INTRODUCTION

1.1. Background

Bats are important in maintaining healthy ecosystems therefore, beneficial to human health. Globally, rapid destruction of natural habitats affecting roosting and foraging areas is the primary cause of loss of species diversity and abundance of bats (American Institute of Biological Sciences 2001). Negative attitude in local people towards bats is the next impacting factor on the abundance and distribution of bats (Phuyal 2005, Thapa 2011). Climatic change, natural disorders and anthropogenic threats also affect them in several ways (Hutson 2006). Wooden houses are replaced with modern concrete houses is an important cause of habitat degradation of insectivores' bats. Deforestation of *Bombax* sp., *Ficus* sp., Palm tree and other large tree species is the main cause of habitat loss for frugivores bats. Extreme use of pesticides, insecticides and other poisonous substances in agricultural fields causes loss of species and population of bats (Eidels 2010). Anthropogenic threat from bird hunters (Chidimar) and local people is also important cause of degradation of the population and species diversity frugivores and insectivores bats. People kill bats for food as well as medicinal proposes (Lohoni 2011(a, b) Jaroli et al. 2010). Houses and gardens are the main habitats of bats. Lack of public awareness is high as the people are found disturbing the bats for amusement. Flood lighting and sound pollution affect the nocturnal and foraging activities and increases the natural threats on bats species (Swift 1980, Schaub et al. 2008). In case of Sunsari-Morang industrial corridor human's population growth due to cause of this anthropogenic factors like pollution, habitat degradation, poaching etc are increasing. However, no research has been conducted to investigate these issues thus, no authentic information is available. Therefore, it is necessary to develop baseline information about their diversity, abundance, and distribution and disseminate information about many benefits that bats provide to maintain a sound ecosystem and a healthy human society.

1.2. General Description of Bats

Bats are mammals under the order Chiroptera, which is the second largest among 20 mammalian orders with the latest record of 1117 species in the world (Srinivasulu et al. 2010). The order Chiroptera is divided into two sub-Orders-Yinpterochiroptera and Yangochiroptera on the basis of molecular phylogenetic studies (Telling et al. 2005). Bats are widely distributed and have been recorded throughout the world except in the Antarctic and few Oceanic islands (Mickleburgh et al. 2001). According to Bates and Harrison (1997), a total of 119 species of bats are known in South Asia, which has reached to 128 species Srinivaulu et al. (2010).

Taxonomic classification:

Kingdom: Animalia
Phylum: Chordata
Group: Vertebrata
Subphylum: Gnathostomata
Class: Mammalia
Subclass: Theria
Infraclass: Eutheria
Order: Chiroptera

1.3. Bat Studies in Nepal

In Nepal, Hodgson (1835) started the study of bats and collected some specimens such as *Pipistrellus* and *Scotophillus heathii* later on Scullay (1887), Hinton and Fry (1923), Fry (1925), Sanborn (1950), Worth and Shah (1969), Frick (1969), Chesemore (1970), Abe (1971), Agrawal and Chakraborty (1971), Sinha (1973), Lekagual and Mcneey (1977), Johson et al. (1980), Michell (1980) have carried out studies on bats. Similarly, Koopman (1983) and (1993), Martens (1987), Corbet and Hill (1992), Kock (1996), Bates and Harrison (1997), Csorba et al. (1999), Molar et al. (2002), Acharya (2006), Phuyal and Dhoubhadel (2006), Acharya and Ruedas (2007), Acharya (2008), Koju (2008), Baral and Shah (2008), Thapa (2008) have done several research on bat population in Nepal. Likewise, Thapa, (2009), Thapa and Thapa (2009), Thapa et al.(2009), Giri (2009), Thapa (2010), Thapa et al. (2010), Ghimire at al. (2010), Adhikari (2010), Lamichane (2010), Dahal and Thapa (2010) and Dahal (2011) also studied and collected specimen of bats.

1.4. Bats Diversity in Nepal

Molur et al. (2002) presented 51 species of bats from Nepal were as (Thapa 2010) reported 53 species. The recorded number of bat species represent about the five percent of the world bat diversity and over 40% of South Asia's bat diversity respectively. Out of the 53 species of bats found in Nepal, 20 species belong to sub-order Yinpterochiroptera and the remaining 33 species belong to the sub-order Yingochiroptera (Acharya et al. 2010). According to Myers et al. (2000), 87 probable species of bats are present in Nepal.

1.5. Bats and Seasonal Variation

Colony size is important variable for understanding biology, ecology and conservation of the group of living organisms. Sizes of bat colonies are highly variable in seasonal and daily basis. Sizes of naturally roosting colonies are dependent upon various factors such as the seasonal food viability and local and large-scale weather pattern (Haristov et al. 2010). In Bonin Flying Fox (*Pteropus pselaphon*) roosting pattern is seen as colonial habitat in winter and solitary habitat in summer. Therefore, copulation frequencies are more in the winter season (Sugita et al. 2009).

Activities of bat species also changes seasonally. In summer, bats typically travel a long distance at night from their foraging and roosting areas. Nocturnal activities of bats are more in early and mid summer in comparison to late spring, late summer and other seasons (Encarnacao et al. 2006). Flight activities of bats are severely reduced when air temperature is dropped below 10ºC (Wilkison and Barclary 1997) but such condition is not followed in case of *Myotis daubentonii* (Diltz 2006). Seasonal variation and activities of bats vary from the species to species. Generally, they have greater frequency of occurrence during the wet season but some species occur more during the dry season. Their activities depend upon the availability of food and shelter available in surrounding areas (Zortea and Alho 2008). Species diversity of bats varies according to the climatic conditions. In tropical and subtropical climate, both the species diversity and population density are high (Simmons 2005). Species diversity, richness and evenness are positively correlated with the elevation as it is related to the temperature and food availability (Graham 1983). Seasonal change controls food variation, feeding behavior and fat reserve of body in bats of temperate zone (Arevalo et al. 1990, Mcnab 1976).

1.6. Objectives

This study was designed in order to address these issues with the following objectives.
The main objective of this research was to investigate the species diversity of bats in Sunsari-Morang industrial corridor. However, specific objectives were to:

- ❖ Examine the occurrence, abundance and distribution of bats.
- ❖ Investigate the seasonal variation of bats.

- Identify major anthropogenic threats and recommend for proper conservation.

1.7. Justifications and Limitation of the Study

This study is an attempt to produce baseline information of bat diversity and the impact of seasonal variation on the population of different species of bats in Eastern Tarai, where bats are not well studied. Enough scientific information about species diversity, population size, impacts of climatic and anthropogenic factors on roosting sites of bats were unknown. The industrial corridor is comparatively more polluted and locally warmer area. These factors may affect species diversity and population of bats (Swift 1980). The study also identified threats on bats and developed awareness programs to help mitigate these threats and encourage local people and school children in conservation of bats.

This study covered a small area (about 52 Km^2) of the Sunsari-Morang industrial corridor. Environmental temperature and relative humidity were taken instead of roost temperature in case of *Pteropus giganteus* and *Cynopterus sphinx* whereas room temperatures were recorded for the house dwelling bats. Climatic datas were produced by using a simple hygrometer. The surveys were carried out four times during a year (once every three month).

2. LITERATURE REVIEW

2.1 Diversity of Bats

Eight species namely, *Rhinolophus ferrumequinum, R. rouxi, R. luctus, R. peasonii, Hipposiderous armiger, Pipistrellus circumdatus, Philetor brachypterus, Eptesius serotinus* were reported from Sankhuwasava (FMNH. Specimens of *Myotis blythii* have been reported from Tumlingtar, Sankhuwasava district, where as specimens of *Scotomanus ornatus* has been reported from Sankhuwasava without specific location. The specimens are deposited at FMNH. *Rhinolopus lepidus* was reported from Ilam district (Mitchell 1980).

R. ferrumequium was collected from an elevation of 2738m at Num. *R. pearsonii* was collected from elevation of 1123m at the Dima near Num in Sukipatyl forest. *Hipposiderus armiger* was collected from 2301 m in the Sukipatyl forest near Num (FMNH). *Arielulus circumdatus (Pipistrellus circumdatus)* was also collected from the Sukipatyl forest near Num, Sankhuwasava on 31 May 1973 (FMNH). Num Bridge at 862m was also collected specimens of bats (FMNH and Koopman 1983).

Nine species including *Hipposideros armiger, Myotis mystacinus, M. siligorensis, Plecotus auritus, Barbestella leucomanes, Pipistrellus javanicus, P. coromandra, Eptesicus nilssoni, E. serotines* can be found from Makalu Barun National Park. *P. coromandra* can also be found in Ilam (Suwal *et al.* 1995). *Taphozous longimanus* can be found from Tarai and Curia hills of eastern Nepal (Baral and Shah 2008).

Specimens of six species collected from eastern Nepal have been deposited at Hungarian Natuaral Histry Museum (HNHM) and Zoological Museum of Moscow state university, (ZMMU). Adult male of *Rhinolopus affinis* was collected on April 1, 1996 from Tawa of Tapalejung district at an altitude of 1200m; two adult males and an adult female of *R. sinicus* were collected on April 5 and 7, 1996, from above Yampudin, Tapalejung at 2650 m and Mamankhe, Tapalejung at 1700m respectively. An adult female and male of *Myotis muricola* were collected on April 12 and 13, 1996 Lampokhari and Tinjure phedi, Therathum district at 3000 and 2900m respectively. Five adult males and seven adult females of *Kerivolua hardwickii* were collected on April 7, 1996 from Mamankhe at 1700m (Csorba *et al.* 1999). Altogether 22 species of bats can be found from eastern Nepal (Baral and Shah 2008).

Four species namely *Megadarma lyra, Scotophilus heathii, Pipistrellus sp*. and *Taphozous sp*. have been recently recorded from Sunsari, Morang and Jhapa districts of eastern Nepal (Thapa 2009). Similarly fourteen species of bats were recorded from Shankhuwasava, Taplejung and Ilam districts of eastern Nepal (Acharya et al. 2010).

Three species namely *Pipistrellus coromandra, Cynopterous sphinx* and *Hypsugo sp.* have also been recorded from Shankhuwasava district of eastern Nepal (Dahal and Thapa 2010)

2.2 Abundance and distribution

Loss of critical foraging habitat can affect the stability and survivorship of bats population. Several critical factors are needed to balance. For insectivores bats, foraging in less clattered habitat is most energy efficient because of less physical requirements. It is risky in foraging in open area due to predation by owl at night or other raptors before darkness (Erickson and West 2002).

Human impacts on foraging habitats usually come in the form of cutting of forest and other degradation as likely cause to some bats (Barclay 2003). Insectivores' bats are predominant factors of night flying insects including adult mosquitoes (Altringham 1996).

Bats are susceptible to human disturbance, infectious diseases and responsive climatic variation. Year to year pattern may shift and thus require long term effort to understand seasonal ecology population dynamics stability.

2.3 Seasonal Variation in Bats

Seasonal variation of population distribution of the Indian Flying Foxes (*Pteropus giganteus*) was seen in north eastern districts of Rawalpindi and Chakwal province of Punjab (Pakistan). However, it is not common in other fruit bats like short- nosed fruit bat (*Cynopterus sphinx*), fulvous fruit bat (*Rousettus leschenaultii*) and Egyptian fruit bat (*Rousettus egyptiacus arabicus*) (Noureen et al. 2011).

Bonin flying fox *Pteropus pselaphon* showed the seasonal roosting pattern in Chichi-Jima oceanic island of Japan. Colonial habitat in winter and solitary habitat in summer were a common feature and number of roosting individuals varied seasonally in colonial roost.

Colonies are of three types: female groups, multiple male and multiple female groups and male groups. Copulation frequently occurs in colonial roost in winter (Sugita et al. 2009). Seasonal migration and back aggregation has been known in flying foxes in Australia. Fluctuating colony size of Flying Foxes is linked to factors such as seasonal change, quality and distribution of food as well as their reproductive cycle (Nelson 1965, Eby 1991, Spencer et al. 1991, Vardon and Tidemann 1999, Parry-Jones and Augee 2001, Fleming and Eby 2003 and Welbergen 2005).

Seasonal variations in colony size are taken in the Brazilian Free-tailed Bat (*Tadarida barsiliensis*) in Carlsbad Caverns national park, New Mexico. Large fluctuation occurs in the number of bats on a seasonal and daily basis. In April the size of colony, sharply increases but in spring, its size decreases due to migration. In June, female bats typically give birth in caves. In light pronounced change, the colony size of such kind of changes represent the natural responses of the colony factors such as food availability and weather pattern (Haristov et al. 2010).

Seasonal variations occur in activities of Ozark Big-Eared bat (*Corynorhinus townsendii ingens*) in Boston Mountain of the northern Oklahoma. In winter season, bats may leave the caves to void waste materials or to fly in open weather and drink (Avery 1985, Speakmen and Racey 1989). Hibernation only occurs in coldest month (Kunz and Martin 1982, Clark et al. 2002). In summer season, bats living in temperate zone cluster around and give birth to their young ones (Kunz 1974). Shift foraging activities of females throughout the summer, relative to parturition and location were varying similar to observe vagina (Bagley and Jacobs 1985). Emergence of bats is taken from the maternity roost started sunset in June and July (Shiel and Fairey 1999, Kunz 1974, Macaney and Fairley 1988, Shen and Lee 2000).

Nocturnal activities of male Daubenton's bat (*Myotis daubentonii*) in central Germany expands more in early to mid summer and late spring to late summer. Winter condition determines reproductive activities and foraging activities increases as the population of insect is high during mid-summer. During the autumn, the number of insect population decreases, hence the nocturnal activities of bats are less (Encqrnaco et al. 2006).

Seasonal variation has been observed in population density of bats in Cerrado habitat of central Brazil where higher frequency of majority of species is observed during the wet season. In some species like *C. perspicillata* and *S. lilium*, higher frequency is observed only during the dry season (Zortea and Alho 2008).

