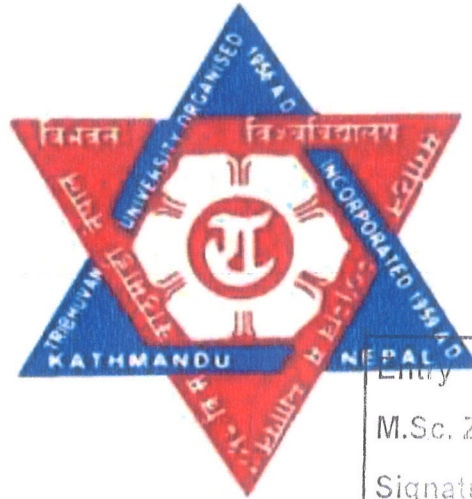


**DISTRIBUTION AND ABUNDANCE OF SMALL MAMMALS IN  
CHANDRAGIRI HILL, KATHMANDU**



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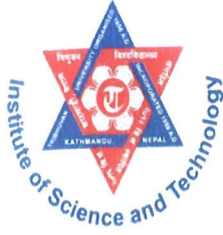
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A Thesis submitted in partial fulfillment of the requirements for the award of the degree of  
Masters of Science in Zoology  
with special paper Ecology and Environment

**Submitted to:**

Central Department of Zoology  
Institute of Science and Technology  
Tribhuvan University  
Kirtipur, Kathmandu  
Nepal

September, 2019



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### RECOMMENDATION

This is to recommend that the thesis entitled “**DISTRIBUTION AND ABUNDANCE OF SMALL MAMMALS IN CHANDRAGIRI HILL, KATHMANDU**” has been carried out by Miss Shruti Shakya for the partial fulfillment of Masters Degree of Science in Zoology with special paper Ecology and Environment. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

Date: ...2019/9/18.....

  
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### LETTER OF APPROVAL

On the recommendation of supervisor Prof Dr Tej Bahadur Thapa, this thesis submitted by Miss Shruti Shakya entitled “**DISTRIBUTION AND ABUNDANCE OF SMALL MAMMALS IN CHANDRAGIRI HILL, KATHMANDU**” is approved for the examination in partial fulfillment of the requirements for the Masters Degree of Science in Zoology with special paper Ecology and Environment.

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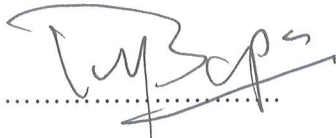
Kirtipur, Kathmandu, Nepal.




### CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Miss Shruti Shakya entitled “**DISTRIBUTION AND ABUNDANCE OF SMALL MAMMALS IN CHANDRAGIRI HILL, KATHMANDU**” has been accepted as a partial fulfillment for the requirements of Masters Degree of Science in Zoology with special paper Ecology and Environment.


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## DECLARATION

I hereby declare that the work presented in this thesis has been done by myself and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by the reference to the authors or institutions.

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**Shruti Shakya**

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## ABSTRACT

Small mammals are an integral part of the ecosystem due to their major ecological role as consumer of plant material and invertebrates on the one hand, and as prey items for snakes, birds of prey, and carnivorous big mammals on the other. Distribution and Abundance of small mammals were studied along the elevational gradient in five community forests of Chandragiri Hill, Kathmandu: Gumalchowki CF, Mahankal CF, Ganeshdevi-Bandevi CF, Chandragiri CF and Mahalaxmi CF. This study aimed to explore the diversity of small mammals at different altitudes and to determine the relative abundance of small mammals in the study area. Live trapping of small mammals was done using four different live traps: Sherman Traps, Tube Traps, Local Traps and Pitfall Traps and applying the grid method at 1600 m, 1800 m, 2000 m and 2200 m. A total of 76 individuals belonging to eight species and two orders of non-volant small mammals were recorded in 1000 trap nights with 7.6 % trap success and six recaptures. Species richness was highest at 1600 m altitude in all the sampling sites and slightly decreased along with elevation. Highest abundance of small mammals was found in Chandragiri CF followed by Ganeshdevi-Bandevi CF, Gumalchowki CF, Mahankal CF and Mahalaxmi CF. Relative Abundance of small mammals was observed to be highest at 1600 m and least at 1800 m. Shannon Weiner Diversity Index showed highest species diversity in Ganeshdevi Bandevi CF. *Rattus andamanensis* was the most abundant species and was found in all the five study sites and also at all altitudes. The species *Soriculus nigrescens* was also found in all the study sites except Mahalaxmi CF where no shrew species were recorded. Sherman Traps was found to be highly efficient with trap success 2.9% and six species of small mammal individuals were trapped by the Tube Traps with 2.2% trap success.

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## LIST OF ABBREVIATIONS

<b>Abbreviated form</b>	<b>Detail of abbreviations</b>
ARR	Abundance Range Relationship
CBD	Conservation on Biological Diversity
CNP	Chitwan National Park
SNNP	Shivapuri Nagarjun National Park
CF	Community Forest
GPS	Global Positioning System
IUCN	International Union for Conservation of Nature
Kg	Kilogram
No.	Number
SMCRF Foundation	Small Mammals Conservation and Research
SSC	Species Survival Commission
MAT	Mean Annual Temperature
MAH	Mean Annual Humidity
MDE	Mid-Domain Effect

# INTRODUCTION

## 1.1 Background

Small mammals have been classified into three orders by the IUCN SSC Small Mammal Specialist Group – the rodents, tree shrews and the eulipotyphlans, made up of the shrews, moles, hedgehogs and solenodons. These three orders contain more than 2800 species worldwide, of which 437 are considered threatened with extinction by the IUCN (SMSG 2010). Non-volant small mammals are known as species that are approximately less than one kg in weight such as rodents, marsupials, shrews, and tree shrews (Lim and Pacheco 2016). Some studies define small mammals as non-flying adult mammals with adult live weight ranging from less than two grams to five kilograms (Meritt 2010). SMCRF (2012) considers small mammals as the mammals up to ten kilogram including one hundred fifty one species of eight orders Rodentia, Chiroptera, Carnivora, Eulipotyphla, Lagomorpha, Artiodactyla, Pholidota and Scandentia.

Rodents are specially characterized by enlarged top incisors and elongated, pointed snouts, being largely herbivorous, some carnivorous and omnivorous too and they breed almost throughout the year during favourable temperatures (Baral and Shah 2008). Shrews are characterized by long, pointed snout, depressed conch-shaped ears, white, unpigmented teeth, long scattered hair on long, slim tails, and prominent ears, small or vestigial eyes, a streamlined shape, reversible hair, and powerful digging limbs (Menon 2014). Threats to rodents and shrews include habitat loss, introduction of native species and competition, disease and use of pesticides and insecticides close to their habitats (Menon 2014).

## 1.2 Ecological role of small mammals

Small non-volant mammals are ecologically vital in the sense that most of them are prey species for many different kinds of predators like wild cats, snakes, etc., change in their species diversity and relative abundance can have a huge effect on large predators that are in high need of conservation (Lim and Pacheco 2016). Small mammals are indicators of ecosystem health and part of ecosystem function such as seed dispersal (Jnawali et al. 2011). The distribution and diversity of the community of granivorous rodents importantly helps in the function and conservation of many forest ecosystems (Urigoiti et al. 2018). Small mammals like the Himalayan marmot found in the Himalayan alpine mountain ecosystem play a vital role as an ‘ecosystem engineer’ through soil modification resulting from extensive borrowing (Nikol’skii and Ulak 2006). They may also be indicators of

human disturbance as invasive species (Lim and Pacheco 2016), major pests of agriculture, forestry and food storages and transmitter of diseases of man and domestic animals (Shrestha 1997).

However, some small mammal species are endemic to specific habitats or elevations making them a high conservation priority (Lim and Pacheco 2016). *Apodemus gurkha* (Himalayan Field Mouse) and *Myotis csorba* (Myotis eared bat) are the endemic mammal species of Nepal (Baral and Shah 2008).

### **1.3 Distribution, abundance and diversity of small mammals**

Small mammal species are terrestrial and world-widely distributed, ranging from the sea level to the high Himalayan pastures at an altitude of 5000 metres (Adhikari 2001). Variation in mammal species richness along elevational gradients have been importantly caused by environmental and non-environmental factors (Wu et al. 2016). For species occurrence, the major requirement is habitat suitability (Luza et al. 2016). Non-random patterns of species distribution along ecological gradients (as grassland–forest ecotone) may be an effect of changes on vegetation structure along edges, which alter edge permeability to abiotic factors (e.g. light, temperature), flux nutrients and individuals, and also alters resource distribution, availability and acquisition by species (Ries et al. 2004). Small mammal abundance is directly associated with plant cover, it decreases along with decrease in plant cover (Hamilton 2015).

In South Asia, a total of 185 non-volant small mammals' species are known out of which 62 are endemic to the region and 123 are non-endemic species (Molur et al. 2005). In Nepal, 212 species of mammals are present constituting of 4.1 % mammalian diversity of the world (Amin et al. 2018). A total of 136 species of small mammals are found in Nepal including 63 species of bats, 17 species of shrews, 15 species of rats, 13 species of mouse, 11 species of squirrels, seven species of pikas, four species of voles, three species of hare, two species of marmots and one species of hamster (Baral and Shah 2008).

## **1.4 Objectives**

### **1.4.1 General Objective**

- i) To explore the distribution and abundance of small mammals in Chandragiri area of Kathmandu, Nepal.

### **1.4.2 Specific Objectives**

- i) To explore the diversity and distribution patterns of small mammals in different altitudes.
- ii) To determine the relative abundance of small mammals in the study area.

## **1.5 Rationale of the study**

The status of most of the small mammal species in Nepal are data deficient due to insufficient research and limited knowledge of the local people as well as researchers on them. According to CBD (2014), the identification of diversity trends, underlying factors and monitoring changes in temporal and spatial scale along altitudinal gradients help to explain Nepal's biodiversity and becomes groundwork for conservation and decision making as Nepal's altitudinal gradients ranges from lower tropical to upper alpine climatic zone within north to south. This study has determined the present status and diversity of small mammals in Chandragiri Area along the elevational gradient. This study may be useful to attract the attention of future researchers towards the small mammals, their status and role in the ecosystem. This study has generated a baseline data for further research on small mammals in Chandragiri in different aspects.

## **1.6 Limitation of the study**

The field work was carried out during March covering only a season. The survey of the volant small mammals including the order Chiroptera (bats) has not been done in the present study due to additional procedure of mist netting which was not feasible in the present work as well as due to the winter climate. The present study lacks the information on association of environmental variables with species diversity, distribution and abundance.

## LITERATURE REVIEW

### 2.1 Altitudinal distribution of small mammals' diversity

Various researchers have identified four main trends in elevational species richness; decreasing species richness with increasing elevation, plateau in low elevation and decreasing with or without mid-elevational peak and a unimodal patterns with a mid-elevational peak (McCain and Grytnes 2010, Chen et al. 2017). The most commonly observed patterns are decreasing richness with increasing elevation as been mentioned by the early naturalists since nineteenth century (including Linnaeus, Willdenow, Von Humboldt, Darwin and Wallace) and the other, hump shaped pattern with a richness peak at intermediate elevation (McCain and Grytnes 2010).

