1. INTRODUCTION

1.1. Crop Damage by Wildlife

When both the farmers and the wildlife share the same resources, the integration of conservation with other forms of land use is difficult in such case (Heinen 1993). Problems become more acute when special conservation interest for some species is involved. In such cases, the wild animals enter into the agricultural areas and may lead to a chain of events ranging from crop or livestock damage and injury or death to people (Wang et al. 2001). One of the main issues of wildlife - human interaction of protected areas and its periphery is crop depredation by wild animals (Tweheyo et al. 2001). Thus, crop raiding is a form of human wildlife conflict which directly affects livelihood, local people's perception of and support for conservation initiative (Basnet 2003). Crop damage causes economic loss and promotes negative perceptions towards species of conservation concerned (Priston 2008).

The relation between park and people is unbalanced when the park animals damage outer peripheral areas and disturb the adjacent settlements. Damage to agricultural crop, human harassment and livestock depredation are the common problems of this human wildlife conflict (Sharma 1991, Gurung 2002). In Nepal, crop damage is very common along the periphery of protected area (Sharma 1991, Gurung 2002). Determining the actual impact of wildlife damage to crop yield depends on various elements such as the stage of plant development, location of damage in the field, amount of damage and the location of damage on the plants (Macgowan et al. 2006). Crop damage by wildlife such as the rodents and birds is a very common problem of the protected area (Purkait 2008, Priston 2008). Porcupine is one of the animals which uses crop plants extensively as a food resource, thus leading to a significant loss in agricultural crop. Its adaptability to a wide range of habitats and food habits helps to maintain their healthy population. In search of food, porcupine are reported traveling more than ten miles (16.66 km) in a single night (Walker et al. 1968). Thus, porcupines are real cause of damage of crops in the peripheral areas of the protected area where they are found.

1.2.Porcupine

The so-called "Big Five" group of animals includes the elephant, rhino, Bengal tiger, snow leopard and musk deer. Some years back a scientist suggested a “Small Five” group of animals consisting the aardvark, ratel, porcupine, pangolin and the naked mole-rat (www.awf.org). Porcupines are the third largest rodents with a coat of sharp spines or quills that defend them from predators (www.awf.org). The name 'porcupines' comes from middle French **porc de pine** which could be translated as 'thorny' 'spines' or 'quilled' 'pork' or 'pig,' hence the nickname 'quill pig' for the animal. A group of the porcupines is called princkle.

Porcupines occupy a wide variety of habitats in tropical and temperate parts of Asia, Italy, Africa and North and South America. They live in forest, desert, rocky outcrops, hillsides and grasslands. They are endemic in both the Old world and New world. The Old world porcupines are almost exclusively terrestrial, tend to be fairly large and have quills that are grouped in cluster. The New world porcupines are mostly smaller and have their quills attached singly rather than grouped in cluster and are excellent climbers, spending much of their times in the trees. Terrestrial porcupines (Family Hystricidae) are also referred to as Old world porcupines in order to differentiate them from arboreal porcupines (Family Erethizontidae) of the New world.

The terrestrial porcupine (Family Hystricidae) was divided by Lyon (1907) into two subfamilies, Hystricinae and Atherurinae and these are accepted by some authors (Skinner and Smithers 1990, Smithers 1983). Three subgenera (*Acanthion* Cuvier, 1823, *Hystrix* Linnaeus, 1758 and *Thecurus* Lyon, 1907) include eight living species: *H. africaeaustralis*, *H. brachyura*, *H. crassispinis*, *H. cristata*, *H. indica*, *H. javanica*, *H. pumila*, and *H. sumatrae* (Corbet 1978, Corbet and Hill 1992, Corbet and Jones 1965, Van Weers 1978). Subgenus *Hystrix* was reviewed by Corbet and Jones (1965). The following key to the genus is modified from Van Weers 1983 (Barthelmess 2006).

Table 1.1. Key to Genus modified from Van Weers (1983)

S.N.	Description	Sub genus	Go To	Species
1	i. Length of rattle quills >35 mm; many quills with >1 blackish ring	Hystrix	2	-
	ii. Length of rattle quills <35 mm; quills with ≤ 1 blackish portion	Acanthion, Thecurus	3	-
2	i. Crest predominantly brown	-		Hystrix indica
	ii. Crest predominantly white	-	4	-
3	i. Crest present, but not conspicuous; longest hair ≥ 45 mm with white tip ≥ 5 mm	-	-	Hystrix brachyuran
	ii. No crest; hairs on head equal in length and without white tip	-	5	-
4	Length of rattle quills< 60 and usually < 50 mm with diameter 2–5 mm; midline along rump black or mottle	-	-	Hystrix cristata
5	Length of rattle quills long, >50 and usually >60 mm with diameter 5–7 mm; midline along rump white	-	-	Hystrix africaeaustralis
6	i. Length of largest rattle quill 15–20 mm with diameter 3.5 - 6.1 mm	-	-	Hystrix javanica
	ii. Length of largest rattle quill 8–16 mm with diameter 6.3 – 8.3 mm	Thecurus	6	
7	i. Length of largest rattle quill 12–16 mm	-		Hystrix crassipinis
	ii. Length of largest rattle quill 8–11 mm	-	7	-
8	i. Some quills with blackish terminal region and some with white tips; length of white tips 10–30 mm	-	-	Hystrix sumatrae
	ii. Quills nearly completely black with only a small white base	-	-	Hystrix pumila

Note: Number in go to refer the S.N.

1.2.1. Hystrix indica

Indian crested porcupine is a large nocturnal, herbivorous, spiny rodent which belongs to family ‘Hystricidae’. It is easily recognized by its hair modified more or less completely into spines. Its body is 70 to 90 cm long with 8 to 10 cm long tail covered by 18 to 30 cm spines except on foot and nose (www.north-india. in / fauna /seh.htm). The spines are stiffened, sharpened and thickened. The tail is covered with short, stout, white spines. Its hair is highly modified to form multiple layers of spines. Quills present at the end of the tail produce a rattling sound to alarm predators. The feet and hands are broad with long claws that are used for burrowing. The dental formula; I 1/1, c 0/0, pm 1/1, m 3/3 × 2 = 20 (Walker et al. 1968).

The most notable feature of porcupine is its quill which makes it unique among the mammals. Porcupines' quills or spines take on various forms, depending on the species but all are modified hairs coated with thick plates of keratin and they are embedded in the skin musculature. Indian crested porcupine’s neck and shoulders are crowned with a crest of bristles 15 to 30 cm long (www.north-india. in / fauna / seh.htm). Each quill is ornamented with deep brown or black and white rings. Quills are as sharp as needles and easily detached as they are a form of modified hair. When irritated or alarmed the porcupine raises its quills and rattles the hollow spines on its tail. If the disturbance continues, the species launches a backward attack.

The Indian crested porcupine favors rocky hill sides. It is nocturnal although it can be occasionally seen during the day. It inhabits in self constructed burrows with a long entrance as well as other burrows made by other animals. These burrows are most commonly occupied in family units. It has a keen sense of smell and displays high intelligence in evading traps. The main food source for the Indian porcupine is vegetables including fruits, grains and roots. They have also been known to chew on bones and dropped antlers in search of minerals (such as calcium) that helps them to grow their spines.

The breeding habit of porcupine is not much known in the wild but the gestation period of the Indian crested is about 112 days (www.awf.org). Litter size ranging

from one to four is born in a grass - lined burrow but generally two litters per year are common. They are well developed and have their eyes open at birth. At birth, their body is covered by a soft quill but later it begins to harden. The young ones leave home for the first time at about two weeks of age (www.awf.org). Nursing lasts for about 3.5 months. They are usually monogamous and both the parents care for the young ones during the nursing period. The life span is up to about 20 years.

1.2.2. Conservation Status and Distribution

Porcupines are not listed in the IUCN Red list of Threatened Spices. According to South Asian Non Volant Small Mammals Conservation Assessment and Management Plan Report 2005, *Hystrix brachyura* Linnaeus 1758 is listed nationally as a near threatened species in South Asia. Although *Hystrix brachyura* is listed as near threatened species, the other species of porcupines are common throughout their range and do not face significant threat. Due to their ability to adapt to a wide range of habitats and food types, they are able to maintain their population.