Studies in *Eptesicus serotinus* (Catto *et al.* 1995), *E. nilssonii* (Rydell 1989) and *E. fuscus* (Wilkinson and Barclay 1997) showed that the flight activities are severely reduced when the air temperature is dropped below 10^{o}C. Such condition do not affect *Myotis daubentonil* and the foraging activities is seen even at the ambient temperature of about 5^{o}C (Dietz 2006).

3. STUDY AREA

3.1 Brief Description

Sunsari-Morang industrial corridor lies in two districts namely, Sunsari and Morang of the eastern development region of Nepal (Figure 1). It extends from Itahari, Sunsari to Biratnagar, Morang within approximately 35 Km. Industries, are situated along two sides of the Koshi Highway and more densities are in Duhabi of Sunsari and Tankisiniwari of Morang. The study site starts from northern part of Itahari, Sunsari and ends in southern part of Tankisiniwari, Morang covering a length about 26 km.

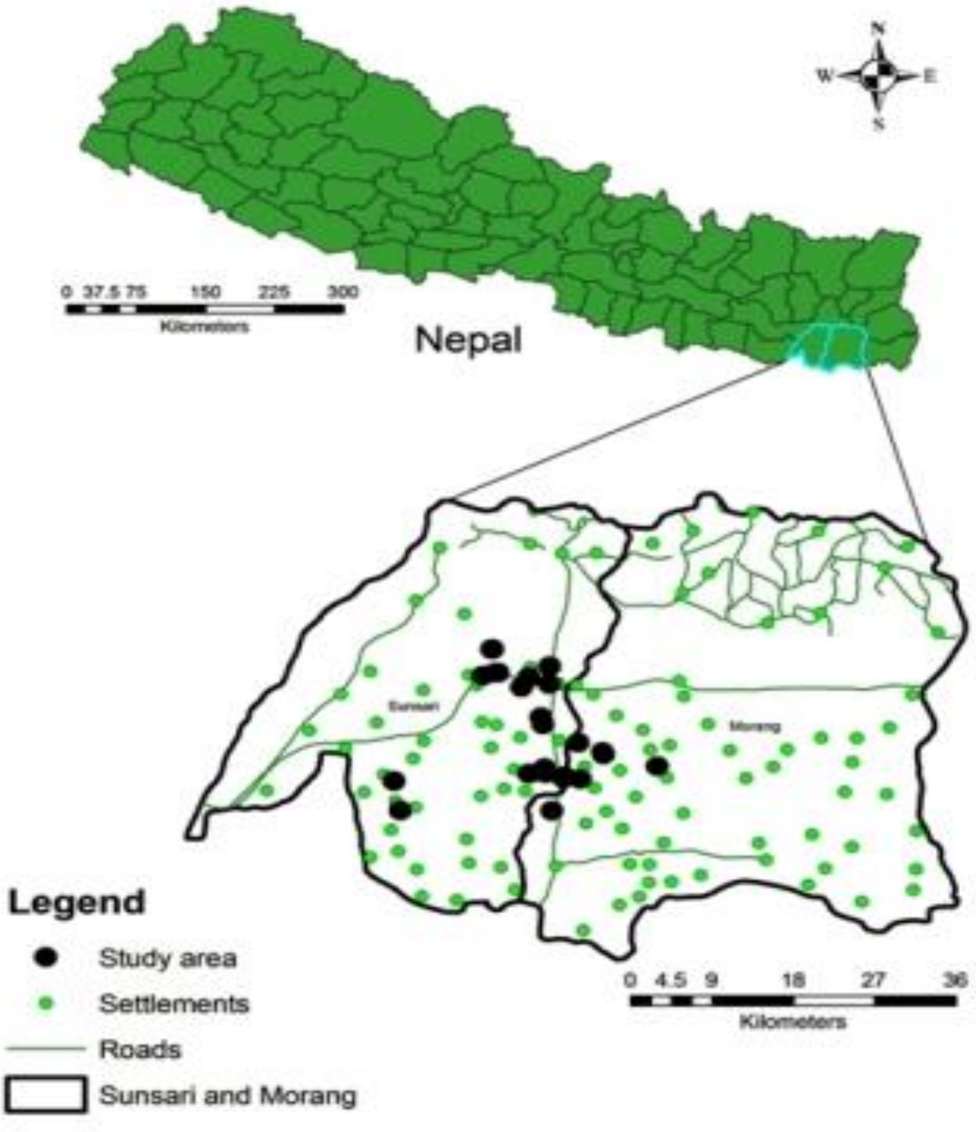


Figure 1. Map of study area

3.2. Climate

The climate of Sunsari-Morang industrial corridor is tropical monsoon. Annual average temperature, rainfall and relative humidity of Sunsari district are 27.3ºC (max.), 20.44ºC (min.), 225.875 ml, 75% respectively, whereas annual average temperature, rainfall and relative humidity of Morang district are 30.61ºC (max.), 19.85ºC (min.) 108.22 ml and 73 % respectively (DHM 2010).

3.3. Floral Diversity

A record of floral diversity of Sunsari-Morang industrial corridor was not available; therefore, with the support of local people, local flora and floral diversity of the area was compiled. In agricultural plants, Banana (*Musa paradisiacal)*, Coconut (*Cocos nucifera*), Potato (*Solanum tuberosum*), Mango (*Mangifera indica*), Jack fruit (*Artocarpus heterophyllus*), Litchi (*Litchi chinensis sonner*), Bamboo (*Bambusa tulda*), Palm tree (*Borassaus flabellifer*), Paddy (*Oryza sativa*), Maize (*Zea mays*), Mustard (*Barassica rapa*), Areca nut (*Areca catechu*), Garden pea (*Pisum sativum*), Papaya (*Carica papaya*), white jute (*Corchorus capsularis*), Sugarcane (*Saccharum officinarum*) and Wheat (*Triticum aestivum*) were the major crops. Besides agricultural plants, Sissou *Dalbergia sissoo*, Sal (*Shorea robusta*), Simal (*Bombax ceiba*), *Banyan* (*Ficus benghalensis*), Kadam (*Anthocephalus chinensis*), Peepal (*Ficus religiosa*), Bael fruit (*Aegle marmelos*), Black plum (*Syzygium cumini*), Tallow tree (*Sapium insigne*), Local mulberry (Morus bombycis) etc. were the main trees found in the area.

3.4. Faunal Diversity

Most of the study area covered with urban and sub-urban areas. During the study the faunal diversity based was compiled for field observation and identification with the support of local people. Major wild species included: Bengal Fox (*Vulpes bengalensis*) (Shaw 1800), Golden Jackal (*Canis aureus*), Rhesus Macaque (*Macaca mulata*) (Gray 1868), Small Mongoose (*Herpestes auropunctatus*) (Geoffroy Saint-Hillarie 1818), Grey Mongoose (*Herpestes edwardsi*) (Geoffroy Saint-Hillarie 1818), Tarai Grey Langur (*Semnopithecus hector*) (Desmarest 1822), Eastern house Mouse (*Mus musculus*), House Rat (*Rattus rattus*) (Linnaeus 1758), Brown Rat (*Rattus norvegicus*) (Berkenhout 1769), Shrew (*Soriculus* sp.), Porcupine (*Hystrix* sp.) and Small Civet (*Viverriculata indica*) (Desmarest 1804), Large Civet (*Viverra zibentha*) (Linnaus 1758) etc. Major bird species included Common Myna (*Acridotheres tristis*) (Linnaeus 1766), House Sparrow (*Passer rutilans*) (Temminck 1835), House Crow (*Corvus splendens*) (Vieillot 1817), Red Vented Bulbul, Red-collared Dove (*Streptopelia chinensis*), Cattle Egret (*Bubulcus ibis*) (Linnaus 1758), Eagle (*Haliaeetius* sp.), Lesser Coucal (*Centropus bengalensis*) (Gmelin 1788), Rose-ring parakeet (*Psittacula karamari*), Black Drongo (*Dicrurus macrocercus*) (Villeillot 1817), Brown Hawk Owl (*Ninox scutulata*) (Raffles 1822), Barbet, Black-corwned Night Heron (*Nycticorax nycticorax*) (Falster 1817), Fulvous-breasted Wood Pecker (*Dendrocopos maceri*) etc. Similarly herptofauna like Cobra (*Naja naja*) (Linnaeus 1758), Banded Krait (*Bungarus fasciatus*) (Schneider 1801), Common Blind Snake (*Typhlops braminus*) (Dauden 1803), Rat snake (*Ptyas mucosus*) (Linnaeus 1758), Buft Striped Keelback (*Natrix stolata*) and Bamboo Pit Viper (*Trimeresurus gramineus*) (Shaw 1802) have also been recorded from this area.

3.5 Socio-culture and Economic Status

The study area was dominated by diverse Tharu communities, which include Saptaria, Morangia, Khabas, Rautar, Halia, Majidar, Dadura ethnic groups. Beside, those, other communities like Chhetri, Brahmin, Mushar, Rai, Limbu, Tamang, Dhimal etc. are also present in the area. People of three religions; Hindu, Buddhist and Muslim reside here and they celebrate their respective festivals. The main occupation of the population of the industrial corridor is labor in factory, agriculture and business. Most of the Tharu communities live in remote areas. They are illiterate and have poor economic condition as compared to other communities. More population of Brahmin, Chhetri, Limbu and Rai live in urban areas of industrial corridor. They are comparatively literate and have higher economic status. In Tharu community there is a negative attitude toward bats, but other local peoples did not show neither positive nor negative view.

4. MATERIALS AND METHODS

4.1 Study Design

Five sampling blocks were established between Itahari and Tankisiniwari covering about 26 Km length of Sunsari-Morang industrial corridor. Total area of each block was four square kilometer. The Koshi highway had divided the study site in two equal parts at eastern and western sides. Five blocks were laid out four kilometers apart along the highway. Three blocks namely Itahari, Khanar and Duhabi were laid in Sunsari district where as two blocks Hattimuda and Tankisiniwari laid in Morang district. Vegetation and human population density in all the blocks were approximately similar but industrial density was slightly high in Duhabi and Tankisiniwari area. Altitudes of all blocks were approximately the same.

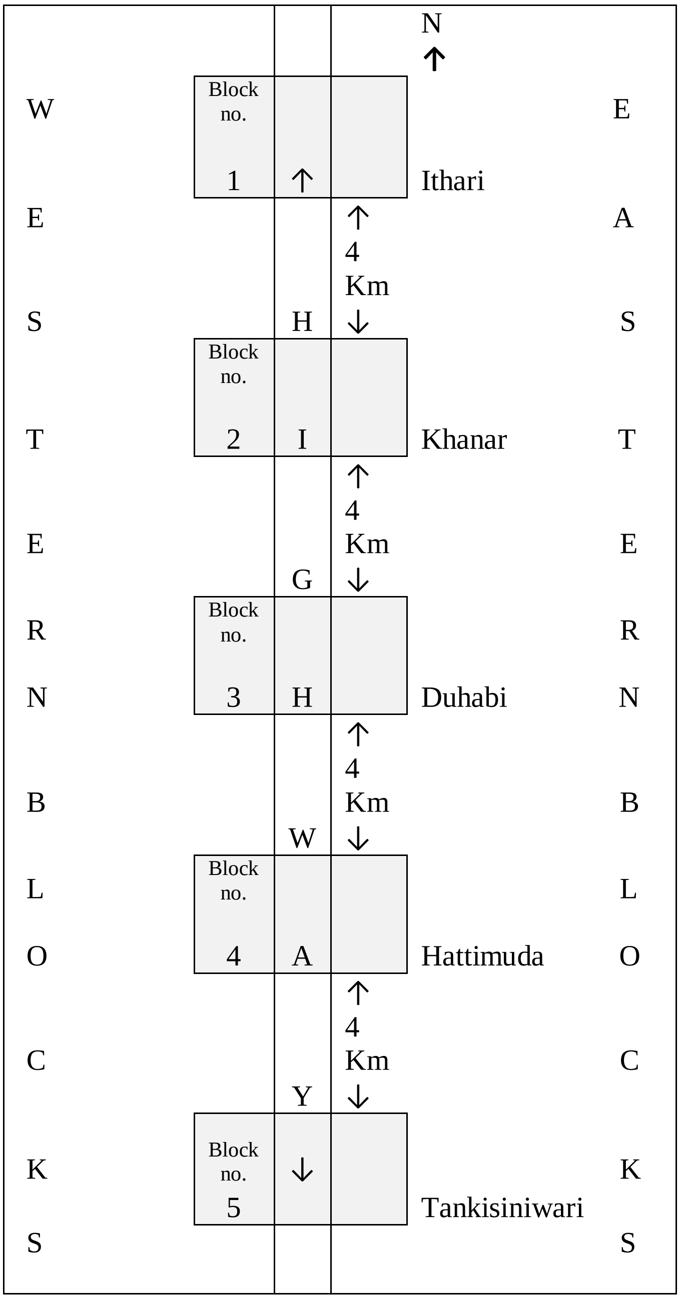


Figure 2. Diagrammatic representation of the study area.

4.2 Bat Capture and Identification

Bats were captured in each of these blocks from their roosts and also by mist netting. Diurnal roosts like banana leaves, bamboo holes, wall crevices and attics in houses were searched during the day time using focusing torch-lights. Bats were captured by hands using gloves. Mist netting was done randomly in each block. A mist net was deployed near water sources and bamboo fields before early evening to till 10 o'clock at night.

4.2.1. Morpho-metric Study

The following external measurements were taken with the help of millimeter graded steel scale to the nearest 1 mm. The body weight was measured with the help of Pesola light line spring balance graded with gram. After capturing the bats, they were identified on spot with the help of the standard taxonomic keys (Bates and Harrson 1997 and Srinivasulu et al. 2010). All bats were photographed digitally. Additionally, the reproductive stage of them was noted by observing their genitalia/ nipples. Later on, all were released immediately after the measurement.

