# Chapter One

## Introduction

How interesting the nature is, we human being also falls in the class of mammal. But we can not dare to fly without airplane. Chiropteran (Greek, Cheiros: Hand and Pteron: wing ; spells like ki-rop-ter-ah, are the only flying (Volant) mammals in which forelimbs are modified into wings and are perhaps the most easily recognizable group of animals. There are mammals, unlike flying Squirrels and flying lemurs, which glide through the air supported by parachute-like extensions of skin from their bodies. But such a parachute does little more than prolong the squirrel's leap and reduce the impetus of its landing; whereas with bats there is true and sustained flight affected by an upward and downward beat of wings (Wilson and Reeder, 2005).

Bats are the second-most specious group of mammals after rodents. The most currently tally of mammals recognized 1116 species of bats worldwide. Those bat species numbers represent about one fifth (20%) of the 5418 known mammal's species. Bats are often divide into two major groups, usually gives the rank of suborders- Megachiroptera and Microchiroptera. Although these groups probably do not represent monophyletic lineages, these are several relevant ecological differences between them. Megachiroptera includes one family (Pteropodidae) and about 186 species. All feed primarily on plant material, either fruit/nectar or pollen. The remaining 16 families (around 930 species) belong to Microchiroptera (Wilson and Reeder 2005).

## 1.1Distribution

Except in polar region and in some isolated islands, bats are found everywhere either in tropical region or in temperate habitats. Although bats are relatively common in temperate regions, they reach their greatest diversity in tropical forest (Hill and Smith, 1984; Vaughan, et al. 2000). The larger bats live in warm areas while smaller bats live in both warm and cold places. The diversity of Chiropterans is enormous in tropics than temperate countries. In temperate countries bats generally migrate to warmer place in winter and they hibernate there.

Typical habitats for bats include temperate and tropical forest, deserts, open fields, agricultural areas and in suburban and urban environments. Many bats forage near freshwater streams, lakes and ponds, preying on insects as they emerge from water. Generally, if a terrestrial habitat provides access to sufficient roost sites and appropriate

food; one or more species of bats may be found to be exist in the same place. Bats generally have very specific roosting requirements, which differ among species. They may roost in caves, crevices, trees, under logs and even in human dwellings. Bats may also use different types of roosts at different times. For example, a species that hibernates in a cave during the winter may use crevices in tree holes as roosts during warmer months.

## 1.2 Evolution

Due to poor fossil record, there is less proper and certain interpretation of the evolution stages by which bats attained this power of flight. Even though, fossils in geological deposits show that even the earliest known bats had wings and were able to fly. The earliest complete fossil in geological deposit shows that even the earliest known bats had wings and were able to fly. The earliest complete fossil bat (Chiroptera) data from the early Eocene (49-53 million years ago). The Eocene bat fauna is extremely rich, comprising hundreds of individual specimen, belonging to 24 genera, including several spectacular forms that are preserved in their entirely (Simmons and Geister, 1998). The only possible bat remains from prior to the Eocene are a few teeth from the late Paleocene (Gingerich, 1987), but their Chiropteran affinities have been questioned (Hand et al., 1994)

The exceptional preservation of the soft tissues of some specimens of bats from the Mussel deposit (49 million years ago) confirms that the Eocene bats had wing membranes (Habersetzer and Storch, 1989) and details of articulation of the shoulder and the enlarged scapulae for attachment of flight muscles (Jepsen, 1970) leave no doubt that they were all capable of powered flapping flight (Habersetzer and Storch, 1989, Norberg, 1989).

The second important feature of these bats is that they have enlarged cochleae are all capable of echolocation, while modern bats that do not echolocate, or have reduced reliance on this form of perception, do not show the same extent of enlargement (Henson, 1970). Since, Eocene bats have enlarged cochleae, and also modified auditory ossicles comparable with those of extant echolocating (Novacek, 1985), they were also clearly capable of echolocation (Novacek, 1985, 1987, 1991, Habersetzer and storch, 1989, 1992). By 53 million years ago, therefore, two major behavioral innovations that we currently associate with bats- flight and echolocation – had already evolved. It is remarkable that in

many respects the bats that suddenly appear over the entire globe, in the Eocene are completely developed (Habersetzer and Storch, 1989).

The problem presented by the sudden appearance of ' completely developed' bats in the fossil record was recognized by Darwin (1859) in the origin of species. Darwin (1859) suggested that the bats posed a problem for the theory of evolution because a credible scenario for the evolution of a flying bat from an insectivorous terrestrial mammal, by the process of natural selection, was too difficult to imazing.

## 1.3 Taxonomy

Traditionally, bats have been considered a monophyletic order (chiroptera), subdivided into two sub-order Microchiroptera and Megachiroptera.

| | | |
|---|---|---|
| Kingdom | - | Animalia |
| Phylum | - | Chordata |
| Group | - | Vertebrate |
| Sub phylum | - | Gnathostomata |
| Class | - | Mammalia |
| Sub class | - | Theria |
| Infra class | - | Eutheria |
| Order | - | Chiroptera |
| Suborder | - | Megachiroptera and Microchiroptera |
| Type | - | Bat |

## 1.4 General character

### 1.1.4 Microchiroptera

Microchiroptera show considerable variation in their form and structure. The size of bat varies from 2.25mm to 115.0 mm long. The smallest bat species *Craseonysteris thonglongyai* (found in Thailand) weight less than 2-3 gm which may be the smallest mammal in the world. The longest microchiroplera is nearly 200gm (Vaughan Rayan and Czaplowski 2000). In microchiroptera snout is short with or without nose leaf. Their pinna are large and often provided with flags serving as tactile organs and also in making the power of hearing more acute. Eyes are small and vision is weak as the visual rods are poorly developed. Tail is included in the inter-fermoral membrane provided with district flap. All microchiropterans capture food and orientate themselves using a system of

echolocation. Microchiropterans are insectivorous though occasionally frugivorous. They are gregarious living in colonies of thousands (Shrestha 1995).

### 1.4.2 Megachiroptera

Megachiroptera are larger in size. The largest bat of the *Pteropus* genus weighs up to 1.5kg and may have wings span over 2m wide. The smallest megachiropteran found weighing only 13gm (Fenton 1997). Their body is covered by brown fur, the snout is long without nose leaf. The face is like that of fox in appearance. Eyes are large, ears are oval. Tail is small or absent. Megachiropterans are frugivorous- food chiefly consist of figs and guava. Their muzzle and jaw are strongly built (Shrestha 1995).

## 1.5 Status of bat: in the world

Bats are one of least studied mammal. As they are active at night it is difficult for its detail study. But bats have succeeded in occupying all inhabitable regions of the world in the course of their phylogenetic development probably due to the two facts i) the ability of fly and ii) lack of their competitors at night. These allowed bats to occupy large number of ecological niches in land and water to become one of the most successful mammals that has been existed and survived (Kulzer, 1992).

IUCN considered nearly 240 species (about 25%) threatened and over 60 species are listed as endangered (IUCN, 2000). Bat population as well as diversity is declining day by day in one side and new species are being discovered all the time. Within the last few years 50 new species were discovered (CCINSA, 2002).

Bats are one of the least studied mammalian groups in south Asian region (CAMP, 2002). South Asian region hoards 123 species of bats (Bates and Harrison, 1997). There is an obvious dearth of information of bats in the wild. Information for many species is based only on museum specimens or literature reference with no recent distribution information in the wild state. The paucity of information is so dramatic that there could be few species that may be locally extinct already, but this possible extinction cannot be ascertained for want of systematic surveys.

Most bat species in the past have been recorded through occasional and opportunistic collections for taxonomic works and in a few cases distribution and status in certain areas has been performed. Systematic surveys have been conducted in India for few well-known species and also discovered new species. This indicates not only the

range extension of species but also the fact that the species could be distributed more widely than is known today in Indian subcontinent region (Bates and Harrison, 1997).

## 1.6 Status of bat in Nepal

Systematic studies in bat have not been still initiated in Nepal very few sample studies were taken which is not sufficient to state the status of Nepal. The conservation sector is not working actively about bat as bats are not fuzzy and cuddly. So they are not in the priority order as other mammals. The data about Nepalese bat are very less due to the lack of systematic study in the wild state. According to BPP (1995), 37 species were documented in Nepal. Bates and Harrison (1997) recorded 47 species in Nepal where as Molur et.al. (2002) reported 51 including threat categories 5 valnerable, 2 critically endangered, 5 data deficient, 1 endangered, 17 least concern and 20 near threatened those species of bat are known to live and breed in Nepal, that comprise 41% of the south Asian and 5% of the global bat fauna, even these data might be incomplete as systematic survey of bats in Nepal is yet to be done.

Bats species confirmed in Nepal are as follows

*1.Areilulus circumdatus (Temminck), 2.Barbastelle leucomelas (Hodgson) 3.Cynopterus sphinx (Vahl), 4.Cynopterus sphinx gangeticus (Anderson), 5.Eptesicus gobiensis (Bobrinski), 6.Eptesicus serotines (Schreber), 7.hesperoptenus tickelli (Blyth), 8.Hipposideros armigor (Hodgson, )9.Hipposideros cineraceus (Blyth), 10. Hipposideros Pomona (Andersen), 11. Kerivoula picta (Pallas), 12. La io ( Thomas), 13. Megaderma lyra lyra (Geoffroy), 14. Miniopterus pusillus (Dubson , 15. Miniopterus schreibersii fulignosus (Hodgson), 16. Murina aurata (MilneEdwards), 17. Murina hutonii (Peters), 18.Murina leucojstr ( Milne Edwards), 19. Myotis blythii (Tomes, ) 20 .Myotis csorbai (Topal, )21. Myotis formosus (Hodgson, )22. Myotis longipes (Dobson), 23. Myotis mustacinus (Kuhl), 24. Myotis mystacinus muricola (Gray), 25. Myotis sicarius (Thomas), 26. Myotis siligorensis (Horsfield), , 27. Nyctalus (Verperugo) noctula (Schreber), 28. Nyctalus montanus (Barrett-Hemilton), 29 .Philetor brachupterus (Temminck), 30. Pipistellus babu (Thomas), 31. Pipistrella coromandra (Gray ), 32. Pipistrellus javanicus (Gray), 33. Pipistrellus tenuis(Temminck) , 34. Plecotus auritus (Linnaeus), 35. Plecotus austrisus (Fischer), 36. Pteropus gyganteus (Brunnich), 37. Rbinolophus (perniger)*

*luctus (Temminck), 38. Rhinolophus affinis himalayanus (Anderson), 39. Rhinolophus ferrumequinum (Schreber), 40. Rhinolophus lepidus (Blyth), 41Rhinolophus macrotis (Blyth), 42Rhinolophus pearsoni pearsoni (Horsefield), 43Rhinolophus pusillus (Temminck), 44Rhinolophus rouxi rouxi( Temminck), 45Rinolophus sinicus (Andersen), 46Rousettusleschenaualti (Desmarest), 47Scotophilus heathi heathi (Horsefield), 48Scotophilus kuchli (Leach), 49Sphaerias blanfordi (Thomas), 50Sxotomanes ornatus (Blyth), 51Taphozous longimanus (Hardwicke)*

## 1.7 Importance of study

Nepal has very less information about its bats and their status. Common people have negative mythical concept about bat as it carries rabbies, it sucks blood, sinistic ecie and Domonic creature etc. Bats are always unwanted and unsolved by the common people so; they always face challenges for their survival. There are many other reasons for as to study about bat as they are indicator of healthy ecosystem and also considered as tool as they are effective on biological control of insects, pollinations for plants, seed spreading, controlling crop parasites and help to keep healthy environment.

