CHAPTER ONE

INTRODUCTION

1.1Background

Biodiversity is the variety that exists among organisms, genes in them and their environment W.G Rosen (1975). The mosquito diversity also the variety of mosquito in the area in terms of genus species or sub species level.

Mosquitoes (Insecta - Diptera - Culicide) belong to true flies. Adult mosquitoes are slender bodied with long wing fringed with scales. The scales are present along the wing veins. The venations of the wings are similar in all species, but the colourations produced are useful in identification of different species especially in *Anopheles*. The mosquitoes differ from other Dipterans by presence of scales in wings. Antenna of mosquito are long, filamentous, each made of 15 segments. Female mosquitoes possessed special elongated, modified mouth part with long, piercing and sucking mouth part. In female the antenna are long and slender with the whorl of a few short hairs at each joint. The male mosquitoes are smaller than female. They have more bushy antennae.

The mouth part of mosquitoes consists of proboscis. The proboscis consist of a number of needle like orangs lying in a groove in the fleshy labium .In female mosquitoes there are six of these needle like organs. The labrum – epipharynx and hypopharyx are the principal piercing organ and act together to form tube for drawing up the blood into the mouth. The maxilla and mandible are much thin flat and flexible. In male mosquitoes the maxillae are mandible are degenerated.

Mosquitoes are most abundant in warm region. They are found from the tropic to the Artic circle from low land to the peak of High Mountain. There are over2500 sps. of mosquitoes all over the world (Floore.et.al.2002).

In Nepal Darsie and Pradhan (1990) reported 130 sps. in 14 genera, recently *Tripteroides* genera were also reported by Darsie and pradhan (1900).The distribution of mosquitoes recorded in Katmandu valley to the elevation of not higher than 4500ft .(joshi Govind et al.1999)

All mosquitoes have four stage of development –egg, larvae pupa and adult .The Female of some mosquitoes deposit egg in moist surface such as mud or fallen leaves. The pupa stage resemblance the lobster stage deprived of appendages with prominent cephalothorax.

The mosquitoes are carrier of various disease germs .The relation of mosquitoes with human is of great medical importance. The different genus of mosquitoes had different relation with human. In Nepal three mosquitoes borne disease are prevalent and causes much morbidity and mortality. They are malaria (Peter et al.1955,Brydon et al 1961, Johnson 1966, Shrestha et al.1988)Japanese Encephalitis(Pradhan,1981 Khatri etal.1983)and filariasis (Kessel 1966, Jung.1973). In 1958 to1978, Malaria was major vector borne disease, so most of the work was confirmed to to the genus *Anopheles* (Darsie and Pradhan 1963).

The important malaria vector in Nepal are *An. Minimus*, *An. maculatus complex*, *An. fluviatilis, An. annularis* (Darsie & Pradhan).The other disease J.E and Filariasis are transmitted by *cucline* mosquitoes, so received nation wide attention .In Nepal *Culex quiquefasciatus* and *Culex pipiens* are the principal vectors (Kessel 1966) *Ades aegyptia* was found to transmit yellow fever virus. The subgenus of *Aedes, Stegomyia* is the sole transmitter of dengue fever. The main vector of the disease are: *Ae. aegypti, Ae. albopictus, Ae. scutellaris* and *Ae. polynesiensis*.(Barr, A.R. 1957).

Virus causing Encephalitis is found to be transmitted primarly by *culex tritaeniorhynucus*(Barr, A.R. 1957). Nearly 60sps. of mosquitoes including sps. of *Anopheles, culex, Aedes, Psorophora* and *Mansonia* served as intermidate host for the filarial worm (Altken, T.H.G.1945) . In many part of tropical America, larvae of *Dermatobia hominis* causes infestation in man and cattle.

1.2 JUSTIFICATION:

The relation of the mosquitoes to man is inevitable. Mosquito being the carrier of various parasite for human and cattle disease such as Malaria, filariasis, Encephalities. The study of diversity, prevalence in an area is important to for an understanding of the epidemiology of the the mosquito borne diseases and their control. The study gives the knowledge of species composition, breeding habit, seasonality, and chance of contact between vector and man. The survey helps in predicting epidemiology and in constructing prognostic map of mosquito borne diseases. The present study also shows the relation of the mosquito with environmental parameter.

Thus this finding of diversity of mosquito in different human shelters of the area would be a effective means to understand the habitat preference and optimum temperature, RH, and Rainfall for their breeding. This is a foundation step for finding a sustainable measure to launch a control programme and awareness in the locality.

1.3 L**MITATION OF STUDY**

The study on the diversity of mosquitoes was done for the partial fulfilment of M.Sc Degree the limitations are as follows:

1) Due to lack of sufficient literature in the context of Nepal the study cannot be conducted properly.

2) The study was conducted with out any proper budgeting.

3) The collection of the specimen is also limited by lack of sophisticated instruments.

4) The study was also limited by short time the duration.

1.4 OBJECTIVE

The following are the specific objective of the study.

i)To study the Indoor abundance of mosquito .

ii) To find the species diversity of mosquito population.

iii) To assess the mosquitoes species with Environmental parameter (temperature, Rainfall, Humidity)

1.5 STUDY AREA

Bhaktapur is the smallest district of Nepal, which consist of 16 V.D.C. s namely Sipadol, Chitpol, Tathali , Sudal , Bagishwori, Nankhel, Nagarkot, Chaling, Jhoukhel, Chagunarayan, Duwakot, Gundu, Katunje, Balkot, Dadhikot and Sirutar.The district is at an altitude of 1330m from the sea level. It is about 7.8km eastward from the Kathmandu.

The selected site is in Sipadohl which is about 1km from the Suryabinayak. A large part of the V.D.C has agriculture land and some part of the area is covered by forest. The study area lies in the North eastern part.

The Sipadol V.D.C. of Bhakatapur is situated between 85°25' 45sand 85° 26' 55s North latitude and between 27˚37’45s to 27˚ 39’58seast longitude. The V.D.C. is at the height of 1325 to 2036m from the sea level (Joshi,1999).

The V.D.C divided into 9 block with total house holds of 1,358 The male and female population of V.D.C.is3,569 and 3,435 The main occupation of the inhabitant is cattle rearing and cultivation. Pond ditches and puddles are frequently visible around the houses .The garbage, cattle and agriculture waste are staked around are inside house. The V.D.C. is covered by *Eupatorium adenophorum*. The climate of V.D.C is characterized by typical monsoon climate, rainy summer and dry winter. Summer temperature is above 30˚Cin the day and below 20˚C at night. Similarly in winter the temperature is about 18˚C to 0˚C or even less. Pre-monsoon season starts from march to may, which is mostly dry and warm. This period is characterized by hazy atmosphere with dirty winds. (Metrological Dept.Babarmahal).

CHAPTER TWO

LITERATURE REVIEW

IN THE CONTEXT OF NEPAL:

In Nepal some works has been carried out on mosquitoes regarding the distribution, diversity and importance. Some of which are as follows:

Theobald (1910) reported one more species of Non *Anopheline, Culex (Culiciomyia) Longifurcatus* from the Eastern Nepal.

Puri (1955) and Peter et al. (1958) were the first to report the species of *Anopheles* while Peter and Dewar (1956) were the first to record certain *culicine* occurring in Nepal.

Peter and Dewar (1956) published a preliminary record of the *Culicine* and *Toxorhynchities* mosquitoes of Nepal. Their collections were made in the vicinity of Hetaura and Bhimphedi in Makwanpur District of Narayani zone from which they recorded 29 species in 8 genera and 12sub genera.

Wattal et al. (1958) published his work about the mosquito fauna of India which have been very helpful in interpreting the findings in Nepal.

Stone, knight and Starcke (1959), Joshi et al. (1965) also reported 2species of *Culex* (*culex*) from the Kathmandu district, Bagmati zone.

Brydon et al. (1961) increase the number of *Anopheles* in 31 species and Joshi et al. (1964) added *Anopheles kochi*.

In the following year, Joshi et al. (1965) made a major contribution by reporting 59 species of *culicine* including 28 new country records.

Joshi, G., S.Pradhan and Darsie (1965) found out that the collection made by entomological staff during numerous *Anopheline* survey in connection with malaria and eradication campaigns since 1956 which resulted 3 more genera they are: *Culiseta*, *Malaya* and *Topomyia*, four more subgenera: three of the genus: *Aedes-Aedimorphus*, *Mucidus* and *Neomelaniconion*; and from the genus *Culiseta-Culiseta* and 28 more species distributed among 9 genera and 11 subgenera as new country record. The

collections have been made mostly in the southern plains (Terai), including some area in inner Terai to the elevation of 4,500ft.

Shrestha (1966) published an extensive review of the mosquito's fauna of Nepal. He recorded 97 species including 36 *Anophelines* and 61 *culicines*.

Over the years, various treatments of specific genera, subgenera or species groups, some of which mention Nepal, have been very useful in constructing the identification keys.