Table 1. Symbolic representation and its meaning morphometric analysis

S.N.	Symbol	Meaning
1	HB	Head body
2	T	Tail length (from the anus to last vertebra)
3	TIB	Tibia length
4	HF	hind foot length (excluding claws)
5	FA	Forearm Length
6	E	Length of ear
7	3mt	Third metacarpal
8	4mt	Fourth metacarpal
9	5mt	Fifth metacarpal
10	1ph3mt	First Phalange Third metacarpal
11	1ph4mt	First Phalange Fourth metacarpal
12	1ph5mt	First Phalange Fifth metacarpal
13	2ph3mt	Second Phalange Third metacarpal
14	2ph4mt	Second Phalange Fourth metacarpal
15	2ph5mt	Second Phalange Fifth metacarpal
16	Thumb	Thumb length
17	WSP	Wingspan
18	NL (H)	Nose leaf height
19	NL (B)	Nose leaf Breadth

4.2.2. Specimen Collection

Some bats were unable to be identified from morphometric analysis therefore four specimen were collected for detailed anatomical study. Voucher specimens were preserved in 70% alcohol in airtight plastic bottle with a label on it and stored in the museum section of Central Department of Zoology, Tribhuvan University. After the anatomical study, specimens were identified. There was one specimen of *Taphozous longimanus*, two specimens of *Scotophillus kuhli* and one specimen of *Cynopterus sphinx* (Albino).

Table 2 List of specimens collected from the study area

S.N.	Accession No. of CDZ T.U.	Specimens Collected	No. of Individuals	Sex	Collected Place	Date of Collection
1	CDZ TU_BAT 028	*Taphozous Longinanus*	1	F	Itahari-5, Bajraha Sunsari	Sep.21,2010
2	CDZ TU_BAT 030	*Scotophillus kuhli*	2	M	Pakali-8,Tikuliatol, Sunsari	Oct. 5, 2010
3	CDZ TU_BAT 032	*Scotophillus kuhli*	1	M	Pakali-8,Tikuliatol, Sunsari	Feb. 12,2012
4	CDZ TU_BAT 033	*Cynopterus sphinx* (Albino)	1	F	Duhabi-4, Labipur Sunsari	Aug.18, 2011

4.2.3 Laboratory Preparation

Skull and baculum of the voucher specimens were prepared in the ecology laboratory of Central Department of Zoology, Tribhuvan University at Kirtipur, Kathmandu.

4.2.3.1. Baculum Preparation and Storage

Baculum of male *Scotophilus* sp. was prepared and stored as follows:

Penis of the voucher specimen was cut-off and placed in a 15 ml. plastic vile. It was transferred in a test tube half filled with cold water and was boiled and simmered for two minutes. The plastic vile half filled with 5% Potassium hydroxide (KOH) and a pinch of alizarin powder was used to stain baculum. The boiled penis was transferred to that vile and left for 24 hours to remove skin and muscles. The baculum was dissected out from the penis tissues under the dissecting microscope with fine forceps and entomological pin. The baculum was photographed using Nikon D90 camera. The length of the baculum was measured with the help of a simple vernier caliper from below of the glass slide. Their sketches were drawn by observing them in electric compound microscope. The baculum was stored in a plastic vile half filled with glycerin. The plastic vile was marked with accession number, species name, date and location of collection.

4.2.3.2. Skull Extraction and Preparation

Skull of *Scotophillus* sp. was prepared and stored as follows:

A cut was made from a corner concern of the mouth at the cheek to enlarge the hole. The facial skin was peeled off from the mandible and rostrum using forceps taking care not to damage the zygomatic arches. The skull was cut at the neck taking care not to damage it.

Cleaning: Each skull was dropped out in a glass beaker partially filled with cold water and labeled with sample number. The skull was heated gently bringing to boiling point and left for about 10 minutes in simmering heat. The boiled skull was left in the same beaker for 24 hours. The muscle in and around the skull was peeled off gently taking care of the skull. The tongue and brain were removed by forceps. The skull was cleaned as much as possible. The skull was dried in air and kept in a plastic vile. Tagging paper was stuck on the skull. The photograph of dentition was taken with the help of AROMA 52 mm close up lenses (+1, +2, +4 and macro). Nikkor 18-55 mm lenses were fitted with Nicon camera.

Craniodental Measurements: Following craniodental measurements from (Table 3) the skull was taken with the help of a dial caliper to the nearest 1 millimeter. The measurements were tallied with Srinivassulu *et al.* (2010) and Bates and Harrison (1997).

Table 3. Symbolic representation of craniodental measurements

S.N.	Representation	Meaning
1	CCL	Greatest length of skull
2	GTL	Condylo-canine length
3	BB	Breath of brain case
4	PC	Postorbital constriction
5	CM^3	Maxillary tooth row length
6	CM_3	Mandibular tooth row length
7	C^1C^1	Anterior palatal width
8	M_3 M_3	Posterior palatal width
9	RW	Rostral width
10	M	Mandible length

4.4 Population Estimation

Populations of bats were estimated by branch counting method.

4.5. Data Analysis

Species Diversity: Species diversity of bats was calculated using the Shannon-Wiener index.

Equitability (E) = H ÷ lnS

Where,

H= Shannon-Wiener diversity index and S= Number of species

Abundance and Distribution: Abundance and distribution was calculated by comparison between number of species and population in different blocks of study area.

Parametric and Nonparametric Tests: The primary data were collected during the field visits. They were analyzed qualitatively and quantitatively. Quantitative analysis was done using one way ANOVA and nonparametric tests (Kruskal-Wallis H test and Mann-Whitney U-test) entered in the SPSS version 16 to test the null hypothesis. Distribution and population of bats species remain the same seasonally in spite of seasonal temperature fluctuation. Alternatively, distribution and population of bats species vary due to seasonal temperature fluctuations.

4.6. Identification of Threats

Threats to the bats were identified by questionnaire survey and direct observation. Ten questions were asked to 15 local and ethnic people of each block using questionnaire format. Major threats were categorized by perceptions of local peoples.

A B

C D

Photo Plate 1. Bat Survey

A: *Pipistrellus* sp. inside the hollow of Bamboo in a Pakali -3, Sunsari

B: Roost of *Cynopterus sphinx* in Duhabi-5, Pasuhat

C: Mist netting in Itahari-5, Sunsari

D: Roost of *Megaderma lyra* Dangraha- 4, Morang

A

B

C

D

Photo plate 2. Awareness campaigns

A: Muslim people reading Brochures in Duhabi-4, Sunsari

B: Awareness campaigns in Post Graduate Campus Biratnagar, Morang

C: Students reading brochures in Saraha Higher Secondary School Khana-6, Sunsari

D: Awareness campaigns in Little Flowers Secondary School Itahari-5, Sunsari

A

B C

Photo Plate 3. Laboratory Work

A: Dissecting the specimens of *Scotophillus kuhli* to take out the skull

B: Boiling the skull

C: Measuring the Skull by using Vernier Caliper

5. RESULTS

5.1. Species Diversity of Bats

Altogether 9617 individuals of bats were recorded belonging to seven species in Sunsari-Morang industrial corridor during the period between September of 18, 2010 to August of 18, 2011 (Table 4). Albino bat of *Cynopterus sphinx* was recorded and collected during the time of survey as the first record for Nepal. *Scotophillus kuhli* was also recorded from the area which confirmed its occurrence in the Nepal for the first time. *Scotophillus kuhli* was identified by morphometric analyses as well as skull and baculum study. Four species of bats (*Cynopterus sphinx*, *Megaderma lyra*, *Taphozous longimanus, Scotophillus hethii* and *Pipistrellus* sp.) were identified by morphometric analysis but *Pteropus giganteus* was identified by its habitat, photographs, and roosting patterns.

Shannon-Wiener of diversity index bats in Sunsari-Morang industrial corridor was 1.11119 (Table 4). This suggested that the diversity of bats was high in this area had less. Equitability also showed good diversity of bat.

Table 4. Species diversity of bats using the Shannon-Wiener diversity index

Name of species	Population	Pi	Pilog$_2$Pi	H	e
Pteropus giganteus	1900	0.788055	0.27075	H = 1.11119	e = H÷lnS
Cynopterus sphinx	60	0.024886	0.13258		
Megaderma lyra	167	0.069266	0.26675		
Scotophillus heathii	38	0.015761	0.09435		0.57103
Scotophillus kuhli	243	0.100788	0.33361		
Pipistrellus sp.	1	0.000415	0.00466		
Taphozous longimanus	2	0.000832	0.00849		
Total	2411	1	1.11119		

Where, H= Shannon-Wiener of diversity index and e = Equitability

A total number of 21 individuals belonging to six species of bats were captured for identification and specified in detailed study purposes (Annex 6). They included two individuals of *Scotophillus kuhli* and one individual of albino *Cynopterus sphinx*. These voucher specimens were collected and destructed preserved for further study. One individual female *Taphozous longimanus* with small baby was dead during the time of morphometric analysis and was included for specimens. All the other captured individuals were released after taking the photographs and morphometric measurements.

A

B C

Photo Plate 4. Morphology and coloration of *Pteropus giganteus* and *Cynopterus sphinx*

A. Colony of *Pteropus giganteus* in Itahari- 4, Army camp

B. *Cynopterus sphinx* in Pakali-3, Kanchhichwk

C. *Cynopterus sphinx* in mist net

A

B

C

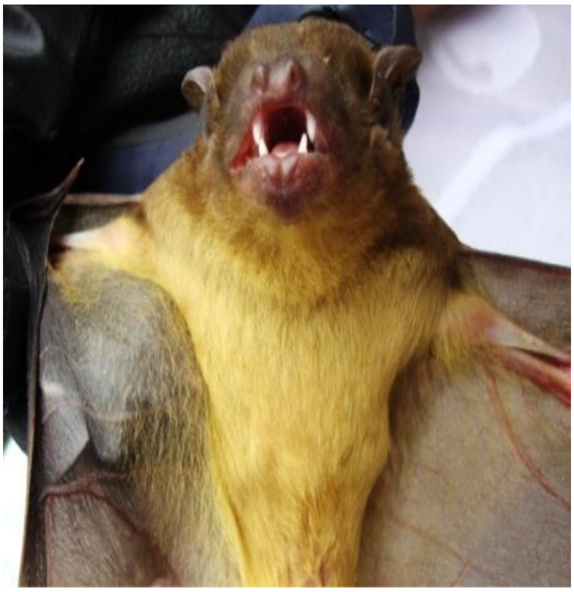
Photo Plate 5. Morphology and Coloration of *Cynopterus sphinx* (Albino), *Megaderma lyra* and *Scotophillus kuhli*

A. *Cynopterus sphinx* (Albino) in Duhabi-4, Labipur

B. *Megaderma lyra* in Dangraha- 4, Morang

C. *Scotophillus kuhli* in Pakali-8, Tukaliatol


A **B**




C D

Photo Plate 6. Morphology and Coloration of *Taphozous longimanus*, *Scotophillus heathii* and *Pipistrellus* sp.

A. Female *Taphozous longimanus* with baby in Itahari-5, Bajraha

B. Small baby of *Taphozous longimanus* in Itahari-5, Bajraha

C. *Scotophillus heathii* in Hattimuda-8, Muslimtol

D. *Pipistrellus* sp. in Duhabi-2, Prastoki

A

B

Photo Plate 7. Morphological Structure of Skull

A**.** Lower jaw of *Scotophillus kuhli* (CDZ TU_BAT 030)

B**.** Skull of *Scotophillus kuhli* (CDZ TU_BAT 032)

5.1.1. Abundance and Distribution

Seven species of bat were recorded form Sunsari-Morang industrial corroder. Six species and 6587 individuals were recorded from Ithari block. Ithari contains reach species diversity and more populations of bats. Four species and 2831individuals were recorded from Khanar block. Four species and 88 individuals of bats were recorded from Duhabi block. Species distributions of Khanar and Duhabi blocks were same but Khanar contain high population then Duhabi. Two species and 73 individuals of bats were recorded from Hattimuda block. Two species and 42 individuals of bats were reported from Tankisiniwari Block. Species diversity of both the blocks were same but block Tankisiniwari contained less population (Table 5).

Table 5. Species distribution and population size in the study area

S. N.	Name of Species	Itahari	Khanar	Duhabi	Hattimuda	Tankisiniwari	Total	Test of Homogeneity
1	*Pteropus giganteus*	5500	2100	0	0	0	7600	Levene statistic 4.71351932
2	*Cynopterus sphinx*	74	23	79	25	24	225	
3	*Cynopterus sphinx* (Albino)	0	0	1	0	0	1	
4	*Megaderma lyra*	0	670	0	0	0	670	df_1 4
5	*Scotophillus heathii*	35	38	0	48	14	135	df_2 30
6	*Scotophillus kuhli*	970	0	5	0	0	975	Significance 0.05
7	*Taphozous langimanus*	7	0	0	0	0	7	
8	*Pipistrellus* spp.	1	0	3	0	0	4	
Grand Total							9617	

Population of bat species in the five study blocks of Sunsari-Morang industrial corridor was homogenously distributed (Table 5). One way ANOVA showed that the null hypothesis did not stand (P>0.05). The result was in favor of alternative hypothesis - population distributions of bats in the five study blocks were not the same (Table 6).

Table 6. One way ANOVA in population of bats and five study blocks

	Sum of square	df	Mean of square	f	Significance Level
Between groups	4703426	4	1175856.457	1.228128	0.32
Within groups	28723147	30	957438.2286		
Total	33426573	34			

All values of significance of multiple comparison of the population distribution of bats of the five study blocks supported the alternative hypothesis (Table 7). However the population distributions of bats of all study blocks were not the same. This was because the habitat and industrial pollution were not similar in different study blocks; hence, it might have affected the population distribution of bats in those places.