The porcupines are widely distributed in Afghanistan, Laos, Malaysia, Iran, Israel, Indonesia, the Philippines, Myanmar, Sumatra, Thailand and Saudi Arabia. In South and Central Asia, they are distributed in Pakistan, India, Nepal, Bangladesh, Bhutan and Sri Lanka. In Nepal, mainly two species are found and they are uniformly distributed in temperate, tropical grassland and subtropical zones.

Hystrix indica Kerr 1792 prefers to live on rocky hill side forests less than 2400m in altitude (www.animals.jrank.org). It is distributed in Bardia National Park, Chitwan National Park, Suklaphanta Wildlife Reserve, Shivapuri National Park and Parsa Wildlife Reserve. It is also found in districts of Chitwan, Rupendehi, Banke, Doti, Bajhang and Bajura (Majupuria et al. 2006, IUCN 2005).

Histrix brachyura Linnaeus 1758 is distributed from arid rock hillsides to monsoon forest less than 2500 m in altitude (Majupuria et al. 2006). It is distributed in Langtang National Park, Sagarmatha National Park, and Makalu Barun National Park (IUCN 2005).

1.3. Objectives

The main objective of the study is to explore crop damage by porcupine in and around the Shivapuri National Park. Specific objectives were to:

- investigate the distribution pattern of porcupines in three VDCs of Shivapuri National Park
- characterize the habitat of porcupine, and
- examine crop damage and estimate economic loss.

1.4. Rationale and Limitation

Studies on small mammals are limited. This has caused serious problem in understanding biology, distribution pattern, habitat and behaviors of small mammals. This is even more challenging in case of porcupine because of its nocturnal habit. Although it causes a serious damage on local crops in Shivapuri National Park, the study on porcupine is scarce. Detailed information about the species and its impact is still lacking.

2.

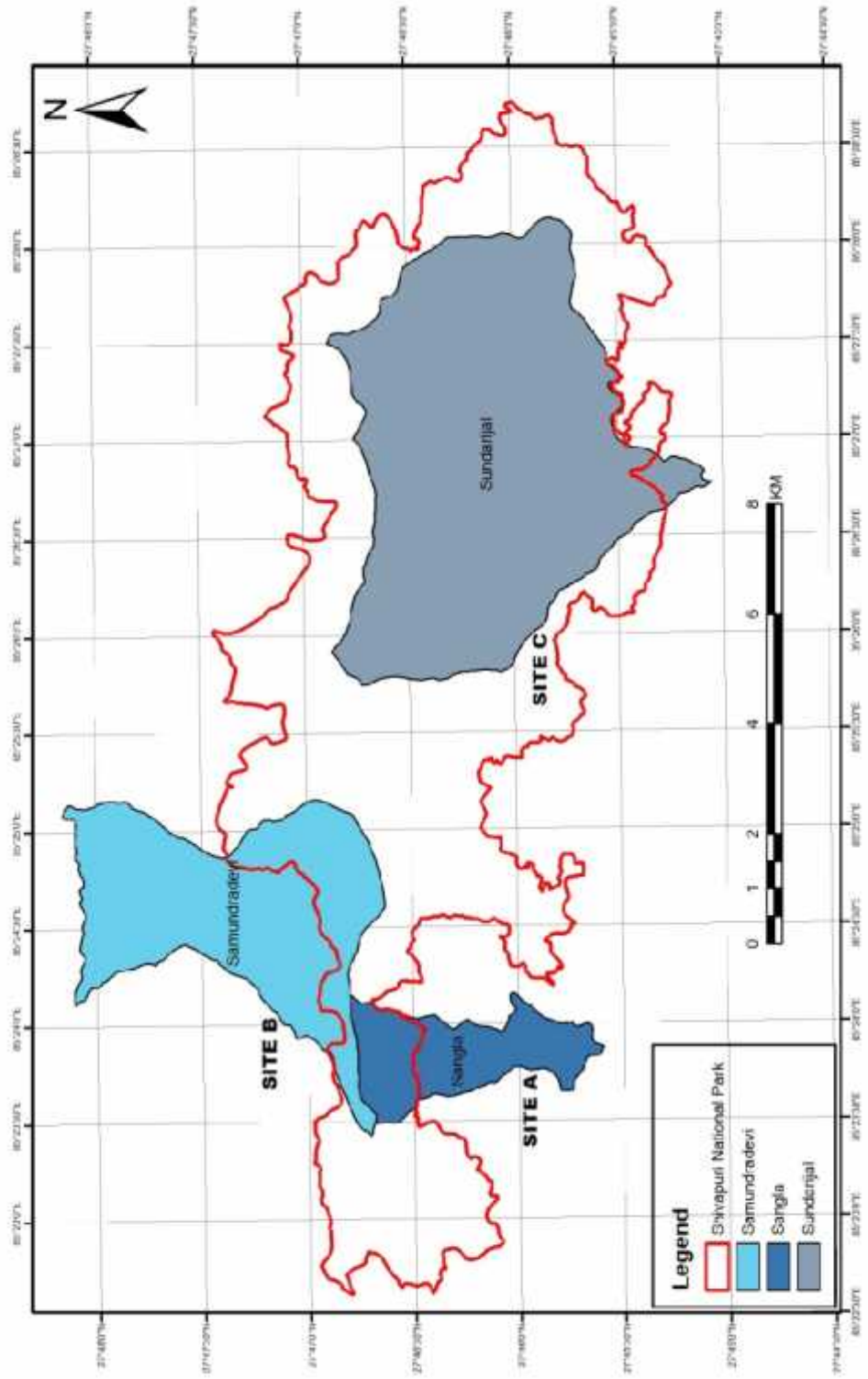


Figure 2.1. Shivapuri National Park

2. STUDY AREA

2.1. Location and Physical Features

Shivapuri National Park (ShNP) is located in the northern side of Kathmandu valley about 12 km away from Kathmandu. It is adjoining with twenty three village development committees (VDC) of Kathmandu (12), Nuwakot (9) and Sindhupalchowk (2) districts of Central Development Region. It lies between 27º 45' – 27º 52' N latitude and 85° 15'- 85° 30' S longitude. The size of the National Park is about 144 km² stretching approximately 9 km from north to south and 20 km from east to west (Department of National Park and Wildlife Conservation, 2002). The highest point is the Shivapuri peak, which is about 2,732m above the sea level. The lowest part is the altitude of approximately 1360m above the sea level.

2.2. Physical Components

2.2.1. Geology

Geologically, Shivapuri area occupies the inner Himalayan region. The dominant rocks are gneiss and migmatite with mica schist and pegmatic granite. The soils of the area range from loamy sand on the northern side to sandy loam on the southern slope (Baniya 1998). Erosion hazards and stream bank erosion both natural and man induced hazards are found all over the area due to its steep topography.

Soil moisture content of ShNP in general increases with the increase in elevation. Moisture content is higher in the natural forest than the barren area. Soil pH is more acidic in disturbed sites than in undisturbed natural sites (Baniya 1998).

2.2.2. Water Resources

Shivapuri being one of the main drinking water supply sources for the Kathmandu Valley, it covers upper watersheds of the Bagmati and Bishnumati rivers. Rivers such as Bagmati and Bishnumati as well as several other smaller streams are constantly being tapped for drinking water purposes. About 30 million liters of water is tapped everyday to supply the drinking water (www.shivapuri.com.np). Tributaries of the Likhu and Shindhu Khola, which drain the northern side, also fall within the park.

There are many rivulets that are tributaries of different spring fed rivers at different sites.

2.2.2. Climate

ShNP lies in the central mid hill region of Nepal and the climate ranges from subtropical to warm temperate. There are three climatological stations at Shivapuri range Kakani, Sundarijal and Budhanilkantha.