Thurman (1959), Delfinado (1966), Bram (1967), Reid (1968), Knight (1968), Tyson and Zavortink (1970). Mattingly (1971), Harrison and Scanlon (1975), Sirivanakarn (1976), Abercrombie (1977), Peyton (1977), Huang (1979), Harrison (1980),Reinert (1984), Harbach (1988) findings are very helpful in constructing the identification keys.

Rao et al. (1973), Bhat (1975), Das et al. (1987), Malhotra (1987) and Nagpal and Sharma(1987) did some more recent works in the findings of the mosquito fauna.

Rao (1981) includes the record of *Anopheles* of Nepal. No new additions to the fauna were recorded until 1989.

Certain species have been included in the Nepal mosquito fauna though the courtesy of N.Burgess, Department of Military Entomological, Royal Army Medical College, Milibank, London, Who collected mosquitoes in Nepal from1983to 1988.They are *Ae.khazani*, An. Indefinites, *An.nivipes*, *Ar. Annulityarsis*, *Ar. Aureolineatus*, *Ar. Dentatus.*

Pradhan (1988) reported 7 new country records which include: *Ae.pulchriventer, Ae.subalbopictus, An.fragilis, An.dravidicus, Armigeres durhami, Culex infula and Culex pseudovishnui.*

Burgess (1990) found out that in Nepal the study of mosquitoes begins only recently, he recorded130 species and subspecies in 14 genera of mosquitoes known from Nepal.

Darsie & Pradhan (1990) reported the taxon *Anopheles (Anopheles) gigas Glies [complex]*, as *Anopheles gigas var bailey*. *Anopheles (celiia) filipinae* Manalang.

This species was also reported by Pradhan & Brydon (1960) from Lamjung district in the North Central Nepal.

Darsie and pradhan (1994) reported that in Nepal, 42 species of *Anopheline* mosquitoes has been identified. Out of these seven has been identified incriminated as vector of primary importance. These are *A.minimus, A.fluviatilis, A.maculatus, A.dravidicus, A.pseudowillmori, A.willmori and A.anullaris.*

Darsie (1994) found out that since1987, a study of species of mosquitoes occurring in Nepal has been under way. No pervious work has been understood to record the total mosquitoes of this Himalayan kingdom of the Nepal.

Darsie (1994) reported 41new country records. There is now 171species known from the country. For the record of fauna of mosquitoes in the country, the author had spent one summer in each region.

IN THE GLOBAL CONTEXT:

James (1901-03) observed at Mian Mir (Lahore) that the population of larvae and adults of *Anopheles subpictus* diminished very rapidly in December and not a single adult was found until the beginning of July.

According to Senior White (1928), its optimum temperature was 32˚c.

Pruthi (1931) observed that at 32-34˚c its larvae could live, but could seldom metamorphose into adults, whereas at 28-30˚c, both pupation and emergence were facilitated.

Nuttall and Shipley (1902), Ross (1911) and Bacot (1915) pointed out on the other hand that the emergence of males and females were more or less equal.

Leicester (1908) reported *Aedes (Stegomyia) gardnerii var imitator* from north eastern India.

Leicester (1908) collected *Armigeres (Leicesteria) dolichocephalous* from Manipur.

Stephens and Christopher (1908), Gorden (1922), Young (1922) and Harold (1923) had noted that the males of *Anopheles subpictus* emerged in excess in summer.

Christopher (1911) draws attention to the fact that during winter, *Anopheline* larvae were scanty and occurred only in water rich vegetation.

Hodgson and King (1914) found that the optimum temperature of *Anopheles* lay between 20 and 26˚c.emergence were facilitated.

The findings of different workers with regard to the ratio of sexes among freshly emerged mosquitoes are variable. It was generally believed by various observers Lamborn (1922), Russell (1925), Bradley (1926), Boyd (1930), Mehta (1934), Sen. (1935) and Rozeboom (1936) that female mosquitoes invariably predominated.

Barraud (1922, 1928) reported *Aedes (finlaya) alboniveus* and *Aedes punctissimus* from north east India.

Borel (1928) also reported *Aedes (Stegomyia) pseudalbopictus* from north east India.

It is almost a truism that temperature is of outstanding importance in a study of insect ecology. According to Chapman (1925) extremes of temperature limit the activities of animal and incidentally determine their abundance during the annual cycle.

Senior White (1928) further showed that the optimum temperature for *Anopheles stephensi* was 24˚c.

Chowdhury (1931) concluded that the *Anopheles subpictus* was a truly hibernating species in the Punjab, probably only as adult, as its larvae could not be found during winter, the author detected its larvae and adults during winter in the Punjab.

Roy (1931) observed that at 24˚c temperature for *Anopheles subpictus* usually matured in 16-20 days. He also pointed out that its eggs hatched even after an exposure up to 5 days at 11˚c, but could not survive exposure beyond 6-8 days.

Barraud (1934) reported *Malaya (Maorigoeldia) jacobosoni Edwards* from Jalpaiguri and Darjeeling district of West Bengal

Herden, F.W and Poolson, B.J (1969) collected 45 species of mosquitoes both larvae and adult from Hancock country, Mississippi from May 1964 to December 1968.*Culex salinarius, Anopheles crucians, Aedes solicitans* and *Aedes vexans* seems to be the most numerous. CDC. miniature light trap containing CO2 provided the best means of collecting numerous species in a short time.

Richiardii. M.W. (1969) recorded mosquito population in southern England through sampling method, which was sampled from 1964 to 1966 with light trap and trap baited with animal. Both zoophilous and ornithophilous species were caught in cylindrical trap baited with rabbit, but very few individuals were caught when they were baited with chicken. Direct bait, catches, however showed that ornithophilous species were not attracted to rabbit outside trap. The most abundant catches were *Aedes detritus* and *Mansonia*.

Knight and Stone (1977) recorded only nine mosquito species of the genus *Armigeres*.

Ward (1984) reported *Culex infula* was encountered for the first time in North Eastern India at an altitude of 600-1200m of Manipur.

Scientific investigators are constantly looking for new mosquitoes, as well as reviewing previously identified specimens for new information or identifying characteristic. Recently such a review made a change in the name of many mosquitoes belonging to the genus *Aedes*.

Reinert. (1984) made a change in the sub genus of *Aedes chlorotatus* to the status of genus.

Nagpal and Sharma (1987) collected 1574 species of *Anopheles nivipes* from north eastern India. They also reported twenty seven species of *Aedes* from the north east.

Rajput and Singh (1988) recorded *Mimomyia (Etorieptiomyia) luzonensis* at an altitude of 600-1200m from Manipur.

Malhotra and Mahanta (1994) reported 130 sps of mosquitoes from north eastern India. These belong to 12 genera, Viz., *Anopheles* (37 sps), *Aedes* (27sps.), *Armigeres* (13sps.), *culex* (30sps.), *Coquillettidia* (2sps.), *Heizmannia* (2sps.), *Malaya* (2sps.), *Mansonia* (4sps.), *Mimoyia* (3sps.), *Toxorhynchites* (1sps.), *Tripteroides* (2sps.), *Uranotaenia* (7sps.).

Alten.B.et al. (1999) studied on the seasonal composition and population dynamic of mosquitoes in Belek region of turkey. In their study light trap was installed at four different site.

In between May and December 4,542 specimen representing seven species of *Culex tritaeniorhynchus*, *Aedes caspius*, *Aedes cretius*, Aedes *vexans* and
Culiseta annulata.

Jiri et al. (1999) study on difference of respond to the temperature and density of two strains of mosquito, *culex pipens* and *c.molestus* .they reared the strain for more than five years under the same laboratories condition to find to what extent the reaction of these strain to constant temperature.

J.Sutherland et al. (2000) found out many kinds of mosquito in State. They found sixty species in New Jersey each of which has different habitat, behavior and preferred source of blood. Among them about ten of these species are so numerous and such vicious biters of man and animals in the state.

Floore et al. (2002) stated that there are over 2500 different species of mosquitoes throughout the world about 200 species occur in the United States with 77 species occurring in Florida. A new species was reported from Florida.

According to Anonymous (2003) in Chinese Journal of Vector Biology and control. Published an article on the diversity of mosquito, which was analyzed from data obtained from Jinan International air port in Shandong, China .The species richness, relative frequency vector capacity, inter-specific encounter and population intensity was analyzed. 2008 mosquitoes were collected, of which 1086 were from human habitation 362 from the surrounding of airport square and 570 from an airport hotel. *Culex pipiens palleus* was dominant especially in human habitat.

Department of population Biology Centre, Sudan (2004) found out that in southern Sudan, many wetlands have been constructed, which raised the problem of mosquitoes in human settlements. The diversity of mosquitoes in constructed wetlands was compared to natural wetlands. Mosquito abundance and species richness were higher in wetland.

