

Distribution and Habitat Preference of Red Panda (*Ailurus fulgens fulgens*) in Jumla District, Nepal

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Received 18 September 2014; revised 19 October 2014; accepted 4 November 2014

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Abstract

Reliable and sufficient information regarding status, distribution and habitat preference of red panda (*Ailurus fulgens fulgens*) is lacking in Nepal. The research activities on red panda in the mid-western Nepal are very limited, so the status of red panda in the region is quite unknown. The study conducted during May, 2013 in three Village Development Committees (VDCs) namely Godhemahadev, Malikathata and Tamti of Jumla district was an important step for providing vital information including distribution and habitat preference of this species. The study included the reconnaissance, key informants survey, interviews and consultation for the most potential area identification, opportunistic survey comprising the direct observation and indirect sign count method for the presence and distribution, habitat assessment consisting vegetation sampling and ocular estimation. The study revealed the presence of red panda in three forests namely Bahirepatan, Imilchadamar and Tyakot of Godhemahadev, Tamti and Malikathata VDCs respectively. The species was found distributed between 2880 and 3244 m with an average dropping encounter rate of 1.04 per hour of searching effort and 12 pellets per dropping. Red panda mostly preferred the habitat in the elevation range of 2900 - 3000 m with southwest facing steep slopes (36° - 45°), associated with water sources at the distance of ≤100 m. Trees such as *Acer* spp., *Betula utilis* and *Quercus semecarpifolia*, shrub species of *Elaeagnus parvifolia*, *Drepanostachyum* spp. and *Jasminum humile*, and the herbs like *Polygonatum cirrhifolium*, *Fragaria nubicola* and *Galium asperifolium* were found to be the most preferred species by red panda. The red panda preferred the habitat with dense crown coverage (>20% - 100%) and 31% - 50% ground cover. Fallen logs (39%) were the most preferred substrate used for defecation.

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How to cite this paper: Bhatta, M., Shah, K.B., Devkota, B., Paudel, R. and Panthi, S. (2014) Distribution and Habitat Preference of Red Panda (*Ailurus fulgens fulgens*) in Jumla District, Nepal. *Open Journal of Ecology*, 4, 989-1001.

<http://dx.doi.org/10.4236/oje.2014.415082>

Keywords

Distribution, Habitat Preference, Jumla, Red Panda, Sign

1. Introduction

The red panda (*Ailurus fulgens*), the sole representative species of the monotypic family *Ailuridae*, one among the two sub-species *Ailurus fulgens fulgens* and *Ailurus fulgens styani* [1] [2], is a threatened carnivore mammal species.

Globally, red pandas are found throughout the Himalayan mountains of Nepal, India, Bhutan, Myanmar and China between 2200 and 4800 m altitude [1]-[8]. The habitat of red pandas is associated with the occurrence of subtropical and temperate forests with an exceptional case in tropical forest of Meghalaya in India [6].

In Nepal, red pandas are distributed within a narrow elevation range between 2500 and 4200 m in the northern part of the country and are confirmed to occur in eight Protected Areas (PAs) including Langtang National Park and Buffer Zone (LNP and BZ) [9]-[11], Kangchenjungha Conservation Area (KCA) [12], Makalu Barun National Park and Buffer Zone (MBCNP and BZ) [13], Sagarmatha National Park and Buffer Zone (SNP and BZ) [14], Annapurna Conservation Area (ACA) [13], Dhorpatan Hunting Reserve (DHR) [15]-[18], Rara National Park and Buffer Zone (RNP and BZ) [19] and Gaurishankar Conservation Area (GCA) [20]. Beside this, some of the studies suggested the presence of red panda outside the PAs in Nepal. The evidences of its presence have been documented in the forest patches of Illam [21] [22], Panchthar and Taplejung [22], and Sankhuwasabha [23] districts in the eastern Nepal. Its presence has also been recorded in Manang district, north-central part of Nepal [24] and Kalikot [25], Jajarkot [26] of mid-western Nepal.

2. Materials and Methods

2.1. Study Area

Jumla district is situated in Karnali zone of the mid-western development region with total area, 2531 km². The district is surrounded by Dolpa district in the east, Kalikot district in the west, Mugu district in the north and Jajarkot district in the south (Figure 1). Jumla Khalanga is the district headquarters of Jumla district. The entire

