

**AN ANALYSIS OF FOOD HABITS AND CONSERVATION OF RED
PANDA (*Ailurus fulgens* Cuvier, 1825) IN LANGTANG NATIONAL
PARK, NEPAL**

BY

ARJUN THAPA

T.U. REGISTRATION NO. : 5-1-49-2001

EXAMINATION SYMBOL NO. : 336

BATCH NO. : 2063/64



**A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE
IN ZOOLOGY
CENTRAL DEPARTMENT OF ZOOLOGY–ECOLOGY PROGRAM
INSTITUTE OF SCIENCE AND TECHNOLOGY
TRIBHUVAN UNIVERSITY
KATHMANU, NEPAL
SEPTEMBER 2010**

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DECLARATION

I, hereby, declare that the work presented in this thesis entitled “**AN ANALYSIS OF FOOD HABITS AND CONSERVATION OF RED PANDA (*Ailurus fulgens* Cuvier, 1825) IN LANGTANG NATIONAL PARK, NEPAL**” was carried out by me and has not been submitted anywhere for the award of any degree. All sources of informations have been specifically acknowledged in the references to the authors or institutions to whom they belong.

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Date:

RECOMMENDATION

Mr. Arjun Thapa has completed the thesis, entitled “**AN ANALYSIS OF FOOD HABITS AND CONSERVATION OF RED PANDA (*Ailurus fulgens* Cuvier, 1825) IN LANGTANG NATIONAL PARK, NEPAL**”, was carried out under my supervision and guidance. This is the candidate’s original work that brings out important findings essential for wildlife conservation in the Langtang National Park. To the best of my knowledge, this thesis has not been submitted for any other degree.

I recommend that the thesis be accepted for the partial fulfilment of the requirements for the degree of Master of Science in Zoology, specializing in Ecology.

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ABSTRACT

This study on food habits and conservation threats of red panda *Ailurus fulgens* in the Langtang National Park, was carried out between March 2009 to March 2010 and was mainly centered on examining diet composition, food niche breadth and conservation threats. Three sites were chosen for the study, which were Gopache, Dhokachet and Trisuli-Origin of Cholangpati-Dhokachet areas. This study included reconnaissance survey for specific site selection, altitudinal line intercept method for faecal sample collection and dung encounter, whereas micro-histological technique was used to examine the seasonal diet composition and niche breadth of the red panda. Conservation threats of animal were analyzed through semi-structured questionnaires and interviews with local people and also through cattle dung encounter rate and grazing intensity. A total of 12 altitudinal line intercepts were laid in three sites at the elevations of 3000m-3600m with vertical lines at the interval of 150 m.

A total of 161 fecal samples were examined using micro-histological analysis. Results showed that the red panda's diet composed of eight different plants including bamboo, tree, herbs, shrubs and moss. They were *Thamnocalamus aristatus*, *Sorbus cuspidata*, moss, *Juniper recurva*, *Acer caudatum*, *Rhododendron campanulatum*, *Abies spectabilis*, and *Rubus sp.* Its diet consisted of *Thamnocalamus aristatus* (mean=245.08±15.74%) in highest proportion, followed by Moss (mean=5.91±1.95%), *S. cuspidata* (mean=5.83±1.22%), *J. recurva* (mean=1.08±0.71.95%), *A. caudatum* (mean=1.00±0.38%), and some others in a low proportion (all<1). Statistically, *T. aristatus* was consumed in all seasons that was insignificant ($\chi^2 > 0.001$, df =11, P>0.05), where as other foods varied seasonally. Niche breadth determination of red panda was 0.000104, which was quite low that resembled its high selectiveness in forage. Unidentified hairs, bones and claws were observed in the few faecal samples. Livestock pressure, specially the *Chauri* caused major threats to the red pandas along with the fire wood and fodder collection. Dhokachet site of Cholang-Dhokachet was found with highest grazing intensity with a higher dung encounter rate (mean=34.19/km), followed by Gopche (mean=24.49/km) and Trisuli (mean=9.6/km). Also the line of regression ($r^2=0.491$) showed there was a decrease in fecal pellet encounter rate corresponding cattle dung encounter rate.

ACKNOWLEDGEMENTS

My hearty gratitude goes to my supervisor Prof. Dr. Khadga Basnet, Central Department of Zoology, Tribhuvan University for his noble guidance and keen supervision throughout my work and inspiration during the field research. I express my gratitude to Professor Dr. Rajana Gupta, Head, Central Department of Zoology, former heads Professor Dr. Anand Shova Tamrakar, and Professor Dr. Vasanta Kumar Thapa for their continuous help throughout the study particularly in providing administrative facilities. I am deeply indebted to all respected teachers as well as non-teaching staffs of the Central Department of Zoology for their continuous encouragements, valuable suggestions and support. I am also thankful to Dr. Rinjan Shrestha a Conservation biologist, Mr. Kamal Thapa a Research Officer (Mountain) and Mr. Gokarna Jung Thapa a GIS Officer at WWF-Nepal. Equally I thank Mr. Kamal Kadel, Mr. Tulsi Ram Subedi and Mr. Naveen Mahato for their guidance during my work at the field and laboratory. My sincere thank goes to Mr. Bishnu Timilsina, Mr. Sunil Thapa, Mr. Santosh Karki, Mr. Raja Gautam and Mr Chhirng Tamag who assisted in all phases of field the work. I also feel gratitude to Mr. Ganesh Tamang, Mr. Mukti Ram Poudel, Mr. Anil Sharma and Mr. Prakash Bhattarai who assisted in laboratory analysis.

I am highly indebted to WWF-Nepal Small Grant Program, and Chester Zoological Garden UK, for providing financial support for this study. My sincere thank goes to Central Department of Zoology, Tribhuvan University for Micro-histological laboratory facilities, Department of National Parks and Wildlife Conservation (DNPWC), for granting permission for study in the Langtang National Park and Tribhuvan University Herbarium Center (TUHC), Central Department of Botany for identification of plant specimens. I am highly thankful to local people, hotel owners, herders for their friendly help and moral support.

Last, but not the least, I would like to record my sincere thanks to Mr. Bhim Raj Dahal, a lecture of English, Tribhuvan University for editing this thesis within a short period of time and to all my friends who have supported, helped and given encouragements. I am also to all my family members for their inspiration, continuous encouragement and love.

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ABBREVIATIONS

CITES	Convention on International Trade for Endangered Species of Flora and Fauna
DNPWC	Department of National Park and Wildlife Conservation
DUHE	Durhams University of Himalayan Expedition
FAO	Food and Agriculture Organization
GLU	Grazing Livestock Units
GPS	Global Positioning System
HMG/N	His Majesty's of Government of Nepal
IUCN	The World Conservation Union
LNP	Lantang National Park
MoFSC	Ministry of Forests and Soil Conservation
PAs	Protected Areas
RIV	Relative Importance Value
RPCA	Red Panda Conservation Area
TUCH	Tribhuvan University Central Herbarium
VDC	Village Development Committee
WWF	World Wide Fund

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1 Introduction

1.1 General Background

An appropriate ecological study is crucial for an effective management and conservation of wildlife species. The concern for saving the endangered species from further exploitation, either by rapid habitat loss and illegal hunting or poaching have been the issue of research for many years. Food habit of different animals had been studied through micro-histological technique by different authors, such as Baumngartner and Martin (1939), Dusi (1994) etc. It is important to evaluate of ecological relationships for decision making. Diet quality and quantity largely determine the optimum carrying capacity of the area of a species of population, as healthy and productive animals of any population depend upon a year round availability of forage. Identification of plants after ingestion by wild animals is a major problem in the food habit research of wild animals. Various solutions have been proposed for both direct observation and histological techniques (Baumgatner and Martin 1939). Identification of plant fragments in the rumen and faeces act as indirect techniques. The rumen analysis is only possible after the killing of an animal while faecal analysis referred in micro-histological technique is considered a an easy alternative in determining the botanical composition of faeces to estimate herbivorous diet.

This analysis includes diet observation, utilization technique, fistula sampling, and faecal analysis. All these procedures have significant limitations as the direct observation requires nominal time and equipments. Utilization studies are generally unsuitable as plants might grow actively and there might be more than one herbivore using the area. Under this study, fistula method was difficult to use in wild animals. The esophageal fistula would be preferable to rumen fistula because it provide more accurate information and less labor. Stomach analysis requires animal killing which was restricted in the case of wild animals. So, faecal analysis had been used extensively to evaluate the diet of wild herbivores through micro-histological technique.

1.2 Objectives

The overall objective of the study was to collect ecological information on food habit and existing threats of red panda in the Langtang National Park. The specific objectives of the study were to:

- i. examine the diet composition
- ii. determine the niche breadth and
- iii. assess existing threats of red panda.

1.3 Rationale

In the global terms, the population of red panda is declining day by day from its viable habitats, and IUCN has now included it under “Vulnerable” category of IUCN red data list (IUCN 2008) in Appendix I as an endangered and protected animal. It is subjected to international trade restriction under the CITES (Traffic 1991). As they have specialized habitat, and diets, they can survive only within a narrow range. The continued habitat loss and fragmentation causes a shrink in their habitat resulting in the threatening of the survival of red panda, making it as an endangered animal. To minimize such a burning problem, there is an urgent need to study red panda ecology regarding distribution, food and habitat conditions.

The proposed study area was facing problems of livestock grazing, fire wood collection, habitat fragmentation and other anthropogenic activities. Besides, the main natural food, the ringal bamboos and shoots are used as vegetables, baskets and other commercial handicrafts by the local people resulting in the indirect impact on the food of red pandas. Previous study showed that the bamboo was the staple food of the red panda but more information on other food items was lacking. If massive bamboo flowering or fire occurs in their habitat areas, it might cause the whole destruction of the habitat. So, only the management of bamboos in their habitat areas was insufficient for the conservation. Thus, it was necessary to identify and manage the supplement food for the survival of red panda in their natural habitat. So, present study was focused on the food habits analysis. The outcome of the study plays a vital role in the management of habitat, food preferences, supplement food and core forage along with mitigation of threats in future.

1.4 Red Panda Biology

1.4.1 General Physical Characteristics

Body mass of red panda (*Ailurus fulgens*) ranges from 3.7 kg-6.2 kg between adult (captive) male and female. Wild adult is 4kg (Yonzon 1989) in the weight and the length from head to the body is between 560 to 625 mm, where as the length of the tail is between 370 to 472 mm. There is no sexual dimorphism in body size or in the colour of the coat (Roberts and Gittleman 1984). The tail is comparatively long and marked with approximately 12 alternating red and buff rings (Roberts and Gittleman 1984). Animals of the sub-species *styani*, are somewhat darker in colour and have more distinct ‘tear track’ markings on their faeces. Red pandas also have a distinct ‘thumb’ (which is actually an enlarged radial sesamoid bone) and this adaptation allows for better manipulation and handling of the bamboos (Anton *et al.* 2006).

1.4.2 Activity and Home Range

Red pandas are generally shy animals but mostly active at dusk and dawn. They show similar activity pattern in different seasons. Probability of activities is highest in autumn and winter due to food resources, i.e., due to the patchy distribution of fruits in autumn and mating season in winter (Yonzon 1989). Home range sizes vary from 1.4-11.6 km², where average home range is 5.12 km² for males and 2.37 km² for females. In the LNP, mean range of males is larger than those of females during mating seasons, however, range overlaps between sexes and, especially within males, but it doesn’t occur between females. Its home range and social interactions are influenced by habitat quality, especially the food availability and shelter (Yonzon 1989).