Table 7. Multiple comparisons of the population distribution of bats in five study blocks of Sunsari-Morang industrial corridor

(I) Plots Itahari to Tankisiniwari	(J) Plots Itahari to Tankisiniwari	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Itahari	Khanar	536.57143	5.23E+02	0.313	-531.5854	1604.7283
	Duhabi	928.57143	5.23E+02	0.086	-139.5854	1996.7283
	Hattimuda	930.57143	5.23E+02	0.085	-137.5854	1998.7283
	Tankisiniwari	935.57143	5.23E+02	0.084	-132.5854	2003.7283
Khanar	Itahari	-536.57143	5.23E+02	0.313	-1604.7283	531.5854
	Duhabi	392	5.23E+02	0.459	-676.1569	1460.1569
	Hattimuda	394	5.23E+02	0.457	-674.1569	1462.1569
	Tankisiniwari	399	5.23E+02	0.451	-669.1569	1467.1569
Duhabi	Itahari	-928.57143	5.23E+02	0.086	-1996.7283	139.5854
	Khanar	-392	5.23E+02	0.459	-1460.1569	676.1569
	Hattimuda	2	5.23E+02	0.997	-1066.1569	1070.1569
	Tankisiniwari	7	5.23E+02	0.989	-1061.1569	1075.1569
Hattimuda	Itahari	-930.57143	5.23E+02	0.085	-1998.7283	137.5854
	Khanar	-394	5.23E+02	0.457	-1462.1569	674.1569
	Duhabi	-2	5.23E+02	0.997	-1070.1569	1066.1569
	Tankisiniwari	5	5.23E+02	0.992	-1063.1569	1073.1569
Tankisiniwari	Itahari	-935.57143	5.23E+02	0.084	-2003.7283	132.5854
	Khanar	-399	5.23E+02	0.451	-1467.1569	669.1569
	Duhabi	-7	5.23E+02	0.989	-1075.1569	1061.1569

	Hattimuda	-5	5.23E+02	0.992	-1073.1569	1063.1569

5.1.3 Distribution Pattern of Species of Bats in Five Study Blocks

Ithari block was rich in species diversity but Hattimuda and Tankisiniwari had less species diversity (Table 8).

Table 8. Number of species distribution of bat in five study blocks

Seasons	Study Blocks				
	Itahari	Khanar	Duhabi	Hattimuda	Tankisiniwari
Sep 18 to Oct15, 2010 (32.76 ^{o}C)	6	4	3	2	2
Jan 4 to Feb 2, 2011 (15.87^{o} C)	5	3	1	1	2
May 3 to May 31, 2011 (34.76^{o} C)	5	4	2	2	1
July 20 to Aug 18, 2011 (35.71^{o} C)	5	4	2	2	2

Table 9. Test of homogeneity of variances of number of species and blocks

Normal form				Log transform				Square root transform			
Levene statistic	df1	df2	Signi. (P)	Levene statistic	df1	df2	Signi. (P)	Levene statistic	df1	df2	Signi. (P)
0.107	4	15	0.978	1.541	4	15	0.241	0.637	4	15	0.644

Data of bat species in five study blocks were not homogenously distributed in normal conditions as well as in log and square root transform method (Table 9). A nonparametric test (Kruskal-Wallis Test) was used to determine the variation of bat. Species diversity in five study blocks was varied from site to site (Table 10).

Table 10. Number of species present in each block and temperature

Rank				Test statistics[ab]	
	Blocks	N	Mean rank		No. of Species
Number of Species	Itahari	4	18.5	Chi-square	15.368
	Khanar	4	14.5		
	Duhabi	4	6.5	df	4
	Hattimuda	4	6.5		
	Tankisiniwari	4	6.5	Asymptote Significance	0.04
	Total	20			

Where, a. Kruskal-Wallis Test. b. Grouping Variable: Block

Table 11. Multiple comparisons between species distribution of bats and five study blocks

Rank					Test statistics[b]	
	Blocks	N	Mean rank	Sum of rank		Number of species
Number Of Species	Itahari	4	6.5	26	Mann-Whitney U	0
					Wilcoxon W	10
	Khanar	4	2.5	10	Z	-2.366
					Asymptote Sig. (2-tailed)	0.018
	Total	8			Exact Sig. [2*(1-tailed Sig.)]	0.029[a]
Number Of Species					Mann-Whitney U	0
	Itahari	4	6.5	26	Wilcoxon W	10
	Duhabi	4	2.5	10	Z	-2.309
					Asymptote Sig. (2-tailed)	0.021
	Total	8			Exact Sig. [2*(1-tailed Sig.)]	0.029[a]
Number Of Species					Mann-Whitney U	0
	Itahari	4	6.5	26	Wilcoxon W	10
	Hattimuda	4	2.5	10	Z	-2.366
					Asymptote Sig. (2-tailed)	0.018
	Total	8			Exact Sig. [2*(1-tailed Sig.)]	0.029[a]
Number Of Species					Mann-Whitney U	0
	Itahari	4	6.5	26	Wilcoxon W	10
	Tankisiniwari	4	2.5	10	Z	-2.366
					Asymptote Sig. (2-tailed)	0.18
	Total	8			Exact Sig. [2*(1-tailed Sig.)]	0.029[a]
Number Of Species					Mann-Whitney U	0
	Khanar	4	6.5	26	Wilcoxon W	10
	Duhabi	4	2.5	10	Z	-2.366
					Asymptote Sig. (2-tailed)	0.18
	Total	8			Exact Sig. [2*(1-tailed Sig.)]	0.029[a]
Number Of Species					Mann-Whitney U	0
	Khanar	4	6.5	26	Wilcoxon W	10
	Hattimuda	4	2.5	10	Z	-2.366
					Asymptote Sig. (2-tailed)	0.18
	Total	8			Exact Sig. [2*(1-tailed Sig.)]	0.029[a]
Number Of Species					Mann-Whitney U	0
	Khanar	4	6.5	26	Wilcoxon W	10
	Tankisiniwari	4	2.5	10	Z	-2.366
					Asymptote Sig. (2-tailed)	0.18
	Total	8			Exact Sig. [2*(1-tailed Sig.)]	0.029[a]
Number Of Species					Mann-Whitney U	8
	Duhabi	4	4.5	18.5	Wilcoxon W	18
	Hattimuda	4	4.5	18.5	Z	0
					Asymptote Sig. (2-tailed)	1
	Total	8			Exact Sig. [2*(1-tailed Sig.)]	1.0[a]
Number Of Species					Mann-Whitney U	8
	Duhabi	4	4.5	18.5	Wilcoxon W	18
	Tankisiniwari	4	4.5	18.5	Z	0
					Asymptote Sig. (2-tailed)	1
	Total	8			Exact Sig. [2*(1-tailed Sig.)]	1.0[a]
Number Of Species					Mann-Whitney U	8
	Hattimuda	4	6.5	26	Wilcoxon W	10
	Tankisiniwari	4	2.5	10	Z	-2.428
					Asymptote Sig. (2-tailed)	0.015
	Total	8			Exact Sig. [2*(1-tailed Sig.)]	0.029[a]

Where, a. Not corrected for ties. b. Grouping Variable: Blocks

A Multiple comparison between species diversity and the study blocks by using Mann-Whitney test showed two types of results. There was significant difference ($P < 0.05$) in comparison between all most all study blocks namely; Itahari and Khanar, Itahari and Duhabi, Itahari and Hattimuda, Itahari and Tankisiniwari, Khanar and Duhabi, Khanar and Hattimuda, and Khanar and Tankisiniwari (Table 11).

It indicated a similar distribution of species in these blocks. However, there was no significance ($P > 0.05$) in between Duhabi and Hattimuda, Duhabi and Tankisiniwari and Hattimuda and Tankisiniwari suggesting species distribution of these blocks were not the same (Table 11).

5.2. Seasonal Variations: Impact of Temperature on Bats Diversity

Numbers of individuals of all species of bats in Sunsari-Morang industrial corridor fluctuated due to the change of seasonal temperature (Table 12). Altogether, 2781 individuals of bats species were counted. During summer season represent high temperature (35.71^{o} C), 1653 individuals of bats were counted. During winter season which represent low temperature (15.87^{o}C). During the full (32.76^{o}C), 2597 individuals of bats and spring (34.76^{o}C) 2618 individuals of bats were counted. During the summer and full the numbers of individuals of bat were nearly same.

Table 12. Population of bats in different seasons of Sunsari-Morang industrial corridor

S. N.	Name of species	Average temperature in different Season			
		Fall (Sep 18 to Oct 1 5, 2010) 32.76 ^{0} C	Winter (Jan 4 to Feb 2, 2011) 15.87^{0} C	Spring (May 3 to May 31, 2011) 34.76^{0} C	Summer (July 20 to Aug 18 2011) 35.71^{o} C
1	*Pteropus giganteus*	1950	1300	2100	2250
2	*Cynopterus sphinx*	50	40	72	78
3	*Megaderma lyra*	150	120	200	200
4	*Scotophillus heathii*	36	22	45	50
5	*Scotophillus kuhli*	405	170	200	200
6	*Pipistrellus sp.*	4	0	0	0
7	*Taphozous longimanus*	2	1	1	3

Analysis of Variance (ANOVA) was not applicable to test the relationship between population of bats and temperature because the population of bats were not homogenously distributed in normal conditions (P= 0.847) and log (P= 0.769) and square root (P= 0.793) transformations (Table 13).

Table 13. Test of homogeneity of variances on population of bats and temperature

Normal form				**Log transform**				**Square root transform**			
Levene statistic	df1	df2	Signi. (P)	Levene statistic	df1	df2	Signi. (P)	Levene statistic	df1	df2	Signi. (P)
0.27	3	24	0.847	0.379	3	24	0.769	0.075	3	24	0.793

Non-parametric test (Kruskal-Wallis H) that determines the effect of temperature on population of bats showed asymptote significances (P = 0.898) (Table 14). The hypothesis, “Abundance and distribution of bats in industrial corridor remain the same seasonally” did not have adequate support indicating population densities of bats in Sunsari-Morang industrial corridor fluctuated seasonally.

Table 14. Kruskal-Wallis test on population distribution of bats and temperature

Rank				**Test statistics[a,b]**	
	Temperature	N	Mean rank		Population
Populations	32.76° C	7	15.07	Chi-square	0.594
	15.87° C	7	12.50		
	34.76° C	7	14.79	df	3
	35.71° C	7	15.64	Asymptote Significance	0.898
	Total	28			

a. Kruskal-Wallis Test. b. Grouping Variable: Temperature.

Multiple comparison of four seasonal temperatures and population of bats using Mann-Whitney U test results did not support the null hypothesis because the values of extract significance [2*(1-tailed Sig.)] were not above in the 95% confidence level (P> 0.05) (Table 15). Changes in temperatures affected the population of all species of bats in Sunsari-Morang industrial corridor.

Table 15. Multiple comparisons between population distribution of bats and temperature variation in Sunsari-Morang industrial corridor

Rank					Test statistics[b]	
	Temperature in	N	Mean rank	Sum of rank		Population
	32.76 ° C	7	8.14	57	Mann-Whitney U	20
Population					Wilcoxon W	48
	15.87 ° C	7	6.86	48	Z	-0.575
					Asymptote Sig. (2-tailed)	0.565
	Total	14			Exact Sig. [2*(1-tailed Sig.)]	0.62[a]
	32.76 ° C	7	7.57	53	Mann-Whitney U	24
					Wilcoxon W	52
Population	34.76 ° C	7	7.43	52	Z	-0.064
					Asymptote Sig. (2-tailed)	0.949
	Total	14			Exact Sig. [2*(1-tailed Sig.)]	1.00[a]
					Mann-Whitney U	23.5
	32.76 ° C	7	7.36	51.5	Wilcoxon W	51.5
Population	35.71 ° C	7	7.64	53.5	Z	-0.128
					Asymptote Sig. (2-tailed)	0.898
	Total	14			Exact Sig. [2*(1-tailed Sig.)]	0.902[a]
					Mann-Whitney U	20
	15.87° C	7	6.86	48	Wilcoxon W	48
Population	34.86° C	7	8.14	57	Z	-0.577
					Asymptote Sig. (2-tailed)	0.564
	Total	14			Exact Sig. [2*(1-tailed Sig.)]	0.52[a]
					Mann-Whitney U	19.5
	15.87° C	7	6.79	47.5	Wilcoxon W	47.5
Population	35.71° C	7	8.21	57.5	Z	-0.64
					Asymptote. Sig. (2-tailed)	0.522
	Total	14			Exact Sig. [2*(1-tailed Sig.)]	0.535[a]
					Mann-Whitney U	22.5
	34.76° C	7	7.21	50.5	Wilcoxon W	50.5
Population	35.71° C	7	7.79	54.5	Z	-0.259
					Asymptote Sig. (2-tailed)	0.796
	Total	14			Exact Sig. [2*(1-tailed Sig.)]	0.805[a]

Where, a. Not corrected for ties. b. Grouping Variable: Blocks

Multiple comparison of seasonal temperature and species wise population distribution of bats did not support null hypothesis with 95% confidence level. Population of seven species of bats present in the study area fluctuated seasonally (Table 16). The rate fluctuation of all species of bats in Sunsari-Morang industrial corridor were the same.