Fischer and Schweigmann. (2004) conducted a study in Buenos Aires city of Argentina, 89 pools were sampled weekly for fort one year period .The aim was to investigate the seasonal dynamics of three *Culex sps*. Breeding in temporary rain pools and to analyze the relationships of the presence of these sps. to pool dimension, pool age, vegetation, and insolation degree. The three species showed differences in their seasonal

patterns, *Culex dolosus* being present during the whole year, *Culex pipiens* mainly in the summer season and *Culex mami* almost exclusively during the fall.

The stastical analysis performed revealed significant positive relationships of all three mosquito species to increasing surface area, whereas no relationship to insolation degree was detected in the studied pools. *Culex pipiens* and *Culex dolosus* showed positive relationships to increasing vegetation cover, whereas the presence of *Culex dolosus* was also related to pool age.

Russell, C. Richard (2005) studied on the species diversity of mosquito on Florida The mosquitoes were collected with the help of CO2 – baited light trap on big pine, from 2000-2004. Twenty species of mosquitoes were collected during this study, the most commonly collected being *Anopheles atropos*, *Culex bahamensis Deinocerites cancer*, *Ochlerotatus taeniorhyncus*. Most of the mosquito species were collected during "high season" month (June to September) than in low season (January to march).

Cruz, Oswaldo (2006) published a new technique for the collection of *Aedes aegypti* mosquito. He found out the BG-Sentinel Trap (BGS-Trap), a new trap for capturing adult *Aedes aegypti*. The BGS-Trap has been recently developed by BioGents GmbH (Regensburg, Germany) and utilizes patent pending technology from the University of Regensburg. The trap consists of an easy to transport, collapsible white bucket with white gauze covering its opening. In the middle of the gauze cover, there is a black tube through which a down flow is created by 12V DC fan that causes any mosquito in the vicinity of the opening to be sucked into a catch bag. The catch bag is located before the suction fan, therefore avoiding damage to specimens passing through the fan. The BG-Sentinel Trap uses a blend of mosquito attractants consisting of lactic acid, ammonia, and caproic acid, substances which are also found on human skin. The blend is constantly emitted in a fixed ratio from a long lasting multi-component dispenser. The dispenser emits the attractants for up to five months. During the tests, the BGS-Traps were simply placed on the ground.

CHAPTER THREE

MATERIAL AND METODOLOGY

3.1. Materials

Table 1.

S.NO.	EQUIPMENTS	FUNCTIONS
1.	Hand aspirator, mosquito net	For the collection of mosquitoes
2.	Paper cup	For killing mosquitoes
3.	Torch light	For the searching of mosquitoes
4.	Camel hair brush	For taking out the collected mosquitoes
5.	Labeling pen	For labeling the collection
6.	Dropper	For dropping the ethyl acetate
7.	Binocular microscope	For the identification of the collected specimens
8.	Entomological pins, Ivory papers, colourless nail polish	For staging of the mosquitoes
9.	Ethyl acetate	As killing agent
10.	Napthalene ball	As preservative

3.2 Methods

3.2.1 Sampling method

Random sampling was used as collection technique Indoor hand collection was done with hand aspirator of size14 by 4cm.(Clark, GG. et al. 1994) inside self baited mosquito net of mesh size 0.05mm. Twenty houses of the V.D.C was selected randomly. The houses were given sample number one to twenty. The indoor hand collection was done in morning and evening. Each dwellings was inspected for 15 to 25 minutes. The collection in the evening was done from 6 to 8pm and the morning collection was done from 5 to 7a.m.The sample collection was done by spreading the mosquito net(185 by 90cm) and closing outlets as doors, windows. The appeared specimen was instantly sucked by aspirator. The collection was done in the first week of the consecutive month, the 20 houses were inspected in four days. The collection is instantly transferred to paper cup.

3.2.2 Killing Method

Collected specimens were killed by placing cotton soaked in ethyl acetate in the paper cup.

3.2.3 Fixing method

Triangular card (staging) pointed at an end was cut out of Ivory paper. A drop of color less nail polish was placed at the apex of the triangular paper. Each collected specimen was fixed with the help of color less nail polish ,the apex of the card is slightly bent at an angle to make the specimen up right .The bent tip was attached to the thorax or pleuron. The other end of the Ivory paper was pricked with Entomological pin and after keeping complete information about collected, locality time and site. Such specimens were fixed in thermocol kept in box (Service, MW. 1993). Such stag specimens are kept in special care to prevent the damage of wings, legs, maxillary palps proboscis and abdomen. Camphor was kept inside the box by attaching with glue.

3.2.4 Identification of mosquitoes:

The collected specimen was identified by following the taxonomic keys published by Mattingly(1971), Barraud(1934),Huang(1977),Knight(1968),Reinert(1973),Tyson(1970), Thurman(1959),Bram(1967), Sirivanakarn(1976) and under the supervision of Epidemiological department, Teku, Kathmandu.

3.3 Statistical Analysis:

3.3.1 Species Diversity Index:

Species diversity was calculated by using the formula (Shannon and Wiener1949),

$(\because pi = ni/N)$

$H_{max} = \log K'$

$H' = - \Sigma pi(\log pi)$

$$E = \frac{H'}{H_{max}}$$

Where,

Pi = proportion of Individuals of i^{th} species to the no. of individuals of all the Species (ni/N)

H_{max} = Maximum possible diversity

H' = Shannon-Wiener diversity index

N = Total number of individuals of all species.

Ni= No. of individuals of species

K = No. of species.

e = Relative density/Evenness index.

3.3.2 Correlation Coefficient test:

Correlation coefficient (r) was used to determine the significance of mutual relationship between climatic factors(temperature, rainfall, relative humidity) and the number of mosquito species collected by using Karl Pearson product moment formula (Gupta 1990)

$$r = \frac{\Sigma xy - \frac{\Sigma x.\Sigma y}{n}}{\sqrt{\Sigma x^2 - \frac{\Sigma x^2}{(n)}.x.\Sigma y^2 - \frac{(\Sigma y)^2}{n}}}$$

Where,

X = dependent variable (no. of mosquitoes)

Y = independent variable (temp., r .h. etc.)

r = correlation coefficient

n = pair of observations

CHAPTER FOUR

KEY FOR INDENTIFICATION

4.1. KEY FOR IDENTIFICATION OF ADULT FEMALE MOSQUITOES OF NEPAL (Mattingly 1971):

1. Proboscis long strongly received posterior border of wing emarginated just beyond tip vein cu2 ……. ……..……...*Toxorhynchities splendens*

Proboscis not so long and only slightly curved, if at all posterior border of wing evenly rounded or only slightly emarginated …….2

2(1). Scutellum, evenly rounded with setae evenly distributed, maxillary palpi about as long as proboscis……...*Anopheles*

Scutellum trilobed, with setae in three distinct groups; maxillary palpi shorter than proboscis ……..... 3

3(2). Proboscis with flexible joint, tip swollen, with long setae ……..…..*Malaya genrostris*

Tips of proboscis only slightly swollen, if at all, with neither flexible joint nor long setae apically……..…….. 4

4(3). Scutum with longitudinal stripe of bread, flat scales usually white or silvery, prespiracular setae present…….....*Topomyia aureoventer*

Scutum with other pattern; prespiracular setae present or absent……....5

5(4). Cell R2 of wing always shorter than vein R2+3 anal vein ending apically before fork of veins cu, and cu2 ……..... *Uranotaenia*

Cell R2 at least as vein R2+3, Anal vein ending apically distal to the fork of veins Cu1 and Cu1 and CU2 ……...…… 6

6(5). Prespiracular area with setae sub costal vein with group of seta; basally on the ventral aspect……. *Culiseta niveitaeniata*

Prespriacualr area and ventral aspect of sub costal vein bare ……7

7(6). Mesopostnotum with setae Scutum covered with bright metallic decumbent scales……..... *Heizmania*

Mesopostnotum without setae Scutum with other types of scales……..…… 8

8(7) Fore and midtarsomere 1 distinctly longer than other 4 tarsomeres combined tarasomeres 4 or fore and mid legs, short about as long as wide

…….. *Orthopodomyia anopheloides*

Fore and mid tarsomere 1 shorter than the other 4 tarsomeres combined, tarsomere 4 of fore and mid legs much longer than wide …….....….9

9(8).Postspiracular setae present…….....10

Postspiracular setae absent…….12

10(9).Dorsal surface of wing with scales broad; abdomen bluntly rounded apically

……...*Mansonia*

Dorsal surface of wing with scales narrow; abdomen more or less pointed apically

……11

11(10).Proboscis rather stout, laterally compressed and curved, occiput with broad decumbent scales……...*Armigeres*

Proboscis fairly slender, not compressed nor notably curved; occiput usually with at least some decumbent scales narrow……....*Aedes*

12(9) Alula bare or with flat decumbent scales ……...*Mimomyia*

Alula fringed with narrow scales…….....(13)

13(12) Pulvilli present; tarsal claws small…….....Culex

Pullvilli absent; tarsal claws prominent……...…*Coquillettidia crassipes*

4.2. KEY FOR IDENTIFICATION OF ADULT FEMALES OF GENUS AEDES (Barraud 1934, Huang 1977, Knight 1968, Reinert 1973 and Tyson1970):