According to the climatic data of 2004 to 2008 collected from *the* nearest station of these VDCs at Kakani (altitude 2064m) and Budhanilkantha (altitude 1350m), the mean monthly maximum temperature reaches around 20.1°C and 24°C at Kakani and Budhanilkantha respectively. Similarly, the mean monthly minimum temperature reaches around 11.5°C at Kakani and 12.6°C at Budhanilkantha.

The mean monthly relative humidity is slightly greater at Budhanilkantha station than Kakani station. The mean monthly relative humidity reaches maximum during June to September in both the stations.

Rainfall of this region is more or less similar to Kathmandu Valley in the southern side of the Shivapuri National Park. The mean monthly precipitation recorded in three stations of Shivapuri National Park was the highest during the month of June to September. The mean monthly precipitation was 536.17 mm at Kakani, 361.11 mm at Budhanilkantha and 273.01 mm at Sundarijal for the month of June to September.

2.3. Biological Component

2.3.1. Flora

Shivapuri National Park lies in a transition zone between subtropical and temperate climates. The vegetation consists of a variety of natural forest types depending on altitude. Four forest types are found within the park (Amatya 1993). They are:-

a) Lower mixed hardwood forest: It extends from 1000m-1500m. *Schima wallichii* and *Castanopsis indica* forest and the others are *Alnus nepalensis* and *Prunus cerasoides*.

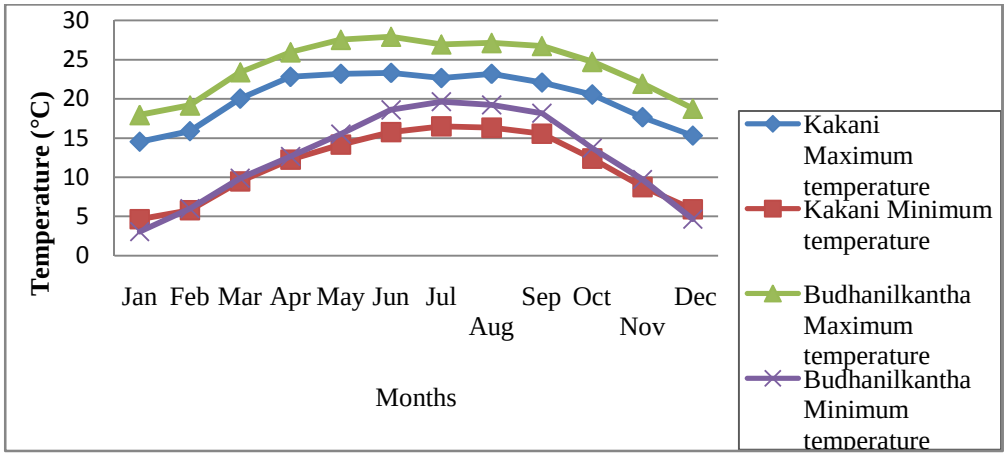


Figure 2.2. Average Maximum and Minimum temperature (°C) at Kakani and Budhanilkantha (2004 – 2008).

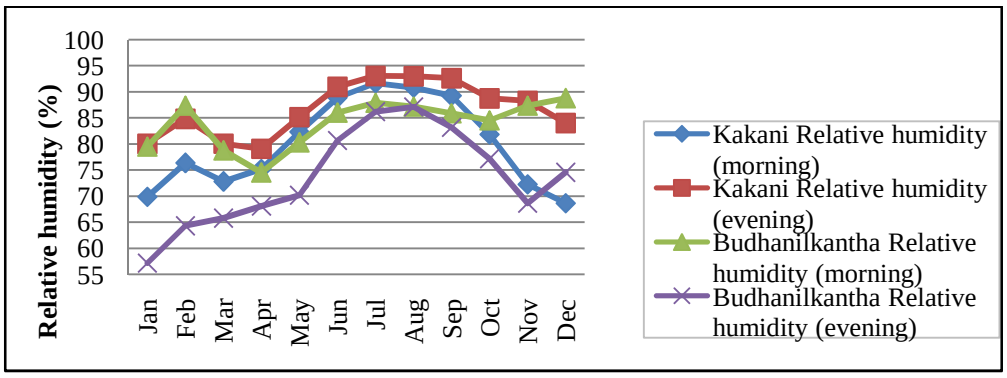


Figure 2.3. Average relative humidity morning and evening (%) at Budhanilkantha and Kakani (2004 – 2008).

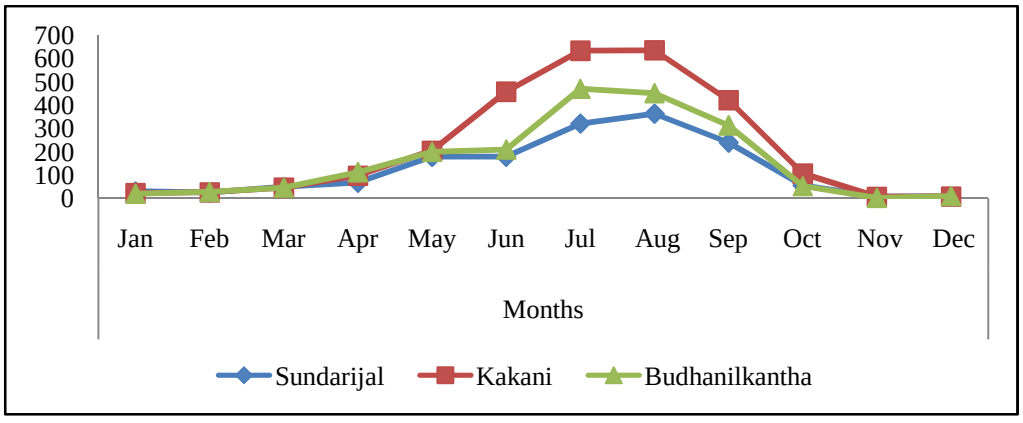


Figure 2.4. Average precipitation (mm) at Sundarijal, Kakani and Budhanilkantha (2004 – 2008).

b) Chir pine forest: Chir pine forest lies from 1000m-1600m. In this forest type *Pinus roxburghii* is dominant to other species *Castanopsis indica and Pyrus pashia*.
c) Oak forest: It extend from 2300m - 2700m. Species combination is Quercus semecarpifolia, Eurya acuminata, llex dipyrens, Michellia champaca, Rhododendron arboreum, Symplocos sp.
d) Upper mixed hardwood forest: Upper hardwoods forest lies at 1500m- 2700m. The species composition in this forest is *Acer sp, Aesculus sp, Juglans regia, Betula sp, Fraxinus sp, Alnus nepalensis, Salix sp, Quercus sp, Celtis sp.*

2.3.2. Fauna

Kattel (1993) recorded 19 species of mammals but Shrestha (2005) recorded 22 species of mammals. Himalayan black bear *(Selenarctos thibetanus*), leopard *(Panthera pardus*), barking deer *(Muntiacus muntjak),* jungle cat *(Felis chaus*), large indian civet (*Viverra zibetha*), himalayan yellow throated marten (*Martes flavigula*), Chinese pangolin *(Manis pentadactyla*), Wild boar *(Sus scrofa*), goral (*Nemorhaedus goral),* Indian porcupine *(Hystrix indica*), and common langur (*Presbytis entellus*) are some of the mammals reported around the park.

Shivapuri National Park is a home to 177 species of birds of which, 9 are enlisted as endangered. There are 19 species of mammals and 150 species of butterflies with a number of endemic and rare species.

