
4	July	566	189(37.20)	687	313(78.05)
5	August	159	36(7.09)	246	12(2.99)
	Total	**1479**	**508(55.89%)**	**1196**	**401(44.11%)**



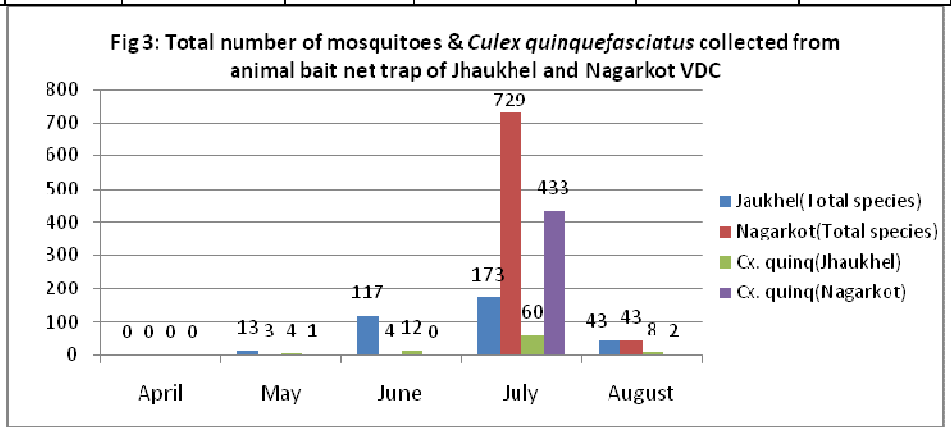


Total number of mosquitoes and *Culex quinquefasciatus* collected from animal baited net trap in Jhaukhel and Nagarkot VDC

A total of 520 *Culex quinquefasciatus* (84 from Thapa Gaun of Jhaukhel VDC and 436 from Lama Tole of Nagarkot VDC) were collected out of 1125 total mosquitoes (346 from Jhaukhel and 779 from Nagarkot VDC respectively) from animal baited net trap. In Jhaukhel VDC the highest no of mosquito collected were during July(173) followed by June(117) but no sample could be collected in April while in case of Nagarkot the highest collection in animal bait net was in July as in case of Nagarkot but no samples were collected in the month of April and June(Table 2, Fig 3).

Table 2: Animal Baited Net Trap Collection

S.N.	Month	Thapa Gaun, Jhaukhel			Lama Tole, Nagarkot			Total
		Total number of mosquitoes	**Type of animal bait**	**Total number of *Culex quinquefasciatus***	**Total number of mosquitoes**	**Type of animal bait**	**Total number of *Culex quinquefasciatus***	***Culex quinquef-asciatus***
1	April	-	1 cow, 2 goats	0	0	2 cows, 4 goats	0	0
2	May	13	2 cows, 2 goats	4	3	2 cows	1	5
3	June	117	3 cows	12	4	12 goats	0	12
4	July	173	3 cows	60	729	2 buffaloes	433	493
5	August	43	2 cows	8	43	2 cows	2	10
	Total	346		**84**	779		**436**	**520**

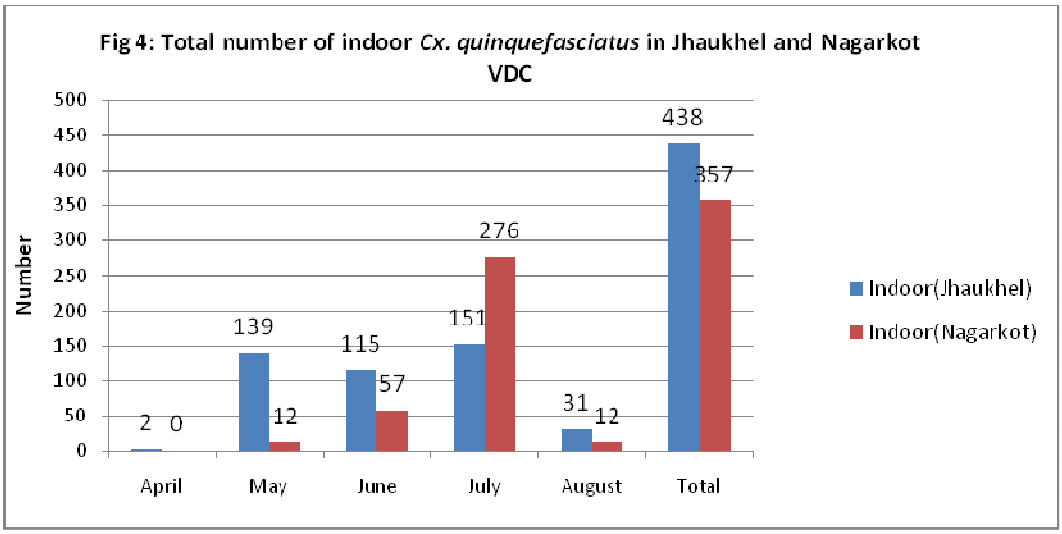


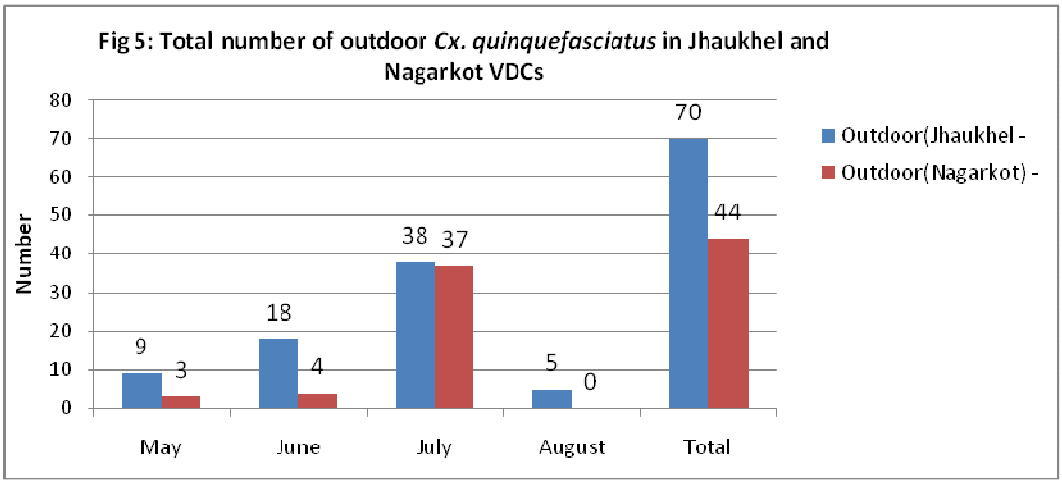
Total number of *Culex quinquefasciatus* collected from indoor and outdoor in Jhaukhel and Nagarkot VDC

