CHAPTER 4

DISTRIBUTION, ABUNDANCE AND STATUS

4.1 Introduction

The abundance and distribution of animal populations vary in space and time. Distribution and abundance are closely related ecological parameters and distribution is considered as the spatial expression of abundance (Andrewartha, 1970). Information on distribution and abundance is a basic requirement in ecological studies (Elton ,1927; Krebs, 1985) and an important necessity for formulation of effective management and conservation strategies for the wild species (Caughley and Sinclair, 1994).

However, methods for the estimation of accurate population size or abundance still continue to elude field workers. Enumeration of population size has been done at various levels- total counts, absolute density, relative density and even simple presence/absence or frequency records (Caughley, 1977; Caughley and Sinclair, 1994). Accurate estimation of animal abundance becomes a bigger challenge when applied to rare, shy, elusive, solitary animals inhabiting inaccessible terrain. Sale and Berkmuller (1987) noted that basic presence/absence data have not been worked out for many such wild animals in India. This holds true for red panda also, for which no such information exists from its distribution range in India. Very little information is available on its status in the wild (Roberts, 1982a; Glatston, 1989; Yonzon and Hunter, 1991; Glatston, 1994). The only detailed study of red panda population dynamics has been conducted in Nepal (Yonzon and Hunter, 1989) who were of the opinion that no standard method of census was applicable for estimation of red panda

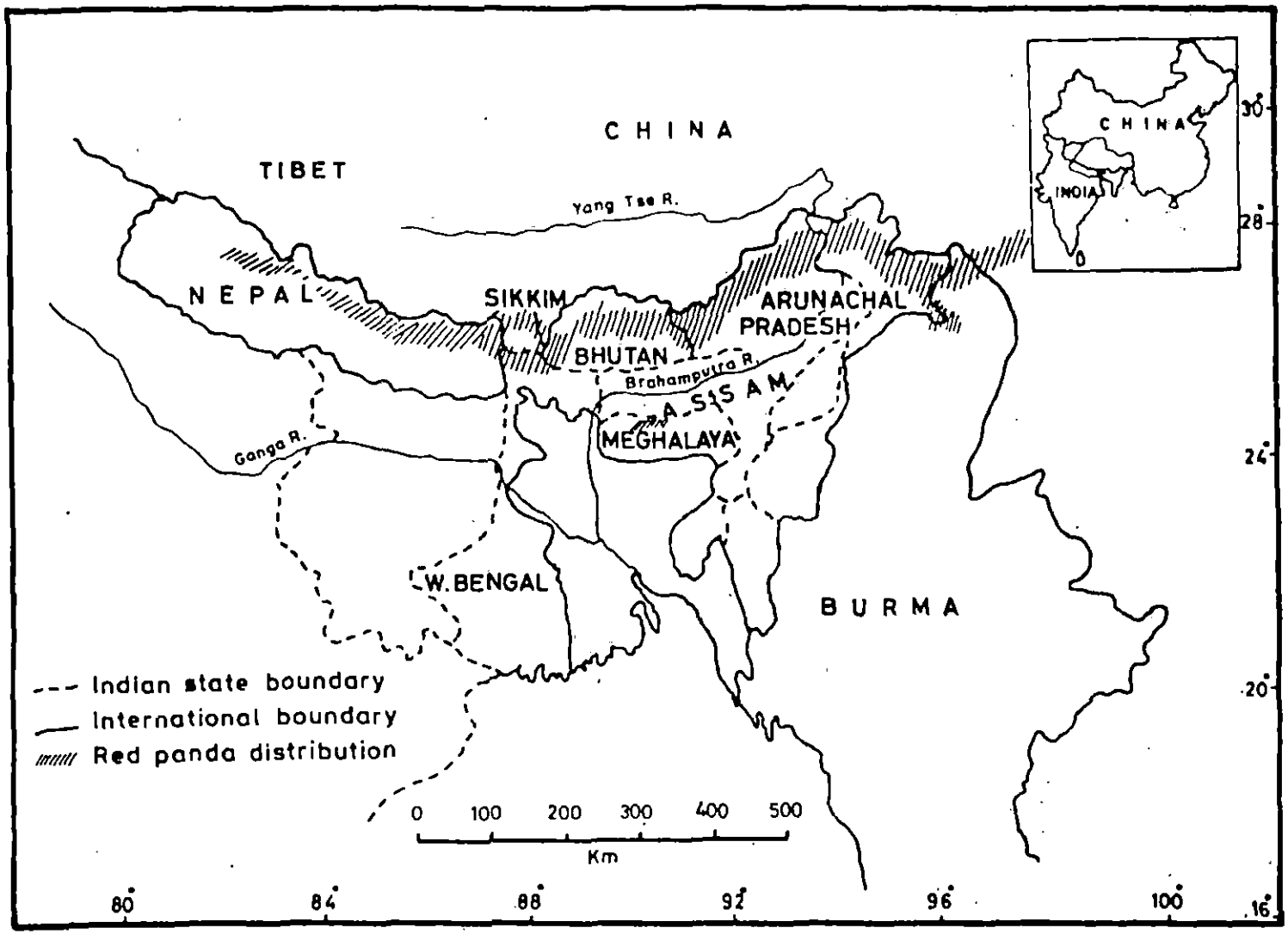


Figure 4.1 Current distribution of red panda

population. They combined radiotelemetry study, SAT imagery and GIS to work out the numbers of red panda in the Langtang National Park.

In India, red panda is known to occur in the Northeast India (Mukherjee, 1982; Rodgers and Panwar, 1988). However, so far, no detailed study or information on the population status of the red panda is available from India, apart from documenting the presence of the species in different protected areas. In the Singhalila National Park, Dareeling, some of the early records of red panda are made by Mclaren (1946), Tikadar (1983), and in the faunal list of the Management Plan of the National Park. Apart from this, nothing was known, not even whether the animal existed anymore or not.

This chapter deals with the distribution, relative abundance and status of red panda mainly based on indirect evidences of the red panda in the Singhalila National Park, along with a review of the current distribution of red panda along its distributional range.

4.2 Current distribution of the red panda

Red panda is found in the temperate forest with bamboo understorey between 1500 m-4000 m in the Himalayas, high mountains of Northern Burma, Western Sichuan and Yunnan (Sowerby, 1932; Allen 1938; Stainton, 1972; Anon, 1978; Jackson, 1978; Miewrow and Shrestha, 1978; Feng *et al.*, 1981; Roberts, 1982a; Yonzon and Hunter, 1991). This stretch of distribution includes Nepal, India, Bhutan, Northern Burma and China (Figure 4.1).