There are not major studies about bat in Nepal though foreign scientist studied about distribution and taxonomy of bats (Hodgson, 1835, Grelber 1969, Weigel 1959, Mitchell 1975, Abes 1982, Scalley 1987) is insufficient. Information about the bats in Bhaktapur is concern and matters of curiosity for both general people and biologist.

The study on *Pteropus giganteus* of Nepal is in fact comparatively few in Nepal. The present study effort to explore fact on bats of Sallaghari area, Bhaktapur, Sallaghari is in between two urbanizing or residential area. It is intervened less by human being in comparison to other places of Bhaktapur. This is the only one place of Bhaktapur where bat are found. So present study will help to study about their population status, their behavior threats, their economic importance the study initiation will motivate people to the conservation of bats later on.

## 1.8 Objectives of study

The major aim of the study is to enumerate the present status of bats in Sallaghari, Bhaktapur. The study will support to add information the research gap on chiroptera of Nepal directly and indirectly. It educates and aware local people about the bats and could focus its economic importance. The specific objectives are as following.

1. To know the population status of *Pteropus giganteus* in Sallaghari area, Bhaktapur
2. To collect general diurnal behavior of *Pterpus giganteus* of Sallaghari area.
3. To explore threats to *Pteropus giganteus* for its survival.

## 1.9 Limitation of study

There are very few studies about bat in Nepal. The lacking of literature of bat species as well as the modern tools and methods are greatly felt. So this study may not claim as a complete assessment of the status and behavior of *Pteropus giganteus* in Sallaghari at Bhaktapur.

The main limitations are follows

1. The bat roost was visited at daytime only. So, the population is only taken at their resting period, hanging on branches and twigs of trees
2. The paucity of information and practice in Nepal caused problem to compare and discuss with previous work.
3. Limited schedule and lack of night vision equipment might be causing limited information of this research on behavior aspects.

# CHAPTER -2

## The study area

The study area is located in Bhaktapur district of mid-region of Nepal. Sallaghari is 13 km far from capital city Kathmandu. The precise geographical location of the site is between 27̊26' to the 27'44' northern latitude and 85'21' to 85'32' Eastern longitude. Bhaktapur is the smallest district of Nepal of Area 119 square kilometer (CBS 2002 ).

The average height of Bhaktapur is 1372 m from sea level (DDC 2059).

### 2.1 Geomorphology

Bhaktapur is small district which can be divided into two regions -Hill areas and valley floor. Its north boundary is Manohara River and Durge Khola, South Suryavinayak hill, east Mahadev Pokhaki and west Manohora River (DDC 2059).

### 2.2 Water resource

The main rivers of Bhaktapur are Hanumante and Monohara. These rivers contain very less amount of water except in rainy season. These rivers are getting more and more pollutants due to increasing population and practices of sewages dumping freely by urban people. There is absence of glacier melt water river. There are more than 35 ponds (natural and artificial) and not less than 10 small rivulets. Rani Pokhari is the small pond at Sallaghariarea within the bat roosting area. The study site and Shiddha Pokhari is (the largest pond in Bhaktapur) in 500m apart. Hanumante River and Khasang Khusung Khola are north, south and west of study site.

### 2.3 Climate:

Bhaktapur is located in the eastern part of Kathmandu valley and has attributes a humid subtropical climate. The average temperature range between $20^0$ C -$25^0$ C. The maximum recorded temperature is $32^0$ C while the least temperature is $3^0$ C. Average rainfall is 56mm. The relative humidity average 95 percent. (District profile analysis 2063).

### 2.4 Vegetation

Land topography is divided into two part viz. hill and valley. Soil in valley is more fertile so the area is used in cultivation while perimeter of Bhaktapur is surrounded by different types of forest. Forest of Bhaktapur has Uttis (*Alnus nepalensis*), Rhododendron (Rhododendron arsoreum), Chutro (*Berberis nepalensis*), pine ( Pinus roxburghii), Oak , Ritha (*Sapinus mukorosis*) etc.

The major tree species of the study area consists of Salla (*Pinus roxburghii*) so the area is named Sallaghari (Patch of Salla Trees). Other species are Champ (*Michalea champaca*), Bains (*Salix sp.*), Lahare peepal (*Populus sp.*), Kapur (*Cinnamomum camphora*), Dhupi (*Cupresus torulosa*), Birendra Phul (*Jacaranda ovalifolia*), Kangiyo (*Grevilia robusta*), Kalki (*Calistamom viminalis*), Kimbu (*Morus alba*), Khari (*Celtis australis*) and other herbs, shrubs and grasses. Rice, wheat a lot of varies of vegetables, maize are cultivated by farmers (DDC 2002).

### 2.5 Fauna

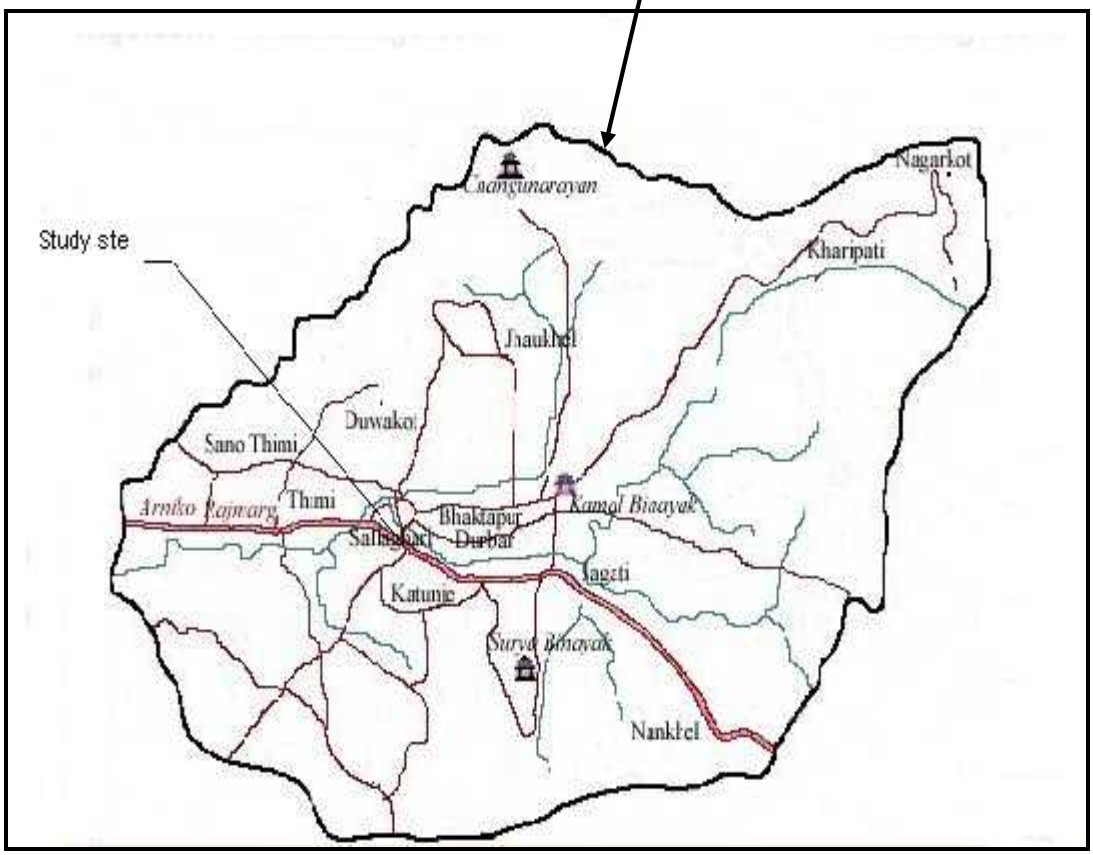
In Bhaktapur wilder areas leopard Cat *(Felus bangalansis*), Barking Deer (*Muntiacus muntijak*), Hare (*Nigracolis sps*.), fox (*Vulpes bangalansis*), monkey(*Macaca mulatta*), wild pig (*Sus scrofia*), snakes are commonly found. Similarly Titra (*Francolinus francolinus*), Kaliz (*Lophura leucomelana*), Koili *(Surniculus lugubris*), Jureli (*Pycuonotus jacasus*), Luiche (*Gallus gallus)* are common wild bird found in Bhaktapur area.

### 2.6 Intensive study Area

Sallaghari is a small hill between two Municipalities, Bhaktapur and Madhyapur (Fig 1). It is surrounding by rivers, pond and green cultivated farm. Politically it lies in Bhaktapur Municipality ward number 17. The main forested area of Sallaghari is almost 16 hectors. It has Ranipokhari (pond) inside and traversed road to core city. Major part of Sallghari lies under the army school territory and protected by army. *Pinus roxburghii* (Salla) is dominant in Sallaghari. *Grevilia robusta* (Silky oak), *Celtis australis* (European nettle wood), *Michelia champaca* (Champ), *Populus sp* (Himalayan poplar), *Cinnamonum camphora* (Camphor), *Calistamon citrinus* (Bottlebrush), *Morus alba* (Mulberry) and herbs, shrubs and different grasses are also found.

Thousands of crows live near the roosting areas. Few numbers of black-kite are found nesting in pine trees.

**Fig 1 Map of Nepal and study area of Bhaktapur**


**Map of Bhaktapur district**

# CHAPTER 3

## Literature review

1. Flying Fox (*Pteropus giganteus)* is common fox bat in midland Nepal. Its head and body measure about 23 cm and wingspan is 112 cm. It weights is over 630gm. The head of the fox bat is dark brown, sometimes blackish. The shoulder and rear part of the neck is brown. The abdomen is yellowish brown. The chin, neck and flanks of the bat are darker. The wings are black due to exposure to heat (Shrestha,1997 ).
2. Sexual dimorphism is distinguished by color. Male is brighter than female and male has oily luster on some parts of their coats especially in neck (Grzimek's encyclopedia, 1998).
3. Australian zoologist John Nelson,(1998) observed that old world fruit bat mark their territories with scent substances during mating season but rubbing the chin and neck against branches and twigs. They also sniff on another females returning to their roost in such a case males sniffed immediately. The bond between mother and offspring is also maintained by sense of smell (603 PP). He also studied on flapping of bat per unit time.
4. G. Neuweiler, 1998 observed flying fox in Madras, India. It was found that they starts flying from their roost about 25min after sun set. About 15min earlier they are busy clearing their wings. All bats of the colony will in air within 10min.

   The bat cycles their roosting tree for some time gradually gaining altitude. They then split into small groups, fly off in different direction.

   The departure from the tree is synchronized exactly with the time of sunset and starts returning back in 4:00 am. Within 5:30 am all bats complete to come back to their place. And after cleaning themselves they start sleeping. They may have internal clock managed within themselves (605p).
5. Dorte Friis Nyhagen, Stephen David Turnball *et al (2005)* studied in the south-west of Mauritius and investigates the diet of the endemic flying fox *Pteropus niger* and its potential role as pollinator and seed dispenser (Biological Conservation : vol 122)
6. Similarly numerous studies in tropical countries have shown that both old world fruit bats and fruit eating insectivorous bats play an important role in the dissemination of seeds and the pollination of flowers. The extermination of these

bats could conceivably have an immense impact on both wild and cultivated tropical plants (Journal of Zoology, Vol. 206).