Outdoor collection was observed to be less in comparision to the indoor collection. Indoor and outdoor collection in Jhaukhel was higher (438 and 70 respectively) than in Jhaukhel (357 and 44 respectively). If compared month wise variation, highest indoor collection of *Cx. quinquefasciatus* was reported to be in July for both sites i.e. 151 for Jhaukhel and 276 for Nagarkot, followed by May(139) for Jhaukhel and June(57) for Nagarkot. The least indoor collection for both sites were in April but highest outdoor collection was reported in the month of July for both viz 38 for Jhaukhel and 37 for Nagarkot and no outdoor sample was reported during April for Jhaukhel and in Nagarkot April as well as August showed no any record of *Cx. quinquefasciatus*(Table 3, Fig 4 & 5).

Table 3: Total number of *Culex quinquefasciatus* collected from indoor and outdoor in Jhaukhel and Nagarkot VDC

Month	Jhaukhel(no of *Cx. quinquefasciatus*)				Nagarkot (no of *Cx. quinquefasciatus*)			
	Human(H)	Cattle(C)	Indoor(H+C)	Outdoor	Human(H)	Cattle(C)	Indoor(H+C)	Outdoor
April	1	1	2	-	-	-	0	-
May	16	123	139	9	1	11	12	3
June	39	76	115	18	11	46	57	4
July	18	133	151	38	92	184	276	37
August	3	28	31	5	3	9	12	-
Total	77	361	**438**	**70**	107	250	**357**	**44**





Sex wise frequency of *Culex quinquefasciatus*:

Female *Culex quinquefasciatus* were found relatively higher (875) in number in comparison to male (34), out of which Jhaukhel collection comprised 486 female and 22 male. Whereas, Nagarkot collection comprised 389 female and 12 male *Culex quinquefasciatus*. Highest number of female were observed during July(502) followed by June(173) and the least was in the month of April(2) while male number was highest during June(21) followed by May(10) but no male sample of *Culex quinquefasciatus* was obtained in the month of April and July(Table 3).

Table 4: Sex wise frequency of *Culex quinquefasciatus* in Bhaktapur District

S.N.	Month	Thapa Gaun, Jhaukhel		Lama Tole, Nagarkot		Total	
		Female	Male	Female	Male	Female	Male
1	April	2	-	-	-	2	-
2	May	139	9	14	1	153	10
3	June	123	10	50	11	173	21
4	July	189	-	313		502	-
5	August	33	3	12	-	45	3
	Total	**486**	**22**	**389**	**12**	**875**	**34**

Indoor and Outdoor density of *Culex quinquefasciatus* :

Resting density (Indoor) : $\frac{\text{Number of } Cx.\ quinquefasciatus \text{ collected indoor/outdoor}}{\text{8 man hour}}$

Resting density (Outdoor) : $\frac{\text{Number of } Cx.\ quinquefasciatus \text{ collected indoor/outdoor}}{\text{4 man hour}}$

Resting density (Total) : $\frac{\text{Total number of } Cx.\ quinquefasciatus \text{ collected (indoor+outdoor)}}{\text{12 man hour}}$

The population density of *Culex quinquefasciatus* was found higher in Thapa Gaun, Jhaukhel VDC (42.33) than in Lama Tole of Nagarkot VDC (33.42)(Table 4& 5, Fig 6). Indoor density showed highest value in Jhaukhel (54.77) than in Nagarkot (44.63)(Table 4&5, Fig 7). Also for the outdoor density Jhaukhel showed the highest value (17.5) and least was in Nagarkot(11)(Table 4&5, Fig 8)..

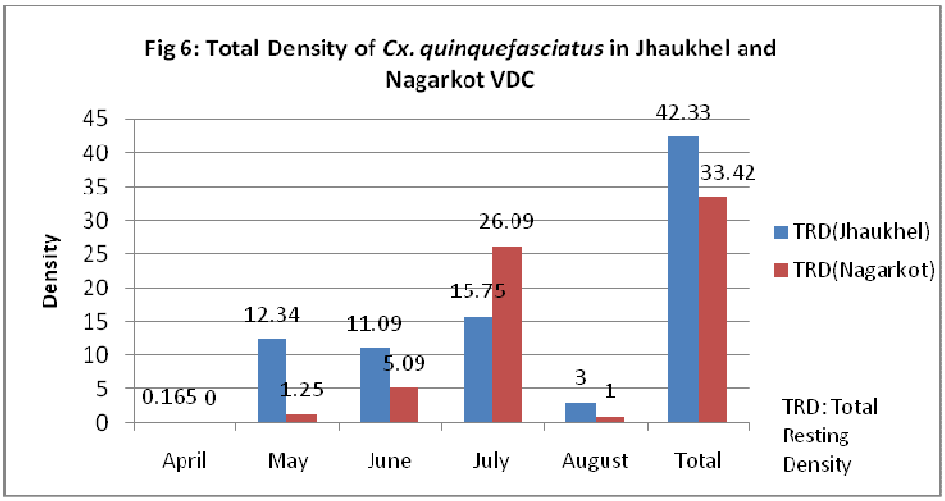
Monthwise variation showed the highest resting density during July for both sites, Jhaukhel(15.75) and Nagarkot(26.09)(Table 4&5).