2.3.Socio-economy

The total human population of study sites is about 1759 with 333 households. Among the total population 49.29% is male and 50.71% is female (CBS 2001). Major ethnic group living in the study sites are Tamang, Gurung, Magar, Chhetri and Brahmin (CBS 2001). More than 75.5% of the economically active human population of the park and its buffer zone is engaged in agriculture as primary occupation and 45% of the total population is working as labor driver, service at nursery, hotel and lodge (Bajracharya 2005). Due to the nature of soil, the maize and millets are the major cultivated crops of in study area

2.4. Detail Study Sites

Three VDC in and around Shivapuri area were selected for intensive survey of crop depredation by porcupine. They are Sangla and Sundarijal of Kathmandu district and Samundradevi of Nuwakot district (Figure 2.1). Sangla lies at the southern side of Shivapuri National Park. Sangla-8 had 54 households, where there were 146 males and 138 females (CBS 2001). There are three villages Mulkharka, Chilaune and Okhareni inside the park. Okhreni -2 and Mulkharka -6 were selected for the study with altogether 143 household and 717 total population with 365 males and 352 females (CBS 2001). Samudradevi VDC was the third study site. Samundradevi VDC lies between 27°48'32" -27° 51' 46" latitude and 85° 18'11" -85° 21'50" longitude. It covers an area of 16.85 km² (CBS 2001). Ward number 1 and 2 of Samundradevi VDC were selected with 136 household, where there were 356 males and 402 females living there.

a) Agricultural land in Sangla VDC

b) Agicultural land in Samundradevi VDC

c) Adjacent agricultural land in Sundarijal VDC

Plate 1. Study sites

3. LITERATURE REVIEW

3.1. Food Habit and Distribution

Indian crested porcupines take maximum amount of food at night. Thus the Indian crested porcupines were not occurring at latitudes where night duration was less than 7 hours (Alkon and Saltz 1988). When agricultural food was available porcupines mainly fed on agricultural crops including vegetables and fruits. Agricultural crops like pumpkin, guava and brinjal were found in their fecal pellets collected from Karachi. Thus the Indian crested porcupine was the serious pest of agricultural crops of Karachi (Pervez et al. 2009).

Indian crested porcupine is distributed in most part of Asia and Africa. It ranges from Iraq, Iran, Israel, Palestine, Lebanon to Turkey (Arslan 2008). In Iraq, it is distributed in additional 19 new localities (Kadhim 1997). In Nepal, Indian crested porcupine is found in adjacent forests of crop land at less than 2400m altitude (Shrestha 2005, Majupuria et al. 2006).

3.2. Density and First Occurrence

Sharma (2001) estimated the density of porcupines in semi- arid Sariska Valley of Western India. Being nocturnal, small in size and shy of humans, it is hard to observe and very difficult to estimate its population. Therefore, methods involving indirect evidence can be very useful for estimation of its population. So he used both direct and indirect methods. According to him, density was estimated to be 8.8±2.4 animals/km² through direct count while pellet group count provided an estimate of 12.4 animals/ km² with a variation of 0.9 to 24.9 animals| km² in different habitats.

Mandal and Ghosh (2000) reported the first record of occurrence of albino crestless Himalayan porcupines *Hystrix brachyura* Linnaeus 1758, in India. They examined the skins of porcupines present in national zoological collection of Zoological Survey of India. All measurements, external and cranial were in millimeters and it concluded that *Hystrix brachyura* collected from Manipur, India was albino specimen of *Hystrix brachyura*.

3.3. Crop Depredation

Wildlife –Human conflict is one of the main threats to the continued survival of many species in many parts of the world and is also a significant threat to many local populations. Crop depredation is one of the causes of wildlife –human conflict in adjacent villages of protected area of Nepal. Protected area of Nepal such as Parsa wildlife reserve (Kasu 1996) Koshi Tappu wildlife reserve (Sharma 1995, Limbu 1998) Bardia national park (Baral 1999) Suklaphanta wildlife reserve (Gautam 1999) Shivapuri national park (Poudyal 1995, Soti 1995, Gurung 2002, Paneru 2004, Bajracharya 2005, Shrestha 2006, Rajak 2007, Bajracharya 2009) show that crop depredation is one of the main issue of wildlife –human conflict of protected area of Nepal.

In Parsa Wildlife Reserve, mainly two types of problems created the conflict, they were the problems created by the reserve and local people. Wild elephant, wild boar and chital are the major pest animals and the most affected crop was paddy followed by wheat and maize (Kasu 1996).

In Koshi Tappu Wildlife Reserve, wild boar and wild buffalo were most important crop raiders (Sharma 1995, Limbu 1998). Limbu (1998) concluded that wild buffaloes mainly raided paddy and wheat in young to adult milky stage and wild boar mainly raided wheat in milky stage and potato in tuber stage. The study also showed that the total loss of crop was 117517 kg.

In Bardia National Park, Baral (1999) showed a heavy economic loss at Thakurdwara and Shivapur VDCs. He found that 52.73% of loss occurred in Thakurdwara and 47.27% in Shivapur. Highest economic loss occurred in paddy crop followed by potato, maize, wheat, mussuro and yam .The percent of potential crop yield damaged ranged from 9.59% to 16.88%. He reported the loss of crop to wild boar ranged from 166.39 kg to 205.51 kg per household. He reported wild boar as the second crop raider animal in Thakurdwara VDC and first major wildlife pest in Shivapur VDC.

In Shuklaphanta Wildlife Reseve, Gautam (1999) gave a report on crop damage by wild animals in proposed buffer zone. He found highest economic loss of 74.28% on paddy crops followed by wheat (17.08%) and maize (8.62%). He found that among

the wild animals, highest economic loss of 43.29% by wild elephant, followed by wild boar (28.32%), chital (2.09%) and blue bull (3.92%). He reported that loss of crop due to wild animals ranged from 61.62 kg to 126.33 kg per household.

In Shivapuri National Park, major crop raiders were wild boar, monkey, porcupine, bear, birds (Soti 1995, Poudyal 1995, Gurung 2002) along with Himalayan black bear, squirrel, jackal, barking deer (Bajracharya 2005, Bajracharya 2009). The affected crops were the maize, millet, paddy, wheat (Shrestha 2006, Rajak 2007, Bajracharya 2009) along with rooted crops (Paneru 2004, Bajracharya 2005). Among the wild life the porcupine, leopard and jungle cat were identified as frequent pests (Bajracharya 2005). Crop depredation by wild animals was high at zero to one km distances for paddy and wheat and 0 to 500m for maize and millet (Soti 1995, Paneru 2004).

Porcupine was the one of the major crop pests in various places such as, the Shivapuri National Park (Gurung 2002, Bajracharya 2005), in a Negev Desert of Israel (Shachak et al. 1991), in Jigme Sigye Wangchuck National Park in Bhutan (Wang et al. 2001), Budongo Forest Reserve in Uganda (Tweheyo et al. 2001), in Pakistan (Khan et al. 2000) and in Karnataka (Chakravarthy et al. 2005, 2007). Porcupine disturbs the vegetation pattern either by the consumption or damage in eighteen species of plants (Shachak et al. 1991).

In Bhutan, the farmers suffered from major financial losses annually due to crop damage by wild pigs, porcupines including barking deer and sambars (Wang et al. 2001). In Uganda 93% of reported crop loss was due to primates, bush pigs and porcupines (Tweheyo et al. 2001). In Pakistan, the Indian crested porcupine is identified as serious pest of traditional as well as nontraditional crops, fruits and vegetables. Khan et al. (2000) estimates the damage of around 52.5% to *Melia azedarch*, 24.3% to *Morus alba* and 1% to *Dalbergia sissoo* in different irrigated forest plantations in Panjab. Crops of economic importance such as maize, ground nuts and potatoes are severely damaged in irrigated plains and mountains.

4. METHODS

4.1. Reconnaissance Survey

I conducted reconnaissance survey in the months of April and May 2009 to find out the habitat and distribution of porcupine as well as to identify the crop damage done by the porcupines. This was done by discussions with park authorities, wardens, army and villagers. According to information collected from this survey, I selected certain portion of National Park and its peripheral area for my study.

4.2. Distribution of Porcupine

Actual field work was initiated from May to October 2009. In order to study the distribution of porcupine, I divided my study area into three sites.

Sangla VDC (site A): This site is situated at south-west aspect of the National Park and it covers an area of about 0.9 square km. The vegetation includes both cultivated land natural plants. Crops like maize, wheat, millet, paddy, potato etc are cultivated in this area. The natural vegetation includes *Pinus roxburghii, Schima wallichii, Castanopsis indica.*

Samundradevi VDC (site B): This site includes the area of the northern part of *the* park which includes the area of 2.4 square km. The natural vegetation consists of dense forest of herb, shrub and trees. The dominant plants are *Quercus lanuginosa, Rhododendron arboreum, Quercus semecarpifolia* etc.