1. Hind tarsi without pale-scaled bands…….....…2

At least some hind tarsi with basal and/or apical pale-scaled bands……...6

2(1).Proboscis almost entirely pale-scaled; hind tarsi with longitudinal stripes of pale scales…….……..pallidostriatus

Proboscis entirely dark-scaled or at most with pale scales ventrally; hind tarsi without pale stripe……...…..…3

3(2).Scutum with broad longitudinal bands of golden scales sub-laterally; lower mesanepimeral setae present ……...*lineatopennis*

Scutum with other pattern; lower mesanepimeral setae absent…….....4

4(3).Scutum with 2 pairs of distinct sub median spots of broad, white scales,1 pair on anterior promontory and other on scutal angle;mid and hind femora and tibiae speckled…….…...*punctifemoris*

Scutum without distinct white-scaled spots, with other pattern; mid and hind femora and tibiae not speckled, with other pattern of dark and pale scales……..…..5

5(4).Scutum with patch of silvery scales in anterior 0.66, sometimes divided by median black-scaled stripe; hind femur with apical 0.33 entirely dark-scaled ……..…….…....*albolateralis*

Scutum with dark scales mixed with golden scales dorsally, with patches of silvery broad, flat scales in front of wing root;hindfemur with apical ring of silvery scales……..……*dissimilis*

6(1) .Some hindtarsomeres with both basal and apical pale-scaled bands …….……7

Hindtarsomeres with basal pale-scaled bands only on at least some segments……...…9

7(6) .Abdominal terga without transverse basal pale-scaled bands ……*assamensis*

Abdominal terga II-VII with narrow to moderately broad, transverse basal pale bands……..…..8

8(7) .Scutum with golden scales varying from large anterior patch to longitudinal lines, background of dark brown scales; fore- and mid femora broadly pale in basal 0.5……...…*aurcostriatus var. greeni*

Scutum with white to creamy scales forming lyre shaped pattern; fore- and mid femora with narrow longitudinal lines of pale scales…. ……...…..*pseudotaeniatus*

9(6) .Proboscis with distinct pale-scaled band near middle……...……10

Proboscis entirely dark scaled or at most pale-scaled ventrally…..……..……15

10(9) .Scutum with distinct spots of pale scales on dark-scaled background; femora with preapical pale-scaled bands …….…..*vittatus*

Scutum with other scale pattern; femora without preapical pale bands …...…….……11

11(10) .Abdomen mostly covered with pale yellow scales; scutum with tufts of brown and white scales mixed… ……..……..…….*scatophagoides*

Abdomen dark-scaled with white to golden scales in various patterns; scutum without scale tufts ……...……...……12

12(11) .Scutum with narrow median and sub median longitudinal stripes of golden scales; hindtarsomeres 4, 5 all dark scaled ...……..……...*chrysolineatus*

Scutum ornamented with pattern of gray-white to silvery scales; at least hindtarsomere 4 with pale scales ……...……..…13

13(12) .Wings with spots of pale scales; all femora and fore- and midtibiae with many white scaled bands …….…….…….....*poicilius*

Wings without pale-scaled spots; femora and fore- and midtibiae with at most sub-basal white-scaled band ….…….14

14(13) .Hind tibiae with pale-scaled band in basal 0.5 ……..……*thomsoni*

Hind tibiae mostly dark-scaled, without pale band …...……....*annulirostris*

15(9) .Hindtarsomeres with narrow basal pale-scaled bands on at least some segments; fore- and midlegs with claws toothed.……..…….……16

Hindtarsomeres with wide basal pale-scaled bands on at least some segments; fore- and midlegs with claws simple ……..…..17

16(15) .Abdominal terga usually with median pale scaled patches, not forming complete transverse bands; scutum with large pale-scaled patch anteriorly ……....…*gubernatoris*

Abdominal terga with complete pale-scaled transverse bands; scutum with pale scales at scutal angles ……...……*caecus*

17(15) .Dorsocentral setae present ….……...……...….18

Dorsocentral setae absent ……...…….……...……...19

18(17) .Scutum with patch of broad flat white scales over wing roots, without round silvery-scaled spots postero-laterally …..……...……..……*albopictus*

Scutum without patch of broad flat white scales over wing roots, with silvery scaled spots on scutal angle ……...……..*unilineatus*

19(17) .Scutum with anteromedian white-scaled patch wider than long, reaching to scutal fossae laterally; some white scales in antealar area broad, flat ……..…….gardnerii imitator

Scutum with anteromedian white-scaled patch longer than wide, not reaching scutal fossae; all white scales in antealar area narrow……..……..*w- albus*

4.3. KEY FOR IDENTIFICATION OF ADULT FEMALES OF GENUS ANOPHELES (Thurman 1959):

1. Wings with 3 or fewer dark spots on Costa, involving Costa and vein R or

Wings all dark scaled (subgenus – Anopheles)...….…….....2

Wings with 4 or more dark spots on Costa, involving Costa and vein R, wing never all dark-scaled (subgenus – Cellia) …….....…….....14

2(1) .Wings without definite pale-scaled markings …..…...…….*aitkenii bengalensis*

Wings with some pale-scaled markings ……3

3(2) .Palpi entirely dark-scaled …….....……..……...….4

Palpi with pale-scaled bands ……..……...……...…….7

4(3) .Hind femur with broad white-scaled band..……..……..……5

Hind femur without broad white band ……..…….……...6

5(4) .Hind femora with pale scales ventrally on basal 0.33; apical portion of at least 3 wing veins pale (veins R2 and anal and at least one another) ……*lindesayi lindesayi*

Hind femora not pale ventrally on basal 0.33, at most with narrow circular band at base; apical portion of only wing veins R2 and anal pale-scaled..... *Lindesayi nilgiricus*

6(4) .Abdominal sterna with scattered pale scales ……..….……..…*barbirostris*

Abdominal sterna without scattered pale scales ……...…….…*ahomi*

7(3) .Hind femora-tibial joint with prominent tuft of black and white scales ……....8

Hind femora-tibial joint without such a tuft... ……..……...9

8(7) .Sub costal pale spot absent on wing …..……...*annandalei*

Sub costal pale spot present …….…….....*interruptus*

9(7) .Basal 0.25 of Costa with pale spots interrupting black scales ……..…..……..…10

Basal 0.25 of Costa completely dark-scaled, or at most with scattered pale scales (hyrcanus Pallas group) …….…….....12

10(9) .Wing vein A with pale scales in apical 0.5; midfemur without large pale-scaled spot dorsally near apex ……...……....*gigas gigas*

Wing vein A entirely dark-scaled; midfemur with large pale-scaled spot dorsally near apex ……...…….….11

11(10) .Pale spots in wing fringe opposite apices of R4+5,usually vein M1 and sometimes other veins, but variable, in addition to the usual large pale spot between veins Cu2 and A……..…….*gigas var. simlensis*

Wing fringe dark opposite vein R4+5 and with no other pale spots except the large one between veins Cu2 and A…….…….*gigas var. baileyi*

12(9) .Basal dark spot on wing vein Cu small, separated by its own length from the middle dark spot in anal vein; pale-scaled bands on hind tarsi narrow,tarsomere 4 without basal pale band ……..……...*sinensis*

Basal dark spot on vein Cu large, separated from middle dark spot on anal vein by less than its own length; pale-scaled bands on hind tarsi moderately to very broad, tarsomere 4 usually with basal pale band …..…….…13

13(12) .Pale band on apex of hindtarsomere 3 and base of 4 seldom longer than length of hindtarsomere 5; abdominal tergum VIII usually with narrow scales

…….……*nigerrimus*

Pale band on apex of hindtarsomere 3 and base of 4 longer than length of hindtarsomere 5; abdominal tergum VIII seldom with scales ...……*peditaeniatus*

14(1) .Femora and tibiae speckled with dark and pale scales ……..…….15

Femora and tibiae not speckled ……...24

15(14) .Some or all of hindtarsomeres 3-5 pale-scaled ……..…..16

Hindtarsomeres 3-5 entirely dark-scaled ……..…….…….22

16(15) .Hindtarsomere 5 with basal dark-scaled band; abdominal sterna with row of conspicuous black –scaled tufts; palpi with 4 distinct pale scaled bands, including apical band …….…...…..*kochi*

Hindtarsomere 5 completely pale-scaled; abdominal sterna without such tufts; palpi with 3 distinct pale bands, including apical band ……..……17

17(16) .Hindtarsomere 5 and part of 4 completely pale-scaled ……....……...18

Hindtarsomere 5, all of 4 and part of 3 completely pale-scaled ……..……...19

18(17) .Scales on dorsum of abdomen either quite few or, if more numerous, do not form marked patch of flat scales on segment II……*maculates maculatus*

Abundant scales on dorsum of abdominal segments III-VIII, and with a marked patch of flat scales on I……..……...*maculatus willmorei*