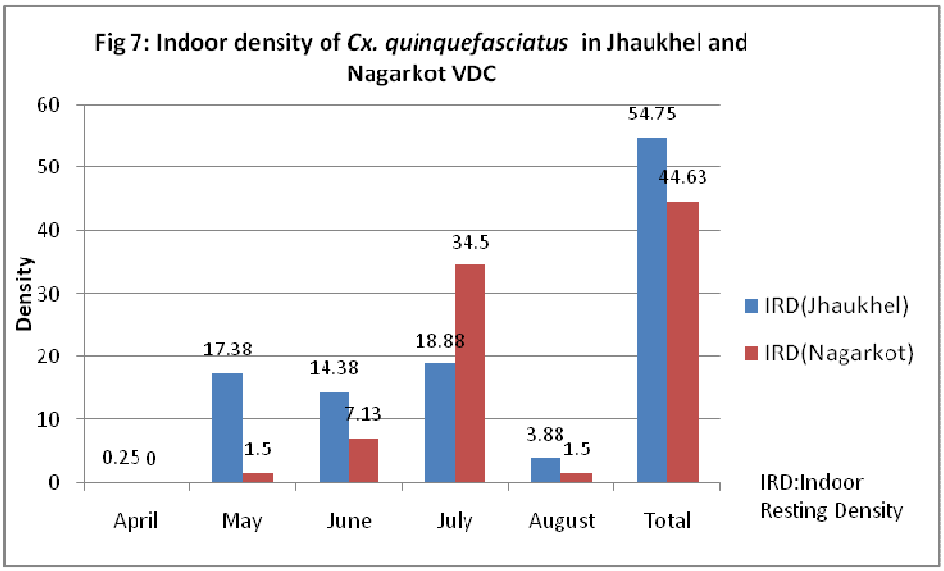
Table 5: Indoor and Outdoor density of *Cx. quinquefasciatus* in Thapa Gaun of Jhaukhel VDC

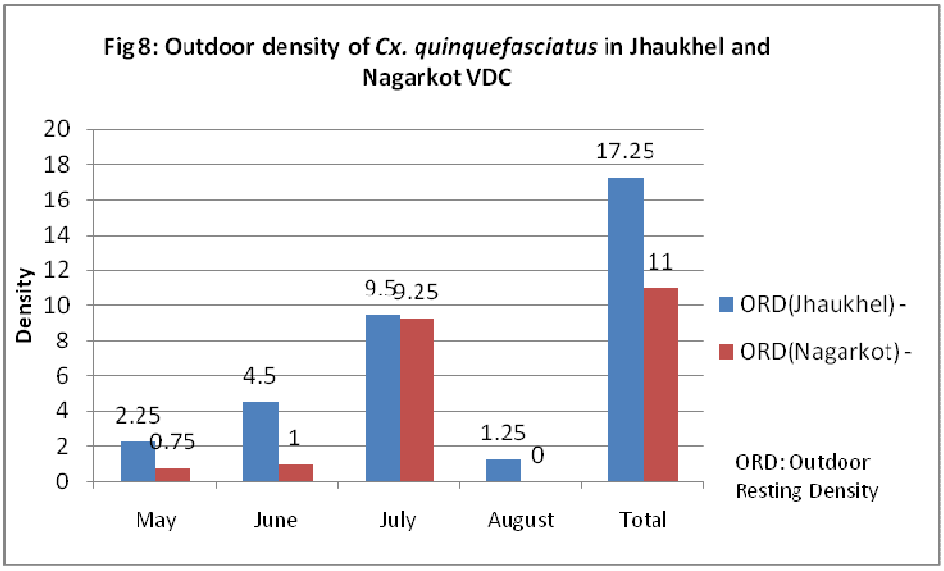
S.N.	Month	Indoor					Outdoor		Total number of *Cx. quinquefasciatus*	
		Number of *Culex quinquefasciatus*		Density			Number of *Cx. quinquefasciatus*	Density	Number	Density
		Human	Cattle	Human	Cattle	Total				
1	April	1	1	0.25	0.25	0.25	-	-	2	0.165
2	May	16	123	4.0	30.75	17.38	9	2.25	148	12.34
3	June	39	76	9.75	19.0	14.38	18	4.5	133	11.09
4	July	18	133	4.5	33.25	18.88	38	9.5	189	15.75
5	August	3	28	0.75	7.0	3.88	5	1.25	36	3.0
	Total	**77**	**361**	**19.25**	**90.25**	**54.77**	**70**	**17.5**	**508**	**42.33**

Table 6: Indoor and Outdoor density of *Cx. quinquefasciatus* in Lama Tole of Nagarkot VDC

S.N.	Month	Indoor					Outdoor		Total number of *Cx. quinquefasciatus*	
		Number of *Culex quinquefasciatus*		Density			Number of *Cx. quinquefasciatus*	Density	Number	Density
		Human	Cattle	Human	Cattle	Total				
1	April	-	-	-	-	0.00	-	-	-	-
2	May	1	11	0.25	2.75	1.50	3	0.75	15	1.25
3	June	11	46	2.75	11.5	7.13	4	1.0	61	5.09
4	July	92	184	23.0	46.0	34.50	37	9.25	313	26.09
5	August	3	9	0.75	2.25	1.50	-	-	12	1
	Total	**107**	**250**	**26.75**	**62.5**	**44.63**	**44**	**11**	**401**	**33.42**







Comparison between morning and evening population density of Jhaukhel and Nagarkot:

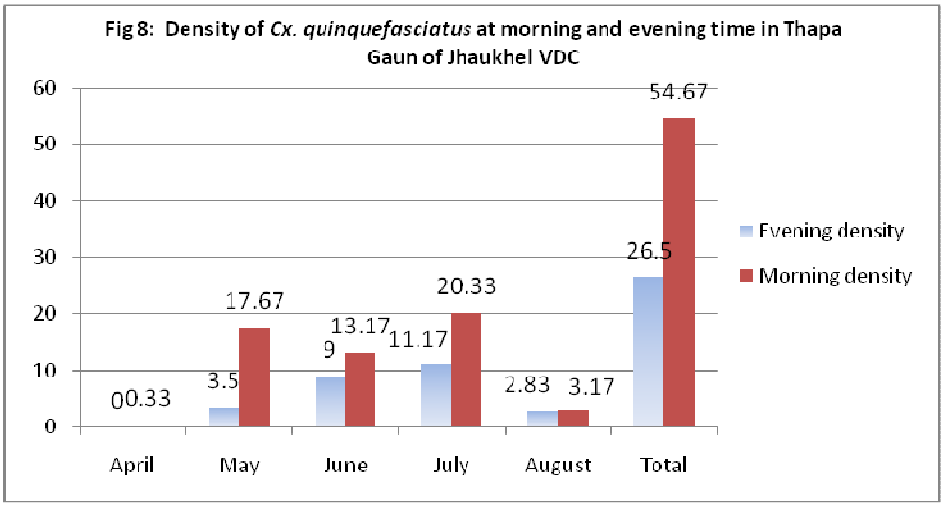
Population density for evening and morning time can be calculated as:

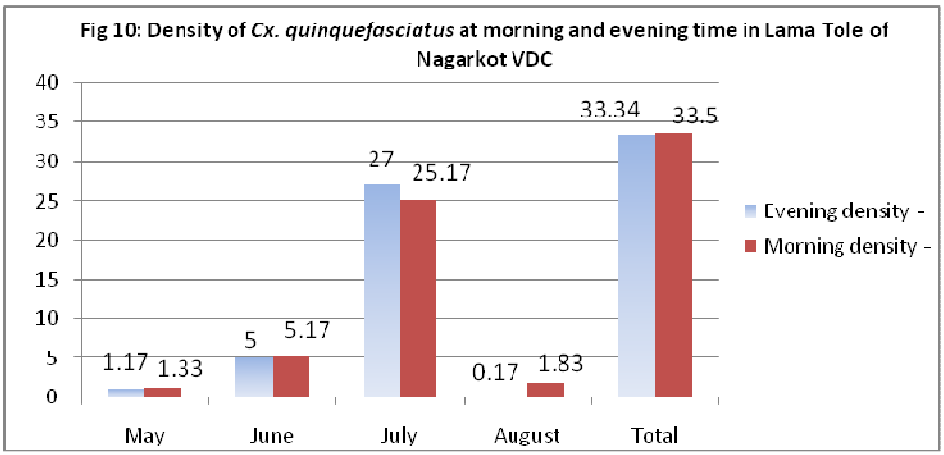
Population density (Evening/Morning): $\frac{\text{Total number of } \textit{Cx. quinquefasciatus}}{\text{6 man hours}}$

Sample analysis of Thapa Gaun of Jhaukhel VDC showed the maximum density during morning (54.67) than in the evening (26.5). The similar type of the result was observed in Lama Tole of Nagarkot VDC also with morning showing higher density (33.5) and evening showing lower density (33.34) (table 8, figure 8 & 9).

Table 7: Comparision between morning and evening density of *Culex quinquefasciatus* in Jhaukhel and Nagarkot VDC

S.N.	Month	Thapa Gaun, Jhaukhel				Lama Tole, Nagarkot			
		Culex quinquefasciatus				*Culex quinquefasciatus*			
		Evening		Morning		Evening		Morning	
		Number	Density	Number	Density	Number	Density	Number	Density
1	April	-	-	2	0.33	-	-	-	-
2	May	42	3.5	106	17.67	7	1.17	8	1.33
3	June	54	9.0	79	13.17	30	5.0	31	5.17
4	July	67	11.17	122	20.33	162	27.0	151	25.17
5	August	17	2.83	19	3.17	1	0.17	11	1.83
	Total	180	**26.5**	328	**54.67**	200	**33.34**	201	**33.5**





Abdominal condition of indoor and outdoor *Cx. quinquefasciatus* of Jhaukhel and Nagarkot

Out of 909 *Culex quinquefasciatus* mosquitoes, 670 were blood fed, 211 unfed and 28 were gravid females. 391 full fed, 99 unfed and 18 gravid samples were from Thapa gaun, Jhaukhel while 279 blood fed, and 112 unfed and 28 gravid samples were collected from Lama Tole, Nagarkot (Table 6).

Table 7 shows the abdominal condition of indoor and outdoor *Cx. quinquefasciatus* of Thapa Gaun, Jhaukhel VDC. Full fed, Unfed and gravid samples were relatively higher in indoor than in outdoor condition in both of the sites(Table 7&8, Fig 9&10) but when compared in between the samples collected from cattle and human, more number were collected from cattle than in the human residences (Table 7&8, Fig 9&10).

Table 8: Site wise abdominal condition in the *Cx. quinquefasciatus* of Jhaukhel and Nagarkot

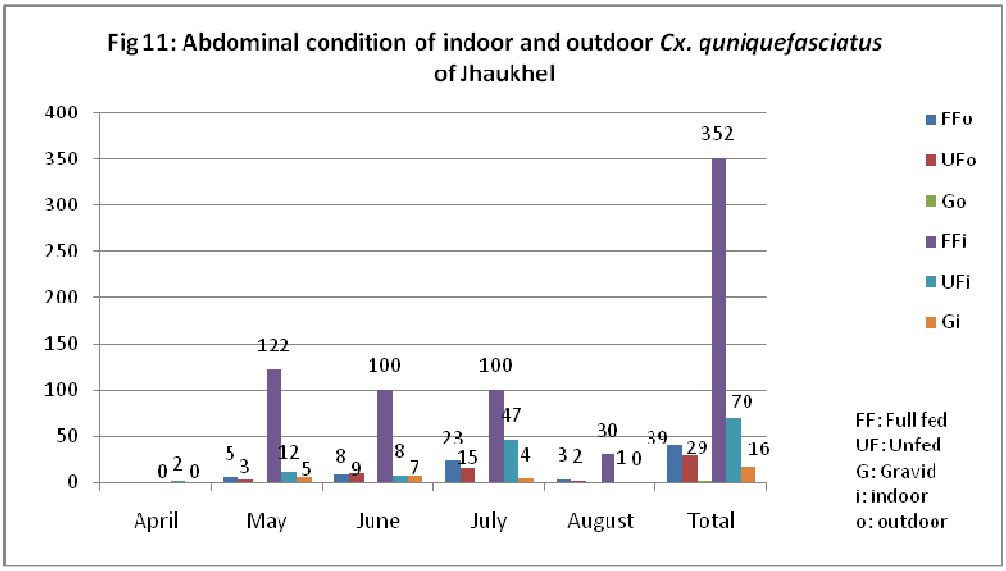
S.N.	Month	Thapa Gaun, Jhaukhel			Lama Tole, Nagarkot			Total			All Total
		Fed	Unfed	Gravid	Fed	Unfed	Gravid	Fed	Unfed	Gravid	
1	April	-	2	-	-	-	-	-	2	-	**2**
2	May	127	15	6	14	1	-	141	16	6	**163**
3	June	108	17	8	44	17		152	34	8	**194**
4	July	123	62	4	214	92	7	337	154	11	**502**
5	August	33	3	-	7	2	3	40	5	3	**48**
	Total	**391**	**99**	**18**	**279**	**112**	**10**	**670**	**211**	**28**	**909**