Sundarijal VDC (site C): This block includes the areas inside the national park. Area covered by this site is about 8.5 square km. Natural vegetation included *Schima, Castanopsis,* and forest with *Pinus roxburghii, Alnus nepalensis* and in upper region the mixed hardwood forest.

4.2.1. Line Transect

Each block was surveyed by diurnal walking through fixed transect line of variable length (500m to 1500m) depending on the availability of track. Two fixed transects were laid on agricultural land in site B and C but in site A only one fixed transect was

laid on agricultural land. Then four transects were laid on forest area. Besides the survey of fixed transect, random search was also carried out to record the occurrence of porcupines.

4.2.2. Field Survey

The blocks were visited regularly in every two weeks from May to October 2009 and the presence of porcupine recorded through indirect evidence such as footprints, quills and burrows. A total of 55 individuals including the army and local people who lived adjacent to the park were interviewed.

4.3. Questionnaire Survey

To collect primary data, the structural questionnaires were developed and interviews were conducted in 47 households which were selected by random sampling method. For my study, I prepared two sets of questionnaire one set for distribution of porcupine and *the* other set for crop depredation done by porcupine. Questionnaire survey was conducted during the month of June, July and August 2009. Before taking interview, people were briefed about the study and tried to interview the head of household, in absence of head of household the person next to head was interviewed.

The questionnaire were designed to receive information on porcupine, frequency and most preferred crop, crop damaged by porcupine etc. Crop loss was estimated in the local scale (pathi, muri) which was converted into kilogram by weighing “a pathi” of different crops for three times and average weight were considered as the standard value. Price of different crops was obtained from local people of my study sites. The average value was considered for estimation of the economic loss.

4.4. Crop Loss

After conducting questionnaire survey, crop loss was calculated by subtracting actual yield from expected yield (Soti 1995). Actual yield refers to the left over grain harvested after being raid by animals in the field. Total crop loss and economic loss were calculated by using following formula:

i) Total crop loss (kg) = Expected yield−Actual yield

ii) Total economic loss = Total crop loss × Price of crop (Rs)

4.5. Data Analysis

F- test was used to compare the crop loss in weight due to depredation by porcupine in three VDCs of the park. They were Sangla, Samundradevi and Sundarijal. The hypothesis was tested at 5% level of significance. Chi-square test was used to determine the distribution of porcupine in different study sites. The hypothesis was tested at 5% level of significance.

a) Taking GPS record

b) Measuring the length of Line Transect

a) Asking questions at Sangla

b) Asking questions at Samundradevi

c) Asking questions at Sundarijal

Plate 2. Questionnaire survey

5. RESULTS

5.1. Distribution Pattern

Porcupines were widely distributed in each site of Samundradevi, Sundarijal and Sangla. The presence of porcupine depended on the availability of food and human non-disturbance in the area. The presence of porcupines in different sites was confirmed by the presence of quills, footprints and burrows. During the study period, the presence of fecal matter rarely confirmed the presence of porcupine.

Altogether, there were found 52 indirect evidences during the study period. Similarly, 21 quills, 28 foot prints and 3 burrows were observed in different sites. In site A the quills were found only in three places. Three burrows were observed during the study period. Two burrows were at Samundradevi near the agricultural field in rocky and bushy area and one at Okhreni in steep slope which was at 500m away from agricultural field (Table 5.1). The entrance of the burrows had scratches. The entrance was approximately 30 cm and it lead to a narrow tunnel with a number of outlets.

Table 5.1. Distribution of porcupine in different sites

Site	**Indirect evidence**				**Total**	**Remark**
	Quills	**Foot print**	**Burrow**			
			Number	**Distance from agricultural land(M)**		
A	3	-	-	-	3	Quills were found in agricultural land
B	12	13	2	200	27	Burrows were found in rocky and bushy area
C	6	15	1	500	22	Burrows were in steep slope

Note: Foot prints also included scratches of damage.

Similarly, chi –square goodness of fit test revealed that there were significant differences in distribution of porcupine in three different sites (χ^2 =18.51>χ p=0.05,df=2).