Table 16. Comparisons between population distribution of bats and temperature variation in Sunsari-Morang industrial corridor

Rank				Test statistics[a,b]	
	Seasonal Temperature	N	Mean rank		Population of *P. gigantus*
Population Of *Pteropus Gigantus*	32.76° C	1	2	Chi-square	3
	15.87° C	1	1		
	34.76° C	1	3	Df	3
	35.71° C	1	4	Asymptote Significance	0.392
	Total	4			
	Seasonal Temperature	N	Mean rank		Population of *C. sphinx*
Population Of *Cynopterus Sphinx*	32.76° C	1	2	Chi-square	3
	15.87° C	1	1		
	34.76° C	1	3	Df	3
	35.71° C	1	4	Asymptote Significance	0.392
	Total	4			
	Seasonal Temperature	N	Mean rank		Population of *M. lyra*
Population Of *Megaderma Lyra*	32.76° C	1	2	Chi-square	3
	15.87° C	1	1		
	34.76° C	1	3.5	Df	3
	35.71° C	1	3.5	Asymptote Significance	0.392
	Total	4			
	Seasonal Temperature	N	Mean rank		Population of *S. heathii*
Population Of *Pteropus Heathii*	32.76° C	1	2	Chi-square	3
	15.87° C	1	1		
	34.76° C	1	3	Df	3
	35.71° C	1	4	Asymptote Significance	0.392
	Total	4			
	Seasonal Temperature	N	Mean rank		Population of *S. kuhli*
Population Of *Scotophillus Kuhli*	32.76° C	1	2	Chi-square	3
	15.87° C	1	1		
	34.76° C	1	2.5	Df	3
	35.71° C	1	2.5	Asymptote Significance	0.392
	Total	4			
	Seasonal Temperature	N	Mean rank		Population of *Pipistrellus* sp.
Population Of *Pipistrellus* sp.	32.76° C	1	3	Chi-square	3
	15.87° C	1	1.5		
	34.76° C	1	1.5	Df	3
	35.71° C	1	4	Asymptote Significance	0.392
	Total	4			
	Seasonal Temperature	N	Mean rank		Population of *T. longimanus*
Population Of *Taphozous Longimanus*	32.76° C	1	3	Chi-square	3
	15.87° C	1	1.5		
	34.76° C	1	1.5	Df	3
	35.71° C	1	4	Asymptote Significance	0.392
	Total	4			

Where , a. Kruskal-Wallis Test. b. Grouping Variable: Temperature.

5.3. Anthropogenic Threats to Bats Diversity

The main anthropogenic threat on bats in Sunsari-Morang industrial corridor was habitat destruction (Table 17). Habitats of bats were continuously decreasing due to destruction of large trees and replacement of old wooden houses and bamboo cottages by modern concrete houses. Poaching of bats for the feeding purpose by some ethnic groups like Chaudhary, Satar, Rai, Kicchhak (Chidimar) was also a major threat to the bats. Orthodox belief of medicinal use of bats for edema, tuberculosis, cancer, urine problems and different diseases of domestic animals was also a major concern in bat conservation. Other threats included negative attitude in local people, poaching recklessly, habitat disturbance of the bats, use of pesticides and insecticides in agricultural field etc.

Table 17. Threats of bats conservation in Sunsari-Morang industrial corridor

(Note: The scale was (Medium and High) determined by qualitative analysis of day to day basis field observation only)

S.N.	Sites	Threats	Impacts	Scale	Remarks
1.	Itahari	a. Habitat destruction b. Poaching c. Human population growth d. Predation e. Negative attitudes	Population decline Shifting habitat	Medium	Urban area
2.	Khanar	a. Habitat destruction b. Medicinal use c. Lack of awareness d. Pollution rise e. Uses of pesticides f. Negative attitudes	Death Population decline Shifting habitat	High	Less settlement More agriculture field
3.	Duhabi	a. Deforestation b. Pollution rise c. Poaching d. Lack of awareness e. Negative attitudes	Population decline Death and shifting habitat	Medium	Industrial area Less settlement
4.	Hattimuda	a. Habitat destruction b. Lack of awareness c. Pollution rise d. Uses of pesticides e. Pollution rise f. Negative attitudes	Population decline Shifting habitat	High	Agricultural Field Less settlement
5.	Tankisiniwari	a. Habitat destruction b. Negative attitudes c. Predation d. Pollution rise e. Negative attitudes	Population decline Shifting habitat	High	Sub-urban area with industries

6. DISCUSSION

6.1 Distribution and Species Diversity

A total of seven species and 9617 individuals of bats were recorded in 52 SqKm area of Sunsari-Morang industrial corridor. This represented a high Shannon and Weiner function of species diversity. Among the seven species, Albino *Cynopterus sphinx* was the first record from Nepal. Altogether, six species of albino bats are reported from Indian subcontinent till date and now this species has been added as the seventh species to the list of albino bat species. Among the six species of albino bats so for recorded in the Indian sub continent were *Rousettus leschenautli*, *Rhinopoma microphyllum, Rhinopoma hardwickii*, *Hipposideros sp.*, *Hipposideros lankadiva* and *Hipposideros diadema lincobarensis* (Devacar *et al*. 2011). Most bat species in which albino individuals have been recorded are known to occupy sheltered roost like caves, mines, building and gallery (Uidea 2000). Beside Indian subcontinent albinism such as the *Molossus molossus*, *Eumopus goucinus, Desmodus rotundus*, *Attibeus palanirostris* and *Rhinophylla pumilio* are reported in Brazil (Gervais1856, Oliveir and Aguiar 2008).

Scotophillus kuhli was observed, recorded, and collected for the first time in Nepal confirming its occurrence here particularly in Sunsari-Morang area. *Scotophillus kuhlii* ranges through much of South Asia, Southern China and Southeast Asia (IUCN 2011). In South Asia, it is presently known from Bangladesh (Chittagong, Khulna and Sylhet divisions). In it is reported from India (Andaman and Nicobar Islands, Andhra Pradesh, Assam, Bihar, Gujarat, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand and West Bengal), similarly in Pakistan (Punjab and Sind) and in Sri Lanka (Central, Eastern, Northern, North Central and Uva provinces) have also been reported for their presence (Khan 2001, Das 2003, Vanitharani 2006, Korad *et al.* 2007). The occurrence of the *Scotophillus kuhlii* in Nepal was based on speculation on Corbet and Hill (1992). Suwal *et al.* (1995) enumerated this species to the mammals of Nepal citing Corbet and Hill (1992). The speculations continued for same time but there was no specific but without specifying the site of occurrence (Shrestha 1997, Thapa 2010, Acharya et al. 2010, IUCN 2011). Following Shrestha (1997), some authors have included the species in the list of mammals that occur in Raxaul-Birgunj (Molur *et al.* 2002) or in the whole Tarai region

(Baral and Shah 2008), however, there had been no record of the species from Nepal either as a collected specimen or a photograph. Many colonies of *Scotophillus heathii* also recorded form Sunsari-Morang industrial corridor. It is the second common species in this area. All colonies of this species were rested in roof and wall of wooden houses. Beside Sunsari-Morang industrial corridor *Scotophillus heathii* was recorded from Kalabanjar (Dahal 2010), Jhapa (Thapa 2009), Raxaual (Johnson *et al.* 1980), Bardia National Park (Suwal et al. 1995), Banke and Dang (Mitchell 1980) and Chitwan National Park (Myers et al. 2000).

Abundance of *Pteropus gigantus* was more during the time of survey. Two colonies were recorded in Sunsari-Morang industrial corridor. The colony present in army camp in Ithari (N 26°39'56.52", E 87° 16'31.99" and elevation 114 m) was larger than the colony present in Dangraha, Morang (N 26°35'14.7", E 87° 19'44" and elevation 77m). Similarly, it was also reported from Dharan (Shrestha 1997), Jhapa (Bates and Harrison 1997), Biratnagar, Jhapa and Koshi Tappu Wildlife Reserve (Thapa 2010).

Cynopterus sphinx was a common species in Sunsari-Morang industrial corridor. More colonies and population were recorded from Ithari block. Besides that Sunsari-Morang industrial corridor *Cynopterus sphinx* was also recorded from Makalu Barun National Park, (Suwal *et al.* 1995), Kalabanjar (Dahal 2010), Koshi Tappu (Thapa 2010), Sankhuwashawa (Dahal and Thapa 2010) and Taplejung and Sankhuwashawa (Acharya 2010) of eastern Nepal.

A large colony of *Megaderma lyra* with an average population of 168 was reported from Dangaraha of Khanar block (N 26º35'5.5", E 87º19'46.9" at an elevation of 82m). It was also reported form Jhapa (Bahundangi and Taaghandubba), Morang (Biratnagar), and Sunsari (Kusaha) (Thapa 2009), Sindhupalchowk and Kathmandu (Bates and Harrison 1997), Shivapuri-Nagarjun National Park (Csorba 1999), Shivapuri-Nagarjun National Park (Malla 2000) and Ilam and Sahkuwashawa(Acharya 2010).

Single colony with three individuals of *Taphozous longimanus* was found in Ithari block (N 26°39'43.49", E 87°14'53.47" at an elevation of 110 m). the colony was situated in palm tree. It was rare species in this area. It was also reported from Jhapa (Mitchell and Shah 1966 and 1969) and Biratnagar (Thapa et al. 2010).

Single colony with 3 individuals of *Pipistrellus* sp. was found in Duhabi block and single individual from in Ithari block. Both colonies were situated inside a bamboo hole. This species are reported from other areas of terai and mountain areas.

Populations of bats distributions of the five study blocks were not same. It might been affected due to the structure of habitat, industrial pollution and other threats. The multiple comparisons of population density and study block more variation in between Ithari and Hattimuda and less variation in between Hattimuda and Tankisiniwari. It may affected by industrial pollution, Ithari block is less polluted area but Hattimuda and Tankisiniwari are more polluted area due to cause of more industries. Species distributions of five study blocks were not the same; more species were recorded from Ithari block than from Hattimuda and Tankisiniwari blocks (Table 9).

6.2 Impact of Temperature on Population and Species Diversity of Bats

Population density and species diversity of bats fluctuated seasonally due to the change in seasonal temperature. The rates of fluctuation of every species of industrial corridor were same. Seasonal variation of *Pteropus gigantus* and *Cynopterus sphinx* were also seen in north eastern districts of Rawalpindi (Noureen et al.2011). Roosting pattern of bats were change according to seasonal temperature (Welbergen 2005, Zortea and Alho 2008).

6.3 Anthropogenic Threats on Bats

Habitat destruction was the main anthropogenic threats to bats. Besides that, habitat destruction negative attitudes, pollution, poaching, uses of pesticides, human population rise and uses of pesticides were other anthropogenic threats in Sunsari-Morang industrial area. To neutralize anthropogenic threats, awareness programs were conducted in ten schools, one post graduated campus and two ethnic communities of Morang-Sunsari industrial corridor. Among ten schools, four were governmental and six were public schools. Ethnic communities included Muslim communities of Duhabi-5 Pasuhat and Chaudhary community of Pakali-8 Tikuliatol. Beside the awareness programs, brochures and posters were distributed among the local communities and school children.

7. CONCLUSIONS AND RECOMMENDATIONS

A total number of seven species and 9469 individuals of bats were reported during the time of this study. Among them *Cynopterus sphinx* was recorded as the first albino bat for Nepal. Similarly, *Scotophillus kuhli* was confirmed for the first time from Nepal. Roost survey was concluded as better technique for bats survey comparatively to mistnets in the study area. Shannon-Wiener species diversity was 1.11119 (Table 5) which suggested a rich diversity of bats in Sunsari-Morang industrial corridor. Seasonal population distribution and block wise species distribution of bats were not homogeneous (Table 15). Nonparametric tests (Kruskal-Wallis H test and Mann-Whitney U test) were applicable and they showed but the population distribution of bats in the study blocks were analyzed using parametric tests (One way ANOVA). Seasonal fluctuation was found in population density of bats caused by temperature (Tables 6, 7, 8, 9, 10, 11, 15, 16 and 17) Seasonal fluctuation of species diversity of bats was not observed in the study site but they varied in different study blocks. Population density and species diversity of bats in Sunsari-Morang industrial corridor were affected mainly by anthropogenic threats caused by local people and industrial pollution. Habitat destruction and uses of pesticides in the agricultural fields, and industrial pollution were major anthropogenic threats to bats (Table 18). Overall conclusion of the study was that the bat populations in Sunsari-Morang Industrial Corridor were affected by seasonal variation and hence the populations of different species of bats regularly fluctuated all the year round.

Based on this study the following recommendations are suggested:

- Detailed monitoring of bats bat is necessary, which may provide new records of bat species for Nepal.
- A detailed study is required, determining the relationship between temperature and population of bat species.
- Researches, awareness campaign and national policies are required for proper bat conservation.

8. REFERENCES

Abe, H. 1971. Small Mammals of Central Nepal. Mammalia Journal of, Hokkaido Univ., Japan 56: 396-403.

Acharya, P. R. 2006. Distribution of the Roosting and Survival and Survival Threats of Bats in Pokhara Valley with Reference to Species and Population Survey at Chamere Gupha. M.Sc. Thesis. Central Department of Zoology, Tribhuvan University Kathmandu, Nepal.

Acharya, P. R. and L. A. Ruedas. 2007. The Bat Fauna of Nepal: A Current Conspectus. BAT NET-CCINSA Newsletter 8 (1-2): 19-20.

Achraya, P. R. 2008. Status and distribution of Indian flying fox in Kathmandu valley, Nepal. BAT NEST-CCINSA Newsletter 9 (1-2): 19-20.

Acharya, P. R., H. Adhikari, S. Dahal, A. Thapa and S. Thapa. 2010. Bats of Nepal, A field guide. Small Mammals Conservation and Research Foundation, New Baneswor, Kathmandu, Nepal Pages 116.

Adhikari, H. 2010. Species richness, distribution and threat of bats in (Palpa and Kaski district) of Western Nepal. A report submitted to Chester Zoo.

Agrawal, V. C. and S. Chakraborty. 1971. Notes on a collection of Small Mammals from Nepal, with a description of a new mouse-hare (Logomorpha: Ochotonidae). In Proceedings of Zoological Society of Calcutta 24(1): 41-46.

Avery, M. I. 1985. Winter activity of pipistrelle bats. Journal of Animal Ecology 54: 721-738.

Baral, H.S. and K.B. Shah. 2008. Wild mammals of Nepal. Himalayan Nature, Kathmandu Pages 157.

Bates, P.J.J. and D.L. Harrison. 1997. Bats of Indian Sub-Continent, Harrison Zoological Museum Publication Pages 215.

Catto, C. M. C., P. A. Racey and P. J. Stephenson. 1995. Activity pattern of the serotine bat (Eptesicus serotinus) at a roost in southern England. Journal of Zoology 235: 635-644.

Chesemore, D.L. 1970. Notes on mammals of southern Nepal. Journal of Mammalogy 51: 162-166.