Rickart et al. (2011) carried out a faunal survey along the elevational gradient in Balbalasang-Balbalan National Park in northern Luzon Island, Phillipines. Their study showed species richness was highest in montane and mossy forest habitats at mid to high elevations revealing that the total species richness is a function of local elevation, having higher species in areas with higher mountain peaks.

Wu et al. (2013) found hump-shaped species richness pattern for non-volant small mammals along the elevational gradients with highest richness at mid-elevations. Temperature, precipitation, plant species richness and geometric constraints (MDE) were most significant in explaining species richness patterns between endemic and non-endemic species, between larger-ranged and smaller-ranged species and between rodents and insectivores (Wu et al. 2013)

Similar hump-shaped patterns were observed by Chen et al. (2017) along elevational gradients on both western and eastern slopes of the Ailao Mountains, Southwest China, but shapes of diversity curves were different on the contrasting slopes. They reported that area and productivity (highly correlated with MAT and MAH) were the most important variables determining the total species richness patterns of small mammals.

Shuai (2017) explored the elevational distribution of alpha and beta diversity of rodents and its underlying mechanisms along the southern and northern slopes of Mt. Taibai, the highest mountain in the Qinling Mountains, China. Their study obtained decreasing pattern of species along the southern slope being influenced by temperature and a hump-shaped elevational pattern along the northern slope being influenced by MDE.

Wen et al. (2018) studied the pattern and driving force behind the ARR on three subtropical mountains of mountain range of south western China and found extremely high levels of

species diversity and endemism. Their study also disclosed a significantly positive relationship between the mean abundance and elevational range size of non-flying small mammals on the subtropical mountains and a consistent positive relationship between mean abundance and elevational range centre. The endemic species were found to be more abundant than non-endemic species and occupy higher elevation sites due to increasing geographical isolation with elevation and the higher degree of ecological specialization of endemic species.

Musila et al. (2019) analyzed the small mammal diversity and distribution on the Chogoria and Sirimon slopes of Mt. Kenya, species and compiled a comprehensive checklist of mammals found on the mountain. The number of small mammal individuals were observed to higher on Sirimon than on Chogoria and the highest abundance was observed at mid-elevations on both slopes, elevational species richness patterns being different between the slopes.

## **2.2 Small Mammals Diversity in Nepal**

In Nepal, study on small mammals started with the record of three insectivores; *Crocidura attenuate*, *Suncus stoliczkanus* and *Suncus entruscus pygmaetoides* during 1966 to August, 1970. Nine species of small mammals were reported along the forest edge bordering cultivated fields of Banke District in the western Terai of Nepal. Mitchell and Punzo in 1975 first recorded Indo-Chinese Shrew in Nepal from midland forest and fields at 2440 m (Kunwar 2016). Survey on small mammals in central Nepal was conducted by Abe in 1982, he suggested altitudinal segregation between sympatric *Soriculus* in Nepal by recording 32 different spp. of small mammals (Karkee 2018). Kazuyuki et al. in 2001 reported Genus *Soriculus*, one of the Asiatic Soricine shrew genera and four *Soriculus* Shrews from Central Nepal. Oliver in 1985 reported a Hispid Hare (*Caprolagus hispidus*) in Sukhibar area of CNP in central Nepal. Different researchers had thought of its regional extinction as this species was not previously reported from the park and not anywhere in Nepal for more than thirty years (Karkee 2018). Bell et al. in 1986 conducted a study on the biology and conservation problems of Hispid Hare in Shuklaphanta National Park indicating that the Hispid Hare confines to patches of unburned tall grassland along streams, during winter season when grass cutting and burning is over, he further recorded the Common Soft-furred Rat (*Millardia meltada*) and Little Indian Field Mouse (*Mus booduga*) from the Terai region (Karkee 2018).

Nembang (2003) reported 12 species of small mammals including eight rodents, two shrews, one carnivore and one lagomorph. The population density was higher in dense grassland areas than in forest area with traces of fire. Similarly, the species richness of small mammals was found to be high with patchy and random distribution pattern.

Shrestha and Basnet (2005) recorded 14 species of medium as well as large mammals and six species of small mammals including Himalayan Pika, Black-naped Hare, Himalayan Squirrel, Fawn-colored Mouse, Brown-toothed Shrew and Black Rat through direct and indirect signs in a field study carried out from July 2003 to July 2004 at SNNP. Thapa (2010) recorded Intermediate Horseshoe, Greater Horseshoe and Big-eared Horseshoe bats in the entrance of the Nagarjuna cave inside the SNNP.

Neupane (2007) recorded 26 species of mammals belonging to seven order and 14 families in Kankali Community Forest by visual observation, indirect evidences and questionnaire survey. The species of order Carnivora was found to be more diverse followed by Rodentia and Artiodactyla.

Dahal et al. (2011) studied the distribution and diversity of small mammals of CNP using transects, trapping procedure, mist netting and roost surveys within three different habitat types: forest, grassland and riverine habitats recording 12 species of mammals including three small mammals in 300 trap nights.

Adhikari (2014) used Eliot, pitfall and camera trap methods & reported 14 species of small mammals (excluding bat) belonging to three order & six families & found their abundance higher in riverine forests than in sal forests in CNP.

Kunwar (2016) recorded a total of 72 individuals of small as well as medium-sized mammals, belonging to the four orders, eight families and 10 species in 2560 trap nights with Asian House Shrew being the dominant species. The species showed clumped distribution in all four sampled habitats, highest abundance was found in cropland followed by grassland, mixed deciduous forests and least in riverine areas whereas highest diversity was found in mixed deciduous forest followed by riverine forest, cropland and grassland. Also, human induced factors were identified to have negative impact on small mammals with water pollution and forest fire having the most significant impact.

Karkee (2018) studied the diversity and distribution pattern of small mammals along the altitudinal gradients of a mid-mountain of Shivapuri Rural Municipality, Nuwakot by live trapping using three types of trap (local mesh trap, tube trap and pitfall trap). Eight murid rodent species and two species of sorcid shrew were recorded with slightly decreasing trend in species richness along the altitudinal gradients.

### **2.3 Small Mammals occurrence in different habitats and trapping efficiency**

Umetsu (2006) conducted standardised small mammals surveys at 26 Atlantic Forest sites and evaluated the efficiency of pitfall traps capturing 29 species higher than that of Sherman traps capturing 14 species.

Hamilton (2015) compared between riparian areas and uplands and found small mammals abundance higher in riparian areas identifiable from uplands by higher plant cover.

Klinger et al. (2015) assessed the habitat use patterns of the Amargosa vole along the Amargosa River in the Mojave Desert, USA. Significantly, high temperature and wetlands nearby were found to be the main reason for occurrence of the voles and its main habitat was found to patches of bulrush (*Schoenoplectus americanus*) where cover is greater than 50%.

Luza et al. (2016) evaluated models addressing the role of factors like abiotic gradients, disturbances and woody encroachment on structuring non-volant small assemblages considering only disturbed and all ecotones (disturbed and undisturbed). Their result showed increase of niche similarity with increasing distance from hydric resources, increase of abundance with increasing vegetation height along with the occurrence of habitat-specialist species on undisturbed sites.

Urgoiti et al. (2018) examined the community of granivorous rodents in the Pyrenees, one of the southernmost mountain ranges of Europe with the confirmation of presence of yellow necked mouse (*Apodemus flavicollis*) in central Pyrenees for the first time. The study suggested that population isolation among valleys may increase the genetic diversity of rodents, like *Apodemus sylvaticus* which are prominent seed-dispersing rodents in Europe along with the potential threat that global warming may represent for species linked to high-altitude habitat at the southern edge of its distribution.

## MATERIALS AND METHODS

### 3.1 Study Area:

#### 3.1.1 Location:

Chandragiri is located in the Mahabharat range forming a portion of southwestern border between Kathmandu-Makwanpur and Kathmandu-Dhading districts. It lies seven kilometres from Thankot (Baniya and Sakya, 1984). The region under present study is situated between  $27^{\circ}67'850''$  N (Gumalchowki CF) to  $27^{\circ}68'778''$  N (Mahalaxmi CF) and  $85^{\circ}22'517''$  E (Gumalchowki CF) to  $85^{\circ}19'448''$  E (Mahalaxmi CF) ranging from 1,400 m to 2,551 m in altitude. Chandragiri Hill comprises of 17 community forests among which 5 community forests have been selected for present study: Gumalchowki CF, Mahankal CF, Ganeshdevi-Bandevi CF, Chandragiri CF and Mahalaxmi CF from east to west direction.

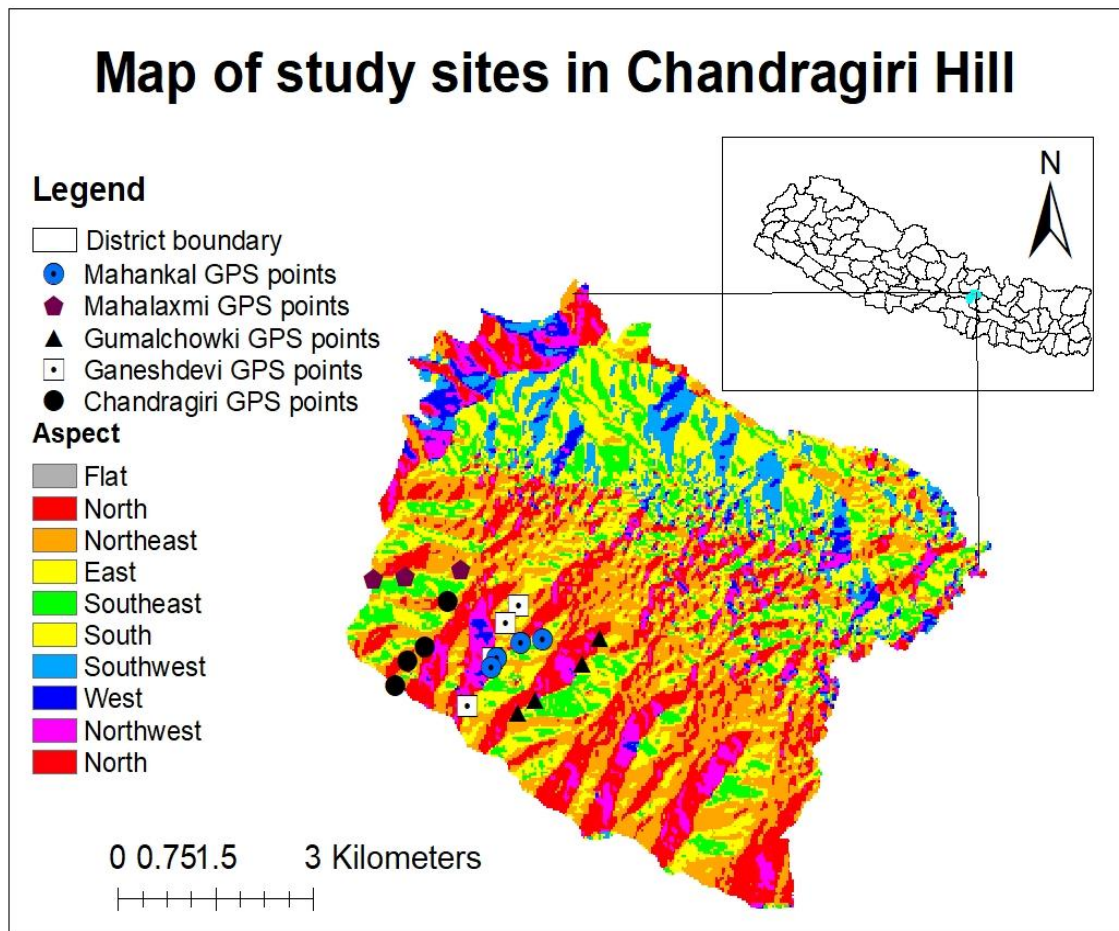


Figure 1: Map of the Study Area Chandragiri Hill, Kathmandu , Nepal

The main range of the hill runs in the East-West direction with slight turning towards north and with its highest point at Bhaleswar (2,563 m), which rises abruptly from the floor of the south-western part of Kathmandu valley. Chandragiri is the main source of catchment-basin for Panighat khola (small river) and Matatirtha khola towards Kathmandu valley. These are among the tributaries of Balkhu khola, which flows east near Kirtipur and mingles with Bagmati river. Chitlang khola and Chakhel khola originate from the south of low hills of Chandragiri range. Soaring peaks and breath taking views of whole Kathmandu Valley covered with lush green blanket of flora and panoramic views of Himalayan ranges from Annapurna to Everest makes Chandragiri truly a great beautiful and pristine landscape (Baniya and Sakya 1984).