1.4.3 Food and Feeding Behavior

Because of their elusive and arboreal nature, very little is known about the behaviour of wild pandas beside their feeding and breeding habits. It is an abnormal member of order Carinivora, but it depends on herbivorous diet chiefly on bamboo leaves. The digestive system is poorly-adapted for proper utilization of its low nutrient of bamboo diet (Roberts and Gittleman 1984, Bleijenberg and Nijboer 1989), so they consume a large amount of bamboo to fulfil their energy requirements (Oftedal *et al.* 1989). *Arundinaria*, *Phyllostachys*, *Thamanocalamus*, *Oionobambusa*, *Semiarundinaria*, *Pseudostachyum* are common genera of bamboos consumed

by red panda (Warnell *et al.* 1989), which in addition eat, wild fruits, berries, mushrooms, roots, acorns, lichen, succulent grasses as food in various seasons, however, they rarely feed on bird eggs, insects and grubs in wild condition. In captive condition animals have shown particular interests in sweet food and readily eat meat (Choudhury 2001).

1.4.4 Life Cycle and Reproduction

The maximum life span of red panda is 14 year but in average it is 8-10 years in wild condition. Mating season has been observed between January and March, outside of this period males and females are asocial (Roberts and Gittleman 1984, Johnson *et al.* 1988, Yonzon and Hunter 1991b, Pradhan *et al.* 2001a). Before parturition, the female begins to carry sticks, grass, leaves barks of birch-betula etc. to make suitable nest site, which may be a hollow tree or rock crevices. Because the young ones develop relatively slowly due to low energy milk produced by the mother, the association between mother and offspring is extended, and can last for more than one year (Roberts and Gittleman 1984). Mother-young association is the only social behavior exhibited in red pandas except for mating during the breeding season (Yonzon and Hunter 1991b).

1.5 Geographical Distribution

The red panda is distributed in the isolated pockets of high mountain ranges between Western China (Sichuan, Yunnan and Tibet Provinces) and the Himalayan mountain chains of Nepal, India, Bhutan and Burma with an exceptional population on the Meghalaya Palteau of north-eastern India (Choudhury 2001, Li *et al.* 2005). Their geographical ranges is surrounded in the north by the Namlung Valley, in Mugu District and lake Rara region in northern Nepal. Similarly, in the south it extends to Liakiang range in western Yunnan and its northern and the eastern boundary is the upper Min Valley of Western Sichuan (Roberts and Gittleman 1984). Its distribution in India is found to be toward the northeast of Sikkim, northwest of Bengal, Arunachal Pradesh and Meghalaya (Parter 1980, Choudhury 1997, Choudhury 2001, Pradhan *et al.* 2001a).

Based on anecdotal history, the studies report, the sightings and signs of red pandas in eight protected areas including Rara National Park (Sharma 2008), Langtang National Park (Yonzon 1989), Sagarmatha National Park (Mahato 2004), Makalu-Barun National Park (Jackson 1990),

Manaslu Conservation Area (Choudhury 1997 as cited in Yonzon *et al.* 1997), Annapurna Conservation Area (Shrestha and Ale 2001), Kanchenjunga Conservation Area (Yonzon 1996), Dhorpatan Hunting Reserve (Kandel 2008, Subedi 2009) with an area about 19,838 km² as potential area (BPP 1995, Yonzon *et al.* 1997) with other protected areas outside, such as Jamuna and Mabu VDC of Ilam (William 2004, Kandel 2009).

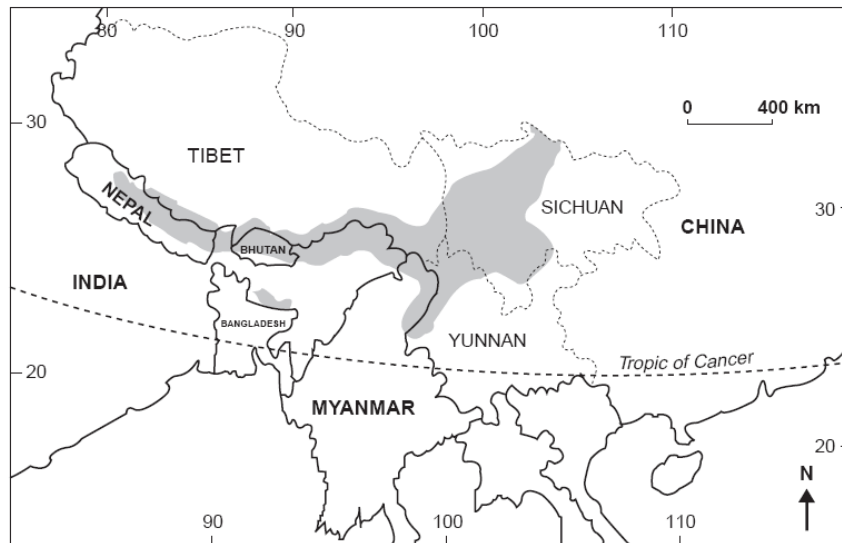


Figure 1. Global Distribution of Red Panda. Adapted from Choudhury (2001).

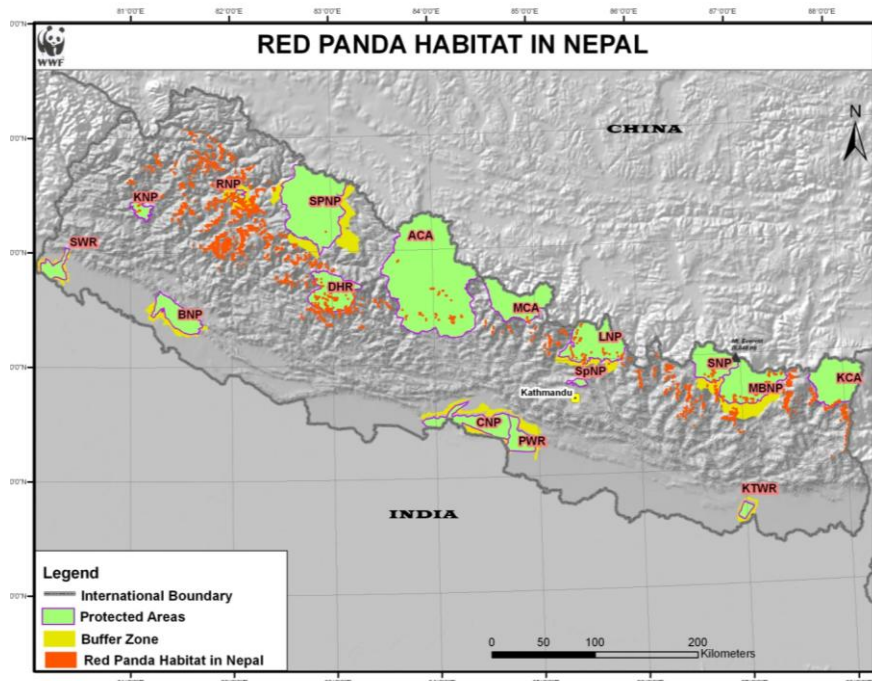


Figure 2. Potential Habitat of Red Panda in Nepal (Source WWF-Nepal).

Distribution of red panda is reported in LNP and its buffer zone area in different isolated population groups (Fox *et al.* 1996). To be more specific, red panda in Rasuwa district of the National park, is reported from Dhunche village development committee (Dhunche lekh), Sayafu VDC (Cholangpati, Dhokachet, lower part of Saraswati Kunda), Bridim VDC and Timure (Chhochen, Nipsu and Mebu). Red panda at the eastern part of park is known to be found in Ghyangphedi VDC (Phedi-Thadepati-Mangingoth area) of Nuwakot district and in lchock, Helambu (Thadepati to Melamchi lekh, Amayangri), Kiuel (Hile Kharka), Baruwa, Selang, Bhotang, Golche and Gomba VDCs of Sindhupalchock district (DNPWC / MoFSC / GoN 2010).

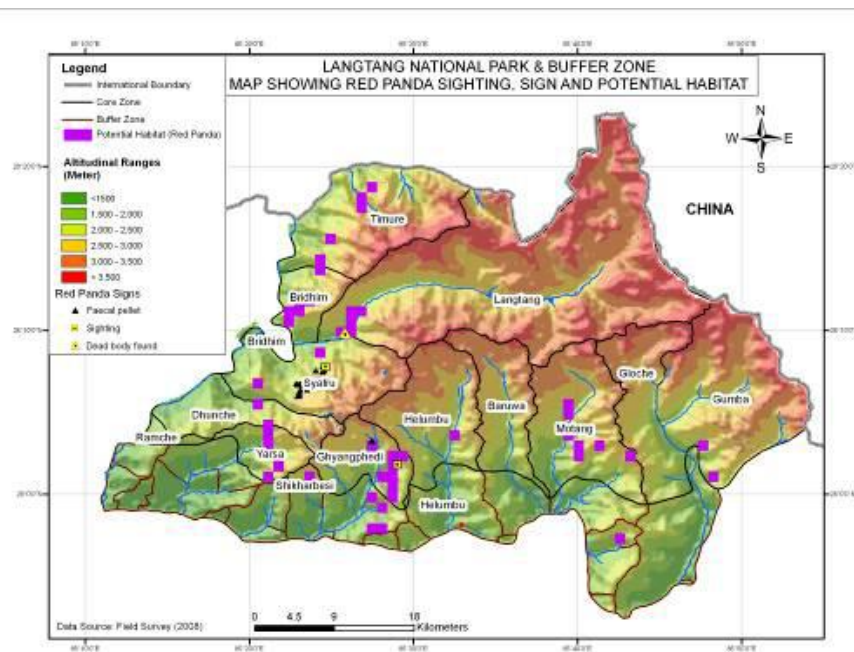


Figure 3. Distribution of Red Panda in Langtang National Park (Source DNPWC)

1.6 Population and Conservation Status

The estimated number of global population of red panda is between 16,000-20,000 which comes to be one panda per 4.4 km² within the potential red panda habitat of 142,000 Km² in five red panda range countries (Choudhury 2001). Average density per red panda is 4.4 Km² and gives an estimated population of 500-6000 animals in India, with the greatest number being in Arunachal Pradesh (Choudhury 2001), while the population in China is estimated to be between 6000-7000 (Wei *et al.* 1999b). The total population of red panda in Nepal is about 314, which is based on

the ecological density of one red panda per 2.9 km² and the total area of 912 km² potential habitats (Yonzon *et al.* 1997). In LNP, a total number of 73 individuals of the red pandas were estimated comprising in four different populations (Yonzon 1989). Similarly, more than 11 red pandas were present in Rara National Park within an area of 31 km² (Sharma 2008). A total of 62% of the potential red panda habitat lie outside the PAs, and their population and conservation status was not known in most of the areas.

The red panda is protected as an endangered species throughout its distribution range and is listed in Appendix I of the International Trade of Endangered Species (CITES) as “Endangered” category IUCN since 1996 (Choudhury 2001, Pradhan *et al.* 2001a, Wei *et al.* 1999b) and is listed as “Vulnerable” species (IUCN 2008). In Nepal, the red panda is listed as schedule I or is being given top priority as an endangered species and protected by the Government of Nepal under National Parks and Wildlife Conservation Act 1973.

1.7 Social Value and Threats

The red panda’s fur is often used in local cultural ceremonies such as weddings and especially, by the bridegrooms in China. The ‘good-luck charm’ hats are used by Chinese newly-weds. Since 13th century AD, the Chinese have portrayed the hunting scenes of the red pandas (Roberts 1983). It has been acknowledged as the state animal of Sikkim. It was the mascot of the international festival in Darjeeling and it is also used as an iconic species in different organizations, hotels, games etc.

Natural population has been worsened by human encroachment as well as anthropogenic activities leading to its range degradation, destruction, habitat fragment, illegal trade and poaching. Threats associated with habitat loss are deforestation, intentional fire, fuel wood collection, over grazing, trampling on ringal bamboo patch and intrusion by herders and dogs etc.