7. A. Alwin Prem Anand and K. Sripathi's (2005) study also reveals that *Pteropus giganteus* consumer's fruits and leaves as their major food. Cellulose and Xylem are the major composition of leaves. As they consume leaves in their diet, their digestive track must contain cellulolytic and xylanolytic bacteria which help in the digestion of cellulose and xylem. The cellulolytic and xylanolytic bacteria were isolated and screened on Berg's agar containing cellulose and xylem. The bacteria isolated were characterized biochemical and found to be *Proteus Vulgaris, Prteus mirabilis, Citrobacter freundil, Serratia liquefaciens and Klebsiella uxytoca* (Biological Conservation, Vol. 122, 491-497 p).
8. Here in Nepal at Kesharmahal, 459 Indian foxes were found while counting in 18 August 2006. 293 were counted on 3rd July 2006 at Sallaghari, Bhaktapur (Acharya, 2006).
9. During November to February, no bats were found in Sallaghari where as July to September it's reached to the highest and that is approximately 3000.
10. Sujus Phuyal, (2005) studied the survey of bats of the Pokhara valley.
11. Puspa Acharya, (2006) studied the distribution of roosting and survival threats of bats in Pokhara valley.
12. Rojan Malla, (2000) studied diet analysis of microchiroptera of Nagarjung cave capturing 23 bats and analyzing elementary components.
13. Chalise (1998) reported some bats and flying foxes from Ghoda ghodi taal area Kailali, Western Terai, Nepal. Similarly, surveying six VDCs of Ilam districs Chalise (1999) reported flying fox and bats are available in Churiya Hill forest, however in rare status.

In the reference to bats study there are not many literature could be collected. There are some citation in biological books referring Nepal some times but there biology and ecology is not properly dealt.

# CHAPTER 4

## Methodology

Bat is nocturnal mammal and many activities are performed at night. It is difficult to study about them at night for this research. Therefore this resting sites or roosting area is explored at day time. About 216 hours were spent in this study area. For collection of behavioral data of bats were categorizing into i) adult ii) old and isolated and iii) infant. The study area was visited frequently for population census of bats in different seasons in a year. The study period was from August 2006 to September 2007 covering the months of availability in the area. The details of methodology to accomplish this research work were following.

Indirect method: Interview, information from locals and literatures.

Direct method: Observation and specimens collections.

### 4.1 Reconnaissance Study

The preliminary study was carried out in August 2006 to acquaint the area and habitat. Local resident, permanent settlers and employed were contacted to acquire the information on the bats and habitat.

### 4.2 Interview

A set of questionnaire format was prepared with open question. Because of the army camp situated in the study site basically armies were asked to know about their behavior. Likewise local people and workers of Dairy Company (near roost site) were also interviewed. All of them live 24 hours in that location and able to tell average decreasing or increasing number of bats from past.

### 4.3 Observation

Scan sampling method is applied to collect population data and to understand behavior (Altmann, 1974, Chalise 2003). Bats were counted thoroughly from August 2006 to September 2007. And their behaviors were also observed categorizing them. They were divided into three age groups for comparison of their behavior. Six bats in each age group were observed for twelve hours or more. Starting from the time of return to roost to the time they depart after sunset.

During roosting time, the behavior shown by them were recorded in every two minutes to focal age groups and number individuals. Basically grooming, resting, flapping wings spreading and cleaning wings, crawling, defending crow's attack, chattering, fighting each other and mating were observed.

### 4.4 Collection of bats specimens

The bat specimens were collected from roosting sites which were killed due to electric current shock and died by other cause. Their morphological structure was studied with the help of those specimens (Photo 1).

**Photo 1: Collection of bats specimens**

# CHAPTER 5
## Results

### 5.1 Population

The total population bats in Sallaghari area were thoroughly counted for 24 times form August 2006 to September 2007. Due to unavoidable situation in November, bats were not counted. All the population was found in three clusters. Two clusters are on the either side of the road where they were roosted in pines and third cluster is near the Rani Pokhari where Eucalyptus species is dominant and the number of the bat is the highest among three clusters. All together bats roosted in 48 trees. Among them 23 were Eucalyptus 9 pinus, 4 Populus, 2 mulberries, 4 camphor, 6 Khari. The population of bats was different with season.

They were the maximum up to 1428 in 30 September 2006 while in winter season number of bats from December to February there was not a single bat in the area (Table no. 1)

**Table 1: Census of bats and their numbers in different months.**

| S.N | Date | No. of bats | |
|---|---|---|---|
| 1 | 27/8/2006 | 598 | |
| 2 | 3/9/2006 | 587 | Phase1 |
| 3 | 10/9/2006 | 590 | |
| 4 | 18/9/2006 | 607 | |
| 5 | 25/9/2006 | 963 | |
| **6** | **30/09/2006** | **1428** | |
| 7 | 2/10/2006 | 1416 | Phase2 |
| 8 | 9/10/2006 | 1012 | |
| 9 | 16/10/2006 | 959 | |
| 10 | 25/12/2006 | 123 | Phase3 |
| 11 | 31/12/2006 | 56 | |
| 12 | 7/1/2007 | 0 | |
| 13 | 14/1/2007 | 0 | |
| 14 | 22/1/2007 | 0 | Phase4 |
| 15 | 5/2/2007 | 0 | |
| 16 | 12/2/2007 | 0 | |
| 17 | 19/3/2007 | 36 | |
| 18 | 2/4/2007 | 53 | Phase5 |
| 19 | 30/4/2007 | 132 | |
| 20 | 15/5/2007 | 317 | |
| 21 | 11/6/2007 | 422 | |
| 22 | 3/7/2007 | 536 | Phase6 |
| 23 | 25/7/2007 | 522 | |
| 24 | 4/8/2008 | 546 | |

The population of bats distinctly showed six phases. The first phase denotes from August 2006 to mid September 2006, where the maximum number is 607 and minimum number is 598. The second phase denotes from last September 2006 to October 2006, where the maximum number is 1428 and minimum number is 959. The third phase denotes from December 2006, where the maximum number is 123 and minimum number is 56. The fourth phase denotes from January 2007 to February 2007, where there were not a single bats. The fifth phase denotes form March 2007 to May 2007, where the maximum number of bat is 317 and minimum is 36. The last sixth phase denotes from June 2007 to September 2007, where the maximum number is 546 and minimum is 422.

One and six phases held almost similar numbers of bats. Where as the third and fifth phase counted also resemble numbers. On the other hand, population in the second and fourth phase is completely opposite with highest population recorded and without bats in research site.

From the last August to mid September, the number is almost similar but in descending order.

The population is the maximum from last September to first week of October. The population declined soon after the second week of October. And it went down to very few numbers in last December (56). It was nil in January and February at the time of mid winter in the area.

In August and September of 2006 and 2007 tend to be equal numbers of bats with slight different only (42).

**Table 2 Distribution of bats in different trees when their population is the maximum**

| **S.N** | **Name of three** | **No. of trees** | **No. of bats** |
|---|---|---|---|
| 1 | Mulberry ( *Morus alba)* | 2 | 82 |
| 2 | Lahare papal (*Populus sp.* | 4 | 350 |
| 3 | Camphor*(Cinnamonum camphora)* | 4 | 12 |
| 4 | Khari(*Celtis australis*) | 6 | 250 |
| 5 | Pines(*Pinus roxburghii*) | 9 | 48 |
| 6 | Eucalyptus | 23 | 786 |
| **Total** | **6 types** | **48** | **1428** |

In Sallaghari, there are different species of trees and are planted in different period. Among them in Eucalyptus, Pines, Populous, Mulberry, Camphor and Khari

bats roost. The more the bats roosted in Eucalyptus fewer bats roosted in Camphor. The number of bat is the maximum in Eucalyptus as its number is also the maximum. The number of Populous is only four but 350 bats roosted because Populous is deciduous plant and the study time was autumn. Hence leaves of the tree were almost fallen that made bats to get more sunlight for sun basking. The evergreen plant pines held comparatively few numbers of bats (48 in 9 trees).

### 5.2 Behavior

The study of behavior of nocturnal mammal is very difficult due to lack of equipments. So its diurnal behavior was studied i.e. from the time they returned in the morning to the time they depart in the evening.

#### 5.2.1 General behavior

General behaviors, rest, groom, flapping wing, spreading wing, crawling, defending crow, chatter, fight and mate was recorded through direct observation. Their general behaviors were different with their age group. Infants (pups) and adult were very active and live in group while old are isolated and not active.

Bats returned to their roosting area before sunrise and start cleaning their body with the help of mouth and claws. They flapped their wings frequently. The rate flapping is more in day than in morning and evening. They departed their roosted area after sunset. Some of them making circle around their roosted area before flying away. They groom and chatter making noise frequently whole day. They chatter with loud noise when black-kite fly near to their roost and some of them fly around making circle. Bats drink water in Rani Pokhari flying like landing airplane. They mate after sunlight cover their colony nearly from 7 am to 9 am. They shows polyandry and polygamy behavior and while mating they produced barking dog like sound. Adult and pups show fighting each other after sunlight cover their roost. Old and isolated bats were attacked by crows in the morning and in the evening. They defended them by fighting as well as they escape by moving from twig to twigs.

#### 5.2.2 Specific categories of behaviors

Though bats behavior is of different kind, here basically nine type of behavior were observed and recorded. See the photographs also.

**Rest**

Motionless or just hanging position of bats is resting. They get rest generally whole day so that they could collect energy and be active at night for different activities

**Groom**

Grooming is a process of cleaning body and fur. They use claws and mouth for grooming purpose.

**Flap**

The continuous to and fro movement of wings for short period is called flapping. It is useful for aeration.

**Spreading wing**

The expansion of wings by bats for short time while they are in rest is called spreading wing.

**Crawling**

The movement of bats from twigs to twigs by using their leg and claws of fore limb is crawling. They crawl while fighting, defending crow's attack, mating and for other activities.

**Defending crow's attack**

Some old and isolated bats are attacked by crows. Crow's generally attack them in the evening. Bats defend the crows by escaping from them or by fighting and chasing the crow.

**Chattering**

Chattering is noise making during rest time.

**Fighting**

Bats fight each other while mating. Pups fight for fun. It is just like playing game. Fight does not mean serious attack with wounds results. It is mild wrestling.

**Mate**

The copulatory behavior between adult male and adult female is mating

### 5.2.3 Behavior categorically

For the research of the diurnal behavior of bat,18 bats were selected from three age groups and six form each category. The categories are i) Infant ii) adult iii) old and isolated. Six bats in each group were observed for the time they returned in the

morning to their departure after the sunset. Basically nine characters were observed during roosting time which is recorded in the interval of every two minutes. They are grooming, resting, flapping, spreading, crawling, defending crow's attack, chattering, fighting and mate.

Six isolated and old bats were observed for 4132minutes that is 11 hrs 22 min per bat in average. During observation, they spent their maximum time in resting (3142 min). They showed no mating behavior and showed the least fighting behavior that is 8 min. Four among six were attacked by crows. Only three of them chatter (Table 3).