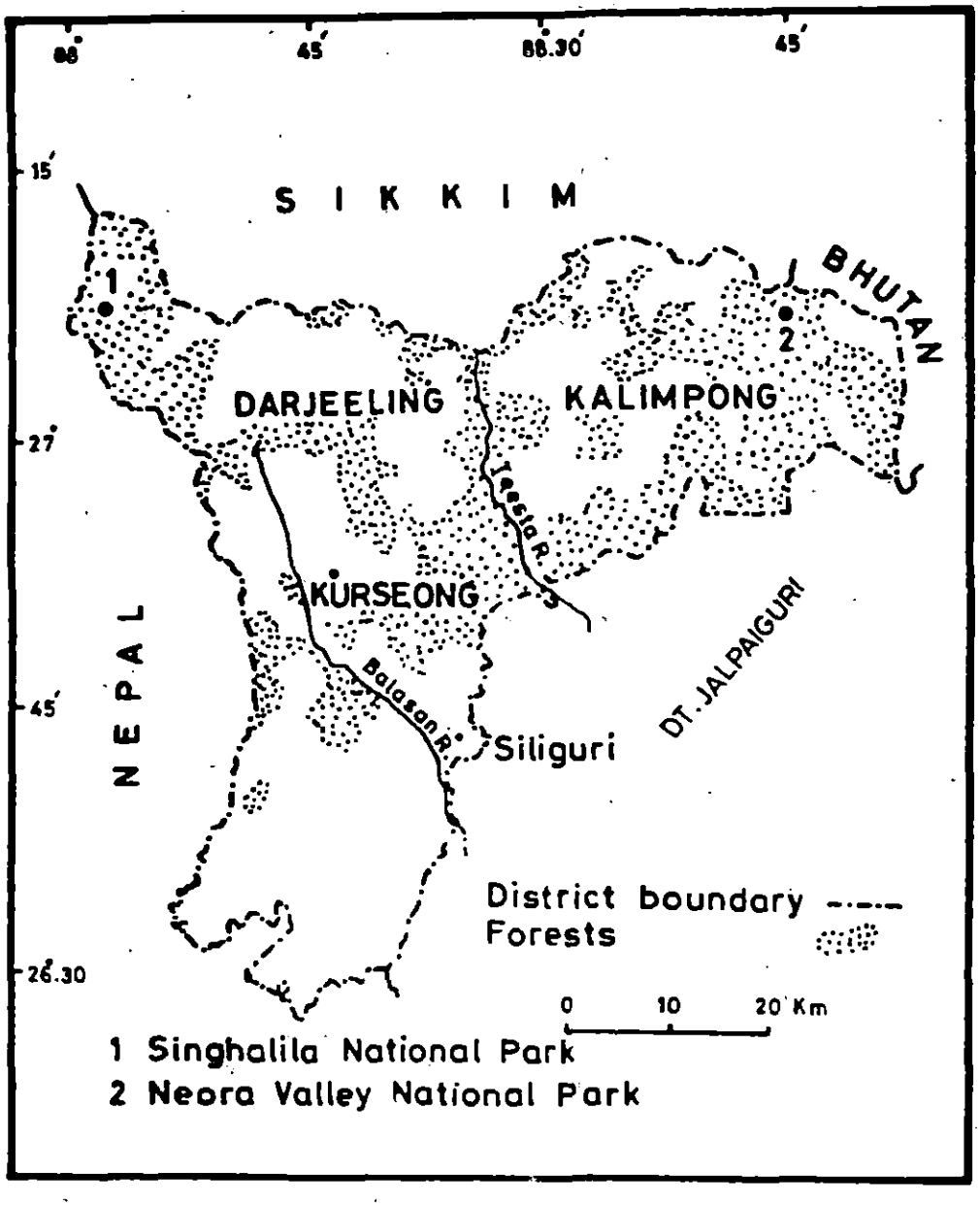


Figure. 4.2 Map showing location of two National Parks in Darjeeling holding red panda.

4.2.1 Nepal: In Nepal, red panda occurs in the Langtang, Sagarmatha, Makalu Barun and Manslu National Parks (Yonzon, 1995). The author reported red panda between 3000 m - 4000 m in the Fir bamboo forest in the Lantang National Park. He also reported red pandas from Namru, Shyla, Samagaon, Shangure Kharka areas in Manslu. Evidences were also found at an altitude of 3000 m in *Abies spectabillis, Acer campbelli* and Birch forest in the Makalu Barun region. Red panda is reported from the upper forest of lower Seng and lower Barkhe Valley (Wegge, 1979; Fox, 1985) and from the Annapurna Conservation Area (Glatston, 1994). The Namlung valley in the Mugu district and the Rara region of North western Nepal seems to be western most limit of red panda distribution (Jackson, 1978). But Yonzon (1995) opines that this needs to be authenticated. Moreover, the Shey Phokshundo Park, which lies between the Annapurna, Dhorpatan Hunting Reserve and Rara National Park has no red panda which makes it less likely for the species to occur in Rara (Glatston, 1994).

4.2.2 India: In India, range of red panda distribution, encompasses three states- West Bengal, Sikkim and Arunachal Pradesh. Recent reports of occurrence of red panda is also received from Meghalaya (Chaudhury, 1997). In the state of West Bengal, red panda is present in the Singhalila National Park and the Neora Valley in the hilly district of Darjeeling (Figure 4.2). Senchel Wildlife Sanctuary, also in the District, lies within the same latitude, with similar forest type as of the two National Parks is also expected to have red panda. However, this has to be confirmed with proper surveys of the area, prior to any scientific documentation.

Sikkim is another Himalayan State in India which has red panda distribution. Red panda in Sikkim has been reported from Kunchendzonga (Northwest Sikkim), Fambong Lho Wildlife Sanctuary and Kyangnoisia Alpine Sanctuary (East Sikkim),

Shingba Rhododendron Sanctuary (North Sikkim) and Barsey Rhododendron Sanctuary (West Sikkim). In Arunachal Pradesh presence of red panda in the Eagle Nest Wildlife Sanctuary has been reported (Mukherjee, 1994; Kakkati, 1996). In Eagle Nest, red panda evidences were found in the Eagle Nest Pass, Chako and Bompa areas (Kakkati, 1996). Other National Parks, where red panda is reported from are Mouling National Park, Namdapha National Park, Mehao, Pakhui, Kamlung, Dibang , Tawang, Lado, Palin Wildlife Sanctuaries. (Rodgers and Panwar, 1988).

4.2.3. Bhutan: Little information is available about red panda in Bhutan except for the documentation of it presence in The Zigme Dorjee Wildlife Sanctuary (Yonzon, 1995). It is also present in the Thumring La National Park where it was seen in a bamboo-fir forest, 6.5 km east of Ura, at 27°28'59" N and 90°54'16" E in April (per. comm. Carol Inskipp).

4.2.4. Burma: Information from Burma on the red panda is also scarse. Its occurrence has been reported from the Chukan pass area (Milton and Estes, 1963). The National reserves holding red panda are Piduang and Hkakuborazi in Nortern Burma (per. comm. K. Htay). Zhina subregion, Yingjiang county (in China) is only approximately 17 km from the China- Myanmar border where red panda is known to be locally extirpated in recent years (Ma *et al.*, 1995). In a recent paper, Rabinowitz and Khaing (1998) considered red panda to be relatively common in the forests, north of Nam Tamai River in North Myanmar.