2 Literature Review

A few studies have been undertaken to acquire information on the ecology and behavior of red panda in Nepal (Yonzon 1989, Yonzon *et al.* 1997), India (Choudhury 1997, Pradhan *et al.* 2001a), and China (Reid *et al.* 1991, Wei *et al.* 1999b). In the context of Nepal, pioneer ecological information about the red panda was given by Yonzon (1989) along with other researchers Shrestha (1988), Mahato (2003), Williams (2004), Kandel (2008), Karki (2009), Subedi (2009) and Kandel (2009) which dealt in different aspects such as various regions of the country.

2.1 Micro-histological Technique

Baumgartner and Martin (1939) first described the micro-histological techniques in study of squirrel diet and later it was refined by Dusi (1949), and Williams (1969). Literature cited in Jnawali, Spark and Malechek (1968) verified the techniques with hand by compounding mixture of grasses and fobs. Thereafter the food habits of different animals were determined through this technique.

Jnawali (1995) demonstrated diet analysis of One-horned rhinoceros (*Rhinoceros unicornis*) in Chitwan National Park through microhistological technique along with other researchers and this method in dietary was used in studies of different animals such as *Moschus chrysogaster* (Gurung 1991), *Cervus duvauceli duvauceli* (Pokharel 1996), *Bos gaurus* (Chetri 1999), *Pseudois nayaur* (Shrestha 2005), *Muntiacus muntjak* (Nagarkoti 2006), *Ursus thibetanus* (Chetri 2006), and *Ailurus fulgens* (Karki 2009), etc.

2.2 Diet

The study carried in between 1986 - 1987 in the Langtang National Park, estimated population of nine and five red panda in 22.2 km² area of Cholang-Dhokachet. Home range size varied from 1.4-11.6 km² with utilization of five different habitats along fir –jhapra as most preferred habitat. Mortality among cubs was 83 -86% (5-6 cubs) and 67% (4 cubs) in the study phase. Mortality in adults and young was associated with disturbances from cattle (chiefly *Chauri*) grazing and other human activities. Study on food habits suggests that there are five categories of food available

for red panda namely, *Jhapra* leaf, *Jhapra* shoot, Mushroom, Berry (*Sorbus microphylla*), and fruits (*Sorbus cuspidata*). Among them dropping comprised of 54-100% *Jhapara* leaves along with *Sorbus* fruits and mushroom. The result of the study also showed that there is no direct competition in food between *Chauri* and red panda as *Chauri* consumed foliage below 2m and red panda above 2m (Yonzon 1989).

Also the bamboo nutrients used by red panda was studied, and the outcome showed a difference in dry matter digestibility significantly among seasons and between diets. Digestibility of dry matter and key nutrients were high in summer and autumn and it was intermediate in spring, and low in winter. It also indicated that red panda poorly processed its bamboo food (Wei *et al.* 1999a).

Study on ecology of red panda in Singhalia National Park points out that red panda was relatively more abundant at the altitudinal range of 2800m-3000m. This research also interpreted that the red panda food consisted mainly of the leaves of two bamboo species including *Arundinaria malig* and *Arundinari aristata* along with seasonal supplement of fruits such as *Actinidia strigosa*, *Sorbus microphylla* and *Rosa sericera* (Pradhan *et al.* 2001b).

Study on feeding behavior of red panda in the LNP elucidated that the diet composed mainly of *Thamnocalamus ariatatus* (90.8%) along with *Sorbus* (6.71%) fruits during summer season. Niche breadth is quit low supporting its high selectiveness in foraging (Karki 2009).

2.3 Threats

Herding of yak and sheep between high elevation summer rangeland above timberline and lower elevation grazing lands in winter greatly exceed the carrying capacity of the land and lead to heavy over-utilization and degradation of common grazing land and forests (Miller 1987). Livestock rearing is major income generating source of Langtang people as they haven't got more than 30 1.5 hectare (30 ropani) of land of their own for agriculture, which is also of a very low productivity (Berzuka 1985). Park Management Plan Preparation study project in LNP clarified that those 6861 to 13148 grazing livestock units (GLU) were dependent of the park fodder resources that equals to consumption of 686100 to 1314700 tons of green fodder each year (DUHE 1977-1982).

Similarly, the LNP faces a great park-people conflict in terms of ecological value for the park management and economic progress of the local community. In Langtang area, more the 30000 people extract 1314700 tons of fodder every year and their livestock grazing needs fully depend on park resources (Kharel 1993). To support economic status, two cheese factories within the park are established (Kayangin and Chandanbari) by Dairy Development Cooperation with technical support from the United Nations of Food and Agriculture Organization (FAO), and it produces 14000 kg of cheese per year. These factories also provide soft loans to local that encourages more people in livestock rearing. Annually 10 million kg of wood was used in cheese processing, which is being marketed to Kathmandu Valley for tourists and it is also regarded as the third tourist destination of Nepal. Both of these activities consume the fuel wood for processing cheese and it is also luxury for tourists and it has a direct effect, primarily exacerbating the over harvest of fuel, and indirect by supporting and sustaining cheese production scheme. Their study also shows the presence of large herds of *Chauri*, their herders and dogs has leading death of many red pandas (Yonzon and Hunter 1991a).

3 Study Area

3.1 Physical Component

Langtang National Park (latitudes 28.00 -28.20 N and the longitude 85.15-86.00E) is situated in the north of Central Nepal, extending in three administrative districts (Rasuwa, Nuwakot and Sindhupalchok) and covering an area of about 1710 km² with Buffer Zone Area of 420 km². (DNPWC 2004). It was designated as the first Himalayan National Parks in 1970-1971 and was gazetted in March 1976. With altitudes varying from 800m to > 7200m, the habitat ranges from subtropical to perpetual snow (DNPWC/DUHE 1977, DNPWC 2004, DNPWC 2006).

Soil in the upper Langtang valley consists of sandy-loam with a higher proportion of rocks, while proportion of sand decreases with elevation and loamy sand is predominant below 2,440m. At lower elevation forest, soil transportation occurs with increasing human activities of grazing, tree felling together with natural occurrence of heavy rain and high run off and low evaporation in monsoon. Livestock grazing and trampling affect the soil of sub and alpine environments by creating soil 'baths' as cattle spend more time in the higher slopes (Tautscher 1970 cited in Shrestha 1988).

Climate of LNP varies with topography which ranges from temperate to glacial-cave cliffs rimmed by snow covered peaks. The weather is also relatively dry except for January-February, and monsoon occurs in June and September (DNPWC 2004, DNPWC 2006). The nearest metrological station from Cholanpati-Dhokachet is Dhunche for weather station. By analysis, the nine years data from 1999 to 2008, shows the mean maximum temperature of the hottest month was found to be 24.43 °C (June), where as the coldest month was 2.58 °C (Januray). The monthly maximum relative humidity was 87.09 mm in August, and minimum relative humidity was 64.6 in March. The maximum annual rainfall was recorded as 207.39 mm in 1999 and similarly minimum annual rainfall was 116.00 mm in 2001.

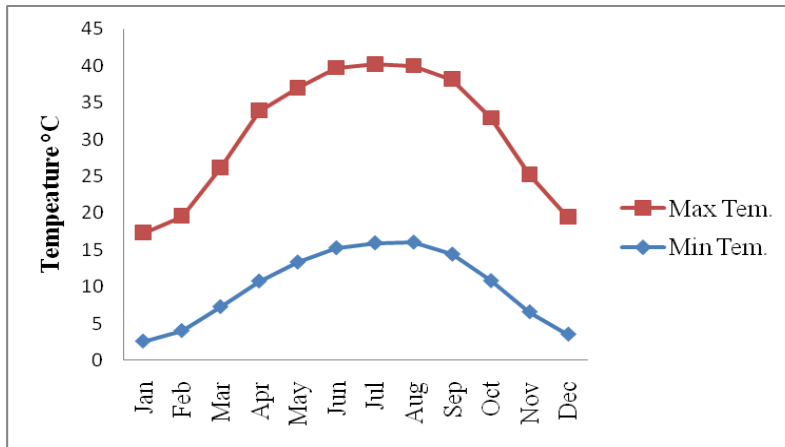


Figure 4. Average Maximum and Minimum Temperature ($^{\circ}$ C) at Dhunche

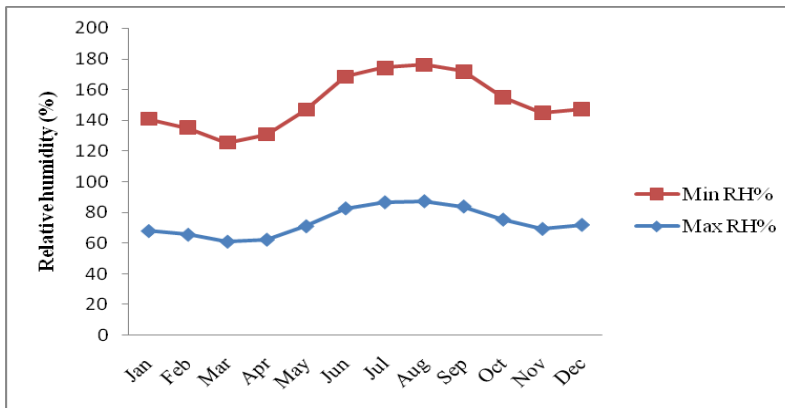


Figure 5. Monthly Average Relative Humidity at Dhunche (1999- 2008)



Figure 6. Average Rain F all (mm) at Dhunche

3.2 Biology Component

3.2.1 Flora

The vegetation of LNP is complex due to the intervening of eastern Himalaya humid vegetation and western Himalayan drier vegetation (HMG 2002). Altitudinal variation, complex topography and geology have produced a rich bio-diversity which is unique patchwork of vegetation. The study on the flora of Langtang was done by HMG's Department of Medicinal Plants under the supervision of Tokyo University Museum, Japan in 1968 to 1975 (HMG 1976). The vegetation of LNP has been divided into following zones (DNPWC 1977).

a. Upper Tropical Zone (<1,000 m)

This zone covers very few portion of the lower Bhote Kosi which is dominated with Hill Sal forest (*Shorea robusta*) and Simal (*Bombax ceiba*) forest along with other *Semecarpus anacardium*, *Adina cordifolia*, *Terminalia temontosa*, *Bauhina vahlii*, and *Butea monosperma* etc. However, vegetation composition is significantly different from those of Sal forests of southern plains of the country. This zone corresponds to the wet hill Sal forest (Champion 1968).

b. Subtropical Zone (1,000-2,000 m)

This zone comprises three different kinds of forests namely, Hydrophilic, Mesohydrophyllic and Xerophyllic forest. Wettest area of the park covered with Hydrophilic forest consists of *Schima wallichii*. However, damper areas fall under Mesohydrophyllic forest of *Schima wallichii*, *Castanopsis indica*. Xerophyllic forest is predominated by *Pinus roxburghii*, which occurs on drier slopes. Due to rocky terrain and reduced rainfall, *P. roxburghii* is often the only tree present. *Euphorbia royleana* occurs in the dry, rocky habitats of the park in association with other strictly xerophyllic plants such as *Agave Mexicana*.

c. Temperate Zone (2000-3000 m)

Agricultural pattern and cattle grazing has largely affected the forest vegetation within the park in this zone. Intensive collection of fuel wood and fodder has degraded the forest. The forest has stunted sparse tree species present which are species associated with shrubs such as *Berberis*,

Rubus and *Lonicera*. Hydrophillic *Quercus lamellosa* forest occurs on the southern side of the park, although, it is also present in the wet part. Mesophyllic *Quercus lanata* forest on south facing slopes together with *Rhododendron arboreum* and *Lyonia ovalifolia* are also present there. In montane zone, vegetation varies from the damp, shaded *Q. semecarpifolia* and *Tsuga dumosa* type, to the mesohydrophyllic standards which are almost pure *Q. semecarpifolia*. Other types of forests include those, which have been burnt and now consist mainly of *Q. semecarpifolia*. This zone corresponds to the Himalayan wet temperate forest (Champion 1968).

d. Lower Sub Alpine Zone (3000-3600m)