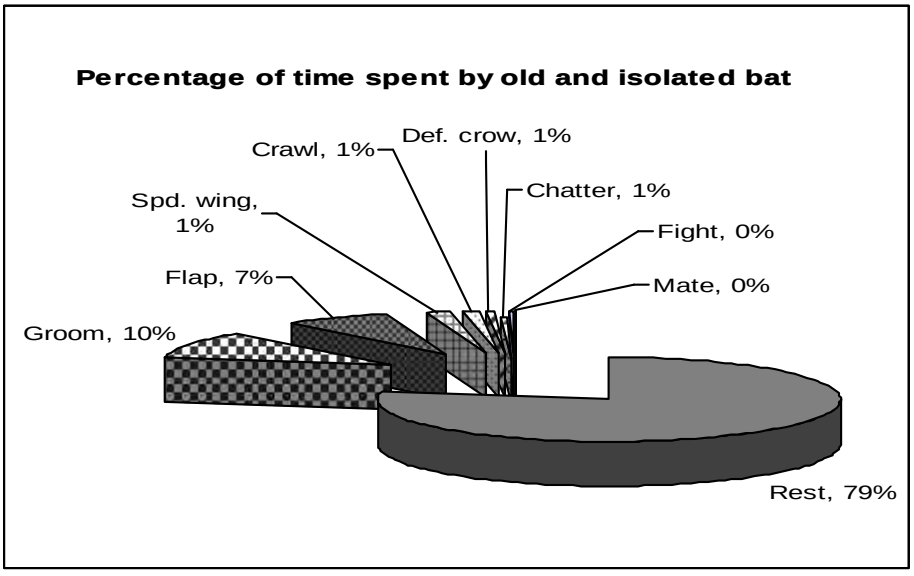
**Table 3: Behavior observes for six old and isolated bats in total observed time.**

| Bat no. | Rest | Groom | Flap | Spreading wing | Crawl | Defending crow | Chatter | Fight | Mate |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 504 | 74 | 58 | 8 | 12 | 10 | 18 | 2 | 0 |
| 2 | 506 | 90 | 72 | 14 | 14 | 10 | 0 | 0 | 0 |
| 3 | 538 | 86 | 48 | 10 | 6 | 0 | 8 | 2 | 0 |
| 4 | 501 | 80 | 60 | 16 | 8 | 2 | 6 | 2 | 0 |
| 5 | 551 | 70 | 40 | 10 | 6 | 0 | 0 | 0 | 0 |
| 6 | 546 | 60 | 52 | 8 | 4 | 2 | 0 | 2 | 0 |
| Total | 3142 | 460 | 330 | 66 | 50 | 24 | 32 | 8 | 0 |
| Average | 573.3 | 76.6 | 55 | 11 | 8.33 | 4 | 5.33 | 1.3333 | 0 |

Therefore it was found that old and isolated bats spend the maximum percentage of time in resting (79%). They groom 10%, flap 7%, spread wing, crawl, defend crow's attack and chatter 1% in each (Fig. 2)

**Fig. 2 Different behavior of old and isolated bats during observation period**

.



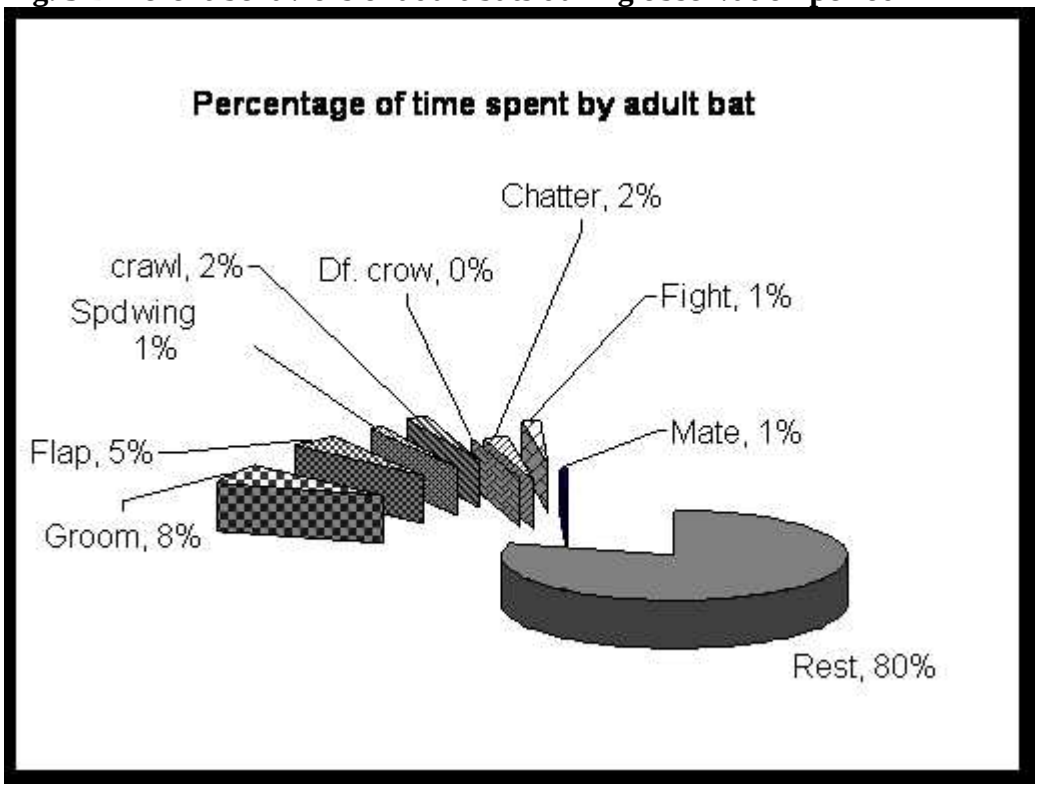
Six adult bats were observed for 4126min. that is 11hrs 26 min per bat in average. During observation, they spent maximum time in resting (3214min). They rest, groom, flap, spread wing, crawl, chatter, fight, and mate for3142, 302, 206, 56, 86, 96, 58, and 38 minutes respectively. Crow did not attack them. They showed mating behavior. (Table 4)

**Table 4 Behavior observes for adult bats in total observed time.**

| Bat No. | Rest | Groom | Flap | Spd.Wing | Crawl | Def. Crow | Chatter | Fight | Mate |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 548 | 44 | 36 | 14 | 22 | 0 | 12 | 10 | 4 |
| 2 | 514 | 62 | 28 | 16 | 14 | 0 | 22 | 16 | 8 |
| 3 | 566 | 30 | 34 | 8 | 8 | 0 | 12 | 4 | 4 |
| 4 | 498 | 36 | 42 | 4 | 20 | 0 | 32 | 16 | 12 |
| 5 | 562 | 64 | 36 | 6 | 6 | 0 | 8 | 0 | 2 |
| 6 | 526 | 66 | 30 | 8 | 16 | 0 | 10 | 12 | 8 |
| Total | 3142 | 302 | 206 | 56 | 86 | 0 | 96 | 58 | 38 |
| Average | 535.66 | 50.33 | 34.33 | 9.33 | 14.33 | 0 | 16 | 9.66 | 6.33 |

Therefore it was found that Adult bats spend the maximum time in resting (80%). They groom 8%, flap 5%, spread wing 1%, crawl 2%, chatter 2%, fight 1% and mate 1% through out the day. None of the adult bats were attacked by crow (fig. 2)

**Fig. 3 Different behaviors of adult bats during observation period**



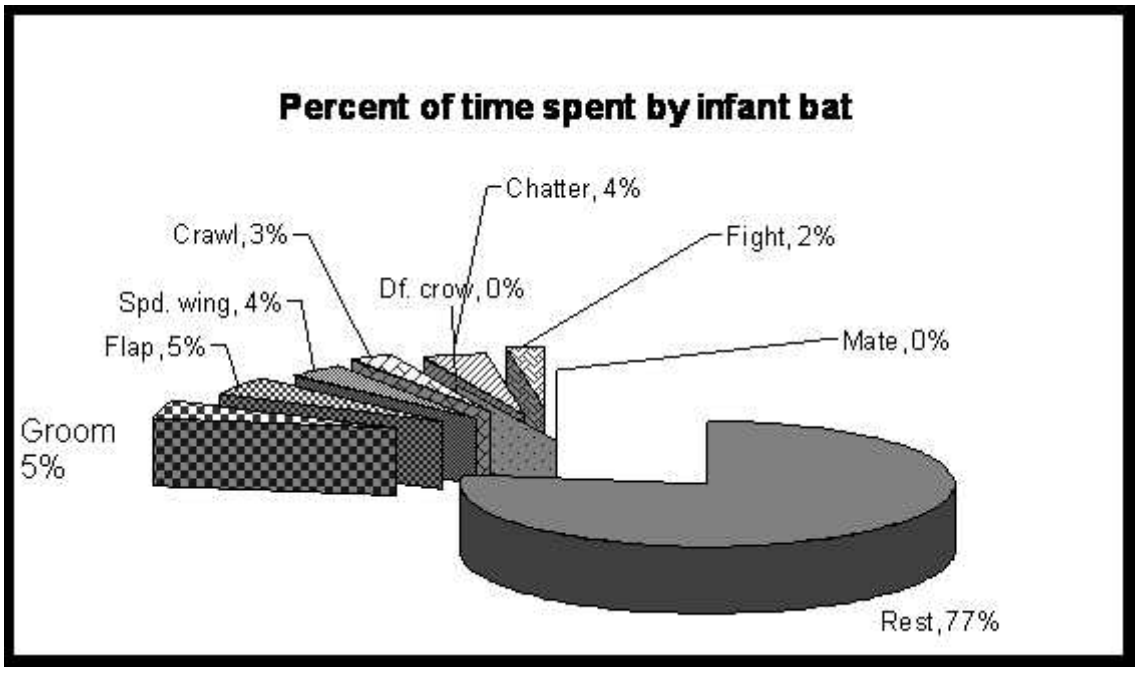
Six infant's bats were observed for 4144min. that is 11hrs 33 min per bat in average. During observation, they spent maximum time in resting (3238 min). They rest, groom, flap, spread wing, crawl, chatter and fight for 196, 184, 152, 110, 168, and 86 minutes respectively. Crow did not attack them and they did not show mating behavior. (Table5)

**Table No.5 Behavior observes for infant bats in total observed time.**

| Bat no. | Rest | Groom | Flap | Spd wing | Crawl | Def. crow | Chatter | Fight | Mate |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 518 | 38 | 42 | 28 | 14 | 0 | 26 | 26 | 0 |
| 2 | 532 | 32 | 28 | 22 | 8 | 0 | 26 | 14 | 0 |
| 3 | 544 | 28 | 24 | 18 | 28 | 0 | 30 | 18 | 0 |
| 4 | 574 | 34 | 26 | 34 | 16 | 0 | 26 | 8 | 0 |
| 5 | 514 | 42 | 46 | 26 | 28 | 0 | 28 | 8 | 0 |
| 6 | 556 | 24 | 18 | 24 | 16 | 0 | 22 | 12 | 0 |
| Total | 3238 | 196 | 184 | 152 | 110 | 0 | 168 | 86 | 0 |
| Average | 519.3 | 32.66 | 30.66 | 25.3 | 18.33 | 0 | 28 | 16.33 | 0 |

Therefore it was found that infant bats spend the maximum time in resting (77%). They groom 5%, flap 5%, spread wing 4%, crawl 3%, chatter 4%, and fight 2% through out the day. None of the infant's bats were attacked by crow and they did not mate. (Fig. 4)

**Fig. 4 Different behaviors of infant bats during observation period**



**Behavior shift-wise**

For making study easier the observation time is categorized into three shifts. They are morning shift, day shift and evening shift.

**Morning shift:** It denotes the time they return at early morning to 10 a.m. In this shift bats are active in grooming, chattering and adults seen mating also. Sunlight covers the roost but it is not hot rather warm.

**Day shift:** Day shift denotes from 10 a.m to 4 p.m. It is the time between the early morning and late afternoon or evening. Temperature in this period is higher than morning and evening. Bats get direct sunlight.

**Evening shift**: Evening shift denotes from 4 p.m to time they depart. They show quite activeness as it the time to fly. Intensity of heat and light decrease in the evening shift.