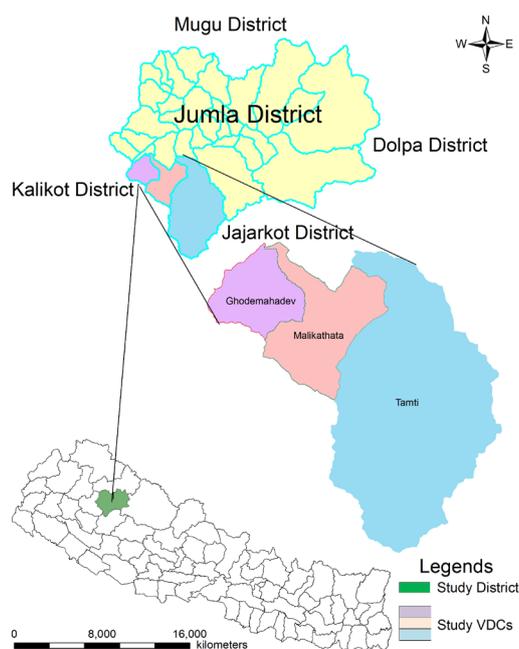


Figure 1. Location map of the study area.

district is divided into nine forest Illakas, and 30 Village Development Committees (VDCs). The district can be accessed either through Surkhet-Jumla Karnali Public Highway (232 km) or via air service from Surkhet and Nepalgunj [27].

Three VDCs namely Godhemahadev, Malikathata and Tamti were selected for the study purpose and the detail study has been carried out in the Bahirepatan, Tyakot and Imilchadamar forests of Godhemahadev, Malika-thata and Tamti VDCs respectively.

2.2. Distribution

We conducted the reconnaissance including the interaction with various representative offices as the key informants comprising the District Forest Office (DFO), ranger posts, District Development Committee (DDC), and VDCs. Similarly, interactions with villagers, herders, village level conservation committee through consultation meeting and focused group discussions regarding presence and distribution of red panda further helped for the exploration and identification of the potential habitats of red panda in the study area. Meanwhile, pamphlets and photographs of red panda, their pellets, habitats, and their preferred foods were displayed during the reconnaissance. For getting representative and reliable information, opportunistic sampling strategy was adopted for the survey. Both direct and indirect methods of wildlife survey were applied in the field. However, indirect sign count method was significant throughout the study period. We have collected geo-referenced with hand-held Geological Positioning System (GPS) unit wherever we observed the direct and indirect signs of the species and Arc Geographical Information System (GIS) and Google earth were used to prepare distribution map.

2.3. Habitat Preference

Ivlev's electivity index (IV) was used to analyze the habitat preference of red panda which includes various habitat parameters such as vegetation, slope, elevation, aspect, vegetation composition, cover and distance from nearest water sources. In addition, the value of index ranges from -1.0 to $+1.0$ where positive values implies preference, negative values refers avoidance and 0 values indicates random use. The formula developed by Ivlev [28] and followed by Yonzon and Hunter [29], Panthi *et al.* [17] was used to calculate the habitat preference of red panda, which can be expressed as $IV = (U\% - A\%) / (U\% + A\%)$, where "A" indicates "availability plots" and "U" infers "use plots".

Vegetation in any area indicates the habitat suitability and preference for the particular species that is core component for the habitat specialist like red panda. The detail vegetation analysis was carried out to determine the floral composition of the habitat. Quadrates of size $10\text{ m} \times 10\text{ m}$ for tree layer (plant above 3 m height and 5 cm DBH), $4\text{ m} \times 4\text{ m}$ for shrubs layer (woody plant below 3 m in height) and $1\text{ m} \times 1\text{ m}$ for herbs layer (plants up to 1 m in height) were used in both habitat use plot (U) and habitat availability plots (A). The quadrates sizes were determined as suggested by Cottam [30]. In each plot, number of trees, shrubs and herbs, their frequency and ground coverage were determined on the basis of ocular estimation. In addition, DBH, height and canopy coverage of trees were also recorded. The unidentified plant species were collected and taken to national herbarium and plant laboratories, Godawari, Lalitpur, Nepal, for identification and further authentication.

3. Results

3.1. Red Panda Distribution in the Study Area

Presence of red panda (locally known as "Nautoto") was confirmed in three VDCs (Godhemahadev, Malikathata and Tamti) of Jumla district. Red panda signs (pellets) were observed in Bahirepatan, Tyakot and Imilchadamar forests of those three respective VDCs (Figure 2).

On 21st May 2013 (9:30 a.m.), one adult red panda was sighted in Tyakot forests of ward No. 9, Khopry, Malikathata VDC. The observed site ($29^{\circ}08'36.7''\text{N}$, $82^{\circ}02'04.0''\text{E}$; 2894 m) was at southwest facing slope with 41° slope and at about 100 m from the nearest water source. The red panda observed at a distance of approximately 50 m was defecating at its latrine site, where freshest pellet group (about a minute after defecation) was seen above the old pellet layer. The red panda got disturbed due to presence of the observers and suddenly escaped from the site and disappeared in the bushes. The site was dominated by *Abies spectabilis* with *Drepanostachyum falcatum* understory.