This zone is mainly characterized by the dominance of coniferous such as *Tsuga dumosa*, *Abies spectabilis*, *Rhododendron barbatum* mixed with *Acer campbelli* in damp sites and gullies. On the drier sites, *Juniperus recurva* is prominent associated with *R. lepidotum*, *R. campanulatum*, *Larix himalaica*, *Caragana sukiensis*. The *Rhododendron* occurring in *Abies* forest is limited to *R. barbatum*, *R. campanulatum*. Broadleaved trees are not common in this *Abies-Rhododendron* forest, broken in places by burnt areas where dense bamboo (*Himalayacalamus falconeri*, *Arundinaria sp.* and *Thamnocalamus aristatus*) stands thrive. These areas are overgrazed by livestock (Chaudhary 1998).

e. Upper sub alpine zone (3,600-4,000 m)

Betula utilis is the distinctive tree species of this zone. Pastures often extend down to areas covered previously by forests. This is largely attributed by overgrazing. On north facing slopes, *Betula utilis* is associated with *Rhododendron campanulatum*, the latter being scattered and stunted above the tree line. In drier habitats, *R. campanulatum* is associated with *J. indica* and *J. recurva*. *A. spectabilis* and is still present in small numbers in the damp areas. Wherever the forest is absent, clumps of *R. lepidotum* and *R. anthopogon* develop and are dominant in and around the pastures (DNPWC/DUHE 1977). This zone corresponds to the Alpine Fir-Birch forest and Birch-Rhododendron forest (Champion 1968).

f. Lower Alpine Zone (4000-4500 m)

This zone lies above the tree line. Bushes of common plant species such as *Rhododendron*, *Lonicera*, *Juniperus*, *Cotoneaster*, are found in this zone depending on the climate and humidity. The heaths are dominated by *Rhododendron sp.* (damp) or *Juniperus sp.* (dry). Occurrence of *Rhododendron anthopogon* is the characteristic of the moist areas. This zone corresponds to dry alpine scrub (Champion 1968).

g. Upper Alpine Zone (4,500-5500m)

Species vary depending upon the soil, aspects and degrees of shelter. Grasses, herbs and cushion plants occur in the most favorable micro habitats (DNPWC/DUHE 1977).

3.2.2 Fauna

Langtang National Park is rich in faunal diversity that comprises of mammals, aves, herpeto and fish along with different colorful butterflies. This national park acts as a refuge for more than 46 mammal species, 345 bird species, 11 species of herpeto-fauna, 30 species of fishes, 70 species of butterflies and 10 species of spiders (Khatiwada2004, Chaudhary 1998, Karki *et al.* 2002).

Langtang's expansive high meadow provides summer habitat of ungulate species such as musk deer and Himalayan tahr. This park is also an important habitat of globally threatened species such as: snowleopard (*Uncia uncia*), Clouded leopard (*Neofelis nebulosa*), Musk deer (*Moschus chrysogaster*) and Red panda (*Ailurus fulgens*). Prey species, such as the Himalayan tahr (*Hemitragus jemlahicus*), Himalayan marmot (*Marmota himalayan*), Pika (*Ochotona sp.*), Ghoral (*Nemorhaedas goral*) are also found here. The park is also well known for other animals such as, the wild dog (*Canis alpinus*), Redfox (*Vulpes vulpes*), common leopard (*Panthera Pardus*), wolf (*Canis lupus*), Himalayan yellow throated marten (*Martes flavigula*), Himalayan black bear (*Selenarctos thibetanus*), large Indian civet (*Viverra zibetha*), common langur (*Semnopithecus entellus*), Barking deer (*Muntiacus muntjac*) etc.

These parks also provide refuse for some important bird species such as, Impeyan pheasant (*Lophophorus impejanus*), Blood pheasant (*Ithaginis cruentus*), Monal pheasant (*Tragopan satyra*). Tibetan snow cock (*Tetraogallus tibetanus*), Snow partridge (*Lerwa lerwa*), Long tailed

minivets (*Pericrocotus ethologus*), Black-capped sibilias (*Heterophasia capistrata*), River chat (*Chimarrornis leucocephalus*), Yellow-billed blue magpie (*Cissa flavirosteris*) and Ibisbill (*Ibidorhyncha struthersii*) etc. Eagles and vultures are often seen soaring above the cliffs and high pastures in search of carrion or prey. White-collared black birds, Himalayan honey guide, Scaly-bellied wood pecker, Redstarts, Tits are other birds which can also be seen around. The Golden eagle (*Aquila chrysaetos*) is also present in small number.

The most commonly seen reptiles are the Himalayan rock lizard, Green pit viper, Himalayan matrix, mountain Pit viper, Large toad viper in the park areas (Fox 1974, Khatiwada 2004).

In the lower reaches of Langtang Khola, blunt snow trout (*Schizothorax plagiostomus*) occurs. Mahaseer (*Tor tor*) is found in Trisuli river.

3.3 Socio –Economy

The Buffer Zone of LNP occupies an area 420km² and it includes 15 village Development Committees (VDCs) of Rasuwa (11) Nuwakot (3) and Sindupalchok (1) that comprised of 10,509 households (Regmi 2008).The present study was focused on the Syabru VDC. Most of the inhabitants of Syabru VDC are the Kerung Tibet. However, there is also an intermingling of Tamangs and refugees from Tibet with the local population. They identify themselves as Tamangs but they do not speak authentic Tamang dialect (Gurung 1988).

The main occupation of the local people is animal husbandry, mainly *Chauri*. Agriculture is secondary occupation in terms of costs and benefits because of low crop production. Thus livestock is very important aspect of the economy and they practice Transhumance system of grazing (Gurung 1988). Besides these, tourism industry is another major income source of Lantang people as it is regarded as the third tourist destination place of Nepal. Within the park, there are many lodges, tea stalls, camping sites and restaurants that are handled by local people. Thus tourism has positive impact on the local economy in creating various employment opportunities. The large and increasing numbers of tourists in small areas have also created some negative impact on the local environment and cultures. Increasing tourism industry has also caused a high fire wood consumption leading to deforestation, garbage problems and disturbances to wildlife (Banskota and Sharma 1988, Khatiwada 2004, Chetri 2006).

3.4 Intensive Study Site

The intensive study site falls inside the Red Panda Conservation Area (RPCA) in Cholang-Dhokachet of LNP. It includes three sites, such as Gopache, Dhokachet and Trishuli origin. Floral diversity was almost in similar pattern. However, it comprised of three major vegetation zones, such as montane zone (2,600-3000m), lower subalpine zone (3,000-3,600m) and upper subalpine zone (3,600-4,000m). The present study tries to focus on the red panda altitudinal range between 3,000m to 3,600m. Major plant species found were the *Abies spectabilis*, *Acer caudatum*, *Betula utilis*, *Rhododendron barbatum*, *R. campanulatum*, *R. arboreum*, *Sorbus cuspidata*, *Juniperus recurva*, *Lyonia ovalifolia*, *L. villosa*, *Viburnum nervosum*, *Ilex dipyrena*, *Thamnocalamus aristatus*, and *Barberis aristata* etc. Rocky cliff separates Dhokachet and Gopache while Trishuli site lies to the west facing slope just near Cholangpati. The red panda habitats of RPCA were differentiated into following habitats, namely rhododendron-maple, fir-raate bamboo, fir- ringal bamboo, fir-rhododendron, rhododendron-ringal, fir-birch, maple-birch, meadows and rhododendron-juniper (Yonzon and Hunter 1991b, Shrestha 1988).

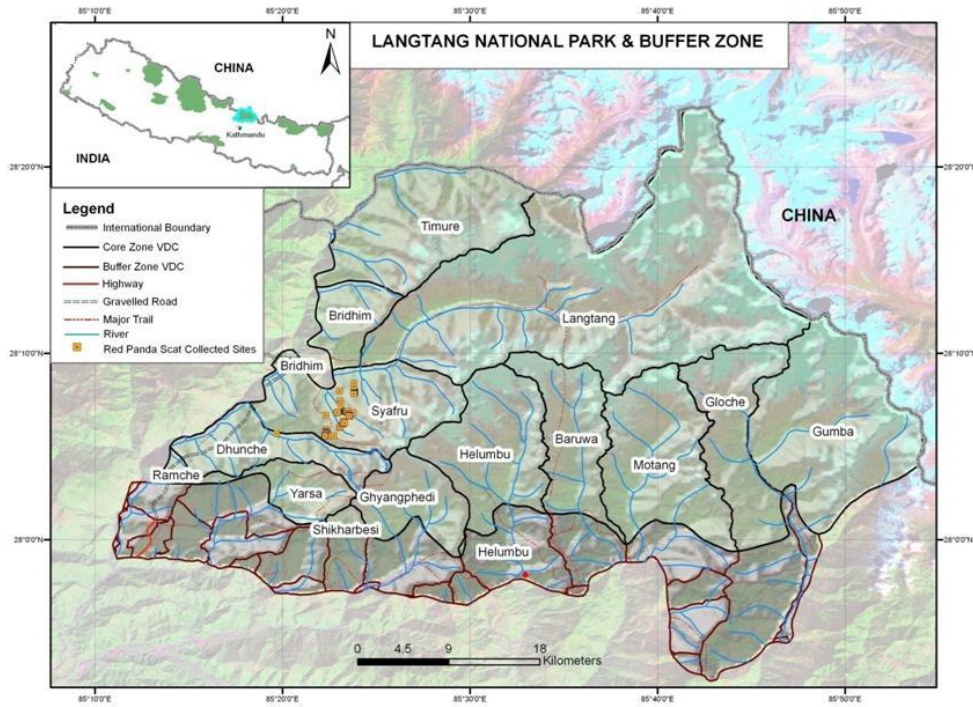


Figure 7. Map of study area.

4 Materials and Methods

4.1 Reconnaissance Survey

A preliminary field survey was carried out during the months of March 2009 in Cholang-Dhokachet Area of the LNP. During this period, a general view of habitat was made by visual observation while potential red panda habitats were identified from the secondary sources of literatures, semi structural questionnaires and informal interviews with local villagers, herders, park staff and hotel staff near the study areas.

4.2 Field Survey

Field studies were carried out in the months of April, July, October and February as seasonal representative months during 2009 to 2010.

4.2.1. Altitudinal Line Intercept

Because of the animal's shy nature, it was difficult to observe feeding activity. So, faecal sign was an effective indicator for its food habit studies. Usually the pandas leave a group of faeces at feeding site with 8-15 number of pellets in single defecation, but they also repeatedly use single sites, called latrines which consist of 15-30 pellets or sometimes more than 100 (Yonzon 1989, Reid *et al.* 1991). The faecal pellets are spindle shaped with soft, moist, light green colour which in average measure 19.2 ± 2.3 mm in diameter and in the case of adults it is 41.6 ± 6 mm (Yonzon 1989). The recognized probable habitat of animal in Cholang-Dhokachet area was surveyed in three sites namely, Gopche, Trishuli river origin and Dokachet. Altitudinal line intercept method (Sutherland 1996) followed by Williams (2004) and Mahato (2004) was used to record the faecal signs. Horizontal transects were laid in each block along contour lines between elevations of 3100 m and 3500 m with an altitudinal spacing by 100m. In this study Garmin Etrex GPS was used for geo-referencing and Government of Nepal (GoN) 1:25,000 survey map as altitudinal guide. When a faecal sign was encountered, the point was geo-referenced with GPS.

4.3 Micro-Histological Analysis

This method is based on microscopic recognition of indigestible plant fragments mainly epidermal features, which are the characteristics of different plant groups (Metcalfe 1960). It is a commonly used method for ascertaining diet composition and food preference studies of herbivores due to its simplicity in operation, effectiveness and manageable qualities (Anthony and Smith 1974, Baumgartner and Martin 1939, Holechek *et al.* 1982), and is the most accurate of all the methods for estimating diets of herbivores (Dearden *et al.* 1975). The red panda possess simple and short digestive tract of carnivores that subsists on entirely plant matter. It lacks symbiotic microbes to ferment and breakdown of cell wall (Bleijenberg and Nijboer 1989). Therefore a large indigestible fragment could recognize easily by this method, though a definite quantification of forage consumed cannot be observed. It is helpful in ascertaining food habitat of endangered or secretive species (Anthony and Smith 1974). This method follows collection of reference materials, preparation of reference slides with diagnostic key, faecal slides and slide interpretation.