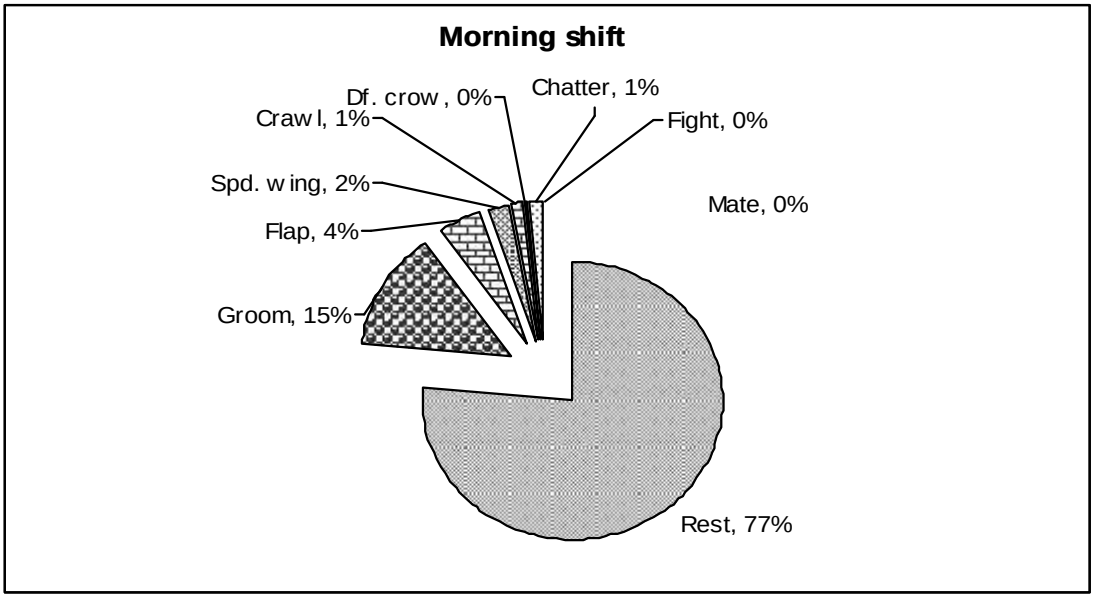
Observed behaviors are different in quantity with respect to shift (Table 6).Six old and isolated bats were observed for 4102 minutes. It is found time spent by them such as1384 minutes; 2260 minutes and 458 minutes in morning, day and evening shift respectively. During observation they spent maximum time in resting in the entire shift (3142 min) which is found 1058 minutes (77 %) in morning shift, 1808 minutes (80%) in day shift, and 276 minutes (61%) in the evening respectively. They showed no mating behavior in all shifts and didn't show fighting behavior in the morning and day shift. Crow didn't attack them in day shift.

**Table no. 6: Diurnal time budget at different shift of day by old and isolated**

| Behavior | Morning Shift | Day Shift | Evening Shift | Total |
|---|---|---|---|---|
| Rest | 1058 | 1808 | 276 | 3142 |
| Groom | 192 | 208 | 62 | 462 |
| Flap | 60 | 218 | 40 | 318 |
| Spread Wing | 32 | 14 | 20 | 66 |
| Crawl | 20 | 6 | 24 | 50 |
| Defend Crow | 4 | 0 | 20 | 24 |
| Chatter | 18 | 6 | 8 | 32 |
| Fight | 0 | 0 | 6 | 6 |
| Mate | 0 | 0 | 0 | 0 |
| total | 1384 | 2260 | 458 | 4102 |

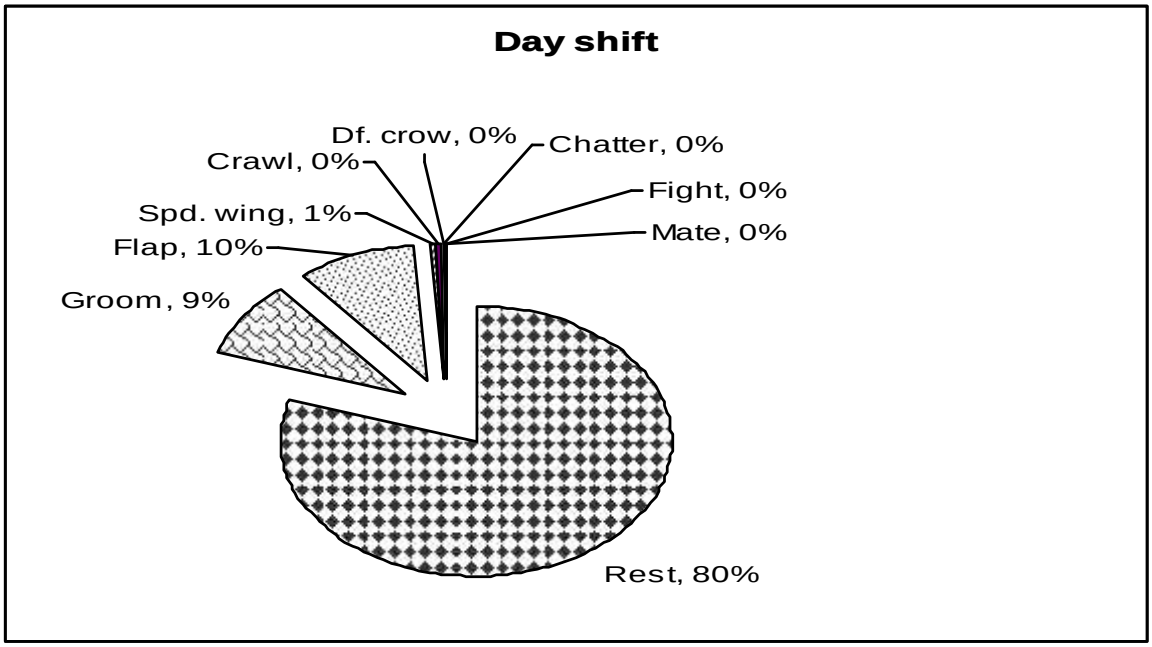
In morning shift, old and isolated bats rest 77%, groom 15%, flap 4%, spread wing 2%, crawl 1%, defend crow less than one percent and chatter 1%. They did not fight and mate in the morning. Crow also did not attack them (Fig. 5).

**Fig. 5 Percentage of time spent by old and isolated bats during morning shift**



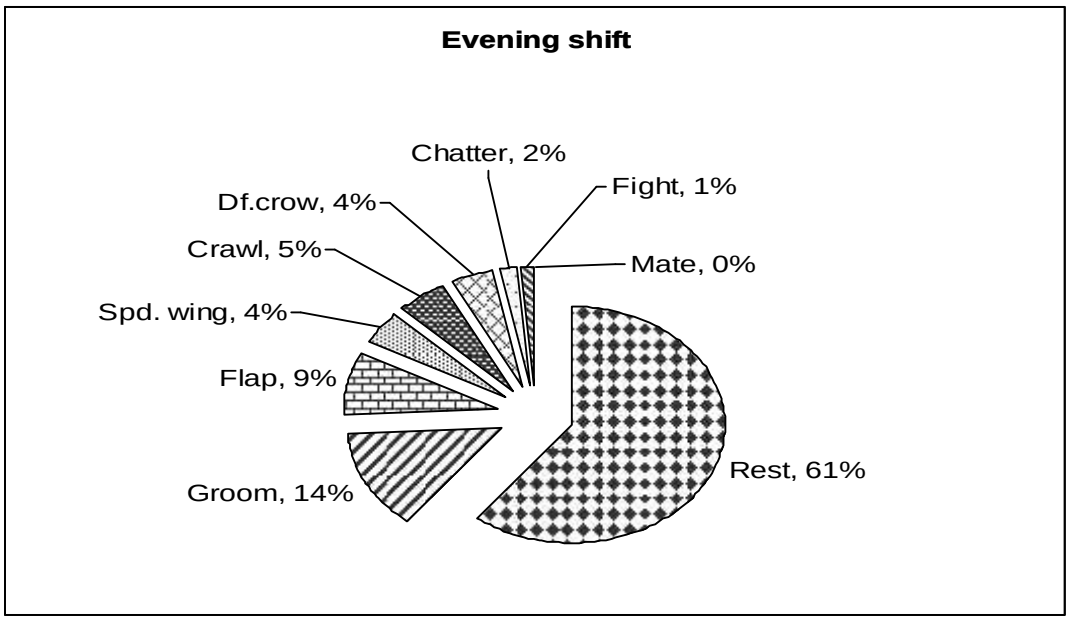

In day shift, old and isolated bats rest 80%, groom 9%, flap 10%, spread wing, chatter and crawl less than 1%. They did not fight and mate in the day. Crow did not attack them (Fig.6)

**Fig 6 Percentage of time spent by old and isolated bats during day shift**



In evening shift, old and isolated bats rest 61%, groom 14%, flap 9%, spread wing 4%, crawl 5%, defending crow 4%, chatter2%and fight 1%. They did not mate in the evening (Fig.7).

**Fig 7. Percentage of time spent by old and isolated bats during evening shift**



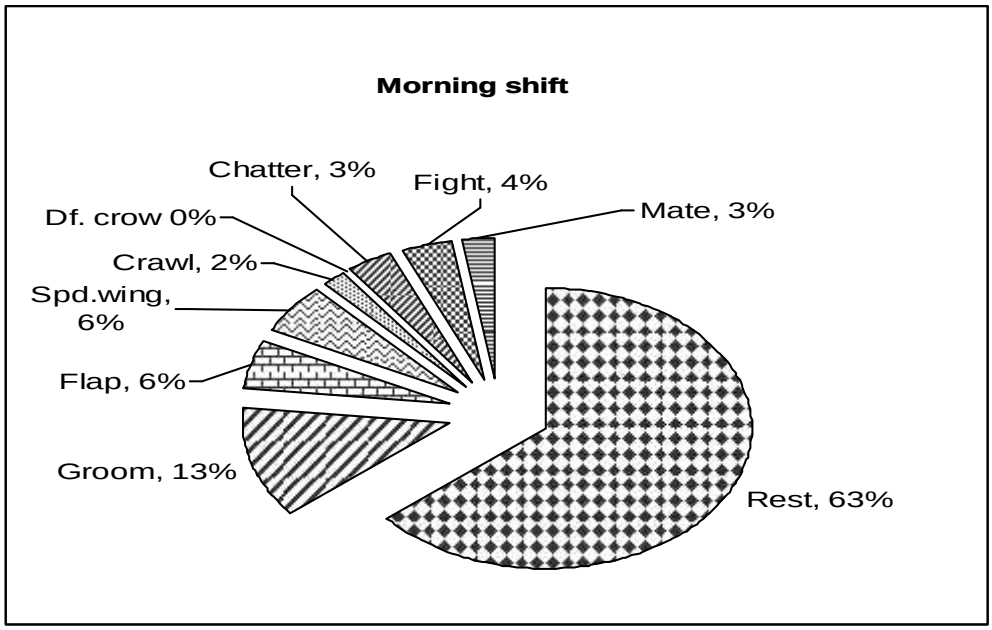

Six adult bats were observed for 4126 minutes. There are 1490 minutes, 2160 minutes and 476 minutes in morning, day and evening shift respectively. During observation they spent maximum time in resting in the entire shifts i.e. 952 minutes ( 63%), 1944 minutes ( 89%) and 318 minutes (67%) respectively. They weren't attacked by crow. They showed mating behaviors only in the morning. They didn't fight in the day and the evening shift.