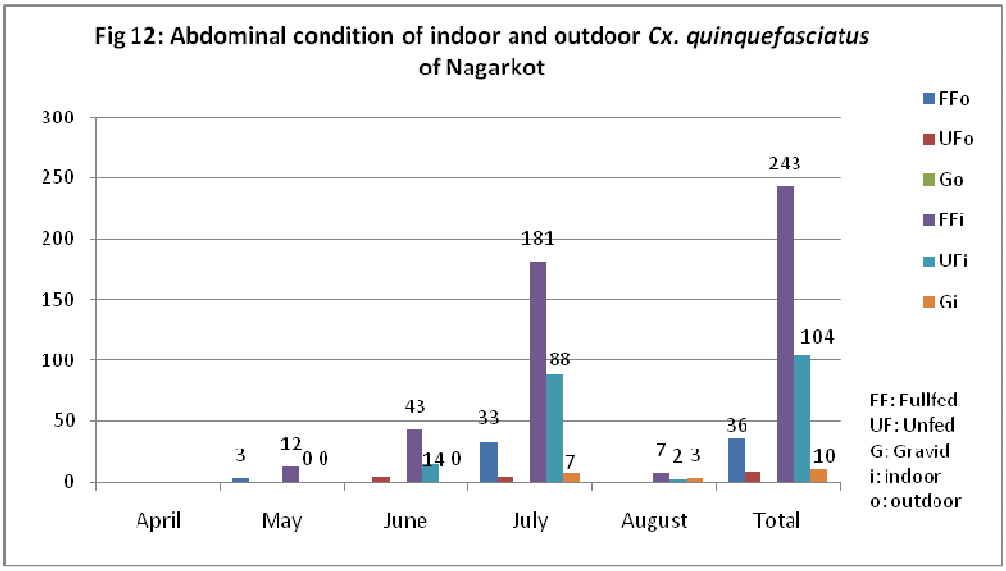
Table 9: Abdominal condition of indoor and outdoor *Cx. quinquefasciatus* of Thapa Gaun,Jhaukhel

Month	Cattle(C)			Human(H)			Indoor(Cattle+Human)			Outdoor			Total
	FF	UF	G	FF	UF	G	FF(C+H)	UF(C+H)	G(C+H)	FF	UF	G	
April					2		0	2	0				2
May	109	9	5	13	3		122	12	5	5	3	1	148
June	65	8	3	35		4	100	8	7	8	9	1	133
July	88	41	4	12	6		100	47	4	23	15		189
August	28	1		2			30	1	0	3	2		36
Total	**290**	**59**	**12**	**62**	**11**	**4**	**352**	**70**	**16**	**39**	**29**	**2**	**508**

Table 10: Abdominal condition of indoor and outdoor *Cx. quinquefasciatus* of Lama Tole, Nagarkot

Month	Cattle(C)			Human(H)			Indoor(Cattle+Human)			Outdoor			Total
	FF	UF	G	FF	UF	G	FF(C+H)	UF(C+H)	G(C+H)	FF	UF	G	
April							0	0	0				
May	11			1			12	0	0	3			15
June	35	11		8	3		43	14	0		4		61
July	146	38		35	50	7	181	88	7	33	4		313
August	5	2	2	2		1	7	2	3				12
Total	**197**	**51**	**2**	**46**	**53**	**8**	**243**	**104**	**10**	**36**	**8**	**0**	**401**



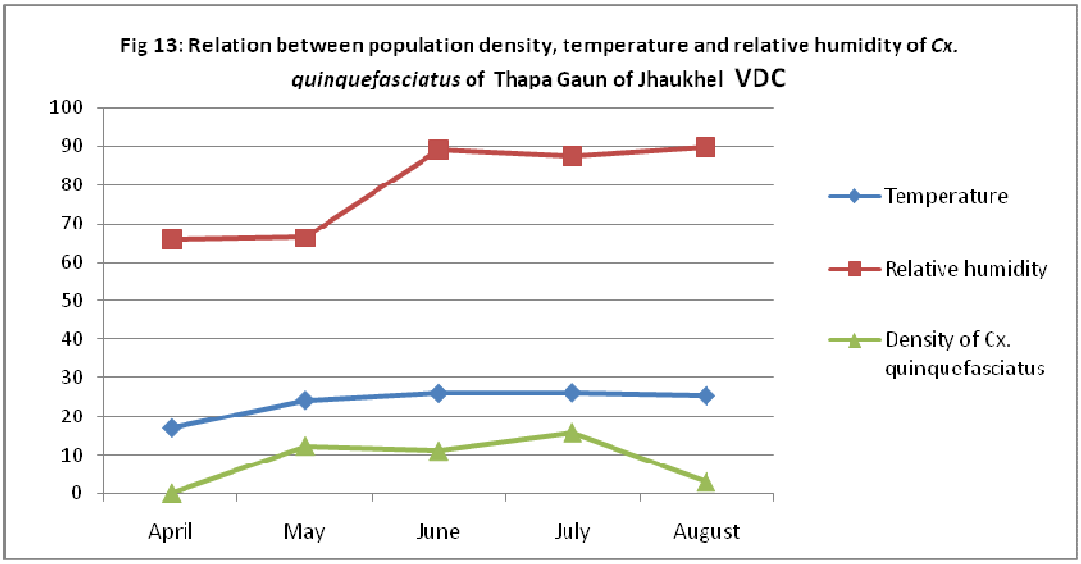


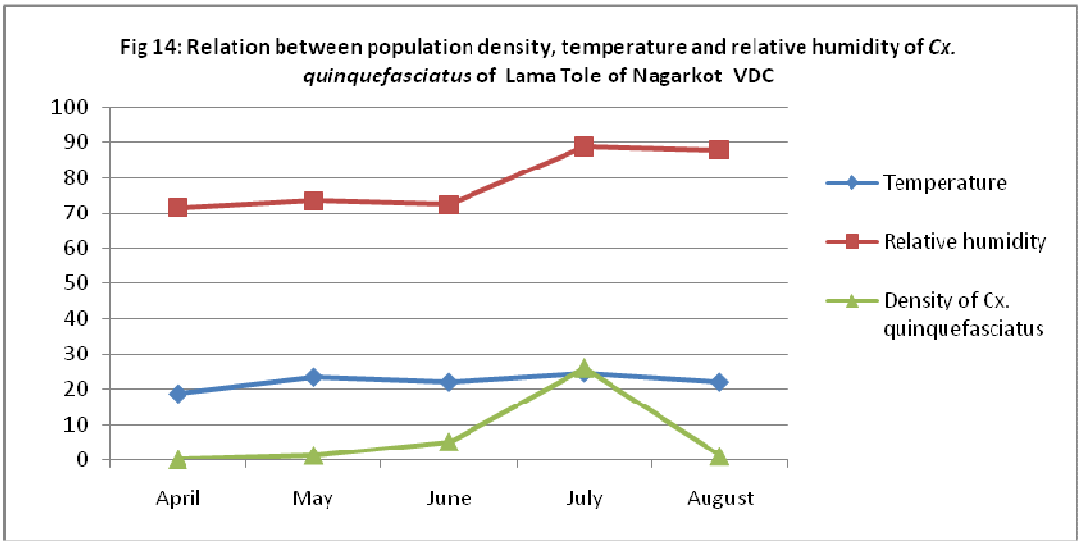
Association of density with temperature and relative humidity:

In the present study, temperature and relative humidity had been found to be directly associated with the density of *Culex quinquefasciatus.* Relation between resting density, temperature and relative humidity of *Culex quinquefasciatus* in Jhaukhel and Nagarkot are tabulated in table 9 and figured in figure 11 & 12. The highest and lowest temperature in Jhaukhel was recorded in the month of July (26.15^{oc}) and April(16.96^{oc}) while in the similar type of temperature was found to be in Nagarkot viz 24.63^{oc} in July and 18.73^{oc} in April. The highest and lowest relative humidity in Jhaukhel and Nagarkot was recorded in the month of August (89.75) and April (65.75) and July (89) and April(71.5)(Table 9, Fig 11&12). The following figure and table showed that that there is the direct association of temperature of density of *Culex quinquefasciatus* with temperature and humidity. The statement is true for Nagarkot while in Jhaukhel it was found the direct relation of temperature with the density but humidity with little association.

Table 11: Relationship between density of *Culex quinquefasciatus* with temperature and relative humidity

S.N.	Month	Thapa Gaun, Jhaukhel			Lama Tole, Nagarkot		
		Temperature (ºC)	Relative humidity (%)	Density of *Cx. quinquefasciatus* (PMHD)	Temperature (ºC)	Relative humidity (%)	Density of *Cx. quinquefasciatus* (PMHD)
1	April	16.95	65.75	0.165	18.73	71.5	-
2	May	24.23	66.25	12.34	23.43	73.5	1.25
3	June	26	89	11.09	22.03	72.5	5.09
4	July	**26.15**	87.5	**15.75**	**24.63**	**89**	**26.09**
5	August	25.4	**89.75**	3	22.05	88	1
	Total			42.33			33.42





Percentage Abundance of *Culex quinquefasciatus* :

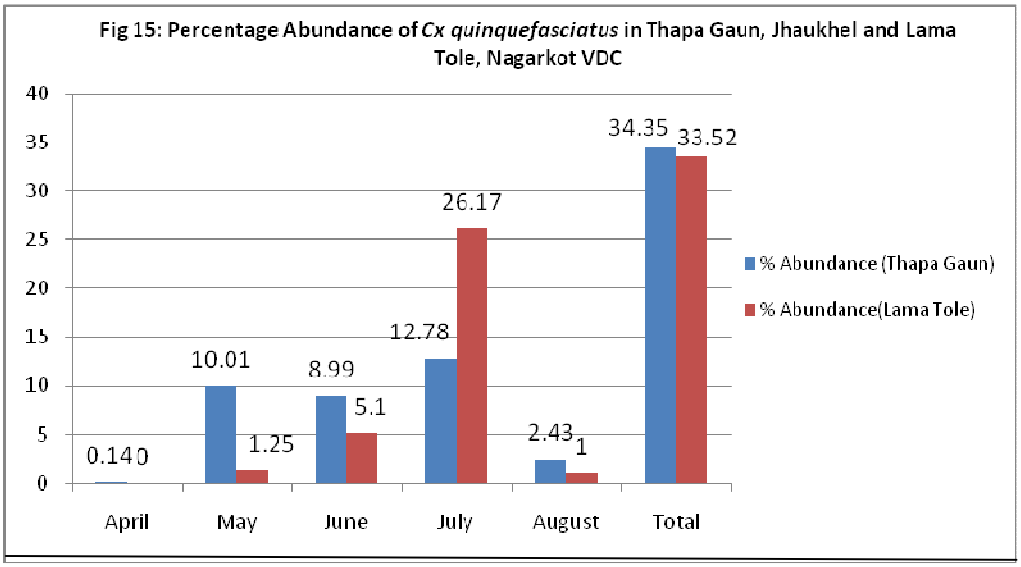
Percentage abundance can be calculated as follows,

$$\text{Percentage abundance: } \frac{\text{Number of } \textit{Culex quinquifasciatus}}{\text{Total number of mosquitoes}} \times 100$$

Thapa Gaun of Jhaukhel VDC showed higher abundance (34.35%) than Lama Tole of Nagarkot VDC(33.52). In both sites, highest abundance was observed during July and least during April (table 9 & figure10).

Table 12: Percentage abundance of *Culex quinquifasciatus* in Jhaukhel and Nagarkot VDC

S.N.	Month	Thapa Gaun, Jhaukhel			Lama Tole, Nagarkot		
		Number of *Culex quinquifasciatus*	**Total number of mosquitoes**	**% Abundance**	**Number of *Culex quinquifasciatus***	**Total number of mosquitoes**	**% Abundance**
1	April	2	6	**0.14**	-	-	-
2	May	148	236	10.01	15	47	1.25
3	June	133	512	8.99	61	216	5.10
4	July	189	566	**12.78**	313	687	**26.17**
5	August	36	159	2.43	12	246	1.0
	Total	50.8	1479	**34.35**	401	1196	**33.52**



Resting Density of *Culex quinquefasciatus:*

Total indoor density can be calculated as follows;

$$\text{Total indoor density: } \frac{\text{Total no of Cx. quinquefasciatus(Human+Cattle)}}{\text{8 man hour}}$$