4.3.1 Faecal Sample and References Material Collection

The faecal samples were collected in line transect as described above and collected samples were tagged and stored in separate paper bags. A total of 161 samples were collected from three study sites in different seasons. Among them, 42, 45, 42 and 32 samples were representative sample of spring (April-June), summer (July-September), autumn (October-December) and winter (January-March) respectively. These faecal samples were air dried separately for minimum of 72 hours to remove moisture content and brought to laboratory of Central Department of Zoology for further analysis.

Different plant species recorded within the faecal defecated area were collected for preparation of reference slides. Most plant species were identified in the field based on Flowers of the Himalaya (Polunin and Stainton 2000) whereas unidentified plants were pressed in the herbarium press. These unidentified plants were brought to Tribhuvan University Central Herbarium (TUCH) in the Central Department of Botany for identification.

4.3.2 Slide Preparation and Interpretation

Slides from faecal samples were prepared following the methodology used by Anthony and Smith (1974), and modified by Holechek, Vavra and Pieper (1982) and Jnawali (1995), which were adapted by Fjellstad and Steinheim (1996), Chetri (1999) and Shrestha (2005).

a. Reference and Faecal Slides Preparation

The collected reference plant samples were dried in an oven at 70°C in the laboratory. The dried plant samples were separately grounded to small size through electric blender then grounded powder was sieved in mesh size 1mm to 0.3mm. The powder retained on the 0.3 mm sieve was chosen as final reference sample for slide preparation while others were rejected. The final sample was then treated with different concentration (10% and 15%) NaOH and boiled for few minutes (5-6 minutes) giving water bath and the process was repeated till the solution became transparent. Later, the sample was cooled, washed with hot water to remove NaOH and dehydrated through a series of alcohol (30%, 50%, 70% 90% and 100%). The alcohol treated samples were finally treated with a series of xylene and alcohol mixture (30%, 50%, 70%, 90% and 100%) for complete dehydration. A small amount of material was dried between tissue paper and mounted in DPX under a 24x50mm cover slip. The slides were air dried for 5-6 days.

Similar procedure was followed on the faecal slide preparation which also followed during the reference slide preparation, where the 10% NaOH solution was replaced by a 5% NaOH. These faecal samples were lightly washed with warm distilled water to remove dirt attached to them. A total of two permanent slides were made for each faecal sample and marked.

b. Slide Interpretation

Slides from faecal samples were prepared and studied thoroughly as recommended by Holechek and Gross (1982). The distinguishable histological features (such as cell wall structure, shape and size of cells, hairs and trichomes, shape and size of stomata) for each species was taken as key features to match with the faecal plant fragments. The fragments of plant reference and faecal samples were photographed using Camera Lucida (DCMJ10) mounted on microscope. A compound microscope of 200X or 400 X magnifications with an ocular measuring scale was

used to read the faecal slide in horizontal transect. Finally, non-overlapping 20 fragments were identified using diagnostic key and photographs of the epidermis of the reference slide.

4.4 Threat Assessment

Habitat disturbances of the red panda were predicted with general observation of its habitat, interviews with the local people and different conservation stakeholders in the area. Semi-structure questionnaires were used randomly among the locals to examine the use of red panda food plants in various purposes of the local need. Beside this, the number of livestock dung as well as livestock grazing encountered in transect was counted to make an index of livestock pressure in different sites. Interviews were taken with herders and villagers to assess livestock number and weekly duration spent in the area. To assess grazing intensity, the present study used data based on the livestock number and weekly duration spent, following the methodology used by Ahlborn and Jackson (1987).

$$\text{Cattle dung encounter} = \frac{\text{Total number of cattle dung encounter}}{\text{Total transect length(km)}}$$

$$\text{Grazing intensity} = \text{Livestock number} \times \text{Weekly duration spent}$$

4.5 Data Analysis

a. Relative Frequency Percentage

Seasonal relative frequency percentage of each species in the faecal sample was estimated using following formula

$$\text{Rf\%} = \frac{n_1+n_2+\dots}{N} \times 100$$

Where,

Rf % = Relative frequency percentage

N= Total number of fragments identified for a given food species

N = Grand total number of fragments read

b. Niche Breadth

To evaluate the niche breadth of plant species included in the diet of the red panda Levin's measure of niche breadth (B) was calculated based on the following formula described by Krebs (1999).

$$B = \frac{1}{\sum_{i=1}^n P_i^2}$$

Where,

P_i = Percentage of total sample belonging to species i ($i = 1, 2, \dots, n$)

n = Total number of species in all samples.

For this index, the proportions of the plant species in the dung were recalculated, as the elimination of the unidentified and undetermined fragments produced large disruptions in the pattern. The value of niche breadth increases with increasing number of species in the diet. A low value indicates that an animal is selective of a few specific forage plant species.

c. Relative Importance Values

Relative Importance Values (RIV) of each plant species observed in the faecal sample was calculated as follows using method described by Jnawali (1995).

$$RVI_x = D_x \sqrt{f_x}$$

RVI_x = Relative importance value for species x

D_x = Mean percent of species x in faecal sample

f_x = Frequency of species in faecal sample

d. Percentage of Occurrence (0%)

Seasonal percentage occurrence of each species of three sites was calculated by using following the formula.

$$\text{Percentage of occurrence (0\%)} = \frac{\text{Number of occurrence of each food}}{\text{Total number of fragments read}} \times 100$$

Chi-square test (χ^2) was used to test significant difference in food composition of red panda in different seasons.

5 Results

5.1 Food Habit

A total of 161 faecal samples were analyzed through microhistological technique, which was collected in different seasons from three sites of the study area. The red panda consumed leaf, shoot, and fruits of eight plants species that comprised of *Thamnocalamus aristatus*, *Abies spectabilis*, *Juniperus recurva*, *Rubus sp*, *Sorbus cuspidata*, *Acer caudatum*, *Rhododendron campanulatum* and moss with a few unidentified hair and bone parts. Among these, *Thamnocalamus aristatus* (mean=245.08±15.74%), locally called as *Jhpara* was at highest proportion in all seasons as major food while other food items varied in different seasons as supplement food. These food plants were separated into bamboo, trees, herbs, moss and unidentified forage categories. *T. aristatus* was kept in separate category as bamboo because it was major food and present in highest percentage. The rest forage categories were tree, herbs, moss and the unidentified where were in least amount(less than 9%) as seasonal supplement food. Among these, tree category had many plants species as that comprised of seasonal fruiting plants and also the resting plants of the red panda. Relative frequency percentage of different food plants were calculated that showed *T. aristatus* (mean=245.08±15.74) as the highest proportion followed by Moss (mean=5.91±1.95%), *S. cuspidata* (mean=5.83±1.22), *J. recurva* (mean=1.08±071.95%), *A. caudatum* (mean=1.00±0.38%), and others in very low proportion (<1).

5.2 Seasonal Diet Composition

Diet composition of red panda varied seasonally in Choolang- Dhokachet area of present study sites (Table 1). *T. aristatus* was consumed in all season that was not statistically significant ($\chi^2 > 0.001$, df =11, P>0.05). But other secondary food items, such as *Abies spectabilis*, *Juniperus recurva*, *Rubus sp.*, *Sorbus cuspidata*, *Rhododendron campanulatum* were seasonally significant data (P<0.05). Likewise, red panda ingested moss in all seasons ensuing statistically insignificant ($\chi^2 = 2.66$, df =7, P>0.05). Thus, secondary food plants varied seasonally (P<0.05), besides moss (Table 1). In spring, percentage occurrence of bamboo consumption was higher in comparison to other seasons along with *A. spectabilis*, *J. recurva*, *Rubus sp.*, which were not recorded in summer. But summer diet composed of *T. arisatus*, *S. cuspidata*, *A. caudatum*, *R.*

campanulatum. However, red panda consumed *T. arisatus*, *A. caudatum*, and moss in the autumn season, while *T. arisatus*, *R. campanulatum* and moss were its winter food.

5.3 Diet Composition in Different Blocks

The diet analysis showed a seasonal difference in proportion of food items consumed in the three study sites except for *T. arisatus* (Table 3). It was found in similar proportion in comparison with other consumed food. At Trishuli, the food consisted of *T. arisatus* (>90%) in the highest proportion in all seasons except for the winter season (82.5%). Other secondary food comprised of *S. cuspidata*, *A. caudatum*, *Rubus sp.*, *J. recurva* and moss. Among them, *Rubus sp.* was found only in spring while *S. cuspidata* in summer only.

At Gopche, the red panda depended on *T. arisatus* as food during spring and autumn (>90%). Summer food composed of fruits, such as *S. cuspidata* (7.12%), which was higher than in other sites. Besides summer, all season possessed similar proportion of moss diet within the site. Along this, other plants, such as *A. caudatum*, *A. spectabilis* and *R. campanulatum* were also consumed.

At Dhokachet, the diet consisted entirely of *T. arisatus* (>90%) during spring, summer and winter but in less proportion in autumn (88.1%). Other supplement food consisted of *S. cuspidata* (5%) in summer but was not found in other seasons. Apart from these, *A. caudatum*, *A. spectabilis* and *R. campanulatum* occurred as traces amount (<1%) in all seasons except winter. Moss was found to be present in higher proportion in autumn (6.1%) but less in other seasons.

5.4 Niche Breadth and Relative Importance Value of Species

Niche breadth of red panda was determined and found to be 0.000104 which quite low resembled its high selectiveness in foraging. The relative importance values of species (RIV) eaten by red panda was determined. (Table 2). The highest RIV was found in *T. arisatus*. (4949) followed by *S. cuspidata* (16.26), and moss (7.99). Rest of the substances had very low RIV in red panda's diet.

Table 2. Plant species eaten by red panda with their mean percent, fragment frequency, relative importance value and niche breadth.

Plant species	No. of faecal samples	Mean %	Frequency of fragment	Relative importance value RIV	Niche Breadth B
<i>Thamnocalamus aristatus</i>	157	91.25	2941	4949	0.000104
<i>Sorbus cuspidata</i>	12	1.94	70	16.26	
<i>Acer caudatum</i>	3	0.34	12	1.19	
<i>Rhododendron campanulatum</i>	2	0.32	9	0.99	
<i>Abies spectabilis</i>	2	0.32	11	1.08	
Moss	13	2.41	71	7.99	
<i>Rubus sp</i>	1	0.02	1	0.26	
<i>Juniperus recarva</i>	5	0.38	11	0.39	

Table 2. Forage categories, relative frequency percentage (Rf%) of different plant species recorded in red panda faecal on the total fragments read in different seasons.

Rf%									
Forage categories	Plant species	Spring (n=42)	Summer (n=45)	Autumn (n=42)	Winter (n=32)	Mean± SE	SD	χ^2	<i>P</i>
Bamboo	<i>Thamnocalamus aristatus</i> (L, Sh)	0.949	0.897	0.909	0.895	245.083±15.749	54.556	0	1
Tree	<i>Sorbus cuspidate</i> (F)	0	0.078	0	0	5.833±3.221	11.158	16	0.001*
	<i>Acer caudatum</i> (L)	0	0.007	0.007	0	1±0.389	1.348	8	0.092*
	<i>Rhododendron campanulatum</i> (L)	0	0.002	0	0.011	0.75±0.579	2.006	9.5	0.009*
	<i>Juniperus recarva</i> (F)	0.001	0	0.014	0	1.083±0.712	2.466	16	0.001*
	<i>Abies spectabilis</i> (L)	0.004	0	0.009	0	0.916±0.514	1.781	11.33	0.01
Moss	Moss	0.013	0	0.033	0.05	5.917±1.959	6.789	2.66	0.914
Herbs	<i>Rubus sp</i>	0.001	0	0	0	0.083±0.083	0.289	8.33	0.004*
Unidentified	Unidentified	0.032	0.017	0.026	0.043	7.667±1.017	3.525	2	0.92

L-leaf, Sh-shoot, F-fruit

Table 3. Seasonal incidence of food items in red panda faecal pellet and % of occurrence in three sites.