19(17) .Hindtarsomeres 5, all of 4 and part of 3 pale-scaled ….……*theobaldi*

Hindtarsomeres 3-5 completely pale-scaled ……...……20

20(19) .Palpi speckled, apical and sub apical pale-scaled bands equal in length ……*splendidus*

Palpi unspeckled, apical and sub apical pale-scaled bands unequal …...……...…….21

21(20) .Abdominal terga VII, VIII covered with golden scales; wing with basal 0.25 and apical 0.33 of Costa mostly pale-scaled ……...…….*jamesii*

Abdominal terga VII, VIII covered with dark scales only; wing with basal 0.25 and apical 0.33 chiefly dark-scaled ……..……*ramsayi*

22(15) .Palpi with 3 pale-scaled bands, usually speckled, the apical and sub apical pale bands equal ……..……..……*stephensi*

Palpi with 4 pale-scaled bands; apical and sub apical pale bands unequal …….....23

23(22) .Hind legs with tibiotarsal joint broadly and conspicuous, banded with white scales…….……*balabacensis*

Hind legs without such tibiotarsal band…….……*cesseliatus*

24(14) .Some or all of hindtarsomere 3-5 completely pale-scaled…….……...25

Hindtarsomeres 3-5 not pale-scaled…….29

25(24) .Only hindtarsomere 5 and part of 4 completely pale-scaled……..……..….26

Hindtarsomeres 3, 4, 5 completely pale-scaled ……..……..27

26(25) .Palpi with 3 pale-scaled bands……...…….*majidi*

Palpi with 4 pale-scaled bands……...……*karwari*

27(25) .Wing vein cu mainly dark-scaled, with dark spot at bifurcation of Cu1 and Cu2……..……..…..*annularis*

Vein Cu mainly white-scaled, with no dark spot at bifurcation of veins Cu1 and Cu2……28

28(27) .Apical part of hindtarsomere 1 dark-scaled; abdominal sterna with scattered broad white scales ; scales present on abdominal terga III-VIII ; scales also on mesokatepisternum ;wing scales paler, dark spot at apex of vein R4+5 with apical dark spot about as long as fringe scales……*pallidus*

Apical part of hindtarsomere 1 with some pale scales ; few or no pale scales on abdominal sterna, except on VI,VIII and occasionally V ; scales present on abdominal terga VI,VII and sometimes V; mesokatepisternum without scale patch ; wing scales darker, dark spot at apex of vein R4+5 about 2.0 length of fringe scales ……*philippinensis*

29(24) .Tarsomeres of forelegs with broad, pale-scaled bands ……..…….……30

Tarsomeres of forelegs entirely dark-scaled or with very narrow pale bands ....……..31

30(29) .Palpi with preapical dark band sub equal to apical pale band ; presector dark spot on wing with part on vein Sc more than 0.5 length of that on Costa ……....*subpictus*

Palpi with preapical dark band not more than 0.5 length of apical pale band ; presector dark spot with part on vein Sc less than 0.5 length of that on Costa ……..…….*vagus*

31(29) .Palpomere 1 dark-scaled ……..…….…..*turkhudi*

Palpomere 1 pale-scaled ……..……32

32(31) .Wing vein R4+5 mainly dark-scaled …….*culicifacies*

Wing vein R4+5 mainly pale-scaled ……...……..33

33(32) .Palpi with apical pale-scaled band sub equal to sub apical pale band ……..…34

Palpi with apical pale-scaled band much longer than sub-apical pale band …….36

34(33) .Vein A of wing with 3 dark-scaled spots and pale fringe spot opposite apex; proboscis with apical 0.5 yellow-scaled ……....…….....*aconitus*

Vein A with only 2 dark-scaled spots and no pale fringe spot opposite apex; proboscis with at most ventral pale-scaled patch …..…….....35

35(34) .Wing with basal 0.25 of Costa without pale-scaled interruption ….....…*varuna*

Wing with basal 0.25 of Costa with at least presector pale spot on at least 1 wing……...……...*minimus*

36(33) .Wing with basal 0.25 of Costa entirely dark-scaled ….…..……..*fluviatilis*

Wing with basal 0.25 of Costa with presector and sometimes humeral pale spots ……..……..*jeyporiensis*

4.4. KEY FOR IDENTIFICATION OF THE ADULT FEMALES OF GENUS ARMIGERES (Thurman1959):

Sterna II-VI entirely pale-scaled……*kuchingensis*

Sterna III-VI dark-scaled, with sub apical bands of pale scales……..*subalbatus*

4.5. KEY FOR IDENTIFICATION OF THE ADULT FEMALES OF THE SUBGENERA OF THE GENUS CULEX (Bram, 1967):

1. Four or more strong lower mesanepimeral setae present; relatively large species……*lutzia*

Mesanepimeral setae absent, or if present, with only 1.2 weak setae ……...…..2

2(1) .Pleuron with distinct scale patches at least on the upper and lower meskatepisternum and on anterior mesanepimeron ……..……..…*culex*

Pleuron without distinct scale patches……3

3(2) .Acrostichal setae well developed…….....(in part)*Eumelanomyia*

Acrostichal setae not well developed except at extreme anterior promontory and rarely near prescutellar space …….…….…….4

4(3) .Lower mesanepimeral seta absent: decumbent scales on occiput narrow ……..(in part) *Eumelanomyia*

Lower mesanepimeral seta present; decumbent scales on occiput broad, if only on ocular line ……..…….……5

5(4) .Pleural area with broad dark integumental band extending from postpronotum to mesanepimeron ……..…….*Culiciomyia*

Pleural area concolorous, without broad dark integumental band……....*Lophoceraomyia*

4.5.1. KEY FOR IDENTIFICATION OF THE ADULT FEMALES OF GENUS CULEX, SUBGENUS CULEX (Sirivanakarn, 1976):

1. One or two lower mesanepimeral setae present; proboscis without distinct pale-scaled ring; tarsomeres without pale bands at joints ……2

Lower mesanepimeral setae absent; proboscis with distinct pale-scaled ring; tarsomeres with basal and apical pale bands……..……6

2(1) .Anterior surface of midfemur without median longitudinal pale-scaled stripe ……..3

Anterior surface of midfemur with median longitudinal pale-scaled stripe……5

3(2) .Abdominal terga without basal transverse, pale-scaled bands; pleuron with striking pattern of dark and pale integumental stripes ……..…….…...*fuscocephala*

Abdominal terga with basal transverse pale-scaled bands; pleuron without striking pattern of dark and pale integumental stripes …….……..……..4

4(3) .Pleural integument with distinct pattern of dark stripes across mesokatepisternum and mesanepimeron; scutal integument reddish brown ……..……...…….*hutchinsoni*

Pleural integument without dark stripes; scutal integument yellowish to pale brown ……...….*quinquefasciatus*

5(2) .Postspiracular area and base of prealar knob without scale patches ……*vegans*

Postspiracular area and base of prealar knob with distinct scale patches ……....….*theileri*

6(1) .Wing without pattern of pale-scaled spots or streaks …….……..7

Wing with pattern of pale-scaled spots or streaks on at least 2 areas of Costa and 1 area on other veins ……...……...……..18

7(6) .Abdominal terga II-VII largely clothed with yellowish or golden scales ……..……..*epidesmus*

Abdominal terga with dark- and pale-scaled bands or entirely dark …...……...8

8(7) .Abdominal terga II-VI entirely dark-scaled, without pale bands and apicolateral pale patches …….....(in part) *whitei*

Abdominal terga II-VI with basal or basal and apical pale-scaled bands or with apicolateral pale patches ……...……..9

9(8) .Abdominal terga II-VI with apical and/or basal pale-scaled bands ……...……..10

Abdominal terga II-VI with basal pale-scaled bands only ……..……..……11

10(9) .Wing with dark scales on all veins; abdominal terga II-VI with dark areas not sprinkled with pale scales …….sinensis

Wing with mixed pale and dark scales; abdominal terga II-VI with dark areas sprinkled with pale scales ……..…….....bitaeniorhynchus

11(9) .Erect scales in center of vertex of head whitish; anterior 0.7 of scutum densely covered with white scales ……..……..12

Erect scaled in center of vertex pale yellow, dingy white or all dark; anterior 0.7 of scutum covered with beige, yellow, golden or dark scales ……...……13

12(11) .Anterior surface of fore- and midfemora without speckling of pale scales ;white-scaled patch on scutum dense, extending to wing root, posterior to that all dark-scaled; wing veins R1, R4+5 and Cu with narrow scales ….……....*gelidus*

Anterior surface of fore- and midfemora extensively speckled with pale scales; pale-scaled patch on scutum thinner, grayish-white, extending posterior to wing root in 4 lines; wing veins R1, R4+5 and cu with broad scales ……....*whitmorei*

13(11) .Midfemur with longitudinal stripe of pale scales on anterior surface; postspiracular area with small patch of semi erect scales on lower anterior aspect ……....14

Midfemur entirely dark-scaled or speckling of pale scales not forming definite stripe; postspiracular area without scales on lower anterior aspect …….....15