Corbet, G. B. and J. E. Hill. 1992. The Mammals of the Indomalayan Region. Natural History Museum Pages 488.

Csorba. G., S. V. Kruskop and A. V. Borissenko. 1999. Recent record of bats Chiroptera from Nepal, with remarks on their natural history, Mammalia, 63(1): 61-78.

Dahal D. R. and S. Thapa. 2010. Monitoring of Bats in Sankhuwasava District of Eastern Nepal. Small Mammals Conservation and Research Foundation New Baneswor, Kathmandu, Nepal, Pages 18.

Devkar R. V., Tayaraman S., Upadhyay K. & Patel P. Albino Microchirochiropteran *Rhinopoma microphyllum* Kinneri, sighted in bat colony inhabiting abundoned mines. Current Science Vol. 100, No 2, 25 January 2011. www.ias.ac.in . Downloaded at 9 August 2011.

DHM, 2010. Climatological and Agrometerological Records 2010. Department of Hydrology and meteorology, Ministry of Environment Science and technology Kathmandu Nepal.

Diltz, M. 2006. Influence of reproduction on thermoregulation, food intake and foraging strategies of free-ranging female and male Daudenton's bats, *Myotis daubentonii* (Vespertilionidae). PhD Thesis, University of Ulm, Germany.

Eby, P. 1991. Seasonal movement of Grey-headed flying foxes, *Pteropus poliocephalus* (Chiroptera: Pteropididae), from two maternity camps in northern New South Wales. Wildlife Research 18: 547-559.

Eidels, R. 2010. Bats and insecticides documenting toxins in the environment. Bat Newsletter 29 (3).

Encarnacaol, J. A., U. Kierdorf and V. Wolters. 2006. Seasonal variation in nocturnal activity of male Daubenton's bats, *Myotis dubentonii* (Chiroptera: Vespertilionidae). Folia Zool. 55(3): 237-246.

Flaming, T. H. and P. Eby. 2003. Ecology of bat migration. *In* Kunz, T.Hand Fenton, M. B. (Editors). Bat ecology . University Chicago Press, Chicago, Illinos. Pages 156-208.

Frick, F. 1969. Die Hohenstufenverteilung der Nepalischen Saugetiere. Saugetierkdal. Mitt 17(2): 161-173.

Fry, T. B. 1925. Report no. 37 a: Nepal. Bombay Natural history society's Mammals survey of India, Burma and Ceylon. Journal of Bombay Natural Hist. Soc. 30: 525-530.

Ghimere, R., S. Acharya and S. B. Thapa. 2010. Monitoring of Chiropteran Status in Tanahun District. Small Mammals Conservation Club, Central Department of Environmental Science, Tribhuvan University, Kirtipur, Kathmandu, Nepal, phage 39.

Hinton, M. A. C. and T. B. Fry. 1923. Report no. 37: Nepal. Bombay Natural History Society's Mammals Survey in India, Burma and Ceylon. Journal of Bombay Natural History Society 29: 399-428.

Hodgson, B. H. 1835. Synopsis of the Vespertilionidae of Nepal. Journal of Asiatic Society of Bengal 4: 699-701.

Hristov, N., M. Betke, D. E. H. Theriault, A. Bagchi, and T. H. Kuntz. 2010. Seasonal variation in colony size of Brazilian free-tailed bats at Carlbad Cavern based on thermal imaging. Journal of Mammalogy 91(1): 183-192.

Huston, T. 2006. Bats and climate change. Inf. Eurobats. AC.11.30. keep website too.
Jaroli, D. P., M. M. Mahawar and N. Vyas. 2010. An ethnozoological study in the adjoining areas of Mount Abu wildlife security, India. Journal of Ethnobiology and Ethnomedicine 6:6 doi. http://www.ethnobiomed.com/content/6/1/6.

Johnson, D. H., S. D. Ripley and K. Thonglongya. 1980. Mammals of Nepal. Journal of Bombay Natural History Society 77: 56-63.

Kock, D. 1996. Fledermause aus Nepal (Mammalia: Chiroptera). Senckenbergiana boil. 67(1-3): 37-42.

Koju, N. P. 2008. Population Status General Behavior and Threats of Flying Fox (Pteropus giganteus) in Sallghari, Bhaktapur, Nepal. M.Sc. Thesis. Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Koopman, K. F. 1973. Significant range extension form philetor (Chiroptera, Vaspertilionidae) with remarks on geographical variation. Journal of Mammalogy 64(3): 225-226.

Koopman, K. F. 1983. Significant range extension for Philetor (Chiroptera, Vespertilionidae) with remarks of geographical variation. Journal of Mammal 64(3): 525-526

Kunz, T. H. 1974. Feeding ecology of a temperate insectivorous bat (Myotis velifer). Ecology 55: 693-711.

Kunz, T. H. and R. A. Martin. 1982. *Plecotus town-sendii*. Mammalian Species 175: 1-7.
Lekagual, B. and J. A. McNeely. 1977. Mammals of Thailand. Association for Conservation of Wildlife Pages 758.

Lohani, U. 2011a. Traditional Uses of Animals among Jirels of central Nepal. Ethno Medicine 5(2): 115-124.

Lohani, U. 2011b. Eroding Ethnozoological Knowledge among Magars In Central Nepal. Indian Journals of Traditional Knowledge 10(3): 466-473.

Martens, J. 1987. Remarks on my Himalayan Expeditions. Courier Forsch-Inst. Senckenberg 93: 7-31.

Mcaney, C. M. and J. S. Fairley. 1988. Activity pattern of the lesser horseshoe bat *Rhinolophus hipposideros* at summer roosts. Journal of Zoology 216: 325-338.

Mitchell, R. M. 1980. New record of bats (Chiroptera) from Nepal. Mammalia 44(3): 339-342.

Molar S., G. Marimuthu, C. Srinivaslu, S. Mistry, A. Hutson, P. J. J. Bates, S. Walker, K. Padma Priya and A. R. Binu Priya. 2002. Status of South Asian Chiroptera: Conservation Assessment and Management Plan (C. A. M. P.) Workshop Report Zoo Outreach Organization, Conservation Breeding Specialist Group South Asia and Wildlife and Wild life Information and Liaison Development Society, Coimbatore, India Pages 328.

Nelson, J. E. 1965. Movement of Australian flying foxes (Pteropodidae: Megachiroptera). Australian Journal of Zoology 13: 53-73.

Noureen S., S. Nadeem and M. A. Beg. 2011. Seasonal changes in the distribution pattern of Indian flying fox in Pothwar, Pakistan. Te Second International South-East Asian Bat Conference Bogor, 6-9 June 2011.

Parry-Jones, K. A. and M. L. Augee. 2001. Factors affecting the occupation of a colony site in Sydney, New South Wales by the grey-headed flying fox *Pteropus poliocephalus* (Pteropidae). Austral Ecology 26: 47-55.

Phuyal, S. P. 2005. A rare study of Nepalese Bats and Surprising Attitudes. Bat magazine 23 (4).

Rydell, J. 1989. Feeding activity of the northern bat Eptesicus nilssoni during pregnancy and lactation. Oecologia 80: 562–565.

Sanborn, C. C. 1950. A Nepal record of the long-eared bat (*Plectous homochrous* Hodgson). Natural Hist. Miscell. Chiengo Acad. Sci. 69: 1-2.

Schaub, A., J. Ostwald and B. M. Simers. 2008. Foraging bats avoid noise. The Journal of Experimental Biology 211: 3174-3180.

Scully, J 1887. On the chiroptera of Nepal. Journal of Asiatic Society. Bengal 56: 233-259.

Shen, H.P. and L. L. Lee. 2000. Mother-young interactions in a maternity colony of *myotis formosus*. Journal of Mammalogy 81: 726-733.

Shiel, C. B. and J. S. Fairley. 1999. Evening emergence of two nursery colonies of Leisler's bat Nyctalus leisleri in Ireland. Journal of Zoology 247: 439-447.

Sinha, Y. P. 1973. Taxonomy on the Indian bats. Mammalia 34: 81-92.

Speakman, J. R. and P. A. Racey. 1989. Hibernal ecology of the pipistrelle bat: energy expenditure, water requirements and mass loss, implications for survival and the functions of winter emergence flights. Journal of Animal Ecology 58: 797-813.

Spencer, H. J., C. Palmermer and K Parry-Jones. 1991. Movement of fruit- bats in eastern Australia, determine by using radio-tracking. Wildlife Research 18: 463-468.

Srinivasulu, C., P. A. Racey and S. Mistry. 2010. A key to the bats (Mammalia: Chiroptera) of South Asia. Journal of Threatened Taxa 2 (7): 1001-1076.

Sugita, A. N. 2004. Roosting behavior of the Bonin Flying Fox (*Pteropus plselaphon*) on Chichi-jima Island, Ogasawara Island. M. S. thesis, Rikkyo University, Tokyo, Japan.

Suwal, R., W. J. M. Verheugt and P. Yonjon. 1995. Eneumeration of Mammals of Nepal. Biodiversity Profile Project Publication No. 6. Department of National Park and Wildlife Conservation, Kathmandu 22-31.

Swift, A.1980. Activity pattern of Pipitrellus bats. Journal of Zoology 190: 212-215.

Thapa, S. B. 2008. Reporting Pteropus colonies and bats roost from Eastern Nepal, Bat NET-CCINSA Newsletter 9(1): 22-23.

Thapa, S. B. 2009. First phase survey of Microchiroptera in Plains (Terai) of Eastern Nepal. Small Mammals Conservation and Research Foundation, New Baneswor, Kathmandu, Nepal Pages 25.

Thapa, A and S. Thapa. 2009. Baseline survey of bats roosting in Kailash Cave, Syagnja district of Western Nepal. Small Mammals Conservation and research Foundation New Baneswor Kathmandu, Nepal Pages 11.

Thapa, S. B., R. Kaphle, A. Thapa and S. Dahal. 2009. Report on Preliminary survey of microchiropteran bats in Kathmandu valley. CDZ Small Mammals Club, Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu, Nepal Pages 13.

Thapa, S. B. 2010. Skull cum baculum morphology and PCR approach in identification of Pipistrellus (Chiroptera: Vaspertilionidae) from Koshi Tappu wildlife reserve, Sunsari, Nepal. M.Sc. Thesis. Central Department of Zoology, Tribhuvan University Kathmandu, Nepal.

Thapa, S. 2010. An Updated Checklist of valid bat species of Nepal. Small Mammal Mail Bi-annual Newsletter of CCINSA & RISCINSA Volume 2(1): 16-17.

Thapa, P. S. 2011. Conservation of Bats in the Local (Peripheral) Communities around the caves of Pokhara valley through Education and Awareness Programmers. A report submitted to Rufford Small Grants Foundation, UK.

Tidemann, C. R. and J. E. Nelson. 2004. Long distance movements of the grey-headed flying fox (*Pteropus poliocephalus*). Journal of Zoology 263: 141-146.

Vardon, M. J. and C. R. Tidemann. 1999. Flying-foxes (*Pteropus alecto* and *P. scapulatus*) in the Darwin region, north Australia: patterns in camp size and structure. Australian Journal of Zoology 47: 411-423.

Welbergen, J. A. 2005. The social organization of the grey-headed flying-fox, Pteropus poliocephalus. Ph. D. dissertation, University of Cambridge, United Kingdom.

Wilkinson, L. C. and R. M. R. Barclay. 1997. Difference in the foraging behavior of male and female big brown bats (*Eptesicus fuscus*) during the reproductive period. Ecoscience 4: 279-285.

Worth, R. M. and N. K. Shah. 1969. Nepal Health Survey, 1965-1966, Honolulu (University of Hawaii Press). *In* Bates P.J.J. and Harrison D. L. 1997. Bats of Indian Subcontinent; Harrison Zoological Museum Publication Pages 251.

Zortea, M. and J. R. C. Alho. 2008. Bat diversity of a Cerrado habitat in central Brazil. Biodiversity and Conservation 17(4): 791-805.

http://www.eurobats.org/EPI/EPI.html accessed on 29 March, 2012.

http://www.editor@actinbioscience.org accessed 29 March, 2012.