Food items	Trisuli				Gopache				Dhokachet			
	SP	SU	AU	WI	SP	SU	AU	WI	SP	SU	AU	WI
<i>Thamnocalamus aristatus</i>	308 (96.3)	275 (91.7)	319 (93.8)	132 (82.5)	266 95	219 (84.2)	216 (90)	197 (89.5)	223 (92.9)	313 (92.1)	229 (88.1)	244 (93.9)
<i>Sorbus cuspidata</i>	0 (0)	20 (6.7)	0 (0)	0 (0)	0 (0)	33 (12.7)	0 (0)	0 (0)	0 (0)	17 (5)	0 (0)	0 (0)
<i>Acer caudatum</i>	0 (0)	1 (0.3)	2 (0.6)	0 (0)	0 (0)	4 (1.5)	3 (1.2)	0 (0)	0 (0)	1 (0.3)	1 (0.4)	0 (0)
<i>Rhododendron campanulatum</i>	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.4)	0 (0)	7 (3.2)	0 (0)	1 (0.3)	0 (0)	0 (0)
<i>Abies spectabilis</i>	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.7)	0 (0)	6 (2.5)	0 (0)	1 (0.4)	0 (0)	2 (0.8)	0 (0)
Moss	2 (0.6)	0 (0)	5 (1.5)	22 (13.7)	5 (1.9)	0 (0)	7 (2.9)	8 (3.6)	4 (1.7)	0 (0)	16 (6.1)	2 (0.8)
<i>Rubus sp</i>	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
<i>Juniperus recarva</i>	0 (0)	0 (0)	8 (2.3)	0 (0)	1 (0.4)	0 (0)	4 (1.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unidentified	9 (2.9)	4 (1.3)	6 (1.8)	6 (3.7)	6 (2.1)	3 (1.1)	4 (1.7)	8 (3.6)	12 (5)	8 (2.3)	12 (4.7)	14 (5.4)
Total fragments	320	300	340	160	280	260	240	220	240	340	260	260

*SP-spring, SU-summer, AU-autumn, WI-winter

5.5 Threats and Disturbances

Threats to the red panda were determined by considering the livestock and human pressure. In the intensive study area, livestock was dominated by *Chauri* (a cross breed of Yak *Bos grunniens* and hilly cow *Bos taurus*) and grazing prevalence in all sites. Seasonally, large herds of livestock were grazed in different pastures near the study site for about six to seven months that possesses higher threat to the red panda. Although, sheds (*Goths*) were not allowed inside the red panda Core Area, grazing pressures have not decreased yet. There was the highest dung encounter rate in Dhokachet (mean 34.19/km) site of study area followed by Gopche (mean 24.49/km) and Trishuli (mean 9.45) site. Grazing intensity also interrelated with cattle dung encounter rate; if there is a higher cattle dung encounter rate, higher will be in the livestock pressure. It showed a higher grazing intensity of cattle the in Dhokachet. Relation between cattle dung encounter rate and the red panda faecal encounter rate was shown by regression fitted line that showed decrease in faecal pellet encounter rate with an increase in cattle dung encounter rate.

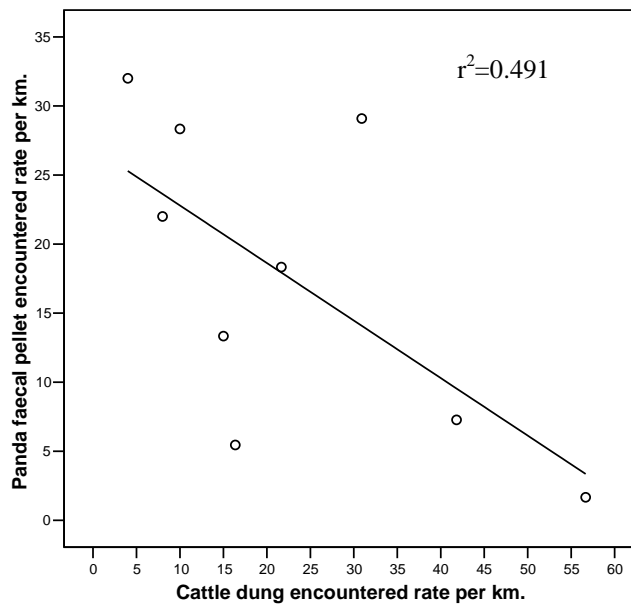


Figure 8. Regression fit line showing the red panda faecal pellet encounter rate and cattle dung encounter rate

Habitat destruction of the red panda was also taking place by trampling due to the persistent movement of cattle in *Jhapara* -forest that inhibit regeneration pattern of the forest. Firewood demand of cattle herder, hoteliers and cheese factory were other causes of habitat destruction. During the study period, three red pandas were killed in snare, targeted for Musk deer trapping in Dhokachet site.

Outcome of questionnaires surveys suggested that the major food of red panda *T. aristatus*, was used in various purposes (figure 9). In the survey, 40% of the respondents suggested that the red panda's food item was used as fodder for livestock, and 25% told that the bamboo was widely used as the roof tops of various huts and *Chauri- Goth*. Similarly, 20% of the people generated income by preparing and selling various types of the baskets used for various purposes in the nearby small markets. Fifteen percent of the bamboo shoots was locally used as vegetables and other food items that were saleable in the market.

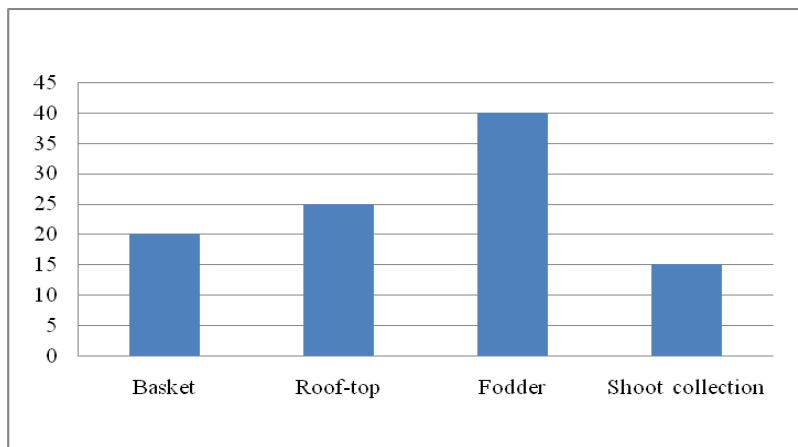


Figure 8. Use of Red Panda food, *Thamnocalamus aristatus* for other purposes

6 Discussion

6.1 Food Habit of Red Panda

Micro-histological study on food habits of the red panda suggested eight sundry plants during different seasons. *T. aristatus*, locally called *jhapra* provided the highest (< 90%) portion in all seasons as major food while, *Abies spectabilis*, *Juniperus recurva*, *Rubus sp*, *Sorbus cuspidata*, *Acer caudatum*, *Rhododendron campanulatum* and moss supplemented in different seasons in small amount. Earlier study in the LNP by Yonzon and Hunter (1991b) suggested that the food of red panda composed of 54-100% *Jhapra* leaves in all seasons and mushroom, *Sorbus cuspidata*, *Sorbus microphylla* were supplemental food. Karki (2009) reported that the red panda feed on six species of plants with *T. aristatus* as the highest constituent. Among the six food plants, five food items were similar with present analysis as her study of summer agrees with summer season of present study as that study focused only on one season. Pradhan *et al.* (2001b) in Singhalia National Park showed seasonal differences in proportion of diet composition of the animals. The total diet comprised of *Arundinaria aristata* leaves (45%), *Arundinaria maling* (35%), fruits of *Actinidia strigosa* (13%) bamboo shoots (6%), *Sorbus microphylla* and *Rosa sericera* in small amount. It also suggested that the winter diet of red panda consisted of *Arundinaria aristata* (53%) and *Arundinaria maling* (47%) but the post - monsoon diet comprised 70% of *A. maling* leaves, 20% *Actinidia strigosa* fruits and 10% bamboo shoots. These studies were based on macroscopic analysis but the present study was done through micro-histological analysis which showed a few different food plants, such as *Rubus sp*, *Juniperus recurva* and *Rhododendron campanulatum* in trace amount in the different seasons. Reid *et al.* (1991) found red panda consuming *Sinarundinaria fagiana* and shoots of *Fargesia spathecea* in Wolog Nature Reserve. The study done by Wei *et al.* (1999a) in Yele Nature China, showed that the bamboo leaves made up 89.9% of red panda's annual diet which preferred short and robust shoots supplemented by fruits and mushrooms. Study of Chetri (2006) in LNP suggested that food plant of Himalayan black bear consisted of *Arundinaria sp.* *Malus baccata*, *Rubus ellipticus* *R. recticullata* *Tiarella polyphylla* and *Berberis aristatus* which showed a few food plants were consumed by both of these animals.

From this study, it was found that 89.5% -94.88% of the red panda diet comprised of bamboo leaves over a year. This result is similar to the findings of Wei *et al.* (1999a). Summer diet consisted of *S. cuspidata*, *A. caudatum*, *R. campanulatum* as secondary food which was also found by Karki (2009). Among the secondary summer food, *S. cuspidata* occurred in higher amount being also the fruiting season. As the summer season also coincided with the period of birth and rearing of the young one of red panda, it could fulfill the more energy requirement. But the study shows maximum bamboo as food, which is due to the reason of being the staple food having low nutrient content that helps in poor digestive system of red panda. *Abies* leaves were found undigested while juniper cone also occurred in food which might have been the opportunistic food. It might have been eaten accidentally as the animals carried these plant parts in the mouth during the nesting. Moss comprised of higher amount than any other food supplement because all trees were covered with moss and the red pandas might rest on such moss mat trees and eat it as stuffer food. Presence of hair were seen in a few faecal pellets, which was probably the result of autogrooming and grooming of the cub (Yonzon 1989), while presence of claw and bone might reflect cannibalism.

6.2 Niche Breadth

Determination of a niche usually involves the measure of some ecological variables such as food size or habitat described as narrow or broad. Niche width or niche breadth provide some indication of resource utilization by a species. Body size is the most important factor determining the metabolic rate and food requirement. Large bodied mammals have higher food requirement since they have higher cost of maintenance and production compared to the smaller mammals (Geist 1974). In the present study, niche of the red panda was calculated as 0.000104, which was quite less, resembling narrower niche as specialized food. This outcome suggested that the red panda was highly food selective. Similarly, Yonzon (1989) also recommended that the red panda had highly specialized niche and diet. Wider the niche, the more generalized the species was considered in their diet. Similarly, narrower the niche, the most specialized the species would be (Smith 1980). Most of the species has broader niches and a sacrificed efficiency in the use of narrow range of resources for the ability to use a wide range of resources (Smith 1980).

6.3 Threats and Disturbances

The red pandas were facing problems of grazing pressures in their habitat. Cattle dung encountered rate was higher in 3500m. Yak sheds were built in the open area near the tree line which acted as better grassland for grazing. Livestock spent less time in the lower elevation sheds than the higher elevation which reflected maximum dung encountered rate. In comparison, Dhokachet site had more problems of livestock pressure because of higher dung encounter (mean.34.19/km) as these sites had more Yak sheds (<14) with large number of cattles. Cattles frequently grazed all accessible parts of this site. Other pasture such as Kolmo, Brana, Chedang and Dangdung were laid near Dhokachet, so the cattles of these pastures also used to grazed inside Dhokachet for a few weeks and later reached to their won pastureland. To keep these livestock around, the cheese factory had established mobile milk collection and processing centers. All these conditions also supported for higher grazing intensity in this area.