### **3.1.2 Climate:**

The Chandragiri region has temperate type of climate at high altitude but warm temperate semi tropical climate at the lower altitude. The winter is moderately cool and the summer is warm and rainy. Occasional winter showers deposit snow on the peaks of the hill and it snows even at 2100 m and below. During the study period, the value of average temperature was 17.44°C and average humidity was 57.1%.

### **3.1.3 Vegetation:**

During the study period, the dominant vegetations around the trap stations were Salla, Khasru, Chilaune, Katus, Laligurans, Ainselu, Bayar, Uttis, Nigalo, Angeri, Titepati and Bhimsenpati, which were also identified with the help of local people. According to Baniya & Sakya (1984), the vegetation of Chandragiri region is classified into six types of mesoxerophytic forests (which have also been depicted in the table below): *Pinus longifolia* and *Schima wallichii* forest, *Schima wallichii* and *Castonopsis indica* forest, Upper Sub-tropical with *Rhododendron arboretum* and *Lyonia ovalifolia* forest, *Quercus lanata* and *Pinus excels* forest, *Quercus lanata* forest, and *Quercus semecarpifolia* forest.

Many people depend upon the forest resources for their livelihood and fulfillment of daily needs, though it was seen that people rarely visit Mahalaxmi CF (making it more dense than others) probably because they don't have to take livestock to the forest for grazing and in many houses, use of firewood has been replaced by modern technologies.

Table 1: Major Vegetations types found in different altitudes of the Chandragiri Hill.

Altitude (m)	Slope	Vegetation
1,450 –1,850	North	<i>Schima walichii</i> forest with <i>Castanopsis indica</i> and <i>Pinus roxburghii</i>
Below 1,800	North	<i>Alnus nepalensis</i> forest
1,850-2,150	West	Lower temperate mixed Broad-leaved forest
2,150-2,400	North	Evergreen Oak Forest
2,350-2,450	Nort-East, East	<i>Rhododendron arboreum</i> and <i>Quercus semecarpifolia</i> forest
2,250-2,563		<i>Quercus semecarpifolia</i>
2,000–2,300	South	Mixed broad-leaved forest with <i>Quercus lanata</i> and <i>Schima walichii</i>
2,000-2,200	South-West & Mid-south	<i>Quercus lanata</i> and <i>Pinus wallichiana</i>
1,850-2,100	South,South-east, South-west facing slopes of Chitlang valley	<i>Pinus wallichiana</i> forest

Source: Baniya & Sakya (1984)

### 3.2 Materials

- Camera (Nikon D5300 18-140 mm)
- Binoculars (Nikon 20×50 mm)
- GPS (Garmin etrex 10)
- Measuring rope
- Sherman trap (Large folding aluminium version, 10.16×11.43×38.1 cm)
- Pitfall trap (8 litre bucket)
- Tube trap (BioEcoSS, detachable double walled nest box, 7.2×7.9×31.5 cm)
- Local trap (Wire mesh trap, 9.9×11.2×26.7 cm)
- Bait
- Weighing machine

### 3.3 Methods

- **Reconnaissance survey:** Firstly, interaction between the Community Forest Officials and local people was done in order to take consent for carrying out the field work, know about the routes and trails in the forest as well as to gain information on their knowledge and perception on small mammals.
- **Sampling Technique:** The field visit was carried out in two phases: Phase I (15 days) and Phase II (10 days). The study area was divided into five sampling plots/ study sites: Gumalchowki CF, Mahankal CF, Ganeshdevi-Bandevi CF, Chandragiri CF and Mahalaxmi CF. Small mammal surveys were carried out from 1600 m to 2200 m on all the five sites. Four trapping grids were established along the elevational gradient of each site. One trapping grid consisted of one trap at the centre with three traps on the right and two traps each on the left, upside and downside, all were set 10 m apart from each other. Thus, 10 trap stations at each of the four grids were established on all the sites thus, 40 trap stations per elevational transect/ study site. In each of the site, a total of 40 traps i.e. 12 Sherman Traps, 12 tube traps, 11 local traps and five pitfall traps (plastic buckets each of 8 litre volume) were deployed. The trap stations were marked by using red ribbon on the stem/branches of the shrubs/trees. Each trap was baited using five type of baits: balls of oatmeal mixed with peanut butter, bread, biscuit, finely chopped carrots and potatoes. An entire plot was trapped simultaneously for three nights during the Phase I and for two nights during the Phase II.  
During the study period, small mammal sampling was done in total 1000 trap nights (25 nights × 40 traps).
- **Capture, Mark and Recapture Method:** The trapped small mammals were first transferred into a thick plastic. They were held on their neck from left hand and on the tail region from right hand. The captured individuals were photographed from different angle and essential information of them like weight, sex, head-body length, tail length, hind foot length and ear length were noted. They were marked on their ventral side of body using fur clipping and released.
- **Sign Survey/ Direct Observation in Line transect survey:** The potential habitats of small mammals were identified on the basis of presence/absence of burrows, feeding sites and on sightings by direct observation (Aryal and Yadav 2010). Opportunistic data collection was also be done.

### 3.4 Identification

The small mammal individuals were initially identified thoroughly according to the identification key “Small Mammals of Central Nepal”. Then, for complete identification, the data of weight, gender, head-body length, tail length, hind foot length and ear length of all the captured individuals were compared with different field guides by Baral and Shah (2008), Menon (2014) and Wilson, Lacher and Mittermeier (2017) along with an article by Talmale and Bharathimeena (2017).

### 3.5 Statistical Analysis:

- ✓ Shannon-Weiner diversity index and Simpson’s Diversity Index were used to find out the diversity of small mammals in the study sites.
- ✓ Margalef’s species richness
- ✓ Relative abundance =  $(N_i/N) \times 100\%$   
where,  $N_i$  = total number of individual of each species in all habitats,  $N_t$  = total number of individuals caught during the entire study.
- ✓ Trap success =  $(N_j / T_n) \times 100\%$ .  
where,  $N_j$  = total number of individual trapped and  
 $T_n$  = total number of trap nights. The trap success shows how many of traps set at a site were able to capture the target species.
- ✓ Data analysis was done using PAST 3.26 Software (Polynomial regression model was applied for species richness and abundance curves) and Microsoft Excel 2013.
- ✓ Arc Map 10.4 was used to obtain the maps of the study areas.

## RESULTS

### 4.1 Occurrence of small mammal species in the Study Sites

A total of 76 individuals belonging to 8 species and 2 orders of small mammals (Table 2) were recorded from Chandragiri Hill from systematic survey in the current study through Capture-Mark Recapture Technique with 7.6 % trap success and 6 recaptures.

Table 2: Species of small mammals captured on the five different slopes of Chandragiri Hill

S. N.	Order	Family	Species		Gumal chowki	Mahan kal	Ganesh devi Bandevi	Chandra giri	Maha laxmi
			Scientific Name	Common Name					
1	Rodentia	Muridae	<i>Mus cervicolor</i>	Fawn colored mouse			√	√	
2	Rodentia	Muridae	<i>Mus musculus</i>	House Mouse	√		√		
3	Rodentia	Muridae	<i>Millardia meltada</i>	Soft furred rat				√	
4	Rodentia	Muridae	<i>Rattus andamanensis</i>	Indo-Chinese Rat/ Sikkim Rat	√	√	√	√	√
5	Rodentia	Muridae	<i>Rattus rattus</i>	House Rat	√	√			
6	Rodentia	Muridae	<i>Rattus pyctoris</i>	Himalyan Rat		√	√		
7	Eulipotyphla	Soricidae	<i>Suncus murinus</i>	Asian House Shrew	√				
8	Eulipotyphla	Soricidae	<i>Soriculus nigrescens</i>	Himalayan Shrew	√	√	√	√	
9	Rodentia	Muridae	<i>Rattus sp.</i>				√	√	
10	Rodentia	Muridae	<i>Mus sp.</i>				√		
11	Unidentified					√	√	√	
Total Number of Species					5	4	5	4	1

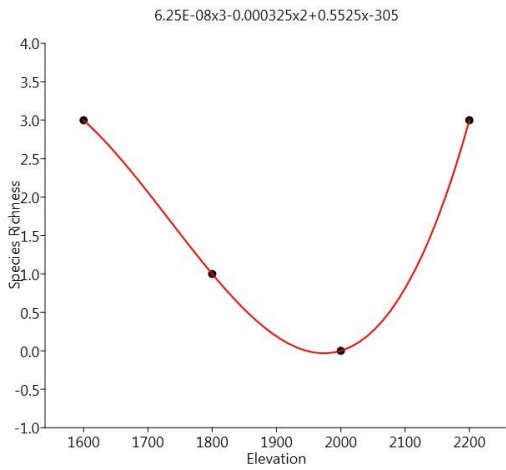
### 4.2 Diversity, species richness and distribution patterns of small mammals in different altitudes:

Highest number of species were recorded at 1600 m and 2200 m of Ganeshdevi Bandevi CF as well as 2000 m of Chandragiri CF (Table 3). Shannon Weiner Diversity Index and Simpson's diversity Index both showed highest value of species diversity at 2200 m of Ganeshdevi Bandevi CF (Table 3). Margalef index showed value of species richness highest at 2200 m of Ganeshdevi Bandevi CF. The value of evenness was highest at 1600 m and 2200 m of Gumalchowki CF (Table 3).