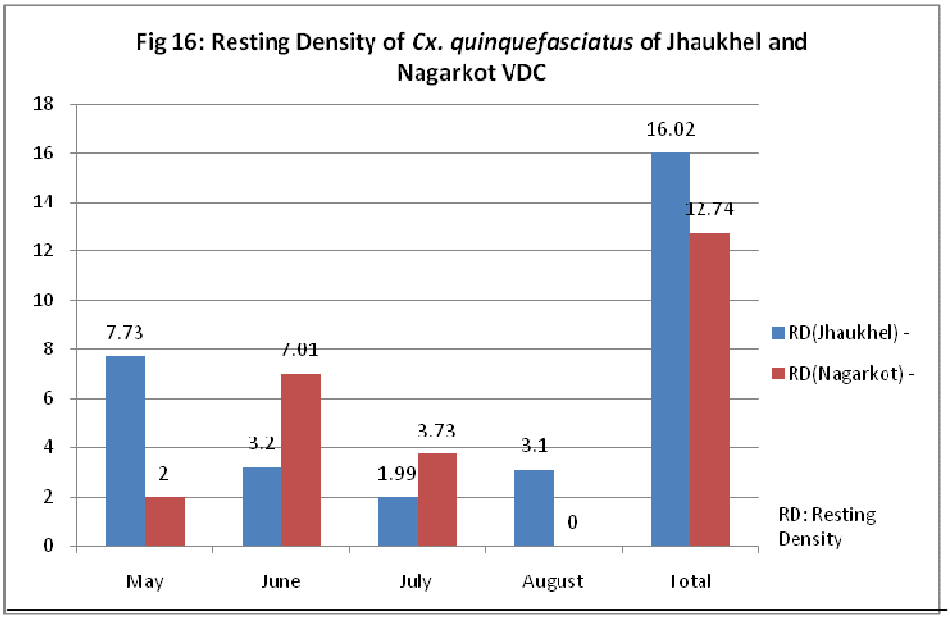
$$\text{Outdoor density: } \frac{\text{Total no of Cx. quinquefasciatus in outdoor collection}}{\text{4 man hour}}$$

$$\text{Resting density: } \frac{\text{Indoor Density}}{\text{Outdoor Density}}$$

As shown in table 10, resting density for *Culex quinquefasciatus* was found higher in Jhaukhel VDC (16.02) than in Nagarkot VDC (12.74)(Table 11, Fig 14). In Jhaukhel May showed the higher resting density (7.73) followed by June (3.20) and the least during April(0). Unlike Jhaukhel, Nagarkot showed highest resting density during June (7.01) followed by July(3.73) while no resting density was observed during April and August(Table 11, Fig 14).

Table 13: Resting density of *Culex quinquefasciatus* of Jhaukhel and Nagarkot VDC

S.N.	Month	Thapa Gaun, Jhaukhel			Lama Tole, Nagarkot		
		Culex quinquifasciatus			*Culex quinquifasciatus*		
		Indoor Density	Outdoor density	Resting Density	Indoor Density	Outdoor density	Resting Density
1	April	0.25	-	-	-	-	-
2	May	17.38	2.25	7.73	1.5	0.75	2
3	June	14.38	4.5	3.20	7.13	1	7.01
4	July	18.88	9.5	1.99	34.5	9.25	3.73
5	August	3.88	1.25	3.1	1.5	-	-
	Total	**54.77**	**17.5**	**16.02**	**44.63**	**11**	**12.74**



CHAPTER VI

DISCUSSION AND CONCLUSION

The present study was carried out form April 2011 to August 2011 with an attempt to determine the population density and vector abundance of filarial vector *Culex quinquefasciatus* in two sites of Bhaktapur, viz Lama Tole of Nagarkot VDC and Thapa Gaun of Jhaukher VDC which were selected on the basis of altitudinal variation. Reviewing the literature, it was found that Sherchand *et al.,* (2003) on mapping of filariasis found out Bhaktapur as one of endemic district for filariasis and also a previous study made by Tamrakar AS in 2009 had recorded the presence of this vector in this district, the present attempt was made.

Five months study resulted a total collection of 3800 mosquito samples which comprises 2675 as indoor and outdoor collection (1479 from Thapa Gaun of Jhaukhel VDC, 1196 from Lama Tole of Nagarkot VDC and 1125 from animal bed net trap collection: 346 from Jhaukhel and 779 from Nagarkot). Out of collected samples, 508 and 401 were identified as *Cx. quinquefasciatus* respectively from Jhaukhel and Nagarkot VDC. Similarly animal bait net trap resulted 84 and 436 *Cx. quinquefasciatus* from the respective sites.

In the present study both the selected sites viz. Thapa Gaun of Jhaukhel VDC and Lama Tole of Jhaukhel VDc showed highest per man hour density (PMHD) which can be compared with a study performed by Murty U.S. *et al.,* 2002. In a similar work on rural and urban areas of East Godavari Districts (EGDT) and West Godavari Districts (WGDT), the rural areas of EGDT showed high density (38.7-39.5) in the months of February, March, November and December and lowest in the month of April, May, June 2000. The rural areas of WGDT showed the highest density 38.7-42.9 in November and December and the lowest in April 2000. While in the urban area of EGDT and WGDT, the highest PMHDs were recorded in the months of February, April, June, August and November 2000 and January 2001 ranging from 4.2 to 7.8; the lowest PMHDs were recorded in February, May, June, October and November 2000 and January 2001. While a study performed by Kaliwal M.B. *et al.,* (2010) reported perennial prevalence of *Cx. quinquefasciatus* with a very highest per man hour density in February (48.6) and lowest in September (6.6). The present study showed the highest per man hour density during July in Lama Tole Nagarkot (26.09) and lowest (0) in the same place in April. A similar type of the study carried out by De S K *et al.,* found out considerably high average man hour density of *C. quinquefasciatus* (31.10). Dixit et al., 2002 found the highest density in March (44.29) and the lowest in November (16.64). Neupane VD, 2009 in an entomological study in Chitwan found out *Cx. quinquefasciatus* to be the most dominant species and September to be the most favorable month for the distribution of *Culex* species.

Highest density during the month of June may be due to increased temperature, pre monsoon showers in April- May months and the onset of monsoon rains in the month of June in Bhaktapur while the sudden decline in August can be attributed to flushing of drains, flooding of outdoor breeding sites and heavy mortalities caused due to physical impact of heavy rains (Kaliwal M.B. *et al.,* 2010).

Predominance of female *Cx. quinquefasciatus* over male was observed to be higher similar to the study performed by Kaliwal M.B. *et al.,* 2010. The present result is similar to earlier observation made in Arthala (Kaul H.N. *et al.,* 1968) and Rajhamindary (Dhar *et al.,* 1968). Less proportion of male in indoor resting collection may be due to their exophagic and exophilic behavior (Laporta *et al.,* 2006) and their lower life expectancy (Kaul H.N. *et al.,* 1968). The same reason might be useful for present study to explain the higher indoor density of *Cx. quinquefasciatus* in selected areas than the outdoor density.