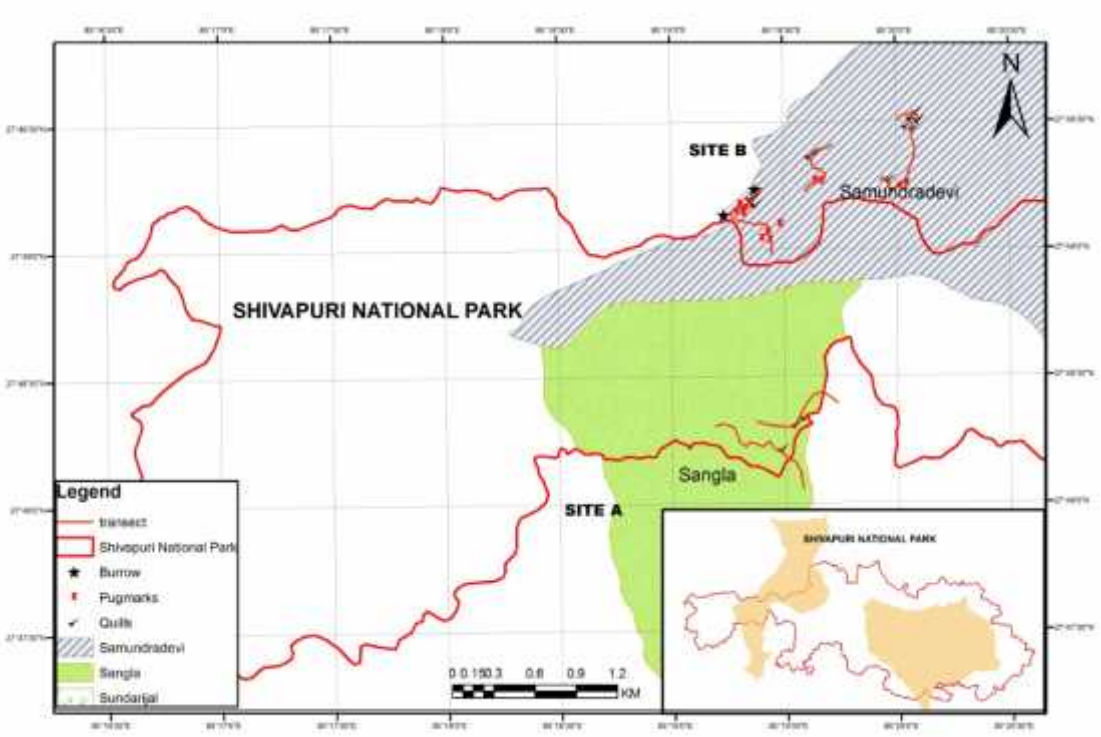


Figure 2.5. Distribution of Porcupines in Sangla and Samundradevi

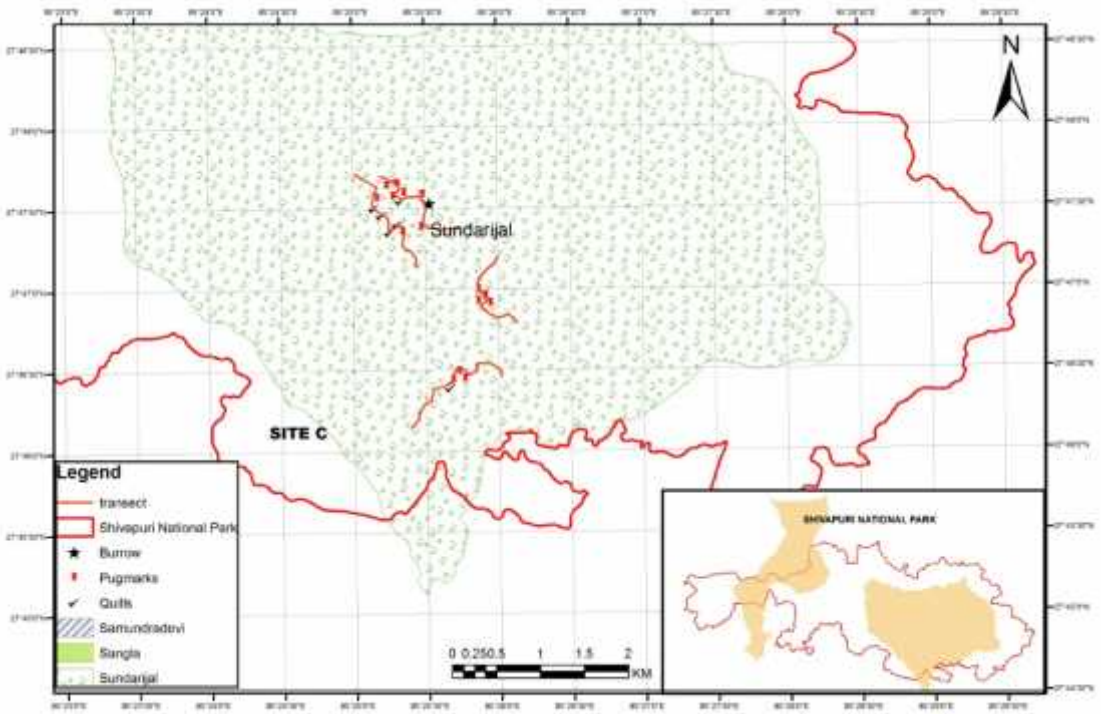


Figure 2.6. Distribution of Porcupines in Sundarijal

5.1.1. Preference and Time of Crop Raiding

Wild boars, porcupines, monkeys, squirrels, jungle cats and leopards were the major pest species of crop depredation in and around the park. Among them, porcupines were the second major pest after wild boars which caused a high degree of depredation of crop. During the study period, 100% of the respondents suffered from crop depredation by animals and 75% of them suffered only by porcupines.

The porcupines were mainly active during the months of June to August. The crops cultivated by the villagers during June to August were mainly maize and potatoes which served as the most preferred food of the porcupines. These crops were mainly raided during the night and early morning. Porcupines also raided millet, wheat and arum but they did not raid the crops like paddy and mustard which were not their preferred crops. Other crops like pumpkin, radish, garlic, ginger and beans were also cultivated in the study area but these crops were grown in very little amount. Among them pumpkin and beans were preferred by porcupine but radish was not preferred. They always came out in a group of one to four in search of food.

Table 5.2. Preference and time of crop raiding

SN	**List of cultivated crop**	**Raiding of crops**	**Preference of crops**	**Time of raiding**
1	Maize	Raided	Most preferred	Night and early morning
2	Potato	Raided	Most preferred	Night and early morning
3	Millet	Raided	Preferred	Night and early morning
4	Wheat	Raided	Preferred	Night and early morning
5	Arum	Raided	Preferred	Night and early morning
6	Paddy	Not raided	Not preferred	Not applicable
7	Mustard	Not raided	Not preferred	Not applicable
8	Other	Raided	Partially preferred	Not applicable

Note: Crops raided every night included in most preferred, crops raided Once or twice during crop season included in preferred and partially preferred included both preferred and not preferred crops.

5.1.2. Stages of Crop Damage and Season and Frequency of Attack

Maize and potato fields were very frequently visited and were raided in very high amount by the porcupines. Porcupines rarely visited on millet and wheat fields. They were active during June to August when their food was available easily. Mainly the porcupines raided maize at its milky stage. Potato and arum were raided at mature stage where as millet and wheat were raided from premature stage to mature stage (Table 5.3).

Table 5.3. Stages of Crop Damage and Season and Frequency of Attack

SN	Name of Crop	Stage of damage	Season of Attack	Frequency
1	Maize	Milky Stage	July to August	VF
2	Potato	Mature Stage	June to July	VF
3	Wheat	Premature to mature stage	March to April	R
4	Millet	Premature to mature stage	October to December	R
5	Arum	Mature Stage	August to September	F

Note: VF = Very Frequent (Every night during the crop season)

F = Frequent (Three to Four times during crop season)

R = Rare (One to two times during the crop season)

5.2. Assessment of Habitat

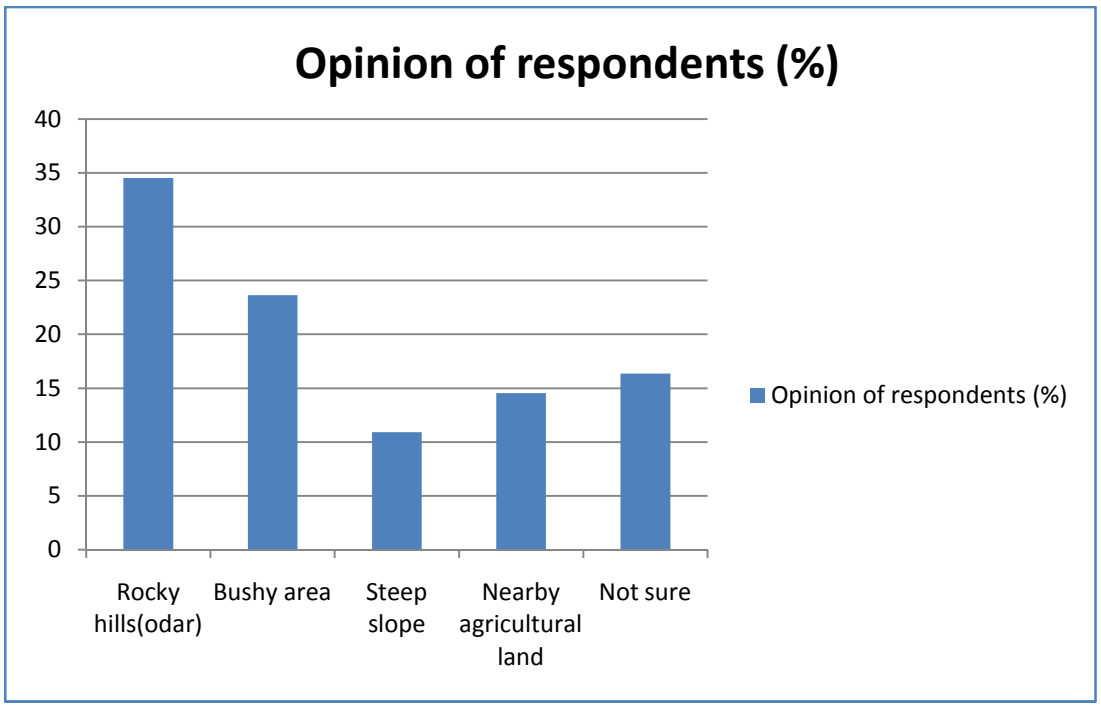
Generally porcupines were found in all types of forests and scrub areas. Rocky and bushy areas with slight steep slopes were good habitat for the porcupines. Burrows of porcupines were found in less human disturbance areas at 35°-40° slope. The average height of burrows was 30cm (Table 5.4).

According to the data 34.54% of the respondents said that porcupines were found in rocky hills, 23.64% said in bushy areas, 14.54% in nearby agricultural area, 10.91% in steep slope and 16.36% of respondent were not sure about the habitat of porcupines (figure *2.4*). However, chi –square goodness of fit test revealed that they were uniformly distributed in all type of habitats (χ^2 =9.36>χ^2 p=0.05, df=4).