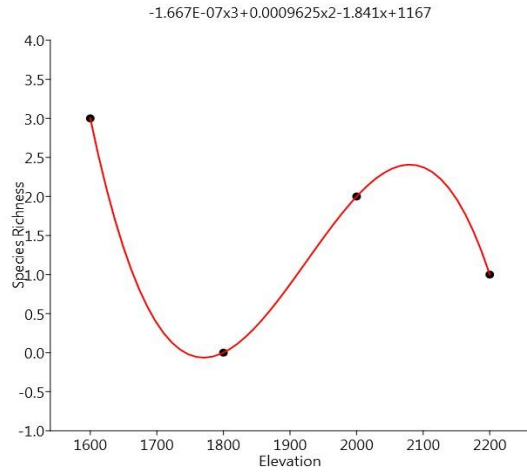
Table 3: Number of Individuals, Species Richness and Shannon-Weiner Diversity Index recorded along the elevational transect of the study sites

Slope	Elevation (m)	No. of Individuals	No. of Species	Shannon Weiner Diversity 'H'	Simpson 1-D	Evenness (e=H/S)	Margalef index
Gumalchowki	1600	5	3	1.06	0.64	0.96	1.24
Gumalchowki	1800	1	1	0	0	0	0
Gumalchowki	2000	-	-	-	-	-	-
Gumalchowki	2200	5	3	1.06	0.64	0.96	1.24
Mahankal	1600	4	3	1.04	0.63	0.94	1.44
Mahankal	1800	-	-	-	-	-	-
Mahankal	2000	4	2	0.56	0.38	0.88	0.72
Mahankal	2200	1	1	0	0	1	0
Ganeshdevi Bandevi	1600	8	4	1.07	0.56	0.73	1.44
Ganeshdevi Bandevi	1800	3	1	0.64	0.44	0.94	0.91
Ganeshdevi Bandevi	2000	3	1	0.64	0.44	0.94	0.91
Ganeshdevi Bandevi	2200	7	4	1.28	0.69	0.90	1.54
Chandragiri	1600	6	2	0.45	0.28	0.78	0.56
Chandragiri	1800	6	2	0.64	0.44	0.94	0.56
Chandragiri	2000	8	2	1.07	0.56	0.73	1.44
Chandragiri	2200	7	1	0	0	1	0
Mahalaxmi	1600	5	1	0	0	1	0
Mahalaxmi	1800	-	-	-	-	-	-
Mahalaxmi	2000	-	-	-	-	-	-
Mahalaxmi	2200	3	1	0	0	1	0
	Total	76	8				

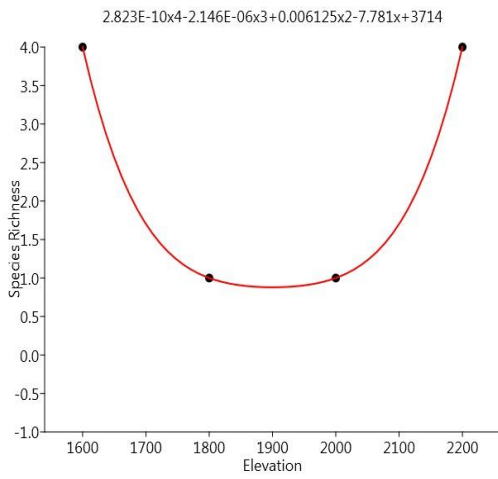
Recorded species richness was highest at 1600 m altitude in all the sampling sites (Table 3, Figure 2). Species richness in Gumalchowki CF and Ganeshdevi Bandevi CF decreased gradually with increasing elevation but, drastically increased at 2200 m (Table 3, Figure 2). Species richness in Mahankal CF was highest at lowest elevation and decreased gradually with increasing altitude (Table 3, Figure 2). Species richness in Chandragiri CF remained constant at 3 altitudes and then decreased (Table 3, Figure 2). Only one species (*Rattus andamanensis*) was captured in Mahalaxmi CF throughout the study period (Figure 2). No species were captured in the 2000 m of Gumalchowki CF, 1800 m of Mahankal CF, and 1800 m as well as 2000 m of Mahalaxmi CF (Figure 2, Table 3).



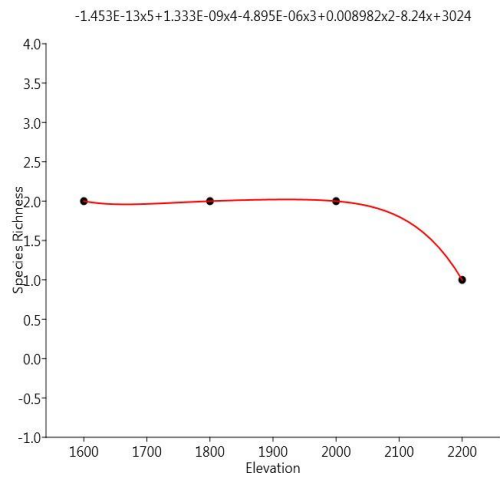
Gumalchowki CF



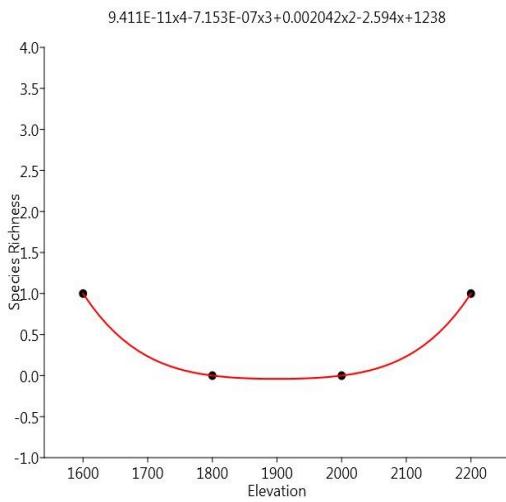
Mahankal CF



Ganeshdevi Bandevi CF



Chandragiri CF



Mahalaxmi CF

Figure 2: Distribution patterns of small mammal species richness with elevation on the five different CFs of Chandragiri Hill

The total species richness at different elevations on the Chandragiri Hill followed the pattern of decreasing species richness with increasing elevation and slightly increase at the top (Figure 3).

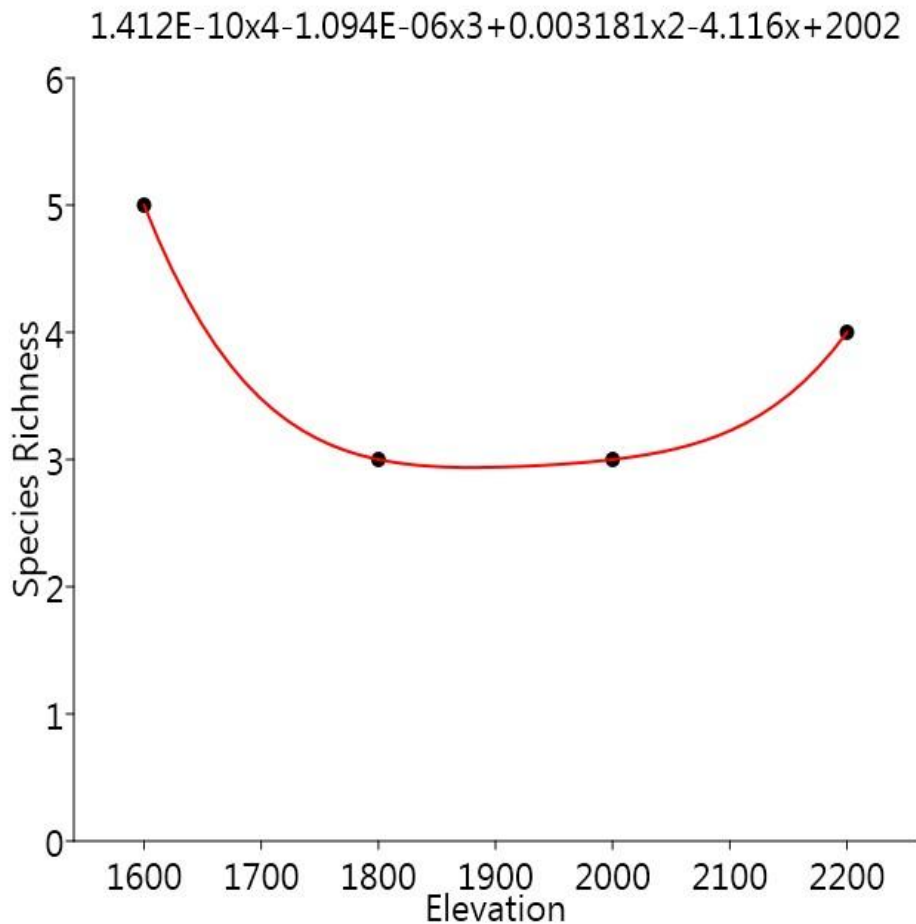


Figure 3: Distribution patterns of total small mammal species richness along the elevational gradient of the Chandragiri Hill

#### 4.3 Captured number of small mammals along the elevational gradient

Highest number of individuals were captured in Chandragiri CF (27) followed by Ganeshdevi-Bandevi CF (21), Gumalchowki CF(11), Mahankal CF (9) and Mahalaxmi CF (8) (Figure 4). Highest number of individuals (8) were captured at 2000 m in Chandragiri CF and at 1600 m in Ganeshdevi Bandevi CF (Figure 4). Mahankal CF had highest number of individuals (4) at both 1600 m and 2000 m (Figure 4). Highest number of individuals (5) were captured at 1600 m in Mahalaxmi CF (Figure 4). Gumalchowki CF had highest number of individuals (5) at both 1600 m and 2200 m (Figure 4).