8 ANNEXES

Annex 1. First field records September 18 to October 15, 2010

DATE	PLACES	GPS COORDINATE	MINIMUM TEMP.	MAXIMUM TEMP.	RELA. HUMI.	NAME OF SPECIES	NO OF INDI.
Sep18 2010	Ithari – 5 Pachrukhi	N 26°40'23.14", E 87°15'18.4" and Elevation 114 m	33.9° C	34.8°C	73%	*Cynopterus sphinx*	4
Sep 18 2010	Pakali- 3 Kanchichowk	N26°40'47'', E 87°13'22'' and Elevation is 112m.	35.1°C	35.5°C	75%	*Pipistrellus sp.*	1
Sep 19 2010	Ithari- 5 Pachrukhi	N 26°40'27", E 87°15'21" and elevation is 110 m	34.4°C	35.5°C	74%	*Cynopterus sphinx*	2
Sep 21 2010	Ithari- 5 Bajhara	N 26°39'43.49", E 87°14'53.47" and elevation is 110 m	37.2°C	37.4°C	79.7%	*Taphozous longimanous*	2
Sep 22 2010	Ithari-4 Armi camp	N 26°39'56.52", E 87° 16'31.99" and elevation is 114 m	35.3°C	35.8°C	73%	*Pteropus giganteus*	1400 Estimated
sep 24 2010	Pakali-3 Kanchichowk	N 26°40'44.52", E 87°13'29.21" and elevation is 111 m	37.5°C	38°C	78.5%	*Cynopterus sphinx*	4
Sep 24 2010	Vasi-6 Jhumka	N 26°40'31.27", E 87°12'32.86" and elevation is 108 m	38°C	38.1°C	75%	*Scotophillus heathii*	5
Sep 25 2010	Hattimuda- 8 Muslimtol	N 26°33'26.82", E 87°17'24.47" and elevation is 91 m	34.3°C	35°C	78%	*Scotophillus heathii*	3
Sep 27 2010	Thankisiniwari - 2, Morang	N 26°31'12.3'', E 87°16'43.23'' and elevation 84 m.	35°C	35.6°C	79%	*Cynopterus sphinx*	4
Sep 28 2010	Hattimuda- 8 Morang	N 26°33'33.29'', E 87°17'28.76'' and Elevation is 93m.	34.7°C	35.7°C	78%	*Cynopterus sphinx*	7

Sep 30 2010	Ithari-2 Jhoda	N 26°41'10.12", E 87°16'35.28" and elevation is 124 m	34.1°C	34.9°C	72%	*Scotophillus heathii*	5
Oct 1 2010	Duhabi- 3 Khikhartol	N 26°34'11.32", E 87°16'16.16" and elevation is 84 m	37°C	38°C	61%	*Cynopterus sphinx*	20
Oct 5 2010	Pakali- 8 Tikuliatol	N 26°42'20.82", E 87°13'8.22" and elevation is 107 m	32.2°C	33.4°C	76%	*Scotophillus Kuhli*	400 Estimated
Oct 7 2010	Khanar – 5 Sardartol	N 26°37'38.7", E 87°16'2.4" and elevation 90 m.	34°C	35.8°C	58%	*Scotophillus heathii*	10
Oct7 2010	Khanar -5 Sardartol	N26°37'10.49", E 87°16'9.82" and elevation 103 m	34°C	35.7°C	58%	*Cynopterus sphinx*	4
Oct 9 2010	Khanar -6	N 26°37'13.59'', E 87°16'15.78'' and Elevation is 104m.	35°C	35.9°C	72%	*Cynopterus sphinx*	5
Oct 11 2010	Thankisiniwari - 2	N 26°31'11.86", E 87°16'42.53" and elevation is 84 m	30.2°C	30.8°C	77%	*Scotophillus heathii*	10
Oct 13 2010	Duhabi-2 Prastoki	N 26° 33'45.1", E 87°15'18.6" and Elevation 82 m	31.2°C	32.7°C	64%	*Pipistrellus sp.*	3
Oct 13 2010	Duhabi-2 Prastoki	N 26°33'46.7" E 87°16'18.8" and Elevation 87 m	31°C	32.1°C	64%	*Scotophillus kuhli*	5
Oct 14 2010	Hattimuda -8 Muslimtol	N26°33'13.91'', E 87°7'18.59'' and Elevation is 91m.	32°C	32.8°C	72%	*Scotphillus heathii*	3
Oct 15 2010	Dangraha-4 Morang	N 26°35'14.7", E 87° 19'44" and elevation is 77m.	31.5°C	32.3°C	72%	*Pteropus gigantus*	550 estimated
Oct 15 2010	Dangraha-4 Morang	N 26°35'5.5'', E 87°19'46.9'' and elevation is 82m.	32.1°C	32.4°C	72%	*Megaderma lyra*	150 estimated

Annex 2. Second field record January 4 to February 2, 2011

Date	Places	GPS Coordinate	Minimum Temp.	Maximum Temp.	Relative humidity	Name of Species	Number of individuals
Jan 4 2011	Vasi-2 Jhumka	N 26°40'31.27" E 87°12'32.86" and elevation is 108 m	17.5°C	21°C	75%	*Scotophillus heathii*	4
Jan 5 2011	Ithari-4 Armi camp	N 26°39'56.52", E 87° 16'31.99" and elevation is 114 m	18°C	22°C	72%	*Pteropus giganteus*	1000 Estimated
Jan 6 2011	Dangraha-4 Morang	N 26°35'14.7", E 87° 19'44" and elevation is 77m.	17°C	19°C	69%	*Pteropus giganteus*	300 Estimated
Jan 8 2011	Pakali-8 Tikuliatol	N 26°40'21.2", E 87°13'5.7" and elevation is 98 m.	15.5°C	16.5°C	77%	*Scotophillus kuhli*	170 Estimated
Jan 9 2011	Ithari-5 Bajraha	N 26°39'44.49", E 87°14'54.47" and elevation is 110 m	16.7°C	17°C	78%	*Taphozous longimanous*	1
Jan 11 2011	Hattimuda-8 polytechnic	N 26°33'21.7", E 87°18'24.38" and elevation is 91 m.	17°C	17.5°C	74%	*Scotophillus heathii*	5
Jan 12 2011	Duhabi-5 pasuhat	N 26°34'19", E 87°17'1.4" and elevation is 76 m.	12°C	14.2°C	71%	*Cynopterus sphinx*	20
Jan 14 2011	Ithari-2 Jhoda	N 26°41'12.12", E 87°16'36.28" and elevation is 124 m	13°C	15°C	70%	*Scotophillus heathii*	5
Jan 15 2011	Tankisiniwari-2 Morang	N26°31'12.3'', E 87°16'43.23'' and Elevation is 84 m.	14°C	14.8°C	73%	*Cynopterus sphinx*	3
Jan 16 2011	Khanar-5 Sardartol	N 26°37'38.7", E 87°16'2.4" and elevation 90 m.	15.5°C	18.5°C	73%	*Cynopterus sphinx*	2
Jan 17 2011	Pakai-3 Kanchichowk	N 26°40'43.52", E 87°13'28.21" and elevation is 111 m	14°C	16°C	71%	*Cynopterus sphinx*	5
Jan 19 2011	Hattimuda-8 Muslimtol	N 26°33'26.82", E 87°17'24.47" and elevation is 91 m	13°C	14.1°C	73%	*Scotophillus heathii*	1
Jan 20	Tankisiniwari-	N26°31'12.3'', E				*Scotophillus*	

2011	2 Morang	87°16'43.23'' and Elevation is 84 m.	13.7°C	15°C	72%	*heathii*	4
Jan 23 2011	Ithari-5 Pachrukhi	N 26°40'27", E 87°15'21" and elevation is 110 m	16°C	17°C	73%	*Cynopterus sphinx*	7
Jan 29 2011	Hattimuda-8 Muslimtol	N 26°33'21.42", E 87°17'24.74" and elevation is 90 m.	14°C	15.5°C	74%	*Cynopterus sphinx*	2
Feb 1 2011	Khanar-5 Sardartol	N26°37'10.49'', E 87°16'9.82'' and elevation 103 m.	15°c	16.2°C	75%	*Cynopterus sphinx*	1
Feb 2 2011	Khanar-6 Sunsari	N 26°37'13.59'', E 87°16'15.78'' and Elevation is 104m.	14.4°C	15.7°C	74%	*Scotophillus heathii*	3
Feb 2 2011	Dangraha-4 Morang	N 26°35'5.5'', E 87°19'46.9'' and elevation is 82m	14.7°C	15.4°C	74%	*Megaderma lyra*	120 estimated

Annex 3. Third field records May 3 to May 31, 2011

Date	Place	GPS Coordinate	Minimum Temp.	Maximum Temp.	Relative Humidity	Name of Species	No. of Individuals
May 3 2011	Ithari-4 Armicamp	N 26°39'56.52", E 87° 16'31.99" and elevation is 114 m	33.1°C	34°C	75%	*Pteropus giganteus*	1500 Estimated
May 4 2011	Ithari-5 Bajraha	N 26°39'35.14'', E 87°14'48.69'' and elevation 108 m.	33.7°C	34°C	75%	*Taphozous longimanou s*	1
May 5 2011	Vasi-2 Jhumka	N 26°40'23.92'', E 87°12'28.64'' and elevation is 108 m.	32.8°C	33.4°C	73%	*Scotophillus heathii*	3
May 7 2011	Pakai-8 Tukaliatol	N 26°40'21.2", E 87°13'5.7" and elevation is 98 m.	31°C	33.2°C	74%	*Scotophillus kuhli*	200 Estimated
May 9 2011	Pakali-3 Kanchichowk	N 26°40'44.32'', E 87°13'25.28' and elevation is 80 m.	34.3°C	34.7°C	76%	*Cynopterus sphinx*	7

May 10 2011	Ithari-2 Jhoda	N 26°41'11.98'', E 87°16'49.65'' and elevation 123 m.	35°C	35.3°C	75%	*Scotophillus heathii*	6
May 11 2011	Dangraha-4 Morang	N 26°35'14.7", E 87° 19'44" and elevation is 77m.	34.7°C	35.4°C	74%	*Pteropus giganteus*	600 Estimated
May 13 2011	Tankisiniwari-2 Morang	N 26°31'6.03'', E 87°16'38.1'' and elevation is 86 m.	36°C	36.8°C	75%	*Cynopterus sphinx*	8
May 15 2011	Khanar-5 Sardartol	N 26°37'38.7", E 87°16'2.4" and elevation 90 m.	36.5°C	37°C	76%	*Cynopterus sphinx*	4
May 16 2011	Khanar-6 Sunsari	N 26°37'13.59'', E 87°16'15.78'' and Elevation is 104m.	36.8°C	37°C	74%	*Scotophillus heathii*	10
May 17 2011	Duhabi-5 Pasuhat	N 26°34'17.74'', E 87°17'3.93'' and elevation is 93 m.	34°C	35°C	75%	*Cynopterus sphinx*	14
May 18 2011	Duhabi-3 Khikhartol	N 26°34'9.7'', E 87°16'15.69'' and elevation is 92 m.	34°C	35.3°C	74%	*Scotophillus heathii*	2
May 20 2011	Tankisiniwari-2 Morang	N 26°30'58.56'', E 87°16'17.38'' and elevation 79 m.	35.2°C	35.7°C	77%	*Cynopterus sphinx*	4
May 23 2011	Hattimuda-8 Polytechnic	N 26°33'21.7", E 87°18'24.38" and elevation is 91 m.	35°C	36.3°C	76%	*Scotophillus heathii*	13
May 27 2011	Hattimuda-8 Muslimtol	N 26°33'13.17'', E 87°17'21.26'' and elevation is 92 m.	34.4°C	34.9°C	75%	*Cynopterus sphinx*	9
May 28 2011	Dangraha-4 Morang	N 26°35'55.12'', E 87°18'56.94'' and elevation is 102m.	35°C	36.1°C	76%	*Megaderma lyra*	200 Estimated
May 29 2011	Hattimuda-8 Muslimtol	N 26°33'6.36'', E 87°17'27.25'' and elevation is 89 m.	35.3°C	36°C	76%	*Scotophillus heathii*	11
May 30 2011	Duhabi-2 Prastoki	N 26°33'38.16'', E 87°16'20.07'' and elevation is 90 m.	34.8°C	35.5°C	74%	*Cynopterus sphinx*	3
May 31 2011	Ithari-5 Pachrukhi	N 26°40'23.35'', E 87°15'18.20'' and	34.2°C	35.2°C	74%	*Cynopterus sphinx*	23

		Elevation is 113m.					

Annex 4. Fourth field records on 20 July to 18 August 2011

Date	Place	GPS Coordinate	Minimum Temp.	Maximum Temp.	Relative Humidity	Name of Species	No of individuals
20 July 2011	Dangraha-4 Morang	N 26°35'14.7", E 87° 19'44" and elevation is 77m.	32.2°C	33.7°C	74%	*Pteropus gigantus*	650 Estimated
20 July 2011	Dangraha-4 Morang	N 26°35'5.5'', E 87°19'46.9'' and elevation is 82m.	37.2°C	38°C	74%	*Megaderma lyra*	200 Estimated
21 July 2011	Khanar-6 Sunsari	N 26°37'13.59'', E 87°16'15.78'' and Elevation is 104m.	34.3°C	35°C	77%	*Scotophillus heathii*	15
22 July 2011	Khanar-5 Sardartol	N 26°37'38.7", E 87°16'2.4" and elevation 90 m.	35.5°C	36.1°C	76%	*Cynopterus sphinx*	12
23 July 2011	Duhabi-4 Khikartol	N 26°34'11.9'', E 87°16'15.1'' and elevation is 89 m.	36°C	36.2°C	72%	*Scotophillus heathii*	4
24 July 2011	Duhabi-4 Khikartol	N 26°34'10.4'', E 87°16'15.6'' and elevation is 95 m.	35.6°C	36°C	73%	*Cynopterus sphinx*	15
25 July 2011	Hattimuda-8 Muslimtol	N 26°33'26.82", E 87°17'24.47" and elevation is 91 m	35.4°C	36.2°C	73%	*Cynopterus sphinx*	7
27 July 2011	Vasi 2 Jhumka	N 26°40'32.70'', E 87°12'32.97'' and elevation is 108 m	35°C	35.2°C	73%	*Scotophillus heathii*	5
28 July 2011	Ithari 4 Armi camp	N 26°39'56.52", E 87° 16'31.99" and elevation is 114 m	35.1°C	36°C	75%	*pteropus gigantus*	1600 Estimated