Table 5.4. Assessment of Habitat

S.N.	Characteristics	Site A	Site B	Site C
1	Land use	Forest, Agricultural land	Forest, Agricultural land	Forest, Agricultural pasture
2	Orientation	East facing	West facing	South facing
3	Slope	50°-55°	35°-40°	37°-45°
4	Water resources	Not available	Available	Small stream
5	Altitude (m)	1582 - 1634	1638 – 1874	1527 - 1856
6	Terrace farming	Present	Present	Present
7	Vegetations	Open mixed forest, grasses and agricultural land	Open mixed forest along with grasses, shrubs and agricultural land	Open mixed pine forest with shrubs, herbs and cultivated land
8	Other animals	Deer, Wild boar, Squirrel	Wild boar, Deer, Jackal	Monkey, Wild boar, Leopard
9	Trails	Trail use by staff, Army, Tourist and researcher	Trail use by Villagers, Army, Tourist and Vehicles	Trail use by Villagers, Army, Tourist and Vehicles
10	Burrows observed	None	2	1
11	Foot prints observed	None	13	15

Figure 2.7. Opinion of Respondents about Habitat



5.2.1. Habitat According to Citation

Literature review showed that the habitat of porcupines included all type of forests plantation, rocky areas, steppes, embankments and near agricultural lands (Table 5.6). Two burrows were found in rocky hills with bushy areas and near water source as well as agricultural land. Porcupines were mainly found in rocky hills, bushy areas and near agricultural land where there was less human disturbance (Table 5.5).

Table 5.5. Habitat of Porcupines

SN	Forest			Rocky hills and near embankment of drainage canal	Steppes	Near agricultural land	Citation
	Tropical	Sub tropical deciduous forest	Shrub and grassland				
1.	+	+	-	+	-	-	Walker et al. 1968
2.	+	+	+	-	+	-	Wilson et al.1993
3.	+	+	-	+	-	-	Siddique et al. 2004
4.	+	+	+	-	-	+	IUCN 2005
5.	+	+	-	+	-	-	Arslan 2008
6.	+	+	++	++	+	+	Present study 2009

Note: + = Presence, - = Not mentioned in citation, ++ = Preferred habitat

5.3. Crop Loss

The total crop loss in the study site was 7320.37 kg of which rooted crop loss alone was 4405.45 kg (60.18 %). Similarly the total loss of maize, millet and wheat was 2558 kg, 261.02 kg and 95.9 kg respectively. The percentages of the loss of maize, wheat and millet due to depredation by porcupines were 34.94%, 1.3% and 3.47% respectively. The total expected yield of different crops and loss of crops in the sampled area are as given in the table (5.6). F- test showed that there was no significant difference between crop loss in the three VDCs of the Park such as Sundarijal, Sangla and Samundradevi (F_c = 2.35< 4.46,df=(2,8), p=0.05). There was no significant difference between crop loss of different varieties of crops (F_r =3.29 < 3.84, df = (4,8), p = 0.05).

Table 5.6. Loss of Different Crops in Study Sites

Crop	Sangla			Samundradevi			Sundarijal		
	E.Y (kg)	**A.Y (kg)**	**Loss (kg)**	**E.Y (kg)**	**A.Y (kg)**	**Loss (kg)**	**E.Y (kg)**	**A.Y (kg)**	**Loss (kg)**
Maize	768	576	192	3420	2194	1226	3564	2424	1140
Potato	-	-	-	8970.5	6279.35	2691.15	3687.13	2197.53	1489.6
Wheat	750	735	15	2345	2291.1	53.9	2250	2223	27
Millet	396	368	28	2034.8	1957.48	77.32	1780.45	1624.75	155.7
Arum	-	-	-	320	239.5	80.5	412	267.8	144.2

Note: E.Y = Expected yield, A.Y = Actual yield

Thus, the analysis of variance of both the VDCs of the Park and different varieties of crops were observed to be insignificant.

Table 5.7. F-test for Comparison of Crop Loss in Study Sites

S.N.	Names of crops	Sangla	Sundarijal	Samundradevi	F-ratio		Remark
					Calculated	**Tabulated 5% of limit**	
1	Maize	192	1148	1226	2.35	F(2,8)=4.46	Accepted
2	Potato	-	1489.6	2691.15			
3	Wheat	15	27	53.9	3.29	F(4,8)=3.84	Accepted
4	Millet	28	155.7	77.32			
5	Arum	-	144.2	80.5			

5.4. Economic Estimation

Based on total crop loss, the total economic loss was estimated to be around Rs. 191639.06 per annum and Rs. 4077.43 per household based on 47 household surveys.

The most affected crop was potato followed by maize, millet, arum and wheat. In comparison to the economic loss in Sangla, Samundradevi and Sundarijal the economic loss due to crop depredation was highest at Samundradevi followed by Sundarijal and Sangla.

Table 5.8. Economic Loss Due to Crop Depredation

SN	**Crop**	**Sangla**		**Samundradevi**		**Sundarijal**	
		Loss (kg)	**Economic Loss (Rs.)**	**Loss (kg)**	**Economic Loss (Rs.)**	**Loss (kg)**	**Economic Loss (Rs.)**
1	Maize	192	4800	1226	30650	1140	28500
2	Potato	-	-	2691.15	75352.2	1489.6	41708.8
3	Wheat	15	330	53.9	1185.8	27	594
4	Millet	28	504	77.32	1391.76	155.7	2802.6
5	Arum	-	-	80.5	1368.5	144.2	2451.4

a) Damages in maize fields

b) Eaten Cob

c) Damages in potato fields

d) Scratches on fields

e) Snare near the Agricultural Land

f) A Burrow

Plate 3. Different Signs of porcupines and Indirect Evidences

6. DISCUSSION

6.1. Distribution and Preference

This study revealed that porcupines were widely distributed in each study site. The presence of porcupines was confirmed by presence of their quills, footprints and burrows. Altogether 52 indirect evidences were observed (Table 5.1). Three burrows were observed during the study period whose average height was approximately 30cm. This result was inconsistent with the study done by Arslan (2008) which revealed that the height of the burrow was 40cm. Among three different sites of the study area, site B and site C had comparatively higher distribution of quills as well as foot prints (Table 5.1) due to rocky hills and slight steep slope. Site A was at the eastern face of the mountain with a higher steep area. Porcupines were distributed around 1600m to 1874m range of altitude. Shrestha (2005) found that burrows of porcupine were distributed at an altitude of 1850m. Porcupines preferred to live on rocky hill side forests of less than 2400m in altitude (Majupuria et al. 2006).

This study revealed that the porcupines were mainly active during the rainy season when their preferred crops were easily available. Maize and potatoes were found to be the most preferred crop for porcupines. This result was consistent with the study done by Gurung (2002), Bajrachaya (2009) and Walker et al. (1968) which revealed that porcupines ate large amount of maize as well as potatoes. Maize, potato, sweet potato and sugarcane were the preferred crops of porcupines (Siddique et al. 2004) which was similar to this result. According to Arslan (2008) and Pervez et al. (2009) porcupines widely fed on vegetables, fruits, flowering plants, root, tubers and buds. Along with maize and potatoes they also preferred millet and wheat. Paddy and mustard were not the preferred crops of porcupines, but during the scarcity of food they also ate spinach sometimes.

6.2. Habitat

Habitat range of porcupine was wide. Walker et al. (1968) and Siddique et al. (2004) reported that they were found in all types of forests, rocky hills and near embankments of drainage canal. It was found that the rocky hills, scrub land as well

as embankments of drainage canals were the preferred habitat of porcupines. Rocky hills and embankments were the habitats of porcupines (Arslan 2008) including scrub land (Siddique et al. 2004). Porcupines also lived near the agricultural land to get their food easily during the rainy season. They were mostly found in a slope of 35°-40°at 1600m to 1874m range of altitude where human disturbance was minimum (Table 5.4). If human activity started towards their habitat, they left their habitat and shifted to other places. Shrestha (2005) found their burrows at 1850m altitude near the agricultural land. Porcupines preferred scrub jungle but they easily adapted to foraging and feeding in open fields dotted with bushes and grass (Chakravarthy et al. 2005).

6.3. Crop Depredation

Khan et al. (2000) identified the porcupine as a serious pest of traditional as well as non- traditional crops, fruits and vegetables. Gurung(2002), Paneru (2004), Bajracharya (2005), Purkait (2008) and Bajracharya (2009) identified the porcupine as pest species in ShNP. Porcupine was serious pest of agricultural crops and fruits in Karachi (Pervez et al. 2009). Present study also revealed that porcupine was one of the pests of agricultural crops in ShNP.