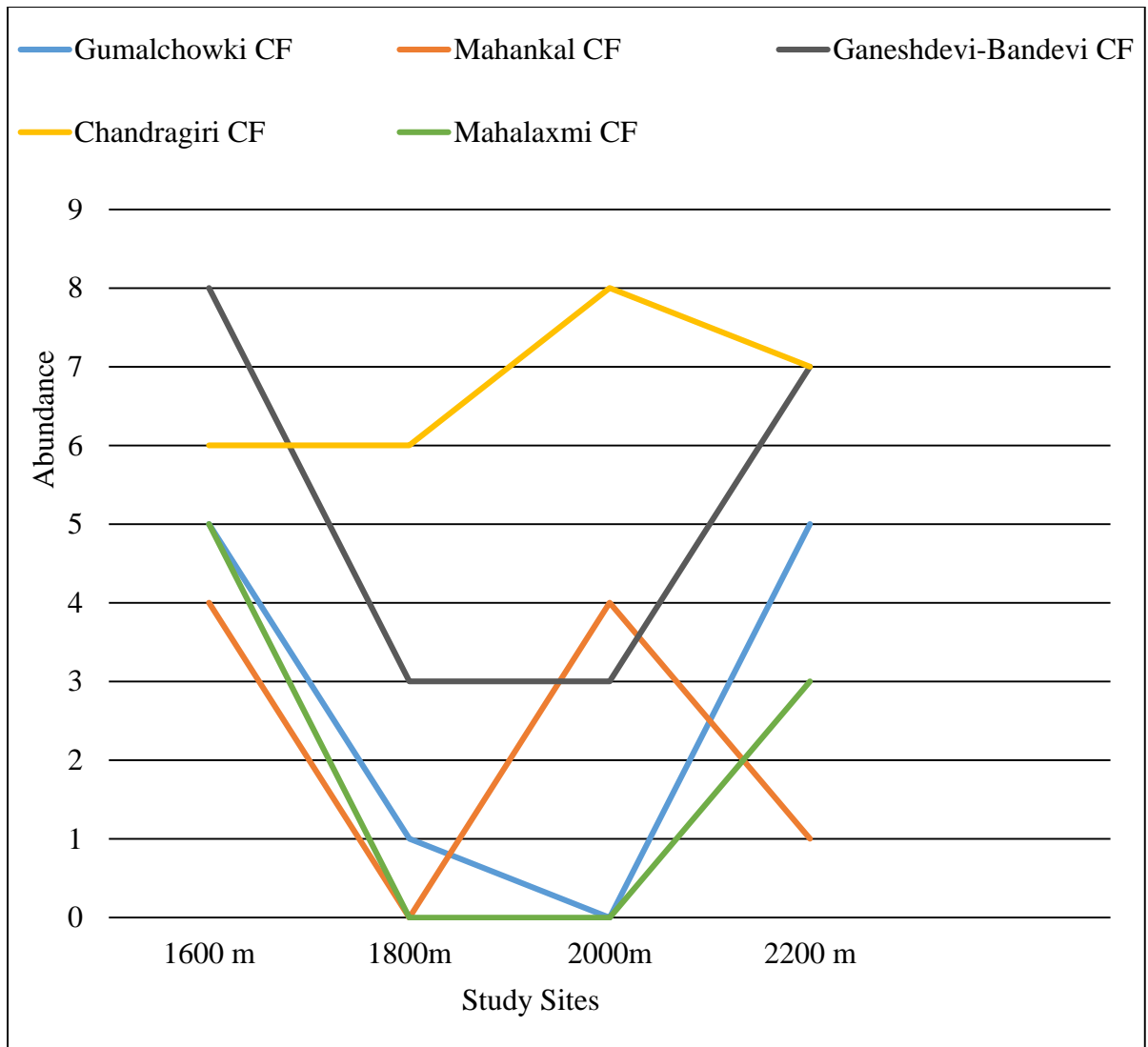


Figure 4: Distribution patterns of total number of small mammal individuals along the elevational gradient of Chandragiri Hill.

The total number of small mammal individuals were recorded highest (28) at 1600 m which is the starting point or lower elevation of the sampling site (Figure 5). The captured number of individuals decreases at 1800 m (10) whereas slightly increases at 2000 m (15) and becomes higher (23) at 2200 m (Figure 5).

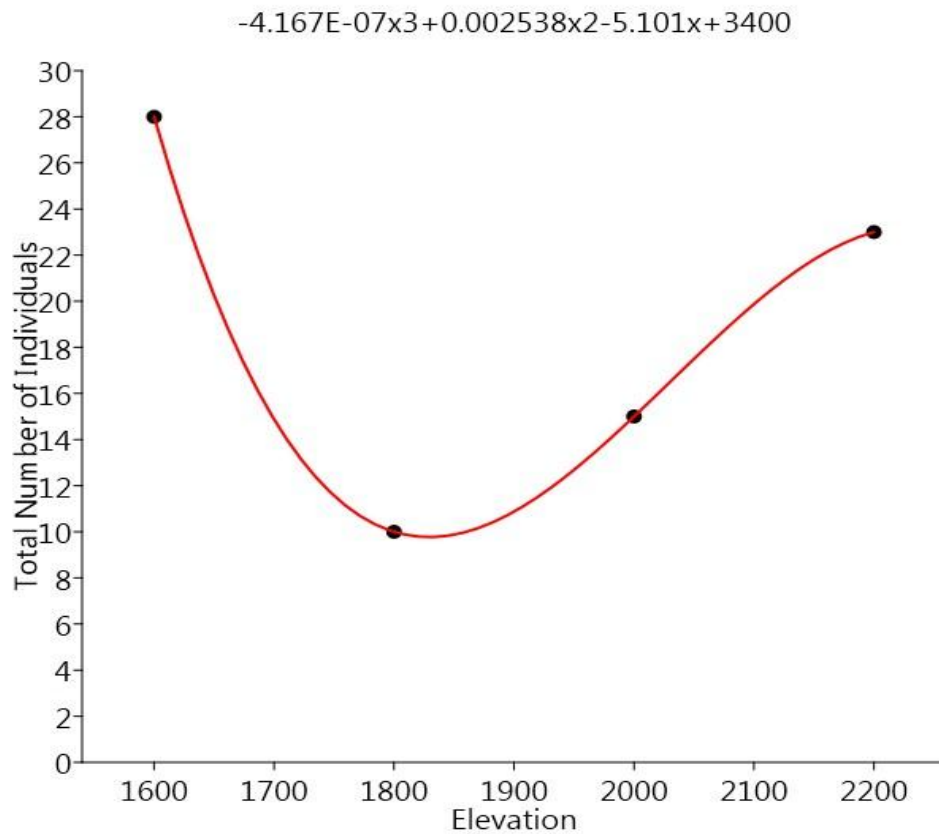


Figure 5: Distribution patterns of total number of small mammal individuals along the elevational gradient of the Chandragiri Hill

#### 4.4 Relative abundance of small mammals

*Rattus andamanensis* was the most abundant species and was found in all the five study sites and also at all altitudes (Table 4, Figure 6). The species *Soriculus nigrescens* was the second most dominant species and also found in all the study sites except Mahalaxmi CF where no shrew species were recorded (Table 4, Figure 7). Relative Abundance of small mammals was observed to be highest at 1600 m followed by 2200 m, 2000 m and least at 1800 m (Table 4). Both Shannon and Simpson Diversity indices showed diversity of small mammals highest at 2000 m followed by 2200 m, 1800 m and least at 1600 m (Table 4).

Table 4: Local Abundance of small mammals in different altitudes

S.N.	Name of species	1600 m	1800 m	2000 m	2200 m	Total
1.	<i>Rattus rattus</i>	3	1	-	-	4
2.	<i>Rattus andamanensis</i>	18	4	9	7	38
3.	<i>Rattus pyctoris</i>	-	-	-	2	2
4.	<i>Mus musculus</i>	-	-	1	3	4
5.	<i>Mus cervicolor</i>	2	-	-	-	2
6.	<i>Millardia meltada</i>	-	-	1	-	1
7.	<i>Soriculus nigrescens</i>	4	3	1	11	19
8.	<i>Suncus murinus</i>	1	-	-	-	1
9.	<i>Rattus</i> sp.	-	1	1	-	2
10.	<i>Mus</i> sp.	-	-	1	-	1
11.	Unidentified	-	-	1	1	2
Total		28	9	15	24	76
Relative abundance		36.84	11.84	19.73	31.57	
Shannon Diversity Index (H)		1.11	1.21	1.39	1.32	
Evenness		0.61	0.84	0.57	0.75	
Simpson Index (1-D)		0.55	0.67	0.61	0.68	
Margalef Index		1.2	1.37	2.22	1.26	

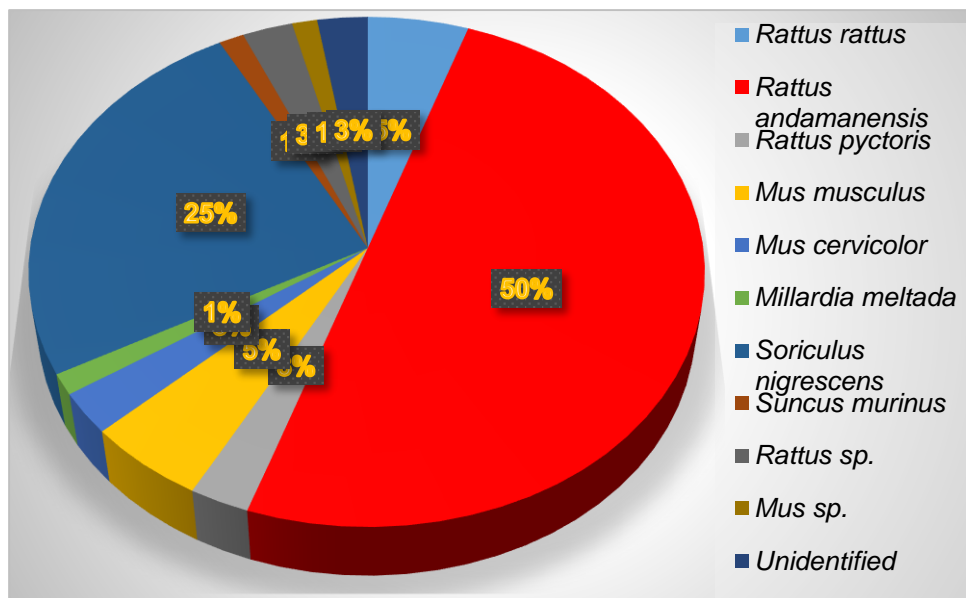


Figure 6: The number of small mammals individuals recorded throughout the study period

*Suncus murinus* was recorded only at the 1600 m elevation of Gumalchowki CF (Figure 7). *Millardia meltada* was recorded only at the 2000 m elevation of Chandragiri CF (Figure 7). Similarly, *Rattus pyctoris* was recorded only at 2200 m whereas *Mus cervicolor* was recorded only at 1600 m altitude during the study period (Figure 7).

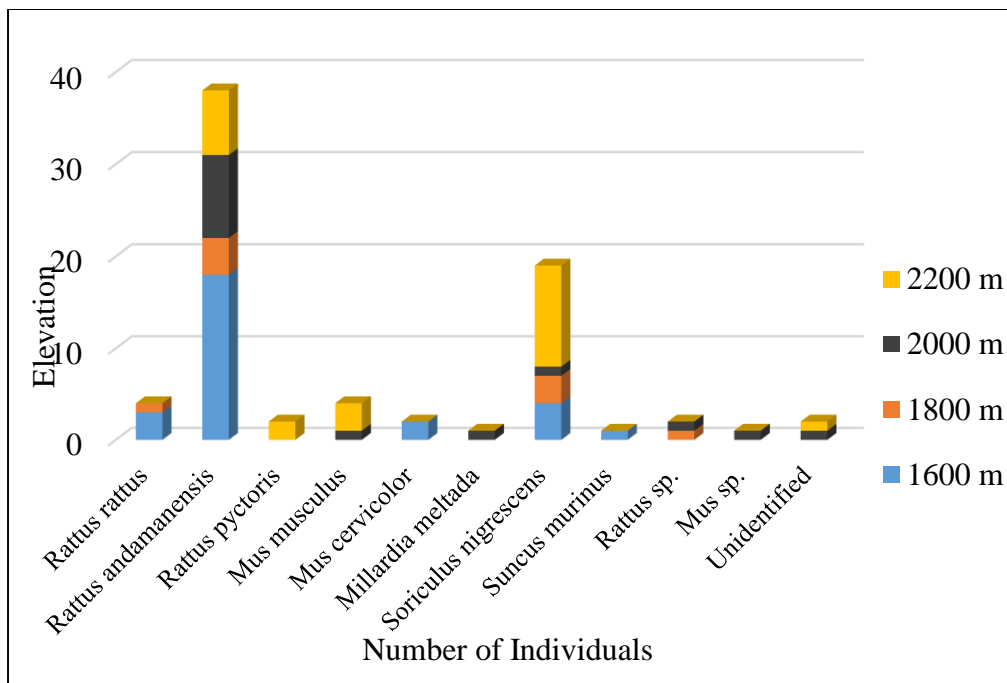


Figure 7: Relative Abundance of rodent and shrew species (N=76)

The relative abundance of the small mammals was highest at 1600 m, decreased at 1800 m, slightly increased at 2000 m and became higher at 2200 m (Figure 8).