14(13) .Longitudinal pale-scaled line on anterior surface of midfemur broken into small spots at middle; costal vein entirely dark-scaled ……*barraudi*

Longitudinal pale-scaled stripe on anterior surface of midfemur complete; pale-scales present on base of costal vein at least to humeral cross-vein ……...…..*edwardsi*

15(13) .Anterior surface of fore- and midfemora with speckling of several pale scales at least on apical dorsal surface……..…….....(in part) *whitei*

Anterior surface of fore- and midfemora entirely dark-scaled …...……..…….…..16

16(15) .Erect scales on vertex mostly dark; anterior surface of hind femur pale-scaled with narrow black-scaled ring apically; scutum covered with dark coppery gold scale……...…*tritaeniorhynchus*

Erect scales on vertex pale yellow in center, dark-scaled posterolaterally; hind femur marked otherwise; scutum with scales paler …...…….…….17

17(16) .Speckling of pale scales usually present on femora and proboscis ; scutum with scales brown and pale mixed in varying degrees ; hind femur without dark-scaled apical band, usually with dark sub apical band extending basally to form stripe…….....*vishnui*

Femora and proboscis never speckled with pale scales; scutum with yellow to silvery scales; hind femur with dark band apically, contrasting with pale-scaled areas

……..…….*pseudovishnui*

18(6) .Second pale-scaled costal spot involves veins C, Sc, R, and sometimes Rs and Cu; basal pale bands of abdominal terga narrow, usually less than 0.25 length of segment……..……...……..*mimulus*

Second pale-scaled costal spot involves only veins C and Sc; basal pale bands of abdominal terga broad, at least 0.25 length of segment ……..…..19

19(18) .Scutal scales predominantly brownish; midtibia with longitudinal stripe of pale scales on anterior surface ……...……..*jacksoni*

Scutal scales predominantly pale; midtibia without longitudinal pale stripe on anterior surface ……..……*mimeticus*

4.5.2. KEY FOR IDENTIFICATION OF THE ADULT FEMALES OF GENUS CULEX, SUBGENUS CULICIOMYIA (Barraud, 1934 and Bram, 1967):

1. Integument of pleuron with prominent dark spot dorsally on mesanepimeron: light brown spot on integument dorsally on mesokatepisternum ..…*nigropunctatus*

Integument of pleuron with brown stripe extending from postpronotum to mesanepimeron……..….22(1)
Narrow scales on vertex of head brown in color ; cell R2 of wing about 2.25 length of vein R2+3 ……..……..……*pallidothorax*
Narrow scales on vertex creamy in color; cell R2 about 3.0 length of vein R2+3
……..…...…*viridiventer*

4.5.3. KEY FOR IDENTIFICATION OF THE GENUS CULEX, SUBGENUS EUMELANOMYIA (Sirivanakarn, 1972):

1. Acrostichal setae and lower mesanepimeral seta absent ……..……*brevipalpus*
Acrostichal setae and usually lower mesanepimeral seta present ……2

2(1) .Decumbent scales on anterior dorsal margin of vertex broad, white or gray, those in central part broad and dark in color ……...…….*malayi*
Decumbent scales on vertex narrow, fine, mostly pale yellow in color .....*foliatus*

4.5.4. KEY FOR IDENTIFICATION OF THE ADULT FEMALES OF GENUS CULEX, SUBGENUS LOPHOCERAOMYIA (Sirivanakarn, 1977):

Decumbent scales on dorsum of vertex mostly narrow, linear ; scales on veins R2 and R3 of wing narrow, linear……..……*minor*
Decumbent scales on dorsum of vertex mostly broad; scales on veins R2 and R3 usually broad, clavate …….….*infantulus*

4.5.5. KEY FOR IDENTIFICATION OF THE ADULT FEMALES OF GENUS CULEX, SUBGENUS LUTZIA (Bram, 1967):

Abdominal terga V-VIII entirely pale-scaled, or with very broad apical pale-scaled bands; terga II-IV entirely dark-scaled, or with very narrow apical pale bands; median pale band of proboscis broad, clearly encircling it …..……....*fuscanus*

Abdominal terga entirely dark-scaled, or with apical pale bands of about same width; median pale band of proboscis narrow, most prominent on ventral aspect …….....….*halifaxii*

4.6. TAXONOMIC CHARACTERISTICS OF IDENTIFIED SPECIMENS:

4.6.1. Identifying Characteristics of family Culicidae:

1. Wings are characteristic by scales along the wing veins.
2. Long with piercing mouth part, proboscis extends far beyond clypeus.
3. The antennae of male are very plumose while those of the female have only a few short hairs.

4.6.2. Identifying characteristics of Genus *Armigeres*:

1. Dorsal surface of wing with scales narrow.
2. Proboscis is rather stout, laterally compressed and curved.
3. Occiuput with broad decumbent scales.
4. Abdomen more or less pointed apically.

Plate 1. *Armigeres sp.*

4.6.3. Identifying Characteristic of Genus *Culex:*

1. The thorax is white or silvery marking in *Culex*.
2. In *Culex* the tip of the female abdomen is generally blunt with thoracic retracted and thorax is usually dull colored.
3. The palpi less than one fifth as long as proboscis.
4. The wing scales are narrow.

Plate 2. *Culex sp.*

4.6.4. Identifying characteristic of Genus *Anopheles:*

1. Postnotum with out setae.
2. Scutellum not lobed.
3. Palps long in both the sex.
4. Wing usually spotted or molted.
5. Resting position usually not humped.
6. Proboscis nearly parallel with axis of body.

Plate 3. *Anopheles sp.*

4.6.5. Identifying characteristic of Genus *Aedes:*

1. Postnotum with out setae.
2. Scutellum usually trilobed.
3. Palpi short in female.
4. Wings rarely spotted.
5. Resting position hump backed.
6. Abdomen of female pointed with exerted cerci.

Plate 4. *Aedes sp.*

CHAPTER FIVE
RESULT

5.1Number of mosquito collection during study period:

Table 2.

Month	*Anopheles sps*	*Culex sps*	*Armigeres sps*	*Aedes sps*	Total
May	7	28	15	1	51
June	20	45	25	7	97
July	30	43	30	2	105
August	36	36	35	5	112
September	19	30	20	0	69

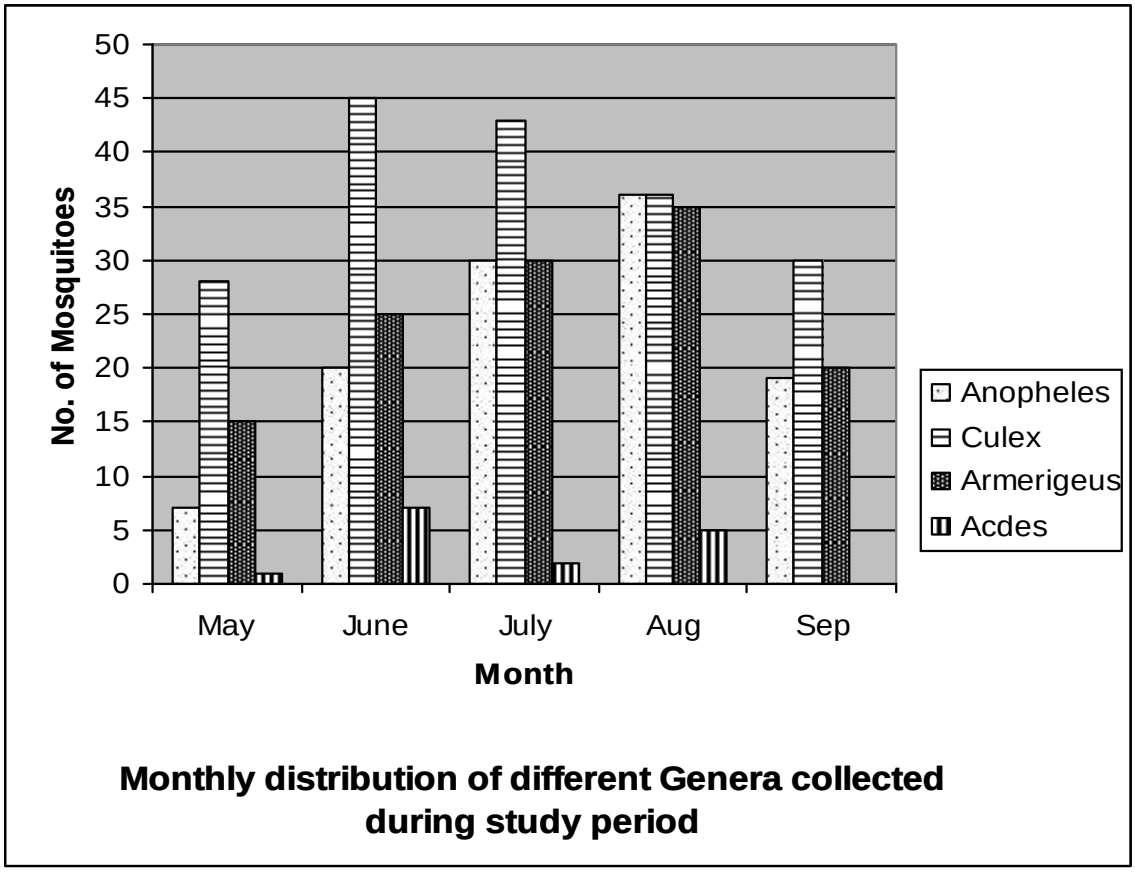

Figure 1.