Occasionally red pandas were also observed by local resident and herders in Dugurnedando, Chilaunepani and

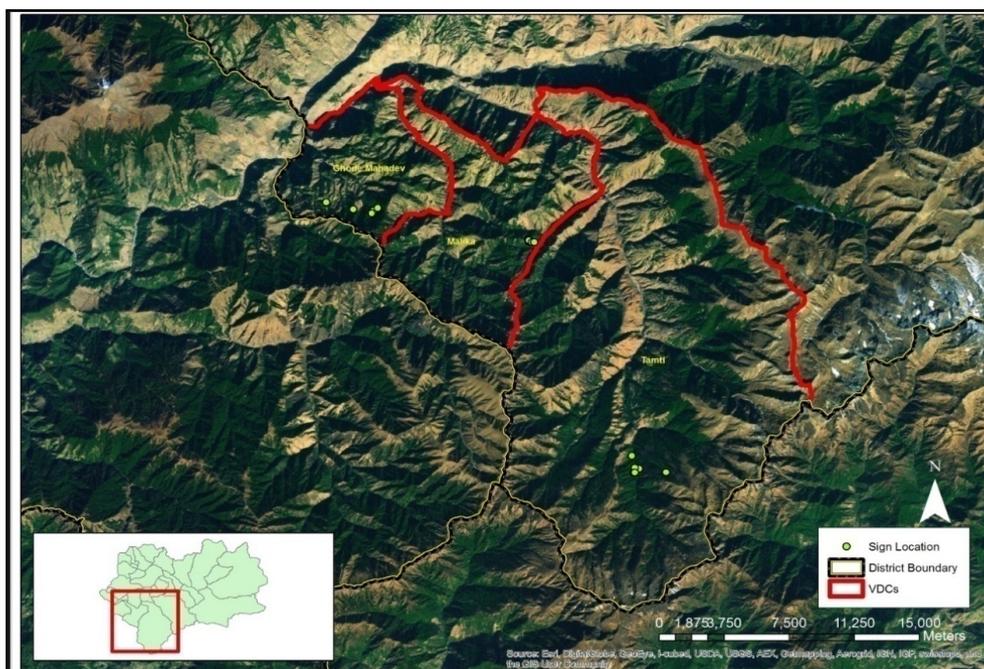


Figure 2. Distribution of red panda in the study area.

Chada forest areas of Ghodemahadev VDC, Tyakot forest of Malikathata VDC and Imilchadamar forest of Tamti VDC. These forests are dominated by *Abies spectabilis*, *Quercus semecarpifolia* and *Picea smithiana* and bamboo understory.

Red panda's droppings were found between 2880 and 3244 m altitude in the study area. Out of 28 pellet groups, 50% of them were recorded in the Tyakot forest of Malikathata VDC followed by 28.57% in Imilchadamar of Tamti and 21.43% in Bahirepatan of Godhemahadev. The red panda defecated at a particular site considered as latrine site, consisting of two or more droppings (pellets group) above the older one, however, the single dropping encountered in a plot was considered as the defecation site. In the studied plots, percentage of defecation site (85.71%) was higher than that of latrine site (14.29%). Single defecation site consisted of 7 to 18 pellets. However, average number of pellets per dropping in defecation site was 12. The number of pellets in the latrine sites could not be counted, due to higher number of broken and decayed pellets. Furthermore, an encounter rate of pellet group/hour searching effort was used as an index in order to quantify the abundance in the study area. The average droppings encounter rate in the studied forests was found to be 1.04 per hour of walk (searching effort), including highest in Tyakot forest of Malikathata VDC (1.56/hour searching effort) followed by Imilchadamar of Tamti VDC (0.89/hour searching effort) and Bahirepatan of Godhemahave VDC (0.67/hour of searching effort).

3.2. Habitat Preference by Red Panda

3.2.1. Elevation

Evidences of red panda's presence were observed between 2800 m and 3300 m elevation. Red panda highly preferred the altitudinal range of 2900 - 3000 m (IV = 0.20), moderately preferred the elevation of 3000 - 3100 m (IV = 0.17) followed by 3100 - 3200 m (IV = 0.14) and 2800 - 2900 m (IV = 0.09) and randomly used the altitude of 3200 - 3300 m. Red panda completely avoided the area below 2800 m and above 3300 m altitude with IV = -1.00 each (**Figure 3**).

3.2.2. Slope

Slope of the red panda habitat was classified according to slope category provided by Anbalagan and Singh [31]. Red panda signs (pellets) were observed between the slope of 15° and 56°. Red panda mostly preferred steep slope (IV = 0.14, 37.50%), moderately preferred escarpment/cliff (IV = 0.06, 30.36%), randomly used moderate