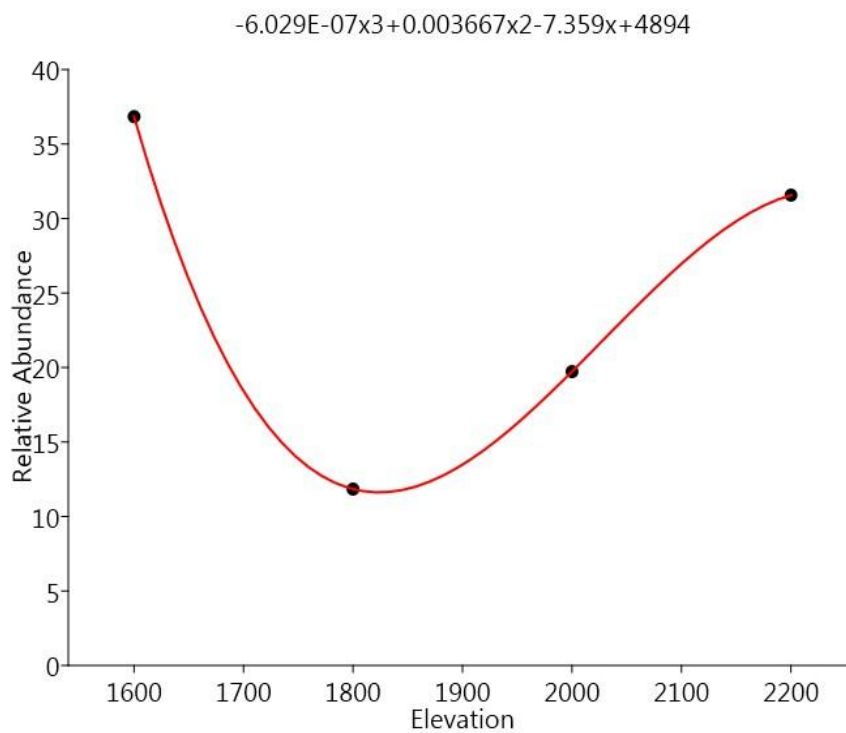


Figure 8: Relative Abundance of small mammal individuals along the elevational gradient of the Chandragiri Hill

#### 4.5 Morphometric measurements of small mammals revealed from the study

*Rattus andamanensis* is characterized by much longer tail than head and body and resembles *Rattus rattus* but is larger in body size and tail length (Table 5). The species *Mus cervicor* has tail length smaller than head and body length in comparison to *Mus musculus* (Table 5). *Suncus murinus* is a common house shrew which is larger in body size in comparison to other shrews (Table 5) and has tail covered by longer hairs (Menon 2014). It has very short tail in comparison to head and body length (Table 5).

Table 5: Average morphometric measurements of recorded rodent and shrew species

Species	Weight (gm)	Head Body Length (mm)	Tail length (mm)	Hind Foot Length (mm)	Ear length (mm)
<i>Mus cervicolor</i>	13	76.5	64	16	14.5
<i>Mus musculus</i>	27	67.75	71.25	16.5	12.25
<i>Millardia meltada</i>	74	136	110	31	20
<i>Rattus andamanensis</i>	107.41	210.76	257.80	22.78	19.99
<i>Rattus rattus</i>	63.33	197.33	171.67	28	18.67
<i>Rattus pyctoris</i>	35	123	152.5	28	18
<i>Suncus murinus</i>	55	100	72	23	13
<i>Soriculus nigrescens</i>	20.52	82.26	45.89	16.05	8.73
<i>Rattus</i> sp.	138	200	181.5	33.5	25
<i>Mus</i> sp.	40	99	110	26	18
Unidentified	24	104.5	110.5	28	19.5

#### 4.6 Diversity indices and abundance of small mammals in the study area

Ganeshdevi-Bandevi CF had the highest (1.57) Shannon Weiner Diversity Index followed by Gumalchowki CF (1.55) whereas Chandragiri CF and Mahankal CF having the equal value (1.21) of “H” (Table 6). Chandragiri CF had the highest abundance followed by Ganeshdevi-Bandevi CF, Gumalchowki CF, Mahankal CF and Mahalaxmi CF (Table 6). Highest no. of species (5) were recorded in Ganeshdevi-Bandevi CF (along with 1 *Mus* sp, 1 *Rattus* sp & unidentified) whereas only 1 species was recorded in the Mahalaxmi CF throughout the trapping period (Table 6). Highest abundance and number of individuals of

small mammals was found in Chandragiri CF followed by Ganeshdevi-Bandevi CF, Gumalchowki CF, Mahankal CF and Mahalaxmi CF (Table 6).

Table 6: Shannon-Diversity Index and Abundance of Small Mammals on the Five Study Sites

CF	Shannon Weiner Indices	Total Individuals	Abundance (%)
Gumalchowki	1.55	11	14.47
Mahankal	1.21	9	11.84
Ganeshdevi Bandevi	1.57	21	27.63
Chandragiri	1.21	27	35.53
Mahalaxmi	0	8	10.53

#### 4.7 Trap success rate and Efficiency of traps

Highest number of rodents were captured at 1600 m followed by 2000 m, 2200 m and least at 1800 m whereas highest number of shrews were captured at 2200 m, equal captures at 1600 m and 1800 m, and only one capture at 2000 m (Table 7). No captures were obtained in 2000 m of Gumalchowki CF and 1800 m of Mahankal CF. Highest rate of trap success was observed at 1600 m and least at 1800 m (Table 7). It was also observed that the total trap success rate of shrews was very low in comparison with that of rodents along the elevational gradient (Table 7).

Table 7: Number of individuals, trap success rates and species of rodents and shrews sampled in total 1000 trap night at each elevation

Elevation (m)	Total Individuals	% Trap success	No. of Species	Rodent			Shrew		
				Individuals	% Trap success	No. of Species	Individuals	% Trap success	No. of Species
1600	28	2.8	6	24	2.4	4	4	0.4	2
1800	10	1	4	6	0.6	3	4	0.4	1
2000	15	1.5	6	13	1.3	5	1	0.1	1
2200	23	2.3	5	12	1.2	4	11	1.1	1

### Efficiency of Traps:

Twenty nine individuals of small mammals were trapped by Sherman trap, 22 individuals by tube trap, 19 by local trap, five by pitfall trap (Table 8). Sherman trap had the highest trap success rate (2.9 %) whereas pitfall trap had the least (0.5 %) (Table 8). Tube trap trapped highest number of species (6) including 1 species of shrew and 5 species of rodent signifying as an efficient trap despite it's small size (Table 8).

Table 8: Total number of individuals and species caught by four types of trap along the four elevational gradients

Altitude (m)	Sherman Trap			Tube trap			Local trap			Pitfall trap		
	Indi vidu als	Species		Individ uals	Species		Individ uals	Species		Individ uals	Species	
		R	S		R	S		R	S		R	S
1600	6	3	1	7	3	1	16	3	1	0	0	0
1800	4	1	1	3	1	1	1	1	0	0	0	0
2000	9	4	0	4	2	0	1	1	0	1	0	1
2200	10	2	1	8	3	1	1	0	1	4	0	1
Total	29	3	1	22	5	1	19	3	2	5	0	1
		4			6			5			1	
Trap night	1000			1000			1000			1000		
Trap success	2.9 %			2.2 %			1.9 %			0.5 %		

### 4.8 Species accumulation in total trap nights at the sampling sites

During the study period, 41 individuals were captured in Phase I of small mammal sampling, whereas 35 individuals were captured in Phase II (Table 9). In 160 and 200 trap nights, the number of species recorded remained constant in Gumalchowki and Mahankal CFs whereas tend to increase slightly in the case of Ganeshdevi Bandevi, Chandragiri and Mahalaxmi CFs (Figure 9).

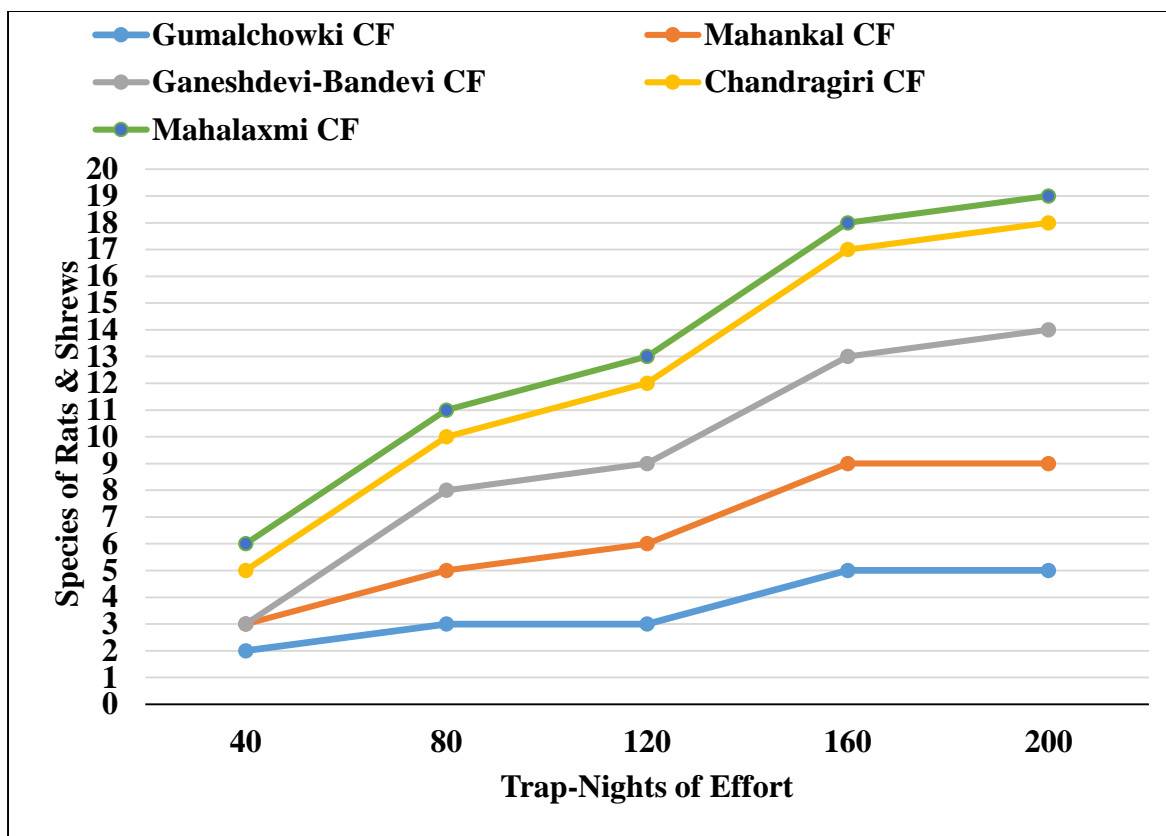


Figure 9: Species accumulation curves of non-volant small mammals at five study sites in Chandragiri Hill

Table 9: Number of species captured per trap night in all the study sites

Trap Nights Effort	Gumalchowki CF	Mahankal CF	Ganeshdevi-Bandevi CF	Chandragiri CF	Mahalaxmi CF
Phase I					
40	2	1	0	2	1
80	2	1	4	2	0
120	2	1	2	4	1
Phase I					
160	2	0	3	0	1
200	2	2	2	5	1

## DISCUSSION

### 5.1 Distribution of species richness of small mammals in different altitudes

This study determined the diversity and distribution patterns of small mammals on Chandragiri Hill along different elevation gradients. This information on small mammal biodiversity may help in effective planning on ecosystem management and the information on species distribution helps to know about the ecology, habitat preference, and species replacement (Musila et al. 2019).