At the elevation of 3300m, dung encounter rate was higher in Gopache (21.67/km), between Dhokachet and Trishuli. This area has a walking trail which leads to other pasturelands (Kolmo, Brana, Chedang and Dangdung). Livestocks spend about one month near this site and use this trail as transition to another pastureland. This is the reason for a high encounter of dung. This finding also agrees with the finding of Mohato (2004), in a research carried out in SNP between the altitudes of 3000-3200m. The abundance of red panda was higher in SNP along this altitudinal range. The study of Yonzon *et al.* (1991a) suggested that the red panda preferred altitudinal range of 3233m±218m with extremely narrow range of 406m. This overlapping of red panda habitat with high grazing of animals as shown by high encounter rate of dung has showed high disturbances resulting into threats to this endangered species. But Yonzon (1989), reported that there was no direct competition between *Chauri* and red panda. In addition to this a high trampling due to grazing herds impede the establishment of seedlings by crushing the tender seedlings and hardening of the soil, resulting into extremely low regeneration of the forest and degradation of the habitat of the animals.

The outcome also allies with Tanshumance grazing practice, which is a major income source of the people living in mountainous areas. Chandanbari-Cholangpati-Lauribinayak areas fall under RPCA, which are grazed by 33 herds annually at their own will in different pasture lands. Most

of the herds are composed of a minimum 12 and a maximum 40 heads of cattle which graze 2-3 weeks in each pasture land which might be changed depending on the availability of fodder in the areas. Cheese factories encouraged herders to increase their livestock number by providing them soft loan and reasonable price for milk. Sing Gomba cheese factory is very near to Cholang-Dhokachet area, where grazing occurs extensively. These activities are the main causes of livestock pressure in around red panda habitat. Besides these, cheese factories have established mobile milk collection and processing centers near to different pastures (limited pasture area) and use fuel wood for boiling milk. About 25 stack of fuel wood are permitted every year for these cheese factories. The use of fuel wood by herders, factories and hoteliers is also a serious problem causing forest destruction of red panda habitat.

Questionnaire surveys related to food suggested that local people used bamboo and shoots for various purposes such as basket, rooftop, fodder and shoot collection. Among these, 40% respondents said that the bamboo was used as fodder for their livestock mainly for calves. Bamboo was also used for making roof tops of huts and Chauri-sheds, while some people generated income by selling various types of handicrafts made from bamboos. Generally, baskets were used for carrying grass and other materials for their daily need. Similarly, 15% of the respondents answered that the bamboo shoots were used as vegetables and other saleable items (pickle). They also used these shoots to feed their livestock as cattle feed. This finding also matched with the study of Williams (2004), where he reported that the bamboo was used as fodder, roofing, fencing walls and making baskets, for beedings, to support crops, kitchen utensils and baby cribs. The study of Pradhan *et al.* (2001b) recorded that bamboo supplied 100% of their diet for seven months of the year and 47% during the other five months. Thus, the staple food of red panda was bamboos, which were rapidly exploited for domestic uses and created a serious problem for the habitat loss and food decline of the panda.

Hunting didn't appear to be as serious threat as habitat loss, overgrazing and fire wood collection. During the study period, three red pandas were found dead in snares in Dhokachet site which were actually intended for catching musk deer by the poachers. This accident showed the ongoing presence of illegal poaching. For about 40 years, live trapping for red panda for the purposes of trade was frequent in eastern sector of the LNP. Hunters do not appear to be deliberately seeking out the red pandas. However, it is shot opportunistically and caught

accidentally in snares during hunting for wild pig musk deer, goat-antelopes (serow, goral) and primates. It is possible that the forest degradation is making the species more visible to hunters. Choudhury (2001) explained that these species were formerly trapped in Nepal, Darjeeling, North West Bengal and Sikkim for sale to the zoos, which might account for the general rarity of the species in these areas which doesn't appear to be the case now. Bahuguna *et al.* (1998) estimated that at least 300 red pandas were trapped for trade in the 1960s in Singalila. In China, red panda pets can be found in many local markets (Glatston 1994). Munro (1969) reported handling 350 red pandas sold to zoological gardens within a span of 17 years suggest that there was a regular trapping of live animals in some parts of their range. Such trade largely stopped following the listing of the red panda on CITES Appendix I (Traffic 1991, Lu *et al.* 1993). The last legal export of wild –caught animals from Nepal was in 1984, but illegal trapping is still sometimes reported. Glatston (1994) noted one animal dealer 1990 who offered a pair of red panda for sale that had repeatedly been born in captivity in Bangladesh although there is no such breeding record in that country. It has been reported that in northernmost Myanmar, the red panda skins are traded by Chinese traders (Rabinowitz and Khaing 1998).

7 Conclusion and Recommendations

The study conducted during 2009-2010, showed that the red pandas feed on eight plant species in different proportions which were confirmed from faecal pellet analysis by micro-histological technique. These dietary plants were *T. aristatus*, *A. spectabilis*, *J. recurva*, *Rubus sp*, *S. cuspidata*, *A. caudatum*, *R. campanulatum* and moss. Among those, it was found that the red panda fed on *T. aristatus* (Jhapara) as the highest percent and it acted as a primary food whereas, the other substance acted as low percent and secondary seasonal food supplements. Primary food *T. aristatus* was insignificant in all seasons but secondary food supplement varied in different seasons. Niche breadth value was found to be low which concluded the red panda was diet specific and had selective feeding behaviour. Besides these, unidentified hair, bone and claws were observed in few faecal pellets. The red panda in study area faced the problems of habitat destruction, livestock pressure, fire wood collection as well as illegal poaching. Fodder collection in the red panda habitat areas was the main threat to its habitat and food that led to habitat destruction, fragmentation and food decline. Similarly, grazing of cattle in the panda habitat and use of bamboos as vegetables, roofing materials and as other raw materials for domestic utensils were also indirect threats to the viable population of red pandas.

From this study, following recommendations were drawn:

- Livestock grazing season overlaps with breeding season in the study area, which has severe impact upon the red panda population. Intensive grazing by the domestic livestock in and around the red panda habitats should be controlled. Grazing should be managed in specific blocks of the park and cyclical grazing system should be implemented. Plantation of other species trees is necessary in different open areas to prevent landslides as well as to fulfil the fodder and fire wood demands of the locals.
- Collection of bamboo shoots is not a basic need to the people but they collect it as an extra food source. So people should be convinced not to collect it.

- Faecal analysis from different geographical areas should be done for a detailed feeding ecology of animals.
- Study on seasonal nutrient analysis as major food of red panda should be done.
- There should be an examination of diet overlap among other related animals in the study area
- The use of fire wood in the factories should be replaced by alternative energies, such as biogas, solar energy, bio-briquette etc.
- The staple food of the red panda *T. aristatus*, gets mass flowering after certain interval which threatens the food as well as habitat. So, identification and management of supplement food should be managed and conserved in natural habitat.
- Regular monitoring of the red panda habitat eco-trail, as declared for tourism promotion is recommended so as to ensure least impact on the red panda habitat of the area.

References

- Ahlborn, G. and R. Jackson. 1987. A survey of Sagarmatha National Park for the endangered snow leopard. Department of National Parks and Wildlife Conservation, and King Mahendra Trust for Nature Conservation. Report, Pages 18.
- Anthony, R. G. and N. S. Smith. 1974. Comparison of rumen and fecal analysis to described deer diets. *Journal of Wildlife Management* 38 (3): 535-540.
- Anton, M., M. J. Salesa, F. F. Pastor, S. Peigne and J. Morales. 2006. Implications of the functional anatomy of hand and forearm of *Ailurus fulgens* (Carnivora, Ailuridae) for the evolution of the 'false-thumb' in pandas. *Journal of Anatomy* 209: 757-764.
- Bahuguna, C., S. Dhaundyal, P. Vyas and N. Singhal. 1998. The red panda at Singalila National Park and adjoining forest. A status Report Small Carnivores Conservation 19: 11-12.
- Banskota, K. and B. Sharma. 1998. Mountain tourism for the local community development in Nepal: A case study of Syaphrubesi, Langtang National Park. ICIMOD, Kathmandu, Nepal.
- Baumgartner, L. L. and A. C. Martin. 1939. Plant histology as an aid in squirrel food habit studies. *Journal of Wildlife Management* 3 (3): 266-268.
- Bezruchka, S. 1985. A guide to trekking in Nepal. Sahayogi press. Kathmandu.
- BPP. 1995. Red Data Book of the Fauna of Nepal Technical Publication. No. 4 Biodiversity profile Project, HMG- Nepal/Government of Netherlands.
- Bleijenberg, M. C. K. and J. Nijboer. 1989. Feeding herbivorous carnivores. In: *Red Panda Biology* 41-50 (Glatston A. R. ed.) SPB Academic Publishing by the Hague, Netherlands.
- Champion, H. G. and S. K. Seth. 1968. A revised survey of forest types of India. Delhi, Government of India.
- Chaudhary, R. P. 1998. Biodiversity in Nepal. Status and conservation. Tecpress books, Bangkok.
- Chetri, M. 1999. Food habit, habitat utilization, and conservation of gaur (*Bos gaurus gaurus*) in Parsa Wildlife Reserve. Nepal, M.Sc. Thesis. Tribhuvan University, Kathmandu, Nepal. Pages 67.

- Chetri, P. B. 2006. Habitat use, food analysis and threats of Himalayan black bear (*Ursus thibetanus*) in mid western part of Lantang National Park, Nepal. M.Sc. Thesis. Tribhuvan University, Kathmandu, Nepal. Pages 69.
- Choudhury, A. U. 1997. Red panda *Ailurus fulgens* (F. Cuvier) in the northeast with an important record from the Garo hills. *Journal of Bombay Natural History Society* 94: 145-147.
- Choudhury, A. U. 2001. An overview of the status and conservation of the red panda in India, with reference to its global status. *Oryx* 35: 250-259.
- Dearden, B. L., R. E. Pegau. and R. M. Hansen. 1975. Precision of Microhistological Estimation of Ruminant Food Habits. *Journal of Wildlife Management* 39 (2): 402-407.
- DNPWC / MoFSC / GoN. 2010 . Red panda conservation action plan for Lantang National Park and Buffer Zone Nepal 2010-2014. Government of Nepal, Ministry of Forest and Soil Conservation, Department of National Nepal Parks and Wildlife Conservation, Lantang National Park.
- DNPWC 2004. Langtang National Park, Booklet. Department of National Parks and Wildlife Conservation, Kathmandu.
- DNPWC 2006. Wildlife Nepal. Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.
- DUHE/DNPWC 1977. Langtang National Park Management Plan 1976-1980, HMC/UNDP/FAO project, Durham University Himalayan Expedition and National park and Wildlife Conservation Kathmandu, Nepal.
- Dusi, J. L. 1949. Methods for the determination of food habits by plant microtechnique and histology and their application to cotton tail rabbit food habits. *Journal of Wildlife Management* 13: 180-186.
- Fjellstand, J. I. and G. Steinheim. 1996. Diet and habitat use of Greater Indian One-horned Rhinoceros (*Rhinoceros unicornis*) and Asian Elephant (*Elephant maximus*) during the dry season in the Babia Valley, Royal Bardia National Park, Nepal. M.Sc. Thesis. Agriculture University of Norway. Pages 48.
- Fox, J. L. 1974. Report on Langtang National park. Report to NPWCO, Kathmandu.