**Table no. 7: Diurnal time budget at different shift of adult.**

| Behavior | Morning shift | Day shift | Evening shift | **Total** |
|---|---|---|---|---|
| Rest | 952 | 1944 | 318 | **3214** |
| Groom | 192 | 62 | 48 | **302** |
| Flap | 82 | 98 | 26 | **206** |
| Spd. Wing | 84 | 28 | 14 | **126** |
| Crawl | 32 | 16 | 38 | **86** |
| Def.Crow | 0 | 0 | 0 | **0** |
| Chatter | 52 | 12 | 32 | **96** |
| Fight | 58 | 0 | 0 | **58** |
| Mate | 38 | 0 | 0 | **38** |
| Total | 1490 | 2160 | 476 | **4126** |

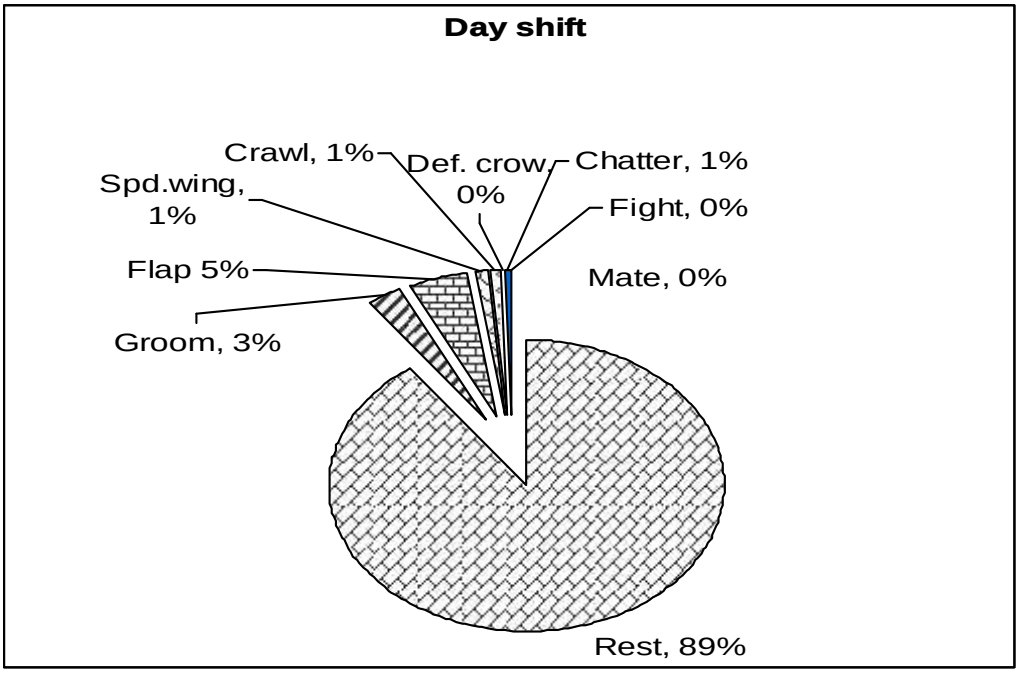
In morning shift, adult bats rest 63% groom 13%, flap 6%, spread wing 6%, crawl 2%, and chatter 3%, fight 4%, mate 3%. Crow did not attack them (Fig. 8).

**Fig. 8 Percentage of time spent by adult bats during morning shift**



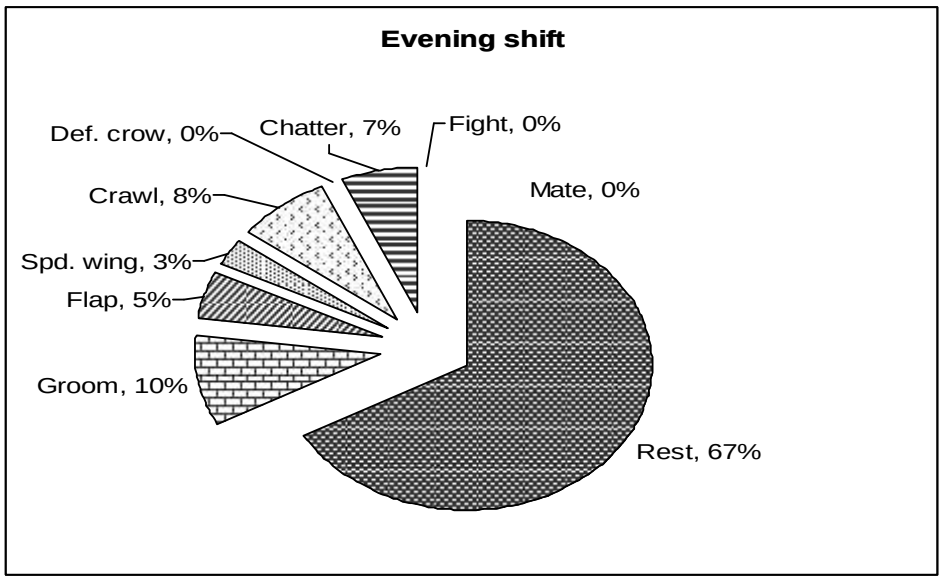

In day shift, adult bats rest 89%, groom 3%, flap 5%, spread wing 1%, crawl 1%, defend crow 1%, chatter 1%, and did not mate and fight (Fig.9 ).

**Fig. 9. Percentage of time spent by adult bats during day shift**



In evening shift, adult bats rest 67%, groom 10%, flap 5%, spread wing 3%, crawl 8%, chatter 7% and did not fight, mate and attack by crow (Fig.10).

**Fig. 10 Percentage of time spent by adult bats during evening shift**



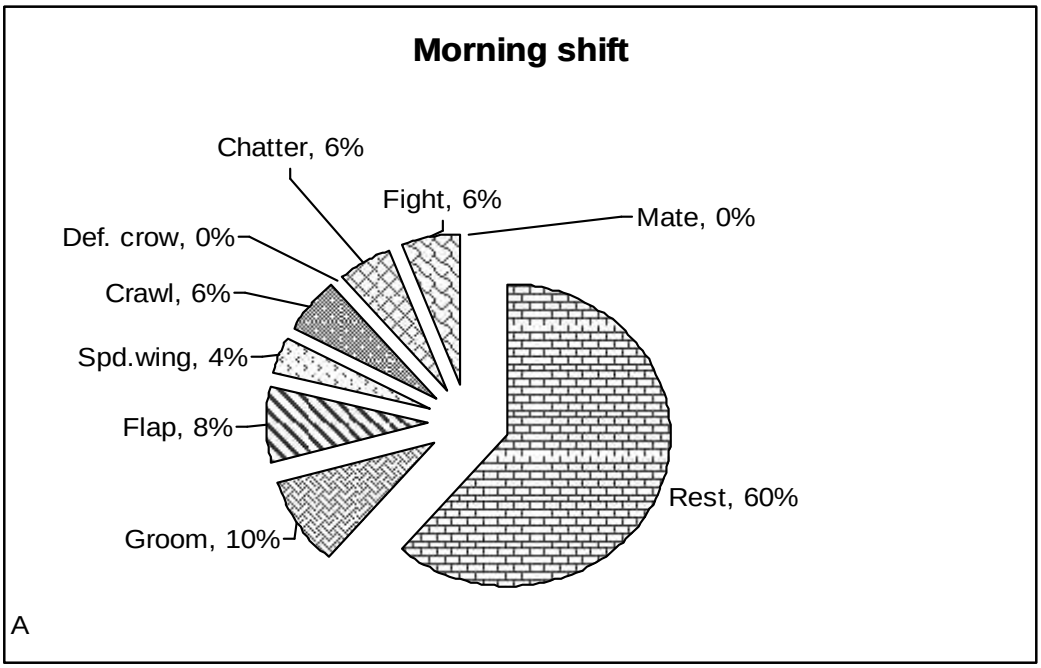

Six infant's (pups) were observed for 4134 minutes (Table 8). These are 1488 minutes, 2160 minutes and 486 minutes respectively in the morning, day and the evening shift. During observation they spent maximum time in resting in the entire shifts i.e. 912 minutes (60%), 938 minutes (90%) and 386 minutes (79%) respectively. They were not attacked by crow and didn't show mating behavior in all the shifts. They showed fighting behavior only in the morning shift.

**Table no. 8: Diurnal time budget at different shift of infant.**

| Behavior | Morning Shift | Day Shift | Evening Shift | Total |
|---|---|---|---|---|
| Rest | 912 | 1938 | 386 | 3236 |
| Groom | 142 | 36 | 20 | 198 |
| Flap | 118 | 48 | 18 | 184 |
| Spd. Wing | 58 | 72 | 22 | 152 |
| Crawl | 88 | 10 | 12 | 110 |
| Def.Crow | 0 | 0 | 0 | 0 |
| Chatter | 84 | 56 | 28 | 168 |
| Fight | 86 | 0 | 0 | 86 |
| Mate | 0 | 0 | 0 | 0 |
| total | 1488 | 2160 | 486 | 4134 |

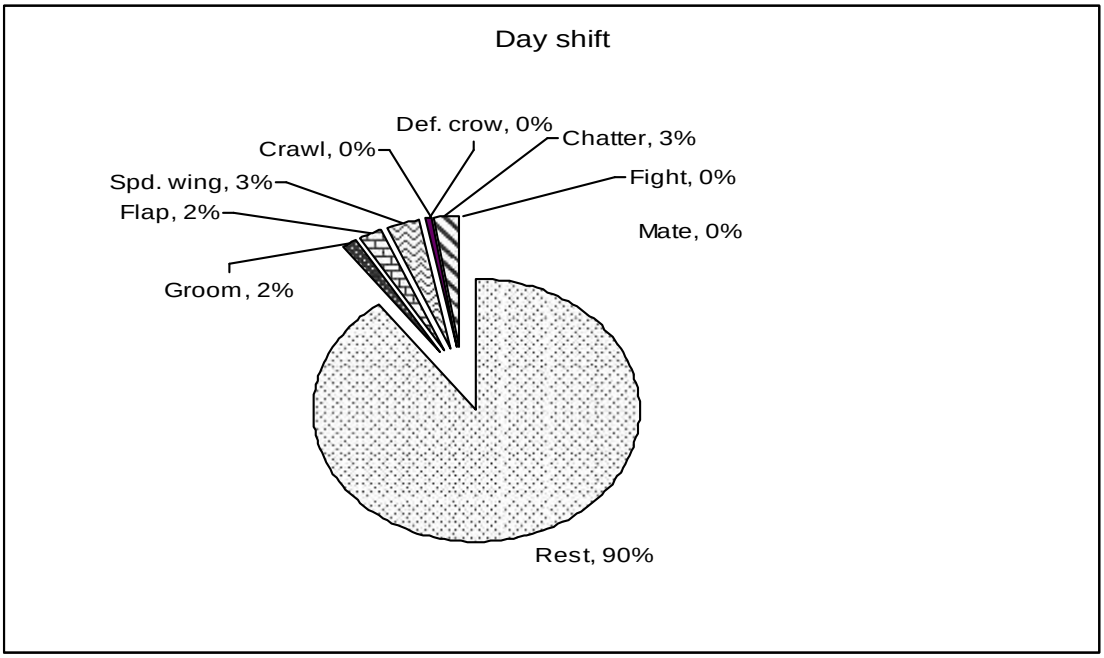
In morning shift, infant bats rest 60% groom 9%, flap 8%, spread wing 4%, crawl 6%, and chatter 6% and fight 7%. Crow did not attack them and they did not mate (Fig.11).