Species richness peaks highest at the lower altitude (i.e. 1600 m) and slightly decreases along with elevation, strongly correlates with the findings of Karkee (2018) in the Shivapuri Hill, Nuwakot. The present study accedes with McCain and Grytnes (2010) which states that decreasing species richness with increasing elevation and hump shaped pattern with a richness peak at intermediate elevation are most commonly observed patterns throughout the world.

In Gumalchowki CF species richness decreases with elevation and increases at 2200 m. In Mahankal CF and Ganeshdevi-Bandevi CF, species richness decreases with increase in the altitude, at 2000 m in Chandragiri CF and at 2200 m in Ganeshdevi-Bandevi CF. In Chandragiri CF, species richness remains to be similar moving up elevationally and becomes lowest at the peak. The present study is inconsistent with Rickart et al. (2011) in which it has been mentioned that samplings carried out along the elevational gradients have predominantly resulted in higher species richness of non-volant small mammals at mid or high elevations rather than in the lowlands. This study agrees with Wu et al. (2016) in the sense that, for species richness pattern of small mammals along altitudinal gradients, factors like annual rainfall, annual temperature, productivity, food resources diversity and high rate of speciation seem to be most likely to be responsible.

### 5.2 Abundance of the small mammals

The highest small mammal abundance was observed in Chandragiri CF followed by Ganesh devi Bandevi CF, Gumalchowki CF, Mahankal CF and least in Mahalaxmi CF. The reason behind this be might high vegetation cover, soil moisture, shrub cover and human interference to some extent. Nembang (2003) had reported higher abundance of small mammals in the area with dense ground vegetation cover and proximity to water source. Adhikari (2001) reported similar situation from the study conducted in Bardia National Park where the distribution of small mammals was highly associated with habitat

heterogeneity and is also an important factor for conservation. Kunwar (2016) reported highest abundance in cropland followed by grassland, mixed deciduous forests and least in riverine areas, but human induced factors have negative impact on small mammals. In this study, small mammals are seen to be in association with the human interference.

*Rattus andamanensis* was the most abundant species and was found in all the five study sites and also at all altitudes. It shows similarity with the common house rat and is moderately larger in size and also has tail length longer than the head body length (Wilson, Lacher and Mittermeier 2017). Many species of small mammals depend on cover for their life requisites; rodent and leporidae are mostly dependent on vegetation for all life requirements, whereas the insectivores use vegetation only for cover or shelter (Adhikari 2001). Similarly, the shrew species *Soriculus nigrescens* was also found in all the study sites except Mahalaxmi CF where no shrew species were recorded and only one species of rodent was recorded. This might be due to the less shrub cover and ground cover which was observed in the site. In this study, the shrew species *Suncus murinus* was only trapped at 1600 m of Gumalchowki CF which is a common mammal around human settlements, along stream-sides, and at the edges of cultivated grounds, sometimes penetrates into evergreen broadleaved forests (Hishashi 1971).

The house rat *Rattus rattus* is a common and dominant species in the towns and villages of Central Nepal (Hishashi 1971). The house rat has been observed in the house of Chandragiri (SMCRF 2015). In the present study, *Rattus rattus* was trapped in Gumalchowki CF and Mahankal CF. One house rat was observed to be running across the trail of the Cable Car station and according to the local people, it commonly dwells around the human settlements for foraging and they regard it as pest due to its crop raiding as well as destructive nature.

### **5.3 Occurrence of the small mammals**

According to the biodiversity survey by SMCRF (2015), a total of 13 mammal species were recorded from the Chandragiri Hill including 11 medium as well as large sized mammals and two small mammals (house rat and house shrew).

The present study has been conducted during the month of March right after the ending of the snowfall. 76 captures were done in a total of 1000 trap nights. The capture rate was very low in comparison to the studies conducted on small mammals most probably because the study was conducted during the winter and other probable reasons like less movement of the animals due to various environmental factors, low availability of food & vegetation cover. The present study agrees with Hamilton (2015) that during the winter, riparian

habitat having high plant cover may lose value for food and cover, as plant production ends and deciduous trees lose their leaves. This result in occurrence of low number of small mammal species in the habitat during winter.

Small non-volant mammals due to their nocturnal behavior are difficult to identify without live-trapping methods. In the present study, '0' capture has also occurred in some trap nights though the species may be present in the site due to their less movement or unwillingness to enter the trap. This agrees with Lim and Pacheco (2016) which says one limitation may occur in that although the overall species diversity of non-volant small mammals is high, but the trap success may be low due to "trap shyness" as a result, many species may not be detected in a rapid survey.

Highest number of small mammal individuals (29) was trapped by the Sherman trap proving it to be the most efficient live trap. Tube trap was also an efficient trap which successfully captured 22 individuals belonging to six species but, it often leads to trap death due to its small size causing suffocation if not handled in time. Although local trap was also a good trap for trapping and captures 19 individuals but mostly it resulted in tail cuts and wounds increasing the sensitivity of the small animal. Pitfall trap were mostly meant for shrews as rodents can leap high. The pitfall trap trapped four individuals at 2200 m of Chandragiri CF and one individual at 2000 m of Ganeshdevi Bandevi CF whereas couldn't capture any individuals of rodent species at any of the study sites. The present study is not consistent with Umetsu (2006) as he found pitfall traps more efficient than Sherman traps in his study.

The present study has resulted in minimum recaptures, 5 during the first 15 days and only 1 in the consecutive 10 days. The reason behind it must be the winter season sampling resulting in less recaptures. This accords with the study conducted by Urgoiti et al. (2018) which has also come up with similar result that the mortality of small mammals being probably high during winter in the study area due to the extreme environmental conditions, abundant snow cover and extremely low temperatures, thus limited food availability and also resulted in the lack of recaptures from the first to the second year of the study.

The capture probability of mice is higher in traps with high shrub cover at the microhabitat scale, which provides protection against predators (Bertolino 2007, Urgoiti et al. 2018). This resembles with the present study as higher trap success was observed in the trap stations where shrub cover was high. For instance, during the Phase I at Ganeshdevi-Bandevi CF, the capture was nil at 1600 m, but, after the increase in shrub cover during Phase II, trap success occurred at the elevation. In the present study, it was also observed

that capture probability of small mammals was high in the surrounding of rocky cavities as it may be unreachable to large predators and may also offer a better chance of escaping from small predators similar to Bertolino (2007).

However, the present study gathered some information on small mammals' ecology, as information on distribution and abundance is important not only for improving understanding of the biology of the species but also for assessing its conservation status and guiding conservations actions and decisions (Wang et al. 2007).

## CONCLUSION AND RECOMMENDATIONS

### 6.1 Conclusion

The present study conducted along the elevational gradient in five different community forests of Chandragiri Hill, Kathmandu confirmed the presence of six species of rodents and two species of shrews belonging to two orders recorded in 1000 trap nights with 7.6 % trap success and six recaptures. Species richness was highest at 1600 m altitude in all the sampling sites and slightly decreased along with elevation whereas only in Gumalchowki CF, species richness increased at the peak of sampling site. Highest abundance and number of individuals of small mammals was found in Chandragiri CF followed by Ganeshdevi Bandevi CF, Gumalchowki CF, Mahankal CF and Mahalaxmi CF. Relative Abundance of small mammals was observed to be highest at 1600 m and least at 1800 m. Shannon Weiner Diversity Index showed highest species diversity in Ganeshdevi Bandevi CF. Relative Abundance of small mammals was observed to be highest at 1600 m and least at 1800 m. *Rattus andamanensis* was the most abundant species and was found in all the five study sites and also at all altitudes. The species *Soriculus nigrescens* was also found in all the study sites except Mahalaxmi CF where no shrew species were recorded. *Suncus murinus* was recorded only at 1600 m elevation of Gumalchowki CF. *Millardia meltada* was recorded only at 2000 m elevation of Chandragiri CF. Similarly, *Rattus pyctoris* was recorded only at 2200 m whereas *Mus cervicolor* was recorded only at 2200 m altitude during the study period. Sherman trap had the highest trap success rate (2.9 %) followed by tube trap (2.2 %) whereas pitfall trap had the least (0.5 %). Tube trap trapped highest number of species (6) including 1 species of shrew and 5 species of rodent.

### 6.2 Recommendations

The present study conducted in the winter revealed that the study area has a good diversity of small mammals, thus further researches on small mammals covering more seasons can provide a better and extended checklist of mammals found in the Chandragiri Hill.

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## **APPENDIX 2: Opportunistic data collection of medium- and large-sized mammals**

Chandragiri Hill is one of the largest natural forests in Kathmandu valley. Although the study was focused on small mammals, opportunistic sampling of medium and large-sized mammals was done both directly and indirectly. Leopard scats, pugmarks and scent mark were highly observed in Mahankal CF and also in other CFs. Leopard sighting also occurred while setting the traps on the first trap night of Mahankal CF. Vocals of barking deer and wild boar were most often heard during the sampling day time. Pellets of ungulates, burrows of pangolin, holes made by small mammals and scratches made by wild boar on the ground were observed at all the trapping sites. Four yellow throated marten were observed running across the Gumalchowki CF and two were sighted at the backyard of the Chandragiri cable car station, most probably while they were roaming for foraging. Six Indian Grey Mongooses were observed mostly near the human settlements. One jungle cat was observed in the Chandragiri CF during the preliminary survey. During the preliminary visit on September 2018, a bat *Rhinolopus luctus* (Great Woolly horseshoe bat) of family Rhinolophidae was observed in a cave at Ganeshdevi Bandevi CF. The local people said that porcupines are largely found at September in maize fields. It was observed that the local people usually mistaken leopard with tiger. A woman said that bears were sometimes used to be seen all of a sudden when they used to visit the forest for firewood, twigs and leaves. According to the local people, there used to be heard howling sound of jackals at evenings which has vanished now.