- Fox, J., P. B. Yonzon, and N. Podger 1996. Mapping conflicts between biodiversity and human needs in Langtang National Park, Nepal. *Biological Conservation* 89(3): 258-291.
- Geist, V. 1974. On relationship of social evolution and ecology in ungulates. *American Zoologist* 14: 205-220
- Glatston, A.R. 1994. *The Red Panda, Olingos, Coatis, Raccoons, and their Relatives*. Status Survey and Conservation Action Plan for Procyonids and Ailurids. IUCN/SSC Mustelid, Viverid and Procyoni Specialist Group. IUCN, Gland, Switzerland.
- Gurung, B. 1988. Socio economic development and conservation in Syabru and Langtang National Park, Central Nepal. M. A. Thesis Central Department of Sociology. Tribhuvan University, Kirtipur.
- Gurung, D. D. 1991. Diet analysis of musk by fecal analysis. M. Sc. Thesis Central Department of Zoology, T.U, Kathmandu, Nepal.
- Holecheck. J. L., M. Vavra., and R. D. Pieper. 1982. Botanical composition determination of range herbivores diets. A review *Journal of Range Management* 35 (3): 309-315.
- HMG 2002. Forest and vegetation types of Nepal. Ministry of Forest and Soil Conservation, Nepal. Natural Resources Management Sector Assistance Programme (NARMSAP). Tree improvement and silviculture Component.
- HMG 1976. Flora of Lantang and cross section vegetation survey (Central zone). HMG, Ministry of Forest, Department of Medicinal Plants, Bulletin of Department of Medicinal Plants, Nepal.
- IUCN 2008. IUCN Red List of Threatened Species. Version 2009.2. <www.iucnredlist.org>. Downloaded on 20 December 2008.
- Jackson, R. 1990. Threatened wildlife, crop damage and wildlife depredation and grazing in the Makalu Barun National Park and Conservation Area. The Makalu Barun Conservation Project working Paper Series, Department of National Park and Wildlife conservation, Kathmandu, Nepal and Woodland Mountain Institute, West Virginia, USA.
- Jnawali, S. R. 1995. Population ecology of Greater One Horned Rhinoceros (*Rhinoceros unicornis*) with particular emphasis on habitat preference, food ecology and ranging behaviour of a reintroduced population in Royal Bardia National Park in Low Land, Nepal . Ph.D. Thesis, Agriculture University of Norway.

- Johnson, K. G., G. B. Shaller, and J. Hu. 1988. Comparative behavior of Red and Giant Pandas in the Wolong Reserve, China. *Journal of Mammology* 69 (3): 552-564.
- Kandel, R. N. 2008. Distribution and conservation status of red panda (*Ailurus fulgens*) in Dhorpatan Hunting Reserve, Nepal. M. Sc. Thesis Central Department of Zoology, Tribhuvan University, Kirtipur, Nepal.
- Kandel, K. 2009. Distribution and habitat use of red panda (*Ailurus fulgens*) in eastern Nepal. Nepal. M. Sc. Thesis Central Department of Zoology, Tribhuvan University, Kirtipur, Nepal.
- Karki, J. B., B. Khanal, and K. Shrestha, 2002. Some beautiful butterflies of Lantang National Park (Booklets).DNPWC, Natural History Museum, Lantang National Park and Tribhuvan University.
- Karki, K. 2009. Habitat and feeding behaviour of red panda (*Aliurus fulgens*) in Choloangpati-Dokachet area Langtang National Park, Nepal. M. Sc. Thesis Central Department of Zoology, Tribhuvan University, Kirtipur, Nepal.
- Kharel, F. R. 1993. Park- people conflict in Langtang National Park, Nepal. Dissertation, Masters of Parks and Recreation Management, Lincoln University, Canterbury, New Zealand.
- Khatriwada, J. R. 2004. The status of snow leopard (*Uncia uncia* Schreber 1778) and its conflict perception in Lantang National Park. M. Sc. Thesis Central Department of Zoology, Tribhuvan University, Kirtipur, Nepal.
- Krebs, C. J. 1999. Ecological Methodology. Addison-Wesley Longman, Menlo-Park.
- Li, M., F. Wei, B. Goossens, Z. Feng, H. B.Tamate, M. W. Bruford, S. M. Funk. 2005. Mitochondrial Phylogeography and Subspecific Variation in the Red Panda (*Ailurus fulgens*). *Molecular Phylogenetics and Evolution* 36: 78-89.
- Lu, B., A. R. Glatston and F. P. G. Princee. 1993. Demographic and genetic analysis of studbook population of *Aliurus fulgens styani*. In Red or lesser panda studbook, no.7: 30-36 (Glatston A.R. ed.). Stichting Koninklijke Rotterdames Dicrgaarde, Retterdam, Netherlands.
- Mahato, N. K. 2004. Baseline survey of red panda (*Ailurus fulgens*) status in the buffer zone of Sagarmatha National Park. A Project Report Submitted to WWF Nepal program, Kathmandu, Nepal.
- Mahato, N. K. 2003. Status of Red panda, (*Ailurus fulgens*) in the Kangchenjunga Conservation Area, Nepal. A project paper submitted in partial fulfillment of requirement of B.Sc. Institute of Forestry, Tribhuvan University, Pokhara. Pages 40.

- Maire, A. 1973. La Vallee du Langtang (Original Not Consulted), Paris. As cited in Shrestha, M. K. 1988. Vegetation study of red panda habitat in Langtang National Park, Central Nepal. M. Sc. Thesis, Tribhuvan University, Nepal.
- Metcalf, C. R. 1960. Anatomy of the monocotyledons. I. Gramineae. Oxford University Press. Pages 731.
- Miller, D. J. 1987. Yaks and grass: Pastoralism in the Himalayan countries of Nepal and Bhutan and strategies for sustained development. Dissertation Master of Forestry University of Montana.
- Munro, G. 1969. Breeding the lesser panda in Bremen Zoo, Germany. International Zoo News 89 : 281-283.
- Nagarkoti, A. 2006. Distribution pattern, habitat preference and food habits of barking deer (*Muntiacus muntjac-Zunernerann*) in Nagarjun forest. M. Sc. Thesis. Tribhuvan University, Kathmandu, Nepal.
- Oftedal, O., K. J. Fulton and S. D. Crissey. 1989. Bamboo as a resource of digestible energy for red pandas. International Theoretical Congress, Rome.
- Prater, S. H. 1980. *The book of Indian animals*. Bombay Natural History Society, Bombay.
- Polunin, O., A. Stainton 2000. *Flowers of the Himalaya*. Oxford University Press, Oxford.
- Pradhan, S., G. K. Saha, and J. A. Khan. 2001a. Ecology of the red panda (*Ailurus fulgens*) in the Singhalia National Park, Darjeeling, India. *Biological Conservation* 98: 11-18.
- Pradhan, S., G. K. Saha, and J. A. Khan. 2001b. Food habits of the red panda (*Ailurus fulgens*) in the Singhalia National Park, Darjeeling, India. *Journal of Bombay Natural History Society* 98(2): 224-230.
- Pokheral. C. P. 1996. Food habit and habitat utilization of swamp deer (*Cervus duvauceli duvauceli*) in Bardia National Park. M. Sc. Thesis. Tribhuvan University, Kathmandu, Nepal.
- Rabinowitz, A. and S. T. Khaning 1998. Status of selected mammal species in northern Myanmar. *Oryx* 32: 201-208.
- Regmi, G. R. 2008. Status of Assamese Acaque (*Macaca assamensis*) in Lagtang National Park, Central Nepal. M. Sc. Thesis Central Department of Zoology, Tribhuvan University, Kirtipur, Nepal.

- Reid, D. G., H. Jinchu and Y. Hunang 1991. Ecology of the Red Panda (*Ailurus fulgens*) in the Woolong Reserve, China. *Journal of Zoology* 225: 345-364.
- Roberts, M. 1983. The red panda: its history and fragile hold on the future. *Cincinnati Zoo News* 1-5.
- Roberts, M. and J. Gittleman. 1984. *Ailurus fulgens*. *Mammalian Species* 222: 1-8.
- Sharma, H. P. 2008. Distribution of red panda (*Ailurus fulgens*) in Rara National park, Nepal: An assessment of their conservation status. Final report submitted to People's Trust for Endangered Species, London.
- Shrestha, M. K. 1988. Vegetation study of red panda habitat in Langtang National Park, Central Nepal. M. Sc. Thesis, Tribhuvan University, Nepal.
- Shrestha R. and S. B. Ale 2001. Species diversity of Modi Khola Watershed. King Mahendra Trust for Nature Conservation, Annapurna Conservation Area Project, Pokhara, Nepal. Pages 47.
- Shrestha, R., P. Wegge and R. K. Koirala. 2005. Summer diet of wild and domestic ungulates in Nepal Himalaya. *Journal of Zoology* 266: 11-119.
- Smith, R. L 1980. Ecology and field biology (Third Edition), Harper and Row, New York.
- Sparks, D. R. and J. C. Malechek, 1968. Estimating percentage dry weight in diets using microscopic technique. *Journal of Range Management* 21: 264- 265.
- Sutherland, W. 1996. Ecological census techniques: A handbook. Cambridge University Press, Cambridge UK.
- Subedi, T. R. 2009. Habitat, status and conservation of red panda (*Ailurus fulgens*) in Dhorpatan Hunting Reserve, Nepal. Final report submitted to Rufford Small Grant Foundation, UK.
- Tautscher O. G. 1970. Erosion Control. Trishuli Watershed Development Project Report. No. 13 Nepal. As cited in Shrestha, M. K. 1988. Vegetation study of red panda habitat in Langtang National Park, Central Nepal. M. Sc. Thesis, Tribhuvan University, Nepal
- TRAFFIC (IUCN/WWF), 1991. The smuggling of endangered wildlife across the Taiwan Strait. TRAFFIC International, Cambridge, UK.
- Warnell, K. J., S. D. Crissey, and O.T. Oftedal. 1989. Utilization of Bamboo and other fiber sources in red panda diets. In: *Red Panda Biology* (Glatston A. R. ed.). SPB Academic publishing, The Hague, The Netherlands. Page 51-56.

- Wei, F. W., Z. J. Feng, Z. W. Wang, A. Zhou, and J. W. Hu. 1999a. Use of nutrients in bamboo by the red panda (*Ailurus fulgens*). *Journal of Zoology* 248: 535-541.
- Wei, F. W., Z. J. Feng, Z. W. Wang, and J. W. Hu. 1999b. Current distribution, status, and conservation of wild red pandas (*Ailurus fulgens*) in China. *Biological Conservation* 89(3): 285-291.
- Williams, B. H. 2004. The Status of Red Panda in Jamuna and Mabu Villages of Eastern Nepal. M. Sc. Thesis Submitted to San Jose state University, USA.
- Williams, O. B. 1969. An improved techniques for identification of plant fragments in herbivores feces. *Journal of Range Management* 21: 51-52.
- Yonzon, P. B. 1989. Ecology and conservation of the red panda in the Nepal-Himalayas. Ph. D. Dissertation. University of Maine, USA.
- Yonzon, P. B, R. Jones and J. Fox 1991. Geographic information system for assessing habitat and estimating population of Red Pandas in Langtang National Park, Nepal. *Ambio* 20 (7): 285-288.
- Yonzon, P. B. and M. L. Hunter 1991a. Cheese, tourists and red panda in the Nepal Himalayas. *Conservation Biology*, 5(2):196-202.
- Yonzon, P. B. and M. L. Hunter 1991b. Conservation of the Red Panda (*Ailurus fulgens*). *Biological Conservation* 57(1): 1-11.
- Yonzon, P. B. 1996. Status of wildlife in the Kangchenjunga region: A reconnaissance study report, Report series No. 23, WWF Nepal Program, Katmandu.
- Yonzon, P. B., P. Yonzon, C. Chaudhary, V. Vaidya 1997. Status of the red panda in the Himalaya. Resources Nepal, Kathmandu and Metropolitan Toronto Zoo Project, Toronto, Canada. Pages 21.