4.2.5. China: Red panda has been reported from the Southeastern Tibet (Feng *et al.*.1981), west Yunnan and Sichuan (Anon, 1978) in China. Recent survey in the West Yunnan (Ma, *et al.*, 1995) showed that the Gaoligongshan Region (western most region of the Yunnan Province) led to the confirmation of red panda in reasonable numbers in the northern areas of Gaoligonshan. It was also reported in the same

report that its population, further south, to have declined since the 1980s. Red panda is reported to occur in the Wolong, Tangjahe, Medong and the Wanglang National Reserves (IUCN, 1993). The eastern limit of red panda's distribution falls in the Quingling mountains of the Shaanxi province (Wu and Hu.,1980). The Liankiang Range of western Yunnan and the upper valley of the Min Valley of Western Sichuan forms the southern and the north eastern limit of red panda distribution, respectively (Ma *et al.*, 1995).

4.2.6. Protection Status: The red panda is a protected species in India, Nepal, China and Bhutan. In Myanmar, it is covered by the Forest Act, which means it is protected in the same way as all other forest products are protected (Glatston, 1994). It is listed as 'insufficiently known'- an (IUCN) category K (Anon, 1988) and in the Appendix I of (CITES) (Brautigam, 1995).

4.3 Methods

A combination of extensive surveys, interviews, intensive study based on direct and indirect evidences of the animal were used to assess the present status, abundance and distribution of red panda in the SNP.

4.3.1 Survey: The objective of the preliminary survey (October 1993 to October 1994) was to establish the presence/absence of the red panda in the National Park and also to locate potential study sites for a detailed study. The survey was done on foot to cover systematically all the compartments of a beat. The compartments and beats are administrative units of the National Park. The existing human, cattle and bridle paths were used to survey the compartments. Because of the presence of the cattle stations previously in the park, there is a good network of such paths. The area

visited was searched for red panda signs and the animal itself. For evidence (indirect and direct) found, variables such as the altitude, general habitat, vegetation of the area compartment number, and the presence of any other animal were noted. The locations of evidences were then plotted on a map of Singhalila National Park. These surveys were done with assistance from the forest staffs and local people. Details of the survey are summarised and presented in Appendix I.

The first survey was carried out in October 1993. The next three surveys were carried out in May 1994, June - August 1994 and September 1994 and following area were covered:

Sandakphu (3636 m), Kalipokhari (3100 m), Gairibans (2625 m), Kaiyakatta (2879 m), Bikhaybhanjyang (3200 m), Molley (3250 m), Sabarkum(3540 m), Phalut (3600 m), Gorkhey (2389 m), Rammam (2300 m), Siri (2200 m), Rimbick (2250 m).

4.3.2 ***Interviews:*** Information on the status and distribution of the species was also gathered by interviewing the local people, forest officials, herders. The red panda was locally known as `pure kudo' and `hokrekpa'. The people were especially asked as to when they had last seen a red panda or red panda evidence, and where. The information given by the local people was checked by visiting the site. This was done because during the interviews with the people, I realized that some had the tendency to give exaggerated information while most of the local people feigned ignorance. However, I relied a lot on the local information as nothing was known or documented about the red pandas in the National Park.

4.3.3 ***Intensive study:*** After the preliminary surveys, and the confirmation of the presence of red panda in the Singhalila National Park, three study sites viz. Gairibans,

(Site 1), Kalipokhari -Kaiyakatta (site 2), Sandakphu (site 3) were selected for initiation of more intensive investigations of red panda ecology (Figure 2.3). A total of twelve with four transects/trails in each study site were selected. Details of the transects are presented in Table 4.1. It was not possible to establish transects as defined by Burhnam, *et al.* (1980) due the rugged terrain and often dense bamboo undergrowth in the study area. Hence, the existing paths and trails in the passing through different habitat types and altitudinal zones in the study area were used as transects. These trails are referred to as transects in the text. The transects were monitored at regular intervals of one month, for collection of direct and indirect evidences of red panda. Apart from this, 91 random plots, 24 in site 1, 27 and 40 plots in site 2 and 3 respectively, were marked along the transects and monitored to check for presence of any direct or indirect evidences of the animal. Five nearest trees were marked and the distance between the fifth and the sixth nearest tree was noted. The mean of the distance from the two trees was taken as the radius and the area calculated accordingly. The vegetation (five tree species and % cover, shrub species and % cover, bamboo species and % cover, ground species and % cover), altitude, aspect, slope of these points were noted while establishing these random plots.

4.3.4 Indirect Evidences: Call, scrapes, tracks, dung, urine trails, nest sites, burrows are reliable evidence of animal presence. For the present study, I used dung and tracks to record the presence and study the pattern of distribution and abundance of red panda in the study area.

Tracts came in handy only during winter when the area was snow covered and when the foot prints stood out sharp and clear. Dung or pellet groups were found to be the best indicator of animal presence. It was comparatively long lived and more easily

Table 4.1 Salient features of the transects in the study area

Site	Transect	Altitude covered (m)	Mean altitude	Major topographies covered	Forest type
1(GB)	1	2630 -2860	2750 m	HS, RDG	OF
	2	2600 -2800	2780 m	HS,HB,RDG	OF,PLT
	3	2600 -2850	2790 m	HS, Vehicular road	OF,PR, MF
	4	2750 -3100	2990 m	HS, north facing	MF,PLT
2 (KP)	5	2645 -2870	2700 m	HS, RDG	OF, RF
	6	2690 -2870	2710 m	RDG,HS	OF, BMS,MF
	7	2870 -3000	2980 m	HS, RDG	MF, BMS
	8	3050 -2890	2910 m	HS, RDG,VA with stream	MX
3 (SD)	9	3636 -3450	3555 m	HS, north facing, RDG	SF
	10	3600 -3340	3500 m	RDG with north &south facing slopes	SF
	11	3430 -3200	3190 m	HS,VA with a stream	SF,BCF
	12	3400 -3550	3450 m	HS, north facing, six valleys.	SF

HS= hill slope, RDG= ridge, HB= hill base, VA= valley.

OF= Oak forest, PLT= plantation, BLDF= broad-leafed deciduous forest, PR= pure rhododendron, BMS= pure bamboo stand, SAF= subalpine forest, BCF= broad-leafed coniferous forest, GB= Gairibans, KT= Kaiyakatta, SD= Sandakphu

found. Red panda dung consists of pellets which are elliptical in shape. A single group comprised of an average of 8.5± 3 pellets. Red panda also have latrine sites using the same area for repeated defecation.

Whenever a pellet group was found during monitoring, data were collected on the total number of pellets in the group, number of groups at one place and the substratum such as tree trunk, tree branch, base of trees, logs, ground, rocks.

Pellet group once found, were either cleared or in case of very large piles, stamped upon to distinguish it from fresh dung when the transect was re-visited. The places where pellet group was found (dung point) was marked, and checked when the transect was re-monitored. If dung was found in a new place on the second visit, this was also marked. This became a new dung-point to be checked in subsequent visits. The random plots were also checked at regular intervals for dung deposition and cleared in case of any deposition.

4.3.5 Direct sightings: There is no apparent sexual dimorphism in red panda which makes it difficult to identify the sex of the animal when sighted. Whenever possible, I assigned sex and age to a red panda as cubs, female to the adult panda seen with the cub, subadult and adult or unsexed for others. For each sighting, note on the habitat, number of animals, sex and age, activity was noted down. Observations on the animal were done as long as it was in sight.