30 July 2011	Pakali 8 Tikuliatol	N 26°40'21.2", E 87°13'5.7" and elevation is 98 m.	35°C	35.7°C	73%	*Scotophillus kuhli*	200 Estimated
1 Aug 2011	Ithari 5 Bajraha	N 26°39'33.27'', E 87°14'48.06'' and elevation is 77 m.	35°C	36°C	72%	*Taphozous longimanous*	3
2 Aug 2011	Hattimuda 8 polytechnic	N 26°33'21.7", E 87°18'24.38" and elevation is 91 m.	36°C	37.2°C	73%	*Scotophillus heathii*	3
4 Aug 2011	Duhabi 5 pasuhat	N 26°34'18.34'', E 87°16'59.93'' and elevation 92 m.	34.7°C	35.3°C	75%	*Cynopterus sphinx*	7
5 Aug 2011	Ithari 2 Jhoda	N 26°41'9.01'', E 87°17'0.5'' and elevation is 122 m	35.2°C	36°C	74%	*Scotophillus heathii*	2
8 Aug 2011	Tankisiniwari 2 Morang	N 26°31'9.98'', E 87°16'40.3'' and elevation is 85 m.	33.5°C	35°C	75%	*Scotophillus heathii*	9
10 Aug 2011	Pakai 3 Kanchichowk	N 26°40'51.56'', E 87°13'19.74'' is elevation is 81 m.	32.8°C	33.9°C	72%	*Cynopterus sphinx*	15
11 Aug 2011	Tankisiniwari 2 Morang	N 26°30'58.31'', E 87°16'16.54'' and elevation is 79 m.	35°C	35.7°C	74%	*Cynopterus sphinx*	13
13 Aug 2011	Ithari 5 Pachrukhi	N 26°40'23.07'', E 87°15'20.73'' and elevation is 113 m	35°C	37.3°C	75%	*Cynopterus sphinx*	7
16 Aug 2011	Duhabi-2 Prastoki	N 26°33'41.05'', E 87°16'17.23'' and elevation is 89 m.	35.3°C	37°C	76%	*Scotophillus heathii*	3
17 Aug 2011	Hattimuda-8 Muslimtol	N 26°33'18.49'', E 87°17'22.70'' and elevation is 90 m.	36°C	37.4°C	75%	*Scotophillus heathii*	9
18 Aug 2011	Duhabi-4 Labipur	26° 34.9' 36" N, 87° 16.9' 64" E and Elev. 84 m.	36.5°C	37.4°C	73%	*Cynopterus sphinx* Albino	2

Annex 5. Morphometric measurement of *Cynopterus sphinx* and *C. sphinx* (Albino)

Name		*Cynopterus*

of Species	*Cynopterus sphinx*						*Sphinx* (Albino)
No of sp.	1	2	3	4	5	6	7
Place	Ithari-5 Pachrukhi	Ithari-5 Pachrukhi	Pakali-3 Kanchichok	Duhabi-3 Khikhartol	Khanar-5	Khanar-6	Duhabi-4 Labipur
Date	Sep-19 2010	Sep-19 2010	Sep-24 2010	Oct-1 2010	Oct-7 2010	Oct-9 2010	August 18 2011
HB	98 mm	85 mm	110 mm	110 mm	100mm	97 mm	98 mm
T	05 mm	05 mm	09 mm	04 mm	06 mm	07 mm	10 mm
TIB	35 mm	35 mm	27 mm	30 mm	35 mm	33 mm	30 mm
HF	14 mm	14 mm	12 mm	10 mm	14 mm	14 mm	12 mm
FA	70 mm	65 mm	70 mm	70 mm	70 mm	69 mm	70 mm
Thumb	19 mm	18 mm	20 mm	20 mm	20 mm	20 mm	18 mm
5mt	47 mm	34 mm	40 mm	45 mm	43 mm	42 mm	42 mm
1Ph5mt	20 mm	15 mm	20 mm	25 mm	25 mm	21 mm	23 mm
2Ph5mt	23 mm	22 mm	24 mm	27 mm	26 mm	27 mm	25 mm
4mt	44 mm	43 mm	40 mm	40 mm	41 mm	41 mm	45 mm
1Ph4mt	21 mm	19 mm	20 mm	24 mm	24 mm	23 mm	22 mm
2Ph4mt	25 mm	21 mm	26 mm	25 mm	25 mm	25 mm	29 mm
3mt	47 mm	55 mm	40 mm	47 mm	47 mm	40 mm	49 mm
1Ph3mt	30 mm	25 mm	30 mm	30 mm	30 mm	30 mm	30 mm
2Ph3mt	43 mm	40 mm	35 mm	45 mm	42 mm	35 mm	37 mm
WSP	380mm	360 mm	420 mm	420 mm	410mm	430mm	440mm
E	19 mm	19 mm	16 mm	23 mm	22 mm	22 mm	18 mm
Sex	F	F	F	M	M	M	F
Testis (Fea.)	A	A	A	W.D.	W.D.	W.D.	A
Nipple (Fea.)	Wd	Wd	Wd	A	A	A	Wd
Wt.	40 gm	44gm	41 gm	41 gm	40 gm	42 gm	42 gm

Where HB= Head body, T= Tail length (from the anus to last vertebra), TIB= Tibia length, HF= hind foot length (excluding claws), FA= Forearm Length, E= Ear length, 3MT= Third metacarpal, 4MT= Four metacarpal, 5MT= Five metacarpal, 1Ph3mt= First Phalange Third metacarpal, 2Ph3mt= Second Phalange Third metacarpal, 1Ph4mt= First Phalange Fourth metacarpal, 2Ph4mt= Second Phalange

Fourth metacarpal, 1Ph5mt= First Phalange Fifth metacarpal, 2Ph5mt= Second Phalange Fifth metacarpal, Thumb= Thumb length, WSP= Wing span, Wt= Weight, A= Absent and Wd= Well developed.

Table 6. List of species captured during the time of survey

S.N.	Name of Species	No. Ind.	Date	Place	Roost Survey	Mist Net
1	*Cynopterus sphinx*	2	Sep 19, 2010	Itahari- 5, Sunsari	√	×
2	*Cynopterus sphinx*	1	Sep 24, 2010	Pakali- 3, Sunsari	×	√
3	*Cynopterus sphinx*	1	Oct 1, 2010	Duhabi-3, Sunsari4	√	×
4	*Cynopterus sphinx*	1	Oct7, 2010	Khanar-5, Sunsari	√	×
5	*Cynopterus sphinx*	1	Oct 9, 2010	Khanar-6, Sunsari	√	×
6	*Cynopterus sphin* (Albino)	1	Aug 18, 2011	Duhabi-4, Sunsari	√	×
7	*Megaderma lyra*	1	July 20, 2011	Dangraha-4, Morang	√	×
8	*Scotophillus heathii*	3	Sep 24, 2010	Vasi-6, Sunsari	√	×
9	*Scotophillus heathii*	1	Sep 25, 2010	Hattimuda-8, Morang	√	×
10	*Scotophillus heathii*	1	Sep 30, 2010	Itahari-2, Sunsari	√	×
11	*Scotophillus heathii*	1	Oct 11, 2010	Tankisiniwari-2, Morang	√	×
12	*Scotophillus kuhli*	2	Oct 5, 2010	Pakali-8, Sunsari	√	×
13	*Scotophillus kuhli*	1	Oct 10, 2010	Duhabi-2, Sunsari	√	×
14	*Scotophillus kuhli*	1	Feb 12, 2012	Pakali-8, Sunsari	√	×
15	*Taphozous longimanus*	2	Sep 21, 2011	Itahari-5, Sunsari	√	×
16	*Pipistrellus* sp.	1	Nov 14, 2010	Duhabi-2, Sunsari	√	×
	TOTAL	21				

Annex 7. Morphometric measurement of *Scotophillus heathii*

Name of Species	*Scotophillus heathii*					
No. of species	1	2	3	4	5	6

Date	Sep-24 2010	Sep-24 2010	Sep-24 2010	Sep-25 2010	Sep-30 2010	oct- 11 2010
Place	Vasi-6 Jhumka	Vasi-6 Jhumka	Vasi-6 Jhumka	Hattimud-8 Muslimtol	Ithari-2 Jhoda	Tankisiniwari-2
HB	89 mm	82 mm	81 mm	80 mm	80 mm	88 mm
T	56 mm	57 mm	50 mm	48 mm	55 mm	57 mm
TIB	27 mm	20 mm	25 mm	24 mm	25 mm	32 mm
HF	09 mm	08 mm	10 mm	08 mm	08 mm	12 mm
FA	58 mm	60 mm	60 mm	62 mm	60 mm	65 mm
Thumb	08 mm	10 mm	07 mm	06 mm	06 mm	10 mm
5mt	55 mm	54 mm	50 mm	50 mm	53 mm	55 mm
1Ph5mt	10 mm	10 mm	10 mm	12 mm	10 mm	11 mm
2Ph5mt	08 mm	08 mm	08 mm	05 mm	07 mm	09 mm
4mt	58 mm	55 mm	55 mm	44 mm	55 mm	56 mm
1Ph4mt	15 mm	18 mm	17 mm	15 mm	15 mm	16 mm
2Ph4mt	13 mm	15 mm	13 mm	10 mm	10 mm	15 mm
3mt	58 mm	60 mm	55 mm	62 mm	56 mm	56 mm
1Ph3mt	18 mm	23 mm	20 mm	22 mm	18 mm	21 mm
2Ph3mt	17 mm	20 mm	15 mm	18 mm	16 mm	26 mm
WSP	400mm	390 mm	390 mm	370 mm	370 mm	37 mm
E	10 mm	09 mm	09 mm	10 mm	10 mm	15 mm
Tragus	05 mm	07 mm	07 mm	06 mm	08 mm	06 mm
Sex	M	F	F	F	M	F
Testis	W. D.	A	A	A	Wd	A
Nipples	A	NWd	Wd	Wd	A	Wd
Wt.	40 gm	41 gm	41 gm	40 gm	40 gm	41 gm

Where HB= Head body, T= Tail length (from the anus to last vertebra), TIB= Tibia length, HF= hind foot length (excluding claws), FA= Forearm Length, E= Ear length, 3MT= Third metacarpal, 4MT= Four metacarpal, 5MT= Five metacarpal, 1Ph3mt= First Phalange Third metacarpal, 2Ph3mt= Second Phalange Third metacarpal, 1Ph4mt= First Phalange Fourth metacarpal, 2Ph4mt= Second Phalange Fourth metacarpal, 1Ph5mt= First Phalange Fifth metacarpal, 2Ph5mt= Second Phalange Fifth metacarpal, Thumb= Thumb length, WSP= Wing span, Wt= Weight, A= Absent, Wd= Well developed and Tragus= Tragus length

Annex 8. Skull measurement of *Scotophillus kuhli*

GTL	CCL	CM^3	CM_3	M	C1C1	M_3-M_3	PC	ZB	BB
19.2mm	17.2mm	6.6mm	7.3mm	13.5mm	6.3mm	7.5mm	3.4mm	13.2mm	10.3mm

Where, CCL =Greatest length of skull, GTL= Condylo-canine length, BB= Breath of brain case, PC= Postorbital constriction, CM^3= Maxillary tooth row length, CM_3= Mandibular tooth row length, C1C1=Anterior palatal width and

M_3 M_3=Posterior palatal width.

Annex 9. Morphometric measurement of *Pipistrellus sp.,Megaderma lyra, Taphozous longimanus and Scotophillus kuhli*

Name of Species	*Pipistrellus Sp.*	*Megaderma lyra*	*Taphozous longimanus*		*Scotophillus kuhli*			
No of sp.								
Place	Duhabi-2 Prastoki	Dangraha-4, Morang	Ithari-5 Bajara	Ithari-5 Bajara	Pakali-8 Tukaliatol	Pakali-8 Tukaliatol	Duhabi-2 Prastoki	Pakali-8 Tukaliatol
Date	Nov-14 2010	July 20 2011	Sep-21 2010	Sep-21 2010	Oct-5 2010	Oct-5 2010	Oct-13 2010	2012

HB	30 mm	80 mm	85 mm	82 mm	60 mm	65 mm	75 mm	67 mm
T	28 mm		24 mm	23 mm	40 mm	45 mm	45 mm	41 mm
TIB	15 mm	31 mm	30 mm	27 mm	20 mm	20 mm	19 mm	17 mm
HF	04 mm	19 mm	14 mm	16 mm	07 mm	07 mm	10 mm	09 mm
FA	32 mm	68 mm	62 mm	59 mm	50 mm	50 mm	53 mm	47 mm
Thumb	04 mm	9 mm	05 mm	04 mm	10 mm	08 mm	07 mm	08 mm
5MT	28 mm	60 mm	32 mm	30 mm	40 mm	42 mm	45 mm	43 mm
1Ph5MT	09 mm	20 mm	13 mm	12 mm	09 mm	09 mm	10 mm	09 mm
2Ph5MT	07 mm	22 mm	10 mm	09 mm	05 mm	05 mm	08 mm	10 mm
4MT	30 mm	58 mm	45 mm	48 mm	45 mm	45 mm	45 mm	44 mm
1Ph4MT	10 mm	17 mm	14 mm	12 mm	15 mm	16 mm	15 mm	12 mm
2Ph4MT	06 mm	24 mm	07 mm	07 mm	10 mm	12 mm	10 mm	13 mm
3MT	10 mm	54 mm	55 mm	57 mm	45 mm	46 mm	47 mm	45 mm
1Ph3MT	13 mm	28 mm	25 mm	23 mm	19 mm	15 mm	12 mm	15 mm
2Ph3MT	15 mm	52 mm	22 mm	22 mm	20 mm	22 mm	22 mm	21 mm
WSP	220 mm	460mm	360 mm	350mm	330 mm	340 mm	370 mm	374 mm
E	06 mm	08 mm	09 mm	08 mm	10 mm	10 mm	10 cm	10 cm
Tragus	03 mm	18 mm	A	A	05 mm	05 mm	04 mm	07 mm
NL(L)	A	16 mm	A	A	A	A	A	A
NL(H)	A	08 mm	A	A	A	A	A	A
Sex	F	F	F	M	M	F	F	M
Nipple	W.D.	W.D.	W.D.	A	A	W.D.	W.D.	A
Testis	A	A	A	W.D.	W.D.	A	A	W.D
Wt.	9 gm	40 gm			20 gm	20 gm	25 gm	22 gm

Where HB= Head body, T= Tail length (from the anus to last vertebra), TIB= Tibia length, HF= hind foot length (excluding claws), FA= Forearm Length, E= Ear length, 3MT= Third metacarpal, 4MT= Four metacarpal, 5MT= Five metacarpal, 1Ph3mt= First Phalange Third metacarpal, 2Ph3mt= Second Phalange Third metacarpal, 1Ph4mt= First Phalange Fourth metacarpal, 2Ph4mt= Second Phalange Fourth metacarpal, 1Ph5mt= First Phalange Fifth metacarpal, 2Ph5mt= Second Phalange Fifth metacarpal, Thumb= Thumb length, WSP= Wing span, Wt= Weight, A= Absent , Wd= Well developed and Tragus= Tragus length.