The monthly distribution of mosquitoes shows that the highest number of genera culex was collected in the month of June and July. These two month s provides the sufficient breeding places because of accumulation of rain water in the ponds and puddles. This two month has Average rainfall of 308 mm and 572mmrespectively. The paddy puddles during these month also provides the suitable breeding place. The total highest collection of mosquitoes were recorded in the month of August, when Anopheles Culex and Armigeres were found in same range. These month has record of the RH(105%) suitable for these genus.

5.2. Abundance of mosquitoes in the study area

The mosquitoes were collected from May to September in the study area. Five monthly observations were made during the study period. The specimens were collected in the first week of each month. During four days collection of each five months record four hundred thirty four individuals. In each month twenty houses were inspected. The individuals were found to be of four genera of mosquitoes namely: *Anopheles, Aedes, Armigeres* and *Culex.*

The collection was done with the help of aspirator and mosquito net. Mosquito net was spread and collection was done by hand aspirator by closing the outlets like: doors and windows.

Among the four identified genera, the most abundant genera in the study area were found to be *Culex with* total number of one hundred ninety two. Genus *Armigeres* stood in second position with total number of one hundred twenty five. The total count of *Anopheles* during study period was one hundred twelve.The genus *Aedes* was the least abundant genera with total count of only fifteen.The most abundant collection was done during the month of August.

5.2.1Total number and percentage of different genera collected during five month period.

Table 3.

S.No.	Genus	Number of collection	Percentage
1.	*Anopheles*	112	25%
2.	*Culex*	192	44%
3.	*Armigeres*	125	28%
4.	*Aedes*	15	3%

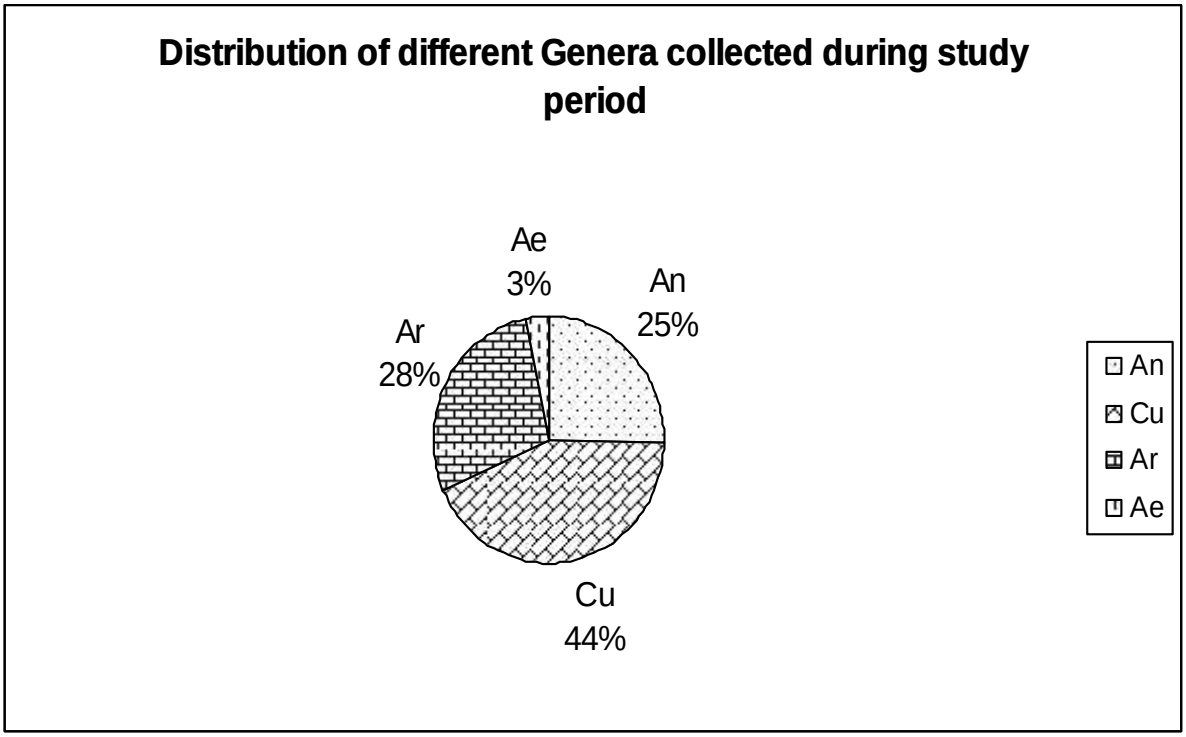

Figure 2.

An-anopheles Cu-Culex Ar-Armegeries Ae-Aedes

The distribution of the genera in the study area indicates highest percentage of genera Culex (44%). Armigeres is found in second highest percentage (28%).The genera Anopheles and Aedes is found in 25%and 3% respectively.

5.3. Diversity of mosquitoes

The commonly used diversity index is Shannon's index (H').

Table of Diversity Index(H'):

Table 4.

S.NO.	Name of genera	No. of genera	pi = ni/N	H' = -∑pi log pi
1.	*Anopheles*	112	0.252	0.1505
2.	*Culex*	192	0.1505	0.157
3.	*Armigeres*	125	0.432	0.154
4.	*Aedes*	15	0.033	0.048

From the calculation of diversity index the most diverse genera in the study area was found *Culex* (H' = 0.157). Similarly *Armigeres* (H' = 0.154) and the least diverse genera was found to be *Anopheles* (H'=0.1505) and *Aedes* (H' = 0.048).

5.4 Correlation between mosquitoes and climatic parameters:

The total count of mosquitoes collected in different month is correlated with different environmental parameter viz. temperature, Relative humidity and Rainfall. The relation was found significantly positive.

5.4.1Table of Correlation Coefficient(r)

For Temperature (˚c)
Table 5.

X	Y	∑X″	(∑X)″	∑Y″	(∑Y)″	∑XY	∑X∑Y	r value
51	22.1							
97	25.8							
105	24.8							
112	24.8							
69	24.7							
∑X=434	∑Y=122.2	40340	188356	2994.22	14932.84	10715.6	53034.8	0.76023

The value of r for temperature is calculated0.76022, which is a significant result. The value shows that the mosquito population reaches its peak with raise in temp.

The population density reaches its peak in month of July and August with average temperature of 24.8˚c.

For Rainfall (mm)

Table 6.

X	Y	∑X″	(∑X)″	∑Y″	(∑Y)″	∑XY	∑X∑Y	r value
51	195							
97	308.16							
105	572.2							
112	546.9							
69	235.95							
∑X=434	∑Y=1857.70	40340	188356	814977.69	3451086.4	177425.37	806246.14	0.8865

The r value for rainfall is also positive. This indicates a positive relation between population density of mosquito and average rainfall. The highest average rainfall was recorded in the last week of July. This resulted higher number of collection of mosquitoes in the first week of August.

For RH (%)

Table 7.

X	Y	∑X″	(∑X)″	∑Y″	(∑Y)″	∑XY	∑X∑Y	r value
51	94							
97	103.1							
105	106.3							
112	105.9							
69	102.8							
∑X=434	∑Y=512.1	40340	188356	52547.95	262246.41	44910.2	222251.4	0.89626

Similarly, RH (%) with appropriate temp. of 24.8˚C. is the most suitable condition for breeding of adult in the study area. The r =0.8962464 for RH (%) is also significant.

CHAPTER SIX
DISCUSSION

Four genera of mosquito were identified from a total collection of four hundred and thirty four from study area. Among them *Culex* was found to be dominant followed by *Armigeres, Anopheles* and *Aedes*. Darsie and Pradhan (1990) had reported fourteen genera of mosquito from different part of Nepal. Durimg the study period of (May to June) all the three genera were recorded except *Aedes.* The fluctuation in the genera of occurs in each month during study period.

A total of one hundred ninty two specimen of *Culex* were collected from the study site. The population of *Culex* reaches its peak in the month of June and July. This was probably due to sufficient breeding and suitable temperature of the site. This genus was collected mainly from houses which were in the vicinity of paddy field and irrigation channels and ditches. Peter and Dewar (1956) had similarly collected the adult of the genera from rice field and shaded jungle pools of Kathmandu, Balaju and Lalitpur. The collection of the adult were mainly done when rice paddies reaches 0.3m in height. Bram (1967) has similar collection from stream and road side. The adult of genus is also significantly collected from houses with cattle shed and open latrine. But Darsie and Pradhan (1989) has reported adults from piggeries at an altitude of 1200m.The zoophillic and peri domestic nature of the adult was reported by Joshi et al. (1965).