4.3.6 Secondary information: I maintained a record of the sightings of the red panda by others made during the course of the study, to supplement the information gathered during the present study.

4.3.7 Extensive Surveys: Parts of the national park other than the intensive study sites were revisited once again after the preliminary surveys and initiation of intensive study in order to get better information on the distribution and status of the species.

4.4 Analyses

Quantification of the red panda evidences was done based on the encounter rate of pellet groups and red panda per 100 hours in each transect, in each study site and vegetation zones. The encounter rate was used as an index for determination of relative abundance of red panda. Standard non parametric statistical tests such as Kruskal Wallis, Mann-Whitney U-test and Spearman rank correlation were used following Zar (1984). The statistical tests were done using the statistical program, Stata 5.0 (1997).

4.4.1 Estimation of red panda density in the study area: The animals were not radio collared nor were there any standard methods to identify individual animals. In the present study I have used data on the individuals/sighting, identification of individual animal by age, presence of cub pellets and my personal experience and familiarity with the study area to enumerate the number of animals in each transect. I then used this to get a crude density of red panda in the study area.

I considered only the data of individuals/sighting because number seen in one group at one time would be an independent event and thus independent animals. I also made sure that the transects were at least 3 km apart from each other so that the chances of seeing the same animal on two transects is reduced. Sighting of a cub or subadults can also ensure the sighting of independent animals. Pellet size especially of the cubs can also ensure the presence of individual animals (Table. 4.2). I have also added a

male to the sighting of a female with cubs with the assumption that a male was definitely present in the area. Area of the intensive study area is approximately 25 km^2. With the total number of red panda calculated for the study area, density of the species per km^2 was calculated.

4.5 Results

4.5.1 ***Survey:*** During the first survey in May, no direct sightings of red panda were obtained from the areas surveyed. During this survey in May 1994, the only evidence obtained in the form of pellet-group were from the north facing slopes of Phalut at an altitude of 3555 m on a *Rhododendron sp.* tree. This evidence was based on local report (the survey team was taken to the spot where the red panda pellet groups were present), hence encounter rate was not calculated. During the second survey of June 1994-August 1994, a red panda (secondary information) was sighted in Gairibans at an altitude of 2830 m in a forest of *Acer, Rhododendron* and *Quercus* species and an understory of *Arundinaria maling*. In addition to this, 3 indirect evidences were also found from Gairibans, 5 from Kalipokhari-Kaiyakatta areas (refer Table 4.1 for encounter rates). No evidences were found from Sandakphu but reports of local sightings were gathered and the areas visited.

During the third survey in September-October 1994, a red panda was sighted (encounter rate of 1.4/100 hours) in Phalut at an altitude of 3540 m. Reports of local sighting of red panda from Saberkum was obtained. Local information of red panda with a cub was also obtained from Sandakphu from a forest staff. This was in the area which was later covered by transect 10 of Sandakphu. I was able to collect as many as 3 indirect evidences (dropping from three different areas) in Sandakphu from Fir-birch-rhododendron forest at 3450 m, an area later covered by transect 9. All these

three indirect evidences of pellet groups were on Birch (*Betula utilis*) trees on the northern aspect.

Red panda evidences were not reported or found from Rammam, Gorkhey, Samanden and Rimbick. The extensive surveys carried out later to survey areas which were not covered during the preliminary survey and also to confirm the presence/absence of red panda in areas visited during the preliminary survey but no evidences were found. I was able to confirm the presence of red panda from Molley and upper Gorkhey during the extensive survey which was not done during the preliminary survey. No evidences were found from Lower Gorkhey, Rammam, Siri and Jarayotar (Rimbick), Gurdung, Pedi even during these extensive surveys (Appendix II).

4.5.2 ***Intensive study:*** An average of 32 trips per transect (total of 380 trips) were made to the transects, and a total monitoring time of 742.35 hours spent in the three study areas with 236.20 hours, 229.00 hours and 227.15 hours in Gairibans, Kalipokhari-Kaiyakatta and Sandakphu respectively.

4.5.2.1 ***Direct Sightings*****:** Sightings were extremely infrequent, details of which are presented in Table 3.5. 28.12% of the sightings were made on transect 7, 18.75 % on transect 10 and 4, 9.38% on transect 8, 6.25% on transect 3 and 9, 3.15% on transect 11and 12 and none on transects 1, 5,and 6 (Table 4.4).

The nine sightings on transect 7 included the sighting of three adults (3 individuals/sighting) in December 1994, two cubs and a female (3 individuals / sighting) on two consecutive days of October 1995 and a subadult in January 1995. The

Table 4.2 Detail of sightings of red panda on transects during different months

	Transect	Sight	Individual	Age	Cub pellets
Jun	2	1	1	A	0
Jul	2	1	1	A	0
Aug	3	1	1	A	0
Dec	3	1	1	A	0
Jul	4	1	1	A	0
Aug	4	1	1	A	0
Oct	4	1	2	A	0
Jan	4	2	2	A	0
Apr	6	1	1	A	0
Jan	7	1	1	SA	0
Feb	7	2	2	A	0
Mar	7	1	1	A	0
Apr	7	2	2	A	0
May	7	1	1	A	0
Oct	7	1	3	A,C	Y
Dec	7	1	3	A	0
Jul	8	1	1	A	0
Oct	8	1	1	A	0
Nov	8	1	1	A	0
Oct	9	1	2	A,C	0
Apr	9	1	1	A	0
Mar	10	1	1	A	0
Apr	10	1	1	A	0
Jun	10	1	1	A	0
Oct	10	2	2	A	Y
Mar	11	1	1	A	0
Oct	11	0	0	0	Y
Apr	12	1	1	A	0

A= Adult, SA= subadult, C= cub

maximum number of sightings during the study period was done in October (Table 4.3).

The six sightings on transect 4 included the sighting of two adult animals together in October 1995. Two sightings of red panda on transect 9 included the sighting of a female and a cub in November 1994. Apart from these, all the other sightings were of single animal (Table 4.2).

4.5.2.1.1 Observations: The longest observation on sighting red panda in the study area was for 180 minutes (10.00 hours - 13.00 hours) when three adult red pandas were seen together on 26 th December (Winter) approximately, the period of mating for the red panda. They were seen on a huge *Rhododendron arboreum* tree resting on the different branches at Kalipokhari-Kaiyakatta transect 5 at 2900 m. Along with other tree spp. such as *Magnolia cambelli, Acer campbelli, Ilex sp., Osmanthus sauvis, Sorbus cuspidata* and *Daphepyllum himalyensis*, the area where this sighting was made, is dominated by an association of Rhododendron-bamboo. Although the three red pandas interacted very little, they were together in the same tree throughout the three hours of observation. Finally one of the animal got up, climbed up to a higher branch, defecated and left the tree. While climbing up the tree, it brushed past one its mate, but no aggression or offence was shown by the animals during this short period of direct interaction.

Two adult red pandas were see together on 28 th October in Gairibans research base (2600 m) at 14.30 hours. As October is not known to fall within the breeding period of the species, it is difficult to say anything about the togetherness of these animals.