**Fig. 11 Percentage of time spent by infant bats during morning shift.**



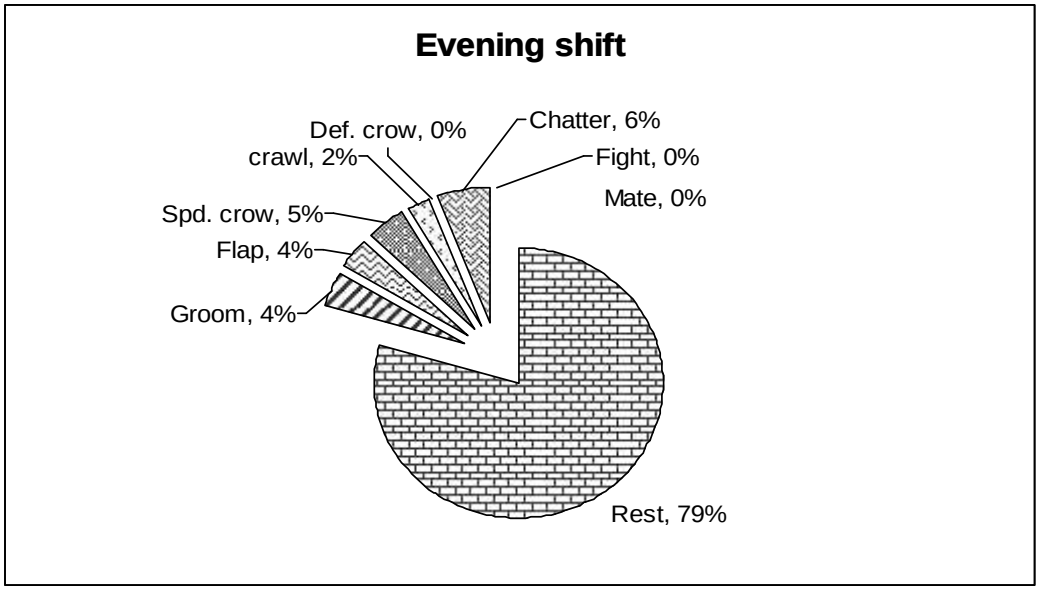

In day shift, infant bats rest 90%, groom 2%, flap 2%, spread wing 2%, and chatter 2%. They did not mate, crawl, fight and attacked by crow (Fig. 12).

**Fig. 12 Percentage of time spent by infant bats during day shift.**



In evening shift, infant bats rest 79%, groom 4%, flap 4%, spread wing 5%, crawl 2%, and chatter6%. They did not mate, fight, crawl and attacked by crow in the evening (Fig.13).

**Fig. 13 Percentage of time spent by infant bats during evening shift.**




Total study time for18 bats of three categories is 12362 minutes or 206 hrs i.e average 11 hrs 26 minutes per bats. During observation among the three groups infants rest the most (78.27%) of the total study time, old and isolated groom the most (11.26%) which very different in frequency than adult and infant. Old and isolated bats flapped more. Crows did not attack adult and infant. Infants crawl, chatter, spread wings and fight each other much more than other two groups. Adult along were found active in mating (Table 9).

**Table 9 Diurnal time budget of different groups of bats.**

| Behavior | Old and isolated | | Adult | | Infant | |
|---|---|---|---|---|---|---|
| | Time in min. | Time in % | Time in min. | Time in % | Time in min. | Time in % |
| Rest | 3142 | 76.59 | 3214 | 77.8 | 3236 | 78.27 |
| Groom | 462 | 11.26 | 302 | 7.3 | 198 | 4.7 |
| Flap | 318 | 7.75 | 206 | 5 | 184 | 4.4 |
| Spd. Wing | 66 | 1.6 | 126 | 3 | 152 | 3.6 |
| Crawl | 50 | 1.2 | 86 | 2.08 | 110 | 2.6 |
| Def.Crow | 24 | .006 | 0 | 0 | 0 | 0 |
| Chatter | 32 | .008 | 96 | 2.32 | 168 | 4.06 |
| Fight | 6 | .001 | 58 | 1.4 | 98 | 2.4 |
| Mate | 0 | 0 | 38 | .9 | 0 | 0 |
| Total | 4102 | 100 | 4126 | 100 | 4134 | 100 |

### 5.3 Threats to bat in study area

Bhaktapur is the densest city of Nepal. Increasing population is degrading quality of environment. Urbanization decrease land, farm and forest. The roosting area is situated in the army school area where a school hostels and teachers quarter with 1500 students, 85 teachers and 600 armies resided there. So, anthropogenic activities are the most crucial threats to bats' survival in Sallaghari. The threats observed during research period are recorded as follows.

#### 5.3.1 Destruction of habitat

Army school expands it ground, build hostel and classroom for its students. Army school cut down trees around the bat roosting area. They had fallen down trees of the roosted area too. The number of tree is decreasing hence the number of bats declining due to decreasing of roosting trees numbers.

#### 5.3.2 Disturbance at roosting site

Near the roosting area there is Ganesh Temple. People visit there for worshiping as well as daily morning walk. They make fire after scarifying preys to god. Similarly, picnic spots are also there. Hence, much more sound is generally produced by people.

Students of Army school play and make unnecessary noise in the roosting area. Sometime people and students throwing stone with catapult were also found.

#### 5.3.3 Hunting

People hunt bats for medicinal belief. Dry meat of bat was found in local people’s house near roosting area. They believe that bat’s meat improved the heart treatment, asthma, and cancerous patient. Some people capture bat to use with oil. They believe it strengthen their hair. In the lack of adequate scientific research and proof, people are forced to believe on such myths and belief on bats. If there were some studies, general people would have known the basic knowledge whether medicinal values are scientific or only myths (Photo 8 and 9).

### 5.3.4 Pollution

Rivers Hanumante and Khasang Khusung which are on the either side of roosting area are completely polluted. Total drainage of Bhaktapur mixed in these rivers. Amount of water in Rani Pokhari (pond in roosting area) is being polluted and water level is decreasing. These are the main source of drinking water for bats.

### 5.3.5 Electrocution

During the field visit the dead bats were found hanged over electric wire. This conformed that bats are killed by electrocution due to electric shock in naked metallic wire. Three bats were found hanging during research duration (Photo 2).

**Photo 2: Dead bats hanging over electric wire**

### 5.3.6 Using Insecticide and pesticide by farmers

The rate of using insecticide, pesticide and herbicide is increasing in cultivation as well as in household purpose. Farmer use DDT, Malathion, chemical fertilizer and other chemicals excessively for more production. Bats feed on insects and agricultural products which may affects bats indirectly.

# CHAPTER 6

## Discussion

Sallaghari is the only one habitat of bats in Bhaktapur, urban area. The population was dense because the site is with ample number of tall trees and lies outside of the core city of Bhaktapur. A lot of physical changes in Bhaktapur are observed currently. Once the site was out of the urban influence and at the corner of city proper. However, it is almost in the mid of urban city due to increasement of settlement. Hence the human population is significantly increasing and bats' number is decreasing every year. In the meantime the number counted by Archarya and published in Kathmandu Post daily and however data by Rajchal website is quite misleading. In Acharya's study the number listed was very few (293) where as Rajchal's counting more than assumption and the reality (3000). In the same period this research was done and census were conducted monthly that shows only 1428 bats roosted in 48 trees.

On the other hand, the general behavioral study is quite resembled to the finding made by G. Neuweiler and John Nelson, an Australian zoologist. G. Neuweiler (1998) studied bats of Madras. The research work specifically studied bats general behavior like flapping wings, mating behavior, returning back to the roost, departure from roost, roaming around the roost and so on. F.N. Radcliff (1998) coined the term 'day time camp' for bats' habitat. He studied that only adult migrate in winter. His study area was tropical rainforest of Australia. Though the present study observed migration in winter, but not only adult but entire bats migrate during winter. Climatical condition of Australian rainforest and here in Sallaghari is different. Temperature in Shallaghari falls below 0' C in winter which is freezing temperature and is unfavorable to any age group of bats while tropical area seldom experienced such weather change. Likewise in temperate zone very few fruits and green leaves are remain in winter. Habitat alternation and on availability of food forced them for migration. Hence the number of bats decrease as winter comes closer. The study of Malla (2000), Phuyal (2005) and Acharya (2006) also prove the same results.

Long E (1995) studied on *Pteropus rufux* about its migrational behavior and R. Tidemann and John E Welson (2005) studies show the migration by *Pteropus poliocephalus* for food is resembles to the observation of this study. Grooming behavior is also studies by Prof. Wolfram Kutsch and Dr. Gareth James (1995) in Horse shoe bat *(Rhinolophus fessumeguinum*). Their study resemble to the observation of this study showing similar pattern of grooming. Wells (1995) describes about flapping wings by bat *( Pteropus rufux)* in the roost ecology of Malagasy flying fox in hot weather to cool down themselves is resembles to the present study. This study shows the highest rank activity besides usual resting in mid day time when temperature is maximum of day.

Ptero count project CCINSA (2000) describes that flying fox lives in close proximity to human habitat. Sallaghari is also not much far form human habitat before and amidst currently. Animal live near human population as they get secure form larger carnivores and also can receive food easily. They also have higher survival chance due to sympathetic feeling of human (Chalise 2003).

G. Neuweiler's (1998) study showed hanging hierarchy in *Pteropus gigateus* roosting, which is determined primarily by male. For example no weak lings are tolerated in the top most branches of the tree. The hierarchy is vertically structured and the female also occupy specific place in hierarchy. But the present study did not observed such hierarchy. Generally old bats roosted in isolation whereas young and adult bats roost in group. It seems like aggregation of individual without any fix rules and regulations. Such study need more advance method to find out whether they roost in hierarchical order according to age group. W. Ogilvie and M. B. Ogilvie (1998) said that bats roost in the group of fifty. The present study agrees that bats also roost in group and were in average of three individuals to 35 per tree but some are found in isolation too.

General feature and morphological structure of bats of Sallaghari seems similar to Shrestha (1997). Its head and body measure about 23 cm and wingspan is 112 cm. it weigh over 630 grams. The head is dark brown. The abdomen is yellowish brown. The chin, neck and flanks are darker. The wings are black due to exposure to sunlight.

Male is bright color than female. Male has oily luster on some parts of their coats specially neck.

Human factors and artificial structure are prime threats against bats. During field visit, the dead bats were found hanged along electric wire. They were killed by electrocutions as city electric wires are naked and frequent accident happened. The shop near by the site sells bats dry meat for medicinal purpose. People believe that bat's meat improve the treatment for heart diseases, asthma, and cancerous patient. Some people capture bat to use with oil. They believe it strengthen their hair.

The highest density of population (1634 per square km.) lives in Bhaktapur in Nepal. As the human population increases so the sewage system becomes heavy. All the sewage pipes are put to pour into rivers directly. The wastages of the city also dump at the bank of rivers ( Hanumante and Khasang Khsung). In the lack of treatment pond, city's drainage directly flows in rivers near by. Hence the water used by bats is being polluted day by day.

The study finds deforestation in the study site. It is for timber, fire woods, and expansion of cultivable land and to construct. Unless tall trees be conserved, the threat for the existence in Sallaghari is always likely. In this way, the habitat of bats is being lost gradually. The activities and surrounding environment is against bats' survival. Habitat loss has been citied by numbers of authors as the major factors contributing to decline in fruit bats (Wodzicki and Felten, 1975, Racey, 1979, Pierson and Rainey 1992).

Bats, for local people are symbol of bad happening. People believe bat suck blood, transmit rabies, and spoil their crops and fruits. So, they do not want to conserve them. They might be ignoring ecological importance of bats in their own life. If people encounter with bat, they prefer to kill it as they already took it as harmful animal.

Hunting is another threat to bat. Larger bats (*Pteropus)* are sometime eaten by human (Hill and Smith, 1984, Nowak, 1991). Fruit bats are used by people as major dietary item in many areas of the world. In south East Asia, Fruit bats' meat is also

valued as remedy for asthma, kidney ailments and fixedness (Fujita and Tuttle, 1991). In the study area local people use catapult to hunt bats as they believe that bat's meat improve the treatment of different diseases and also cosmetic use.