The collections in the study site also include *Culex tritaeniorhynchus,* a major vector of Japanese encephalitis virus in Nepal. It is commonly encountered in the collection done in the month of June and July when the rice paddies reaches a height of half meter. This habitat was found most suitable for the species, Shrestha and Joshi (1996) has similar collection from Kathmandu and Kalimati.

Genus *Armigeres* was the second abundant collection of the study site. The highest collection was done in the month of August. The collection of the genera is recorded to be high in the dwelling surrounded by bamboo and other kind of bushes. Barrund (1934) found adult of the genus were persistent day biter and in his collection from he had recorded the larvae of the genus from the bamboo internodes and stumps containing liquid with high organic content from Kalimati and Lalitpur.

Shrestha (1966) reported the adult of the genus *Anopheles* from rice paddies, shallow swamps; seepage and rock holes with polluted water from Godavari, Lalitpur and Kathmandu The collection of the adult were mainly done from the dwelling near by irrigation channels and open drains and cattle shed. Adults were numerously seen near near the agriculture and animal waste similar collection was alsio done by Shreasth (1966) from Kavrae and Ramaechap district. He has abundantly collected adults from houses and mixed dwelling. Roa (1981) recorded the zoophillic nature of the adult female. But Obsomer (2007) recorded the distribution of *An.dirus* in the forested foothill, and forest fringe in India to Taiwan.

Aedes was the least abundant genera of the study site The poor collection i the study site was due less breeding place The site has cleared forest. Peter and Dewar (1957) had collected adult of the genus from mainly from the forested area in tree and stumps of Kathmandu Walochock and Sambhunath.

The monthly distribution of mosquito has general trend. The population density was found to be increase with increase in the value of Enviromental parameter.The number of collection was most significant in the month of June, July and August. The highest total collection was recorded in the month of August. This was probably due to sufficient breeding place after a heavy rainfall in the last week of July. The flooding of the breeding place has totally stopped and stagnated pools and ditches were commonly encountered in the study site in the first week of the month.

The Environmental parameter is found to be positively related with population density of mosquito. Temperature is found to influence the longevity of the mosquito, the length of saprogenic cycle and mosquito activity. *An.dirus* seems to be inactive when the temperature falls below 15˚c.Genus *Culex* and *Anopheles* is found in maximum number in the month of June in study site when mean temperature of the area recorded to be 25.6centrigrade. The population density of *Culex pipens* has found to be increase similarly with temperature by Dohm et al (2000).

The mean average rainfall (572.2mm) and RH (546.9%) has also found to be positively related with population density of all the three genera of the mosquito. Similarly Obsomer (2007) found the occurrence of *An.dirus* related with rainfall when exceeds 500mm.in some part Belgium.

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

7.1. CONCLUSION

Diversity of the mosquito was observed in Sipadol V.D.C of Bhaktapur district. In total 434 specimens were collected of which one hundred twelve were *Anopheles*. 192 *Culex,* 125 *Armigeres* and 15 *Aedes.* Genus Culex was the most diverse with(H=0.1507). Similarly, Genus Armigeres(H = 0.154), Genus Anopheles(H =0.1505) and Genus Aedes(H = 0.048). The collection was done from May to September. The total population of mosquitoes reaches its peak in the month of August where as the number of Genus Culex was highly collected in the month of June and July. But with the onset of winter the population decreases abruptly. The study also showed that the population density of mosquito was positively correlated with different environmental parameters viz: with temperature(r = 0.76023), with rainfall(r = 0.8865) and with relative humidity (r = 0.89626). This positive correlation value showed the significant. The study also concludes about the habitat preference of different collected genus. Genus Culex prefers paddy fields and irrigation channels.Genus Armigeres was collected from the household surrounded by bamboo and other bushes. Genus Anopheles and Genus Aedes were least abundant in the collection due to lack of appropriate habitat.

7.2. RECOMMENDATIONS

1. Mosquitoes being a vector of number of human and animal disease needs detail survey and taxonomic identification.

2. The biology and habitat distribution of the mosquito is highly recommended for the eradication of vector borne diseases like malaria, Japanese encephalitis and filarial.

3. Government should give the priority about the research of vector before launching the insecticidal programme.

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Annex:

Number of mosquito collected during study period:

Genus	*Anopheles sps*	*Culex sps*	*Armigeres sps*	*Aedes sps*
Date	-	-	-	-
2nd May	0	7	6	0
3rd May	2	3	3	1
4th May	3	10	4	0
5th May	2	8	2	0
2nd June	8	10	6	2
3rd June	6	12	9	0
4th June	4	11	10	2
5th June	2	12	0	3
2nd July	10	11	10	0
3rd July	8	10	10	1
4th July	12	9	8	0
5th July	0	13	2	1
2nd August	12	12	13	2
3rd August	11	13	10	1
4th August	11	10	10	2
5th August	2	1	2	0
2nd September	10	10	6	0
3rd September	5	2	5	0
4th September	2	10	5	0
5th September	2	8	4	0

Total number and percentage of different genera collected during study period of five months

S.No.	Genus	Number of collection	Percentage
1.	*Anopheles*	112	25%
2.	*Culex*	192	44%
3.	*Armigeres*	125	28%
4.	*Aedes*	15	3%

Rainfall in (mm) of the study area in different year:

Year Month	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
May	72.8	239.1	109.3	225.2	183.0	285.4	109.7	189.3	104.2	232.8
June	341.6	261.8	331.5	314.8	390.1	299.3	332.7	150.6	164.7	213.6
July	709.0	406.7	610.7	568.5	483.0	612.1	566.3	621.8	364.2	340.9
August	530.2	541.5	528.7	506.0	427.2	631.5	511.5	366.3	657.7	222.4
September	146.5	201.0	279.9	240.3	272.0	248.3	445.4	290.1	259.2	306.6

(Source: Metrological department, Babarmahal, Kathmandu, Nepal)

Relative humidity in (%) of the study area in different year:

Month Year	May	June	July	August	September
1997	83.8	91.8	98.1	96.6	93.8
1998	80.6	87.7	99.5	98.4	95
1999	87.1	95.9	96.8	94.8	92.7
2000	87.5	96	97.1	97	92.5
2001	88.5	94.6	95.1	96	93.4
2002	80.5	94	91	94	90.1
2003	75	93.5	93.9	93.5	92.1
2004	85.3	98.1	93.8	98.1	93.8
2005	82.3	94.5	95.2	94.5	88.3
2006	89.4	93.6	91.4	93.6	91.5

(Source: Metrological department, Babarmahal, Kathmandu, Nepal)

Temperature in (˚C) of study Area in different year:

Month Year	May	June	July	August	September
1997	23.2	24.0	22.1	21.0	22.3
1998	23.4	25.3	22.3	21.2	22.5
1999	23.1	23.1	23.2	22.0	23.6
2000	24.1	24.2	23.3	22.9	22.4
2001	23	23.4	23.1	23.2	22.4
2002	23	22.1	23.2	21.5	20.0
2003	23.3	23	22.7	22.2	23.1
2004	22.8	22.1	21.1	23.7	21.4
2005	22	22.6	22.1	21.9	22.6
2006	21.4	21.9	22.2	22.0	20.6

(Source: Metrological department, Babarmahal, Kathmandu, Nepal)

Average of three different parameter of the study Area:

Month Parameter	may	June	July	August	September
	22.3	25.8	24.5	24.8	24.5
	194.5	308.1	572.2	546.9	235.95
	94	103.1	106.3	105.9	102.8

Country records of Malaria in Nepal:

Year	Cases
1990	22,856
1991	29,135
1992	23,234
1993	16,380
1994	9,884
1995	9,718
1996	9,020
1997	8,957
1998	8,498
1999	8,959
2000	7,980
2001	6,420
2002	12,786
2003	9,508
2004	4,637
2005	7,068
2006	5,422

(Annual report 2002, 2005 and 2006 March, Epidemiology and disease control Division, Teku, Kathmandu, Nepal. His Majesty's Govt. Ministry of Health Services.)

Malaria cases are not found in the Bhaktapur and Kathmandu districts till today.

Country records of Japanese Encephalitis in Nepal:

Year	Cases
1990	227
1991	665
1992	650
1993	702
1994	1836
1995	1240
1996	1450
1997	2953
1998	1161
1999	2924
2000	1721
2001	1908
2002	842
2003	931
2004	1543
2005	2824
2006	1500

(Annual report 2002, 2005 and 2006 March, Epidemiology and disease control Division, His Majesty's Govnt. Ministry of health Services

Record of Japanese Encephalitis in Bhaktapur district:

Year	Cases
1994	2
2000	2

(Record from Bhaktapur hospital, Bhaktapur)

549 and 542 cases were found in the country in 2005 and 2006. (Annual report 2005, 2006, Epidemiology and disease control division)