Table 4.3 Sighting records of the red panda in the study area from October 1994-October 1996.

Transects	Jan	Feb	Mar	Apr	May	Jul	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	1*	1*	0	0	0	0	0	2
3	0	0	0	0	0	0	0	1*	0	0	0	1	2
4	2	0	0	0	0	0	1*	1*	0	0	1	0	5
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	1	0	0	0	0	0	0	0	0	1
7	1	2	1	2	1	0	0	0	0	1	0	1	9
8	0	0	0	0	0	0	1	0	0	1*	1	0	3
9	0	0	0	0	1	0	0	0	0	1	0	0	2
10	0	0	1	1	0	1	0	1	0	2	0	0	6
11	0	0	1	0	0	0	0	0	0	0	0	0	1
12	0	0	1	0	0	0	0	0	0	0	0	0	1
Total	3	2	4	4	2	2	3	3	0	5	2	2	32

Table 4.4 Pellet group encounter and proportion of sighting on the transects of the study area.

Transect	Pellet group/100 hours	% Sighting
1	1.58	0
2	22.30	6.25
3	7.33	6.25
4	68.25	18.75
5	0	0
6	3.69	0
7	43.97	28.12
8	66.41	9.38
9	78.92	6.25
10	26.52	18.75
11	40.00	3.13
12	2.53	3.25

Apart from these, cubs and mother were seen during October and November. The cub seen in November 1994 in Sandakphu was suckling. The mother seemed to be resting but the cub was extremely active and playful. It climbed and descended efficiently but did not venture too far away from the mother. These two red pandas were seen on a huge Silver Fir tree at 3450 m on the northwest aspect at 14.30 hr - 15.15 hours) in Fir-birch-bamboo forest. Two cubs and a female red pandas were seen on transect 7 of Kaipokhari-Kaiyakatta at 2820 m, on the southeast aspect in Quercus-rhododendron-bamboo forest in October, 1995.

All the other animals seen were single. Out of all these animals sighted and observed, only one exhibited a kind of aggressiveness. It was sighted in August 1995, in Sandakphu, transect 10 at 3450 m in Silver fir-birch-bamboo forest in the northern aspect at 10.00 hours and was observed for thirty minutes. It was in the base of the slope when it was first seen while we were on the ridge. This animal, instead of walking or running away, walked up the hill towards us. While doing so, it scent marked by rubbing its anal portion on three occasions, twice on a fallen log and once on the base of a tree. We did not move from our place of observation, but the panda positioned itself at about 7 m from us. It stayed there for a few minutes sniffing the air around. It then descended and became out of sight. We packed up and when we were just about to move, realised that the panda had stealthily climbed the birch tree behind us and was looking at us. This was an extremely unusual behaviour for the red panda which is known to be shy. Only on one occasion was red panda observed to be feeding. This animal was sighted in a Rhododendron-bamboo forest 2890 m on a *Rhododendron* tree feeding on leaves of *A. aristata*

Table 4.5 Details of red panda sightings in the study area.

	Site 1(GB)		Site 2 (KP)		Site 3 (SD)	
	Sighting	Individual	Sighting	Individual	Sighting	Individual
JAN	2	2	1	1	0	0
FEB	0	0	2	2	0	0
MAR	0	0	1	1	3	3
APR	0	0	3	3	1	1
MAY	0	0	1	1	1	1
JUN	1*	1	0	0	1	1
JUL	2*	2	1	1	0	0
AUG	2*	2	0	0	1	1
SEP	0	0	0	0	0	0
OCT	1	2	2	4	3	4
NOV	0	0	1	1	0	0
DEC	1	0	1	3	0	0
Total	9	10	13	17	10	11

* secondary information

GB=Gairibans, KP=Kaiyakatta, SD=Sandakphu

bamboo which were tall enough to reach the height of the branch where the red panda was resting.

4.5.2.1.2 Encounter rate of red panda in the three study sites: Site 1 had an encounter rate of 0.44±.03/100 hours. Site 2 and 3 had an encounter rate of 3.04±2.00/100 hours and 2.89±2.1/100 hours respectively (Kruskal wallis: X^2 = 0.657, df=2, p <.05) (Table 4.6).

4.5.2.1.3 Encounter rate of red panda in the three vegetational or elevational zones: Broad-leafed deciduous forest (>2800 m-3100 m) had the highest encounter rate of 3.81±3.00/100 hours, followed by Subalpine coniferous forest (>3150 m-3600 m) 2.78±2.2/100hours with none at Oak forest (2600 m-2800 m) (Table 3.8). The difference was significant (Kruskal wallis; X^2= 5.699, df=2, p >.05).

4.5.2.2 Dung/pellet groups: During this study period, I was able to locate 234 pellet groups during the monitorings of the twelve sample transects.

4.5.2.2.1 Encounter rate in the three study sites: An encounter rate of the pellet groups/100 hours in the three study sites showed site 3 with the highest encounter rate of 37.84±32.24/100 hours followed by site 2 (28.83±32.16/100 hours) and Zone 1 with 24.55±13.09/100 hours. These differences were not statistically significant (Kruskal Wallis; X^2=0.769, df=2, p>0.05) (Table 4.6).

The highest encounter rate within Site 1(Gairibans) was on transect 4 (68.15±32.16/100 hours) followed by transect 2 (22.30±32.30/100 hours), transect 3

Table 4.6 Encounter rate of pellet groups/100 hours and red panda/100 hours in the three study sites

Sites	Sighting	Pellet groups
Gairibans	0.44 ± .03	24.55 ± 13.09
Kaiyakatta- Kalipokhari	3.04 ± 2.0	28.83 ± 32.16
Sandakphu	2.98 ± 2.1	37.84 ± 32.24

Table 4.7 Pellet group deposition in random plots in the three zones of the study area.

Zone	No. of random Points used	Frequency of occurrence in used plots	Density/ ha
1.	1(n=27)	2(0.34%)	3.26
2.	8(n=24)	25(4.44%)	43.66
3.	7(n=40)	24(1.5%)	29.19

Zone 1= Oak forest

Zone 2= Broad-leafed deciduous forest

Zone 3= Subalpine forest

(7.33±2.35/100 hours) and transect 1(58.15±5.8/100 hours) and the difference was significant (Kruskal Wallis; X^2 = 9.265, df=3 $p < 0.05$). (Figure 4.3)

The highest encounter rate of pellet groups in site 2 (Kaiyakatta) was on transect 7 and 8 with encounter rate of (43.97±30.57/100 hours) on transect 7, (66.41±25.70/100 hours) on transect 8. The difference in the pellet group encounter rate /100 hours was significant (Kruskal Wallis; X^2 =13.05 df=3, p=<.01) (Figure 4.3).

At Site 3 (Sandakphu), the highest encounter rate of (79.82±79.5/100 hours) was in transect 9. Transect 10, 11 and 12 has an encounter rate of 40.00±37.50/100 hours, 27.52±50.12/100 hours, 2.52±7.07/100 hours respectively. The difference in the encounter rate of pellet group /100 hours among the transects was not significant (Kruskal Wallis; X^2 =0.332, df=3, p >.05) (Figure 4.3).