The total crop loss in the study sites was 7320.37kg. Among it, rooted crop loss was 4405.45kg followed by maize (2558kg), millet (261.02kg) and wheat (95.9kg) (Table 5.6). Gurung (2002) showed that total loss of crop by porcupines and rats was equal to 10569.14kg which was higher than the present study which was due to inclusion of extra crops as well as losses caused by rats etc. Paneru (2004) and Bajracharya (2005) found that the total crop loss was around 1303.24 quintals or 32662.5kg which was higher than mine 7320.3kg. The reason being the present study was based on single animal and focussed on only five agricultural crops. The economic loss due to crop depredation was estimated to be around of Rs.191639.06 per annum and Rs.4077.43 per household based on 47 household surveys (Table 5.8). Poudyal (1995), Soti(1995) and Purkait (2008) estimated the total loss of Rs.758070, Rs.1159999.45 and Rs. 351618.74 per annum which were higher than this research which included the crop depredation by other wild animals as well. Bajracharya (2005) estimated that total

economic loss due to crop depredation was equal to Rs. 503655.90 per annum and Rs. 18505.77 per household which was higher than mine the present estimation.

Wild animals damage the crops every year. To reduce the problem created by wild animals the local people have adopted some preventive measures, i.e. more than 50% of people have adapted some preventive measures. Some households among the survey area had not used any technique. Local people were practising shouting, drumming, guarding, dog watch, catapult and flags as preventive methods to prevent crop depredation by wildlife (Bajracharya 2005). During the study, 23.4% of the households were using empty tins to chase the wild animals. Altogether 4 snare of porcupine were found near the agricultural lands.

7. CONCLUSION AND RECOMMENDATIONS

The study conducted in three VDCs of ShNP was carried out in 2009. This study concluded that distribution of porcupines widely depended on the availability of food and human disturbance in the area. Three burrows of porcupines were found in west and south facing rocky and bushy hills near the agricultural land. There was a significant difference in the distribution of porcupines in the three VDCs (χ^2 =18.51>χ^2 p=0.05, df=2). They were mostly active during the months of June to August when their preferred food like maize and potatoes were easily available. Paddy and mustard was not the preferred crop of porcupines but during the scarcity of food they also consumed the stems of spinach. They frequently visited maize and potato fields.

Porcupines were mostly found in rocky hills with bushy area of slope 35°-45°. According to the respondents 34.54% of them said the porcupines were found in rocky hills, 23.64% said in bushy areas, 14.54 % said in nearby agricultural area and 10.91% in steep slope. Chi square test revealed that porcupines were uniformly distributed in all these habitats (χ^2 =9.36>χ^2 p=0.05, df=2).

During the study period the total crop damage was found to be 7320.37kg due to the porcupines in the study area. Out of this rooted crop loss was 4405.45kg, which was followed by maize (2558kg), millet (261.02kg) and wheat (95.9kg). The total economic loss was estimated to be Rs. 191639.06 in the study area that was done by crop depredation by the porcupines. A comparison of the economic loss among Sangla, Samundradevi and Sundarijal showed that economic loss due to crop depredation was highest at Samundradevi followed by Sundrarijal and Sangla.

Based on this research, the following recommendations are put forward:

1) Further scientific research should be done on distribution and population status of the porcupines in whole area of the park.
2) Food habits, breeding behaviors and ecology of porcupines should be studied to conserve natural foods and to minimize crop depredation as well as population growth of the porcupines.

3) Specific study on *Hystrix* species could be conducted to promote the conservation of the Malayan porcupine (*Hystrix brachyura*) as it is listed as a nearly threatened species in Nepal.
4) Regular monitoring of the affected areas should be done to ensure the amount of depredation.
5) Awareness program should be launched among local people to give education on the conservation of natural resources.
6) This study could be the baseline information for further research.

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9. ANNEXES

I. Questionnaires related with porcupine

Name

Occupation

Ward no.

Village

VDC

1. Can you identify the porcupine?

a) Yes b) No

1.1 If yes, how?

a) Body size b) Quills

c) Others

2. Have you noticed the presence of porcupine around here?

a) Yes b) No

c) Not sure

2.1. If yes, how did you noticed the presence of porcupine around here?

a) Sighting b) Foot prints

c) Fecal matter d) Burrows

e) Others

3. In which month did you notice the presence of porcupine?

a) Month……

4. Have you seen a live porcupine?

a) Yes b) No

4.1. If yes, at which time?

a) Morning b) Day

c) Evening d) Night

4.2. Where have you seen it?

a) Forest b) Rocky area

c) Steep slope d) Agriculture land

e) Other places

5. Do you know about habitat of Porcupines?

a) Yes b) No

c) Not sure

5.1. If yes, where?

a) Rocky area b) Bushy area

c) Steep slope d) Agricultural land

e) Other places

6. Did you observe the porcupine in group or solitary?

a) Solitary b) Group with number

7. What is the favorite food of porcupine in cultivated land?

a) Maize b) Whea

c) Paddy d) Potato

e) Millet f) Mustard

g) Arum i) Others

8. How often did the porcupine come around the crops?

Crops	Frequency
Maize	……..
Wheat	……..
Potato	…….
Millet	…….
Arum	…….

9. In which stage did the porcupines raid the crops?

Crops	Stage of raiding
Maize	…….
Wheat	……
Potato	……
Millet	……..
Arum	…….

II. Questionnaires about crop depredation

Name

Occupation

Ward no.

Village

VDC

1. How many members are there in your family?

Number……

2. How much land do you own?

a) Khet b) Bari

3. Which crops you grow in your land?

……

4. In how many ropani of land do you grow the following crops?

Crops	Ropani
Maize	…….
Wheat	……
Millet	…….
Potato	…….
Arum	……..
Others	……

5. Do you practise mix cropping system?

a) Yes b) No

5.1. If yes, which crops do you plant together?

a…….. b ……

6. Do the porcupine raid crops in your land?

a) Yes b) No

6.1. If yes,

Raid crops	Most preferred crop	Time of raiding	Number at a time

7. How did you know that porcupine raid your crops?

a) Saw porcupine b) Presence of foot print

c) Raiding pattern d) Quills

e) Other signs

8. What is the average yield of following crops? (Before and after raiding)

Name of crops	Yield if not loss by porcupine	Yield after loss by porcupine	Stage of raiding
Maize			
Millet			
Wheat			
Potato			
Arum			

9. Do you apply any technique to protect your crop from wild animals?

a) Yes b) No

9.1. If Yes,

a) Drumming b) Traps

c) Dog watching d) Others

10. Why do you think the porcupine damage crop?

a) Habitat loss b) Scarcity of food

c) Presence of preferred crop d) Others

11. Did you get compensation from park?

a) Yes b) No

12. Do you know it anybody killed porcupines?

a) Yes b) No

12.1. If yes,

a) Who……. b) When…..

c) Why……..

13. Do you know wildlife killing is illegal?

a) Yes b) No

14. What would be the best controlling measure?

a) ……..

III. Field Survey

Site

Date

A. Site Information

- Land use type:
- Orientation:
- Slope:
- Terrace farming:
- Water resources:
- Vegetations:
- Other animals:
- Trail:
- Sign of porcupine:

B. Field Survey on distribution

Date:

Location

Aspect

Transect

S.N.	Indirect evidence	Altitude	Site	Land use type	GPS point	Remarks

Sign type code. Q=Quills, F=Foot prints with scratches, B= Burrows

IV. Conversion of Units

8 mana =1 Pathi, 20 Pathi = 1 Muri

Maize =1 Pathi=3.4 Kg

Millet = 1 Pathi =3Kg

Wheat =1 Pathi =3.5 Kg

Potato =1 Pathi =2.7Kg

Arum =1 Pathi =2.7 Kg

Local rate of different crops

Crops	Rate per Kg (NRs.)
Maize	25
Millet	18
Wheat	22
Potato	28
Arum	17