Out of total collection, 73.71% of *Cx. quinquefasciatus* were blood fed, 3.08% were gravid and 23.12% unfed. Less number of unfed mosquitoes in comparision to blood fed and gravid one is similar to the result obtained by Kaliwal M.B. *et al.,* 2010 in a research carried out in Panaji, Goa an Gowda and Vijayan 1992 in Mysore city which found out *Cx. quinquefasciatus* females to be 14.7% unfed, 64.7% fed, 12.3% semi-gravid and 8.2% gravid.

Relation of seasons, different climatic factors like temperature, humidity and rainfall on the prevalence of vector have been studied by different scientists (Kaliwal M.B. et al., 2010; Dixit V., 2009; Kaul H.N., 1984; Pipitgool *et al.* in 1998 (Kaliwal M.B. *et al.*, 2010). The present study shows the direct association of temperature and humidity with the density of Cu*lex quinquefasciatus*. Neupane VD, 2009 has showed the positive correlation of *Culex quinquefasciatus* density with at temperature.

Present study found the highest indoor density (54.77) in Jhaukhel VDC while Nagarkot VDC showed 44.63 indoor densities. The density was reported to be more in cattle than in human residences which might be due to the smoky kitchen located at the ground floor and also the use of mosquito coil. The density in cattle was found to be highest in comparision to human and the highest was reported from Jhaukehel (90.25) while the highest density in human was reported from Nagarkot i.e. 26.75. The outdoor density was highest n Jhaukhel(17.5) and the same place also showed the highest resting density(16.02). The outdoor density is less than the indoor density. The result obtained in this study is similar to a study by Nepane VD, 2009 in which she reported the highest indoor density (0.22) from Kholesimal and lowest in Champanagar village. Highest room density of *Cx. quinquefasciatus* (6.5) was recorded from Champanagar in Post monsoon and also the indoor density in human was reported to be highest in comparision to cattle.

Vector abundance showed its highest value(34.35) in Jhaukhel with July showing the peak abundance in Nagarkot (26.17) as well as in Jhaukhel(12.78) while April showed the lowest abundance in both sites which can be compared with a study performed in Chitwan (Neupane VD, 2009). Morning population density was observed to be higher than evening which might be because of the nocturnal feeding habit of the female vectors

CHAPTER VII

RECOMMENDATION

1. The results of studies showed that it is possible to contain the mosquito especially *Culex quinquefasciatus* problem in Bhaktapur district with the existing infrastructure and inadequacy of research. However, it requires concerted efforts with a systematic approach. Hence, the present recommendations are made for tackling the existing situation for effective implementation of the programme are given based on mosquitoes prevalent in the study areas.
2. Identification and enumeration of all potential mosquito breeding sources and quantify the relative role of different habitats in terms of daily mosquito emergence for prioritizing the areas for control operation is recommended.
3. Assessment of the magnitude of the mosquito menace problem through man biting density is necessary.
4. Evaluation of the susceptibility status of the most abundant mosquito species against frequently used larvicides and adulticides is important to suggest the choice of insecticides. To reduce the vector contact, use of insecticide impregnated mosquito bed net and wearing long sleeved cloth is strongly suggested. Also reducing outdoor activities, discouraging to sleep outside especially during summer and rainy season is highly recommended.
5. Development of a mosquito control strategy by integrating different control methods suited to the local needs. Use of biological control methods such as microbial agents like *Bacillus thuriengiensis* and *B. sphaericus*, and introduction of carnivorous fishes like *Gambhusia affinalis* are recommended to control mosquito related diseases.
6. Mass awareness and public health education campaigns at the national level should be conducted so as to aware public about the mosquito and mosquito related diseases. Impart training in control operations to those human resources engaged in this area, design an information, education and communiction system for creating community awareness. Appropriate remedial measures are suggested to correct the defects and implementation of measures to avoid mosquito breeding requires considerable exercise particularly in motivating and mobilizing the community.
7. Environmental and entomological studies in relation to the endemicity of filariasis with respect to vector, its breeding habitat, temperature, humidity etc. should be extended to national level.
8. There is an apparent gap between the engineering and health divisions with respect to mosquito control activities. Therefore intersectoral coordination is an important component for the successful implementation of mosquito control programmes. Provision of a sewerage system will be an ideal solution to the problem. In this process, open drains will no longer exist. As a result not only will the expenditure on insecticides and spraying operations be reduced, but also the environmental pollution will be minimized. However, this can be considered as a long-term plan in a phased manner.
9. Monitoring the effectiveness of operations and reviewing the programme are of paramount importance to ensure the sustenance of an effective control programme. An action committee can be formed with a senior staff member /reputed senior citizen as the Chairman with local members to review the programme from time to time and to overcome bottlenecks, if any.

CHAPTER VIII

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ANNEX

FIELD PHOTOS

Study Areas

Lama Tole, Nagarkot

Thapa Gaun, Jhaukhel

Indoor mosquito breeding areas in the study areas:

Outdoor mosquito breeding areas of study areas

Outdoor cattle resting areas of Nagarkot(a)

(b)

Stagnant water

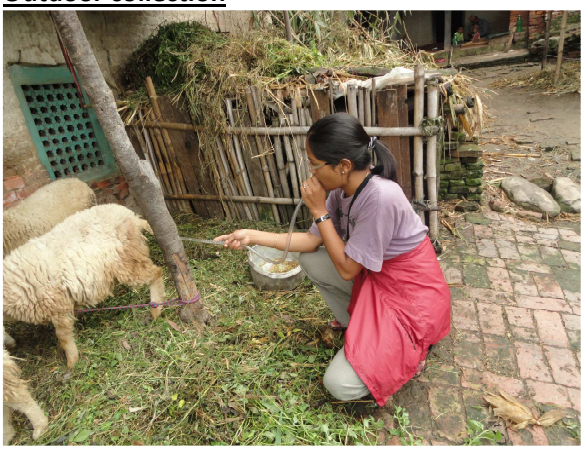
Sullage from kitchen

Outdoor resting areas of Jhaukhel (a)

Accumulated cattle dung and kitchen waste(b)

Indoor collection

Outdoor collection



Jhaukhel

Nagarkot

Sample arrangement in field

Collected samples in paper cups and test tubes

Animal Bait net collection

With the locals of study sites

Jhaukhel

Nagarkot