4.5.2.2.2 ***Encounter rate of pellet groups in the three elevational or vegetation zones***: Highest encounter rate of pellet group was in the Broad-leafed deciduous forest (105.06±29.59/100 hours) followed by the Sub alpine forest (85.00±42.00/100 hours) and the Oak Forest (20.31±10.05/100 hours) the difference being statistically significant (X^2 = 8.71, df=2, $p<0.05$). Mann-Whitney U-test showed a significant difference between Broad-leafed deciduous forest and Oak forest (z=2.66, $p<0.01$), between Oak forest and Sub alpine coniferous forest (z=2.42, $p<0.05$). However, a significant difference was not found between Broad-leafed deciduous forest and Sub alpine coniferous forest (z=0.580, $p>0.05$).

The Kruskal Wallis test for all the difference in the encounter rates in the three vegetation zones during premonsoon monsoon, postmonsoon and winter showed

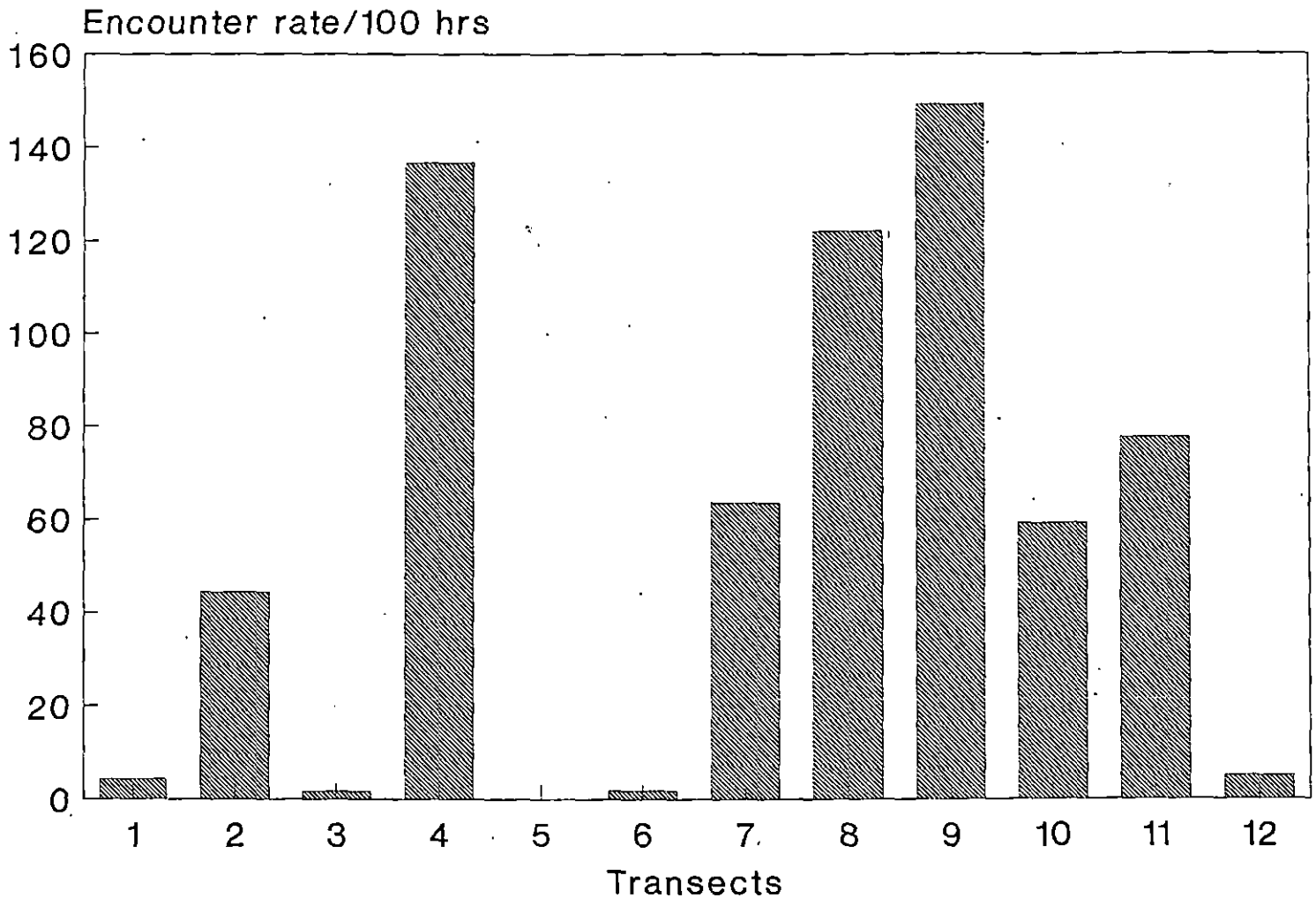


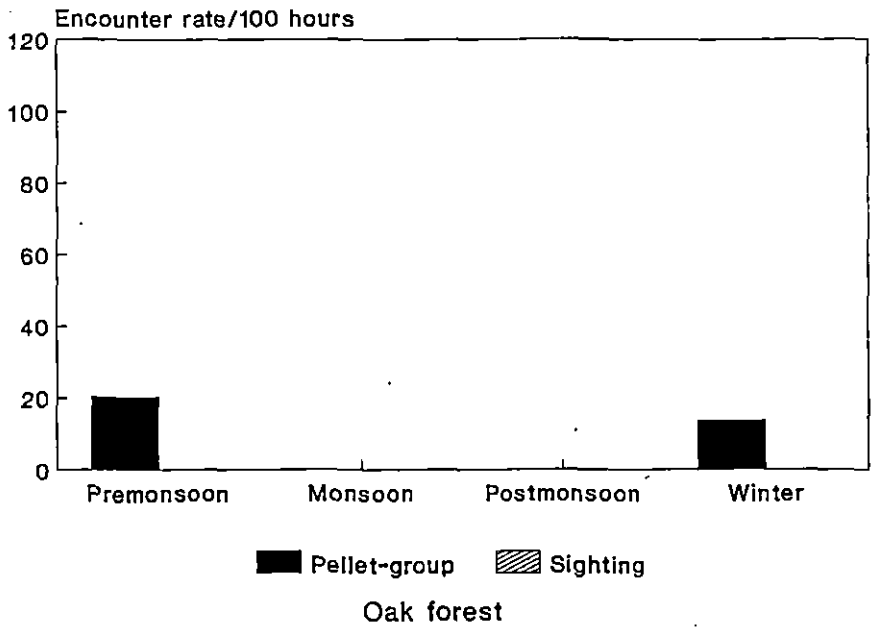
Fig.4.3 Encounter rate of pellet groups/100 hrs on transects

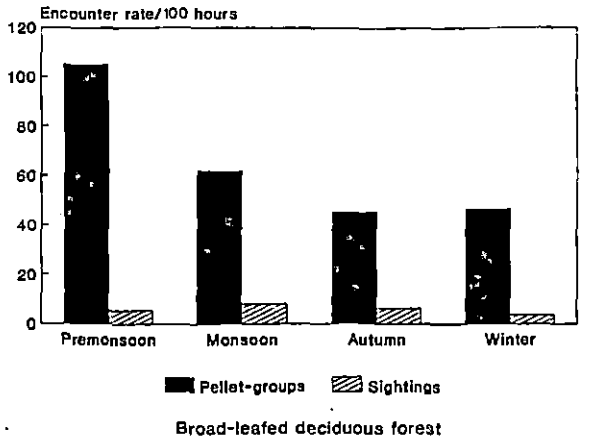
significant difference in the encounter rates between the three zones (Kruskal-Wallis $X^2 = 9.177$, $p < .01$ for premonsoon, $x^2 = 14.66$, $p < .001$ for monsoon, $x^2 = 10.59$, $p < .01$ for postmonsooon, $x^2 = 11.2$, $p < .01$ for winter) (Figure 4. 4).