### APPENDIX 3: Data of small mammals identification collected from the field at Chandragiri Hill.

Comm unity Forest	Day	Mark	Species	Colour		Elevation (m)	Trap	Weight (g)	Head & Body (mm)	Tail (mm)	Hind foot (mm)	Ear (mm)	Sex
				Dorsum	Venter								
PHASE I													
Gumal chowki	2 <sup>nd</sup>	111	<i>Rattus rattus</i>	Orange	Whitish	1600	Local	65	290	170	26	20	Male
		112	<i>Suncus murinus</i>	Greyish	Greyish	1600	Local	55	100	72	23	13	Male
	4 <sup>th</sup>	111	<i>Rattus rattus</i>	Orange brownish	Whitish	1600	Sherman	35	140	175	30	15	Male
		141	<i>Mus musculus</i>	Greyish	Greyish white	2200	Tube	25	60	67	15	13	Male
	5 <sup>th</sup>	121	<i>Rattus rattus</i>	Orange brownish	Greyish white	1600	Local	145	166	165	29	24	Female
		<b>141</b>	<b><i>Mus musculus</i></b>	<b>(Recapture) Brownish</b>	<b>Greyish white</b>	<b>2200</b>	<b>Tube</b>	<b>50</b>	<b>60</b>	<b>67</b>	<b>15</b>	<b>13</b>	<b>Male</b>
Mahan kal	6 <sup>th</sup>	211	<i>Rattus rattus</i>	Orange brownish	Greyish white	1600	Local	90	162	170	28	21	Male
	7 <sup>th</sup>	211	<i>Soriculus nigrescens</i>	Greyish brown	Greyish	1600	Sherman	80	98	45	17	10	Male
		212	<i>Soriculus nigrescens</i>	Greyish brown	Greyish	1600	Tube	25	88	37	18	9	Female
	8 <sup>th</sup>	241	<i>Rattus pyctoris</i>	Orange brownish	Greyish white	2200	Sherman	40	130	151	29	19	Male
Ganes hdevi Ban devi	10 <sup>th</sup>	321	<i>Rattus sp.</i>	Wet greyish brown	Greyish	1800	Tube	120	165	193	33	20	Male
		322	<i>Rattus andamanensis</i>	Orange	Whitish	1800	Sherman	85	141	180	29	17	Male
		331	<i>Mus sp.</i>	Greyish	Whitish	2000	Sherman	40	99	110	26	18	Male
		341	<i>Rattus pyctoris</i>	Greyish	Whitish	2200	Tube	30	116	154	27	17	Male
		342	<i>Soriculus nigrescens</i>	Greyish brown	Greyish	2200	Local	10	96	29	16	7	Female
	11 <sup>th</sup>	311	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1600	Sherman	60	124	165	29	17	Male

		341	<i>Unidentified (Millardia meltada??)</i>	Greyish brown	Greyish white	2200	Tube	25	110	76	28	18	Female
		321	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1800	Sherman	85	130	183	30	18	Male
Chand ragiri	12 <sup>th</sup>	411	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1600	Local	105	156	200	30	21	Male
		421	<i>Soriculus nigrescens</i>	Greyish brown	Greyish	1800	Tube	15	90	50	16	5	Female
		422	<i>Soriculus nigrescens</i>	Greyish brown	Greyish	1800	Sherman	5	81	50	16	6	Female
		431	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2000	Sherman	45	120	180	28	20	Female
	13 <sup>th</sup>	411	<i>Rattus andamanensis</i>	(Recapture) Orange brownish	Whitish	1600	Local	100	160	195	34	21	Female
		421	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1800	Sherman	45	125	160	39	18	Male
		431	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2000	Sherman	55	137	174	29	16	Male
		441	<i>Soriculus nigrescens</i>	(Dead) Greyish brown	Greyish white	2200	Pitfall	10	77	42	15	7	Female
		442	<i>Soriculus nigrescens</i>	(Dead) Greyish brown	Greyish white	2200	Pitfall	10	65	54	17	7	Female
	14 <sup>th</sup>	441	<i>Soriculus nigrescens</i>	Greyish brown	Light Greyish brown	2200	Pitfall	55	88	45	16	8	Female
		442	<i>Soriculus nigrescens</i>	(Dead) Greyish brown	Light Greyish brown	2200	Pitfall	10	70	45	18	9	Female
		443	<i>Soriculus nigrescens</i>	Greyish brown	Light Greyish brown	2200	Sherman	15	90	41	19	9	Female
		444	<i>Soriculus nigrescens</i>	Dead Greyish brown	Greyish white	2200	Sherman	15	51	60	14	6	Female

		431	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2000	Local	55	145	96	29	19	Male
		<b>432</b>	<b><i>Rattus andamanensis</i></b>	<b>(Recapture) Orange brownish</b>	<b>Whitish</b>	<b>2000</b>	<b>Tube</b>	<b>25</b>	<b>132</b>	<b>184</b>	<b>26</b>	<b>17</b>	<b>Male</b>
		421	<i>Soriculus nigrescens</i>	(Dead) Greyish brown	Greyish	1800	Dead outdoor	15	86	51	13	12	Female
		<b>411</b>	<b><i>Rattus andamanensis</i></b>	<b>(Recapture) Orange brownish(Tail cut)</b>	<b>Whitish</b>	<b>1600</b>	<b>Local</b>	<b>70</b>	<b>160</b>	<b>200</b>	<b>34</b>	<b>21</b>	<b>Male</b>
		412	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1600	Local	125	171	183	35	20	Male
		413	<i>Mus cervicolor</i>	Orange brownish	Greyish white	1600	Local	10	73	58	17	14	Male
Maha laxmi	15 <sup>th</sup>	511	<i>Rattus andamanensis</i>	Orange	Whitish	1600	Local	70	139	193	33	17	Female
	17 <sup>th</sup>	<b>511</b>	<b><i>Rattus andamanensis</i></b>	<b>(Recapture) Orange</b>	<b>Whitish</b>	<b>1600</b>	<b>Local</b>	<b>65</b>	<b>151</b>	<b>184</b>	<b>32</b>	<b>17</b>	<b>Male</b>
		512	<i>Rattus andamanensis</i>	(pregnant) Orange	Whitish	1600	Tube	25	147	180	31	16	Female
Phase II													
Gumal chowki	18 <sup>th</sup>	111	<i>Rattus andamanensis</i>	Decaying state (trap recovered) Orange brownish	Whitish	1600	Sherman	115	132	181	34	24	Male
		141	<i>Soriculus nigrescens</i>	Greyish brown	Light greyish brown	2200	Sherman	15	82	41	15	11	Female
	19 <sup>th</sup>	141	<i>Soriculus nigrescens</i>	Greyish brown	Light greyish brown	2200	Sherman	16	99	53	17	7	Female
		142	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2200	Tube	59	131	170	30	20	Female
		111	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1600	Tube	71	140	200	30	17	Male

Mahan kal	21 <sup>st</sup>	211	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1600	Sherman	125	195	223	32	20	Female
		231	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2000	Sherman	33	113	135	26	19	Male
		232	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2000	Sherman	31	112	143	24	20	Male
		233	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2000	Tube	32	114	154	27	17	Male
		234	<i>Soriculus nigrescens</i>	(Dead) Greyish brown	Light greyish brown	2000	Pitfall	14	74	46	16	12	Female
Ganes hdevi Ban devi	22 <sup>nd</sup>	311	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1600	Local	130	180	195	34	20	Male
		312	<i>Mus musculus</i>	Orange brownish	Greyish white	1600	Tube	16	76	75	17	13	Male
		331	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2000	Sherman	41	131	160	25	19	Female
		341	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2200	Sherman	77	131	153	26	20	Male
		342	<i>Soriculus nigrescens</i>	Greyish brown	Greyish	2200	Sherman	16	91	48	18	11	Female
		332	<i>Rattus andamanensis</i>	(Dead) Orange brownish	Whitish	2000	Tube	53	102	160	27	20	Male
		313	<i>Soriculus nigrescens</i>	Greyish brown	Greyish	1600	Tube	22	74	45	16	11	Female
	23 <sup>rd</sup>	341	<i>Mus musculus</i>	Orange brownish	Greyish white	2200	85	17	75	76	19	10	Female
		342	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2200	Sherman	43	119	154	25	19	Male
		311	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1600	Sherman	83	151	176	30	20	Male
		<b>312</b>	<b><i>Mus cervicolor</i></b>	<b>(Recapture) Orange brownish</b>	<b>Greyish white</b>	<b>1600</b>	<b>Tube</b>	<b>16</b>	<b>80</b>	<b>70</b>	<b>15</b>	<b>15</b>	<b>Male</b>
		313	<i>Rattus andamanensis</i>	Orange brownish	Greyish white	1600	Local	124	183	186	35	20	Male
		314	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1600	Local	80	163	135	34	25	Male

Chandragiri	25 <sup>th</sup>	441	<i>Soriculus nigrescens</i>	Greyish brown	Greyish	2200	Tube	15	75	50	16	9	Male
		431	<i>Millardia meltada</i>	Orange brownish	Whitish	2000	Tube	74	136	110	31	20	Male
		432	<i>Rattus andamanensis</i>	Orange brownish	Whitish	2000	Sherman	49	135	190	26	20	Male
		433	<i>Unidentified (Mus or Rattus??)</i>	Orange brownish	Greyish white	2000	Sherman	23	99	145	28	21	Female
		434	<i>Rattus sp.</i>	Orange brownish	whitish	2000	Sherman	156	235	170	34	25	
		421	<i>Rattus andamanensis</i>	(Dead) Orange brownish	Whitish	1800	Local	64	115	186	25	25	Male
		422	<i>Soriculus nigrescens</i>	(Dead) Greyish brown	Greyish	1800	Tube	27	88	40	12	10	
		411	<i>Rattus andamanensis</i>	(Dead) Orange brownish	Whitish	1600	Local	97	140	44	39	26	Female
Mahalaxmi	27 <sup>th</sup>	541	<i>Rattus andamanensis</i>	(Cataract eyed) Orange brownish	Greyish white	2200	Sherman	96	165	178	29	24	Male
	28 <sup>th</sup>	511	<i>Rattus andamanensis</i>	Orange brownish	Whitish	1600	Local	75	169	185	30	18	Male
		512	<i>Rattus andamanensis</i>	Orange	Whitish	1600	Tube	78	126	194	34	20	Female
	29 <sup>th</sup>	541	<i>Rattus andamanensis</i>	(Dead) Orange brownish	Greyish white	2200	Tube	118	131	198	35	29	Male
		542	<i>Rattus andamanensis</i>	(Dead) Orange brownish	Greyish white	2200	Sherman	74	105	200	35	28	Male

**Table 7: Taxonomic Data of all Captured Individuals during the study period**

(Note: The rows in bold are of the recapture individuals)

**Appendix 4: Photographs of Small mammals captured during the sampling period**

**Photo Plate 1: Murid rodents and soricid shrews recorded in Chandragiri Hill**



i) *Mus musculus*



ii) *Rattus pyctoris*



iii) *Rattus rattus*



iv) *Rattus andamanensis*



v) *Millardia meltada*



vi) *Mus cervicolor*



vii) *Suncus murinus*



viii) *Soriculus nigrescens*



2. *Rhinolopus luctus* bat at a cave in captured Ganeshdevi Bandevi CF during preliminary field visit



3. Fur clipping of rodent for marking individuals



4. Baits and traps in the field for small mammals sampling



5. Interaction with President of Chandragiri CF during preliminary field visit



6. Sherman trap laid in the field & red ribbon marked in the tree branch



7. Leopard Pugmarks observed at Mahankal CF



8. Felid scat observed in Mahankal CF



9. Pellets of ungulates in Mahankal CF



10. Yellow throated marten in backyard of Chandragiri Cable Car Station



11. Indian Grey Mongoose observed in Gumalchowki CF during preliminary field visit