South Asian chiroptera CAMP workshop publishes a statistical level of threat analysis of South Asian (Fig. 14) which represent the situation of Nepal too.

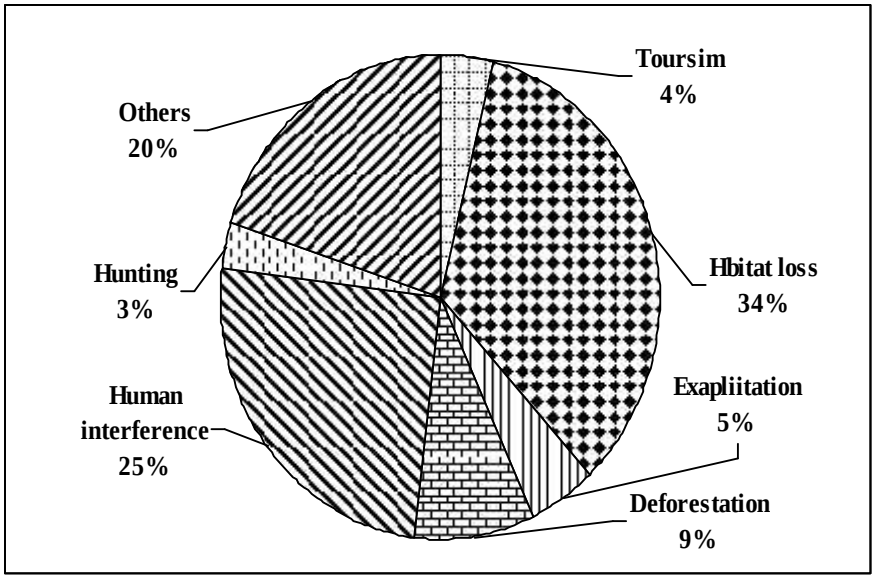



Fig.14 Major Threats to bat species of South Asian Bats

The present study also partially supports this threats categorization. Pteropus is facing substantial threats from habitat loss, hunting, destruction and disturbance in roosting area.

With all these potential threats that the study assumed at first found to be reality during the study. The bats' behavior of Sallaghari is unknown to date. The study is endeavors to reveal almost all general behavior of this isolated population of Kathmandu valley. The study focuses the situation and status of bats in Sallaghari. It is expected to grab the concern of people and specialist.

In upcoming days, the conservation and development for roosting site and conservation of surrounding site can be studied comprehensively. Farmers and local people can be made aware on the defects of using pesticides, herbicides, insecticides and chemical fertilizers.

# CHAPTER 7

## Conclusion

The study focused on the population status, general behavior and their threat for survival of flying fox (*Pteropus giganteus*) of Sallaghari, Bhaktapur. Sallaghari is only one habitat of bats in Bhaktapur. But very rarely the site is chosen for study. Local people are unaware about the bats ecology and its significances in Sallaghari.

Bats of Sallaghari are absent in December, January and February. These three months are very cold climate and difficult to live. Temperature fall below – 3' C. Sun shines for very few hours in roosting area and sunlight is hardly for eight hours.

Census reveals 1428 bats is the highest number in Sallaghari in September. The number gradually decreasing from September to December and fall to nil in three months of winter. They reappear from March and their number goes on increasing up to September.

Bats roost in day light. They go for searching food and involve in other activities after sun set. They completely returned back before sun rise. At day time some of the bats fly roaming around the roost making a circle. They make loud noise showing aggressive behavior when black kite approach near to their roost.

Infants and old bats rest more than adult and infants chatter a lot. In contrary old remain silent. Old bats are also attacked by crow. Only adult bats mate. Bats show both polygamy and polyandry. Old bats prefer to roost in isolation but adults and infants roost in group.

During roosting time they flap, groom, spread wings, chatter and so on. The frequency of these behaviors is different as their age. Human intervention especially new construction of site disturbs bats. Electric poles and wire kills bats accidentally. People hunt bats to eat and to use as medicine. Pollution in roosting area and its surrounding is increasing. Water source for bats in Hanumante River and Khasang Khusung River is seriously polluted due to mixing sewage and dumping freely. Bats in Sallaghari are in threat of being lost. So conservation initiative should be forwarded as soon as possible. The public awareness to the ecological and economical importance of bat is must.

# RECOMMENDATIONS

- The present study concludes that Sallaghari is one of the hotspot for bat study so the researchers should be encouraged to study there on bat ecology and behavior.
- The bat roosts have no any conservation initiatives locally and nationally. So, conservation and monitoring project should be launched immediately.
- Public awareness is a crucial component of a holistic conservation action plan for bats. Education programs about the ecological value of bats as well as the importance of tree for bats' roost should be launched specially to students of army school and local people.
- The local bat club among the community should be established.
- Bat legislation should be formulated and implemented effectively.
- Cutting trees must stop to save bats' habitat.
- In Nepal, bats are always neglected for study by governments, NGO, INGO despite their enormous ecological importance. So the attention should be drawn to concern with wildlife management institutions and departments.
- Due to negligence of the species many species might have extinct from our locality. About 240 are threatened with extinction from the world. So taxonomical study about bats should be carried out.
- The new researcher should be encouraged to study about various aspects of bat biology.
- The burning of forest droppings (leaf litter and twigs) should be located away from the bat habitat not to disturb by smoke to roosting bats.
- The plantation of fruit trees should be encouraged in the forested areas of Bhaktapur and Sallaghari.
- The responsible authorities of Bhaktapur should be convinced on the environment pollution and its negative effect on bats.
- Advance study is necessary to find out range of bats activities, reproduction and migration.
- Sallaghari roosted area should declare conservation area especially for bats.

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# Annex 1

**Photographs of Bats in different status and behavior**

**Photo 3 Bats in roost**

**Photo 4 Old and Isolated bat**

**Photo 5 Bats in group**

**Photo 6 Infant with its mother**

**Photo 7 Road and housing in roost site**

**Photo 8 Dry meat of bat in a shop**

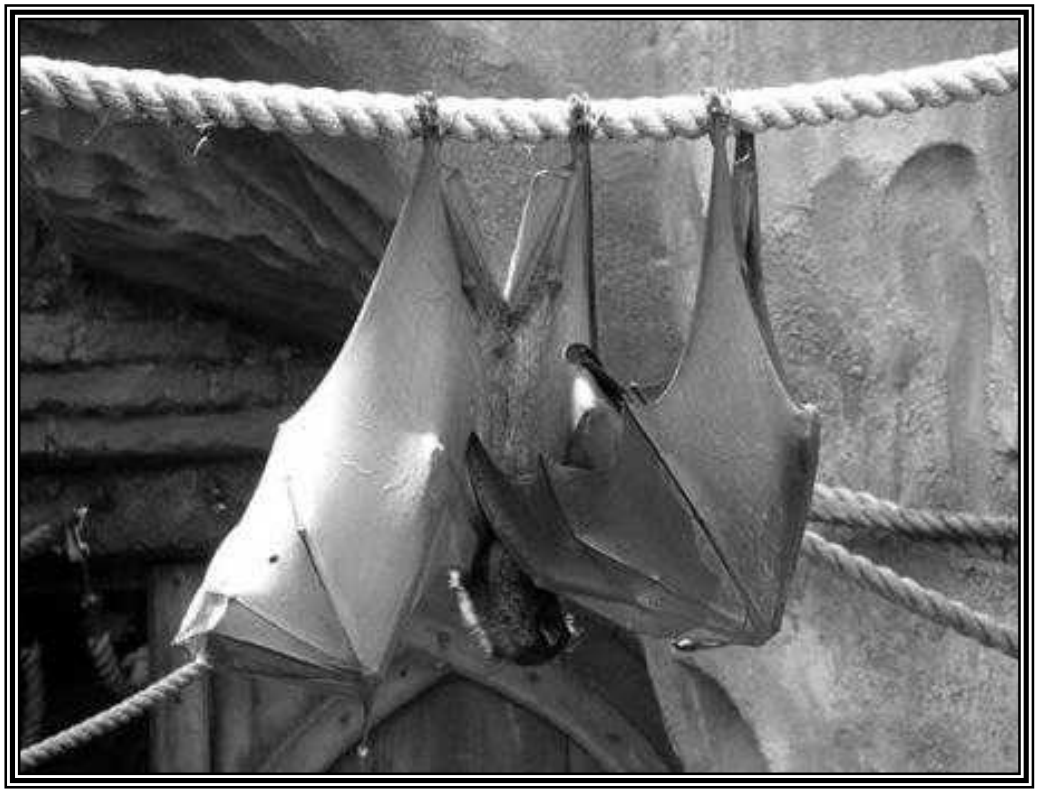

**Photo 9 Bat in trap**

**Photo 10 Bat showing fighting behavior**

**Photo 11 Bat spreading wings**

**Photo 12 Bat showing mating behavior**

**Photo 13 Bat drinking water**

**Photo 14 Rani Pokhari inside the roost**

**Photo 15 Measuring wingspan of bat**

**Photo 16 Flapping wings**

**Photo 17 Collecting specimen of Bat**

# Annex 2

The annual data of maximum temperature, minimum temperature, rain fall and time of sun-rise and sun-set during the study period is as follows:

| Date | Sun rise | Sun set | Max.Temp (in $^0$C) | Min.Temp (in $^0$C) | Rainfall in mm |
|---|---|---|---|---|---|
| 06/Aug17 | 5:35 | 18:40 | 31 | 19.6 | 4.4 |
| 06/Aug31 | 5:42 | 18:26 | 29 | 19.8 | 0 |
| 06/Sept17 | 5:50 | 18:06 | 29.6 | 18 | 19.7 |
| 06/Sept30 | 5:56 | 17:52 | 30.2 | 17.6 | 3.2 |
| 06/oct17 | 6:06 | 17:32 | 27.7 | 13 | 0 |
| 06/oct31 | 6:13 | 17:20 | 27 | 10 | 0 |
| 06/Nov17 | 6:27 | 17:11 | 24.8 | 10.4 | 0 |
| 06/Nov30 | 6:37 | 17:09 | 20.5 | 5.2 | 0 |
| 06/Dec17 | 6:48 | 17:11 | 20.4 | 3.4 | 0 |
| 06/Dec30 | 6:55 | 17:19 | 17.8 | 8.6 | 0 |
| 07/Jan17 | 6:56 | 17:30 | 18.5 | -0.5 | 0 |
| 07/Jan31 | 6:53 | 17:41 | 21.5 | 4 | 0 |
| 07/Feb17 | 6:45 | 17:52 | 15.2 | 9 | 4.8 |
| 07/Feb29 | 6:32 | 18:02 | 20.5 | 8.4 | 1.9 |
| 07/Mar17 | 6:17 | 18:11 | 24.5 | 8.1 | 0 |
| 07/Mar31 | 6:04 | 18:17 | 28.5 | 11 | 0 |
| 07/Apr17 | 5:47 | 18:27 | 27 | 9.5 | 19.2 |
| 07/Apr30 | 5:27 | 18:36 | 27.3 | 12.2 | 19 |
| 07/May17 | 5:15 | 18:45 | 28.5 | 14.2 | 0 |
| 07/May31 | 5:10 | 18:53 | 31.6 | 16.6 | 0 |
| 07/Jun17 | 5:11 | 19:03 | 30.2 | 19 | 0 |
| 07/Jun30 | 5:15 | 19:05 | 30 | 19.5 | 0.2 |
| 07/Jul17 | 5:16 | 19:03 | 28.3 | 19 | 6.1 |
| 07/Jul30 | 5:27 | 19:01 | 30 | 19 | 0 |