4.5.2.3 ***Indirect evidence of red panda in the random plots:*** Evidence of red panda, was found in only 16.7% of the random points (n=91). The maximum number of times an evidence was found in one random point was 10 (20.83%). The overall monthly frequency of occurrence of red panda evidence during the twenty four months of the intensive study, 0.34% of the occurrence was in Oak forest. Broad-leafed deciduous forest and Subalpine coniferous forest had a frequency of 4.3% and 2.5% respectively. The density of pellets found in the three zones are 3.26/hectare in Oak forest , 43.66 and 29.19/hectare in Broad-leafed deciduous forest and Subalpine coniferous forest respectively (Table 4.7).

4.5.2.4 ***Group size:*** The maximum number of individuals seen together or in a group during the sightings of the red panda in the study area was three, seen on three occasions. The mean group size of red panda was highest in Broad-leafed deciduous forest (1.29) followed by Subalpine coniferous forest (1.1) and Oak forest (1.0).

4.5.2.5 ***Estimation of red panda numbers in the study area:*** A summary of the estimated number of red pandas in the transects of the study area is presented in Table 4.10. With the details presented in Table 4.2 and 4.8, I estimated a maximum of fifteen animals in the intensive study area and a crude density of 1 red panda/1.67 km^2.





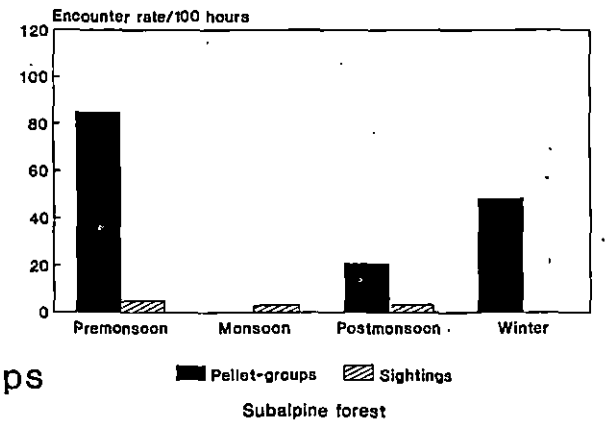


Fig.4.4 Encounter rate of red panda and its pellet groups per 100 hours in the three vegetation zones

Table 4.8 Estimated number of red pandas on the twelve transects of the study area

Transect number	Estimated number of red pandas
1	0
2	1
3	0
4	2
5	0
6	1
7	5
8	1
9	2
10	1
11	2
12	0
Total	15

4.5.2.6 Relation between encounter rate of pellet group and red panda sightings: A spearman rank correlation was used to test the correlation between encounter rate of pellet groups and red panda sightings. A positive correlation was found between the sightings and the encounter rate of the red panda ($r_s = 0.78$, $p < .05$). The correlation was also significantly positive between pellet group encounter rate and percent sightings of red panda on the transects ($r_s = 0.74$, $p < .01$) and also with the independent number of red pandas calculated for the transects ($r_s = 0.843$, $p < .001$)

4.6 Discussion

4.6.1 ***Indirect evidence:*** As seen from the results, red panda sighting was very infrequent. Therefore, it was important to resort to quantification of the pellet groups of red panda for their estimation of the relative abundance in the study area. Dung has been widely used for estimating relative abundance of several wildlife species (Neff, 1968; Putman, 1984). The standard technique involves using or knowing the time period for the accumulation of certain amount of dung per unit area, defecation rate of the species in question, which allows the estimation of population size. The present study was not able to adopt this standard technique due to the dearth of information on these aspects of red panda from the wild. Hence, encounter rate of red panda and red panda pellet groups has been used as an index for estimation of relative abundance of red panda in the study area. This index would only compare the abundance of the animal within different areas in the study area. As there is not even basic information on the red panda in wild, the results of the present study would provide base line information which could be used to assess not only the present status of the red panda in the Singhalila National Park but also the future monitorings.

An index is considered a reliable indicator of abundance if it shows a linear correlation with the population size (Caughley, 1977). However, in this case it was not possible to estimate population size to apply and test the theory. Hence, not much is known about the statistical relationship between the index and population size of the animal. However, the encounter of pellet group being a good index in the present study is testified by the fact that areas with higher pellet encounter rate had more sightings of the red panda. Moreover, a statistical significant correlation was also found between the pellet group encounter rate and the sightings.

It is however, important to take into consideration the sources of errors and biases accompanied with use of dung as index for animal abundance while interpreting the results of the present study. The most important one being the differential search ability of observer leading to unequal recovery of dung from all habitats. Biases may also come due to faecal aggregation by use of latrine sites or areas for repeated defecation by the red panda.

To address both problems, random points were established for search of red panda evidences in all the altitude zones and habitat. The establishment of the random points made the search intensive and equal in all the habitats and cover types, thereby reducing the bias arising from differential search effort.

4.6.2 Distribution and abundance: Results of the present study on the distribution, abundance and status are presented for sites as well as vegetation zones. This is because the three study sites are administrative units in the Singhalila National Park and therefore it will be easier for the managers to comprehend the results. The precision of abundance estimate is also increased when the entire area is stratified.

This is because the result now becomes a function of variability of samples within strata, not of variability across the entire area (Caughley, 1977). Moreover the results of the vegetation zones can also be extrapolated to other parts of the National Park and status of the species evaluated.

4.6.2.1 Distribution and abundance in the three study sites: It can be seen that a significant difference exists among the transects of site 1(Gairibans) and 2 (Kaiyakatta-Kalipokhari) which means the distribution of red panda and red panda evidences are restricted to a few transects or not found equally in all the transects. Whereas the difference in the transects of site 3 (Sandakphu) is not significant which shows the use of all the transects of the study site (Figure 4.3). Gairibans and Kaiyakatta-Kalipokhari areas have two vegetation zones- the Oak forest and the Broad-leafed deciduous forest. Encounter rates of both indirect and direct evidences of red panda was found to be low in the Oak forest (Figure 4.4). Therefore, the absence or low encounter rates of evidences of red panda in transects representing Oak forest accounted for the significant difference of encounter rates among the transects in Gairibans and Kaiyakatta-Kalipokhari.

4.6.2.2 Distribution and abundance in the vegetation zones: Results of the pellet groups, red panda encounter rate, density of pellet groups in the random plots, group size, in the three vegetation zones showed that the red panda in the study area was distributed in the entire study area but were more abundant within an altitudinal range of 2800 m-3600 m which encompasses the Subalpine coniferous forest and the Broad-leafed deciduous forest. (Figure 4.4)

From the results of the vegetation zones, the aggregation of red panda evidences in transects 4 of site 1 and transects 7 and 8 of sites 2 can be explained (Figure 4.3). This is because these transects represent the preferred elevational range of >2800 m-3150 m or the Broad-leafed deciduous forest.

4.6.2.3 Distribution and abundance in the entire National Park: The survey results showed that Gairibans, Kalipokhari, Sandakphu, Phalut, Molley, and upper reaches of Gorkhey had red panda but no evidences were found from Lower Gorkhey, Rammam, Siri, Samanden, Rimbick and Gurdung. These areas, where red panda evidences were not found are in the lower altitudes of the Singhalila National Park. Rammam, Siri, Samanden, Rimbick, Gurdung are in the buffer zone of the National Park and all permanent human settlements are located here. It could be that human settlements caused disturbance to red panda population and habitat which is responsible for low sighting of red panda in these areas. Recent forest fires starting from these altitudes have also destroyed vast stretches of forest at least up to an altitude of 2700 m-2800 m. Red panda being a slow breeder may not have been able to recover its already reportedly small population at these lower altitudes due to these anthropogenic pressures. The lowest altitude from where red panda was reported during the present study was Upper Phedi (2400 m), an area outside the park. From the results of the extensive surveys and of the intensive study it could be inferred that red panda is present and distributed in the entire National Park. However, red panda is abundant above 2800 m and sporadically present below this altitude. The distributional range of red panda distribution in the study area of Singhalila National Park as found during the present study is almost similar to the range (3000 m-4000 m) reported from the Central Himalayas. (Yonzon and Hunter, 1989).

A review of the current distribution of the red panda in its entire distributional range indicates the present knowledge on the distribution of red panda to be restricted to presence/absence documentation. Localities within the larger range remain unexplored for abundance and status of the species. Quick and reliable verification of the presence/absence of red panda in unsurveyed areas is required. In the present study, pellet groups were reliably used to study the distribution, abundance and status of the red panda and could be used and applied for surveys and monitorings in other areas too.

4.6.3 Status of the red panda in the study area: There are no past records on the population status of the red panda in the Singhalila National Park. The density of 1red panda per 1.67 km^2, estimated during the present study is a crude density which is higher than the density estimated for red panda in the Langtang National Park, Nepal (Yonzon and Hunter, 1989). A density of 1 red panda/2.9 km had been estimated for the red pandas in the Langtang National Park. Red panda is a protected animal in Nepal. However, anthropegenic pressures on red panda habitat as evidenced from the study in Nepal is very high with 30,000 human population in and around the Langtang National Park (Yonzon and Hunter, 1991).

In assessing the status of red panda in Singhalila National Park, I would discuss the threats due to the non contiguous habitat, movement of animal between protected and unprotected areas, relative abundance and information on the breeding population of red panda in the three study sites.

Red panda is protected by law in India under the Indian Wildlife Protection Act, 1972 (Anon, 1992). After the Singhalila area was declared a National Park In 1986, the species and its habitat was afforded better protection. However, the study area do not have a contiguous forest mainly due to the presence of settlements and altered land use pattern. The first process that results in habitat fragmentation is the reduction of habitat that inevitably follows human settlements (Scott, 1981). Habitat fragmentation is known to have various negative effects on wildlife population (Merriam, 1991; Haila and Manski, 1993). In this case, the most apparent threat to the red panda population due to this disconnected habitat is the animal getting exposed to the human settlement. It was in October 1995, that two red pandas were sighted very near to base station, Gairibans. This settlement roughly forms a barrier for the sites 1 and 2 at 2600 m. These two animals together descended from the forested area covered by transect 4 of Site 1 but returned back to the area from where they had descended. It would have been too risky for the pandas to venture across the settlement because of the people and children who were excited to see the animals. Even the domestic dogs are a great threat to the animals. I had heard of such events occurring before where the animal was chased, stoned or teased. Had there been a contiguous forest in place of the settlement, the pandas could not have been so conspicuous and such threats from human being lessened. A contiguous forest between site 1 and 2 is found only below 2600 m area which is outside the national Park and falls within the jurisdiction of yet another Division (Directorate) of the Department of Forest. Site 1 and 2 lie within an altitudinal range of 2600 m-3100 m. Therefore, the population of site 1 inhabit a very narrow preferred range of 2800 m-3100 m (Broad-leafed deciduous forest). Moreover only one face of the slope encompasses this elevational or vegetational zone in site 1. The other face of the slope is in Nepal area which is does not have a

protected area status. I received a number of reports of red panda sightings crossing the International border. I also found panda tracks on the snow during winter, crisscrossing between India and Nepal.

The forest is contiguous between site 2 and 3 within the National park but the settlements at 3100 m (Kalipokhari) and 3200 m (Bikheybhanjyang) with an accompanying altered land use system could also prove to be a barrier and hinder safe movement of the red panda between the two sites. The case of sharing its preferred vegetational zone with Nepal in Site 2 and 3 is similar to that of a Site 1. Animals move freely and reciprocally between habitats, in which case the strategy of conserving one area may prove unsuccessful if the individuals go to portions where they are not protected or safe (Bernstein *et al.*, 1991). I, came across the possession of two panda cubs in a nearby Nepal area in September 1995 and possession of one subadult in September 1994. The status and well being of the red panda in Singhalila National Park also depends on the safety and protection of the species across the border.

The location and the settlements in and around of Site 1 is such that it gives very little chance for the red panda population to interact with the population of Site 2. The area had the lowest pellet group and animal encounter per 100 hours. No evidence of the breeding population was found here. Site 2 and 3 seems to be functionally connected with better chances for red panda of the two sites to interact. Moreover, the two sites also have breeding populations as evidenced by the sightings of two cubs and a female in site 2 and one cub and a female in site 3. The pellet group and animal encounter rate was also found to be significantly higher in sites 2 and 3. Hence, it can be said that the status of red panda in respect of breeding population and availability

of contiguous forest, is better in Site 2 and 3 than in Site 1. However, the fact that the areas in the higher altitudes especially Sandakphu (Site 1), is under greater biotic pressure (chapter 3) is a matter of concern. Even, in Site 2, the area is sandwiched between two roads (PWD and MR road) which are in frequent use by the people and vehicles.

Other than the Intensive study area, the entire stretch of area between Sandakhpu and Phalut, which includes Sabarkum (Molley) had evidences of red panda. After Phalut, the stretch of area till upper Gorkhey also harbors red panda. This stretch shares a border with the State of Sikkim. Red panda is the state animal of Sikkim and is protected by law. But the protection of the red panda is limited to each state- Singhalila National Park, Nepal and Sikkim. Nothing is known or done about the habitats or the safety of the animals beyond the man made boundaries. Concerted efforts of all the three states, to protect the red panda in this part of the Himalayas would be therefore a better conservation strategy rather than conserving or protecting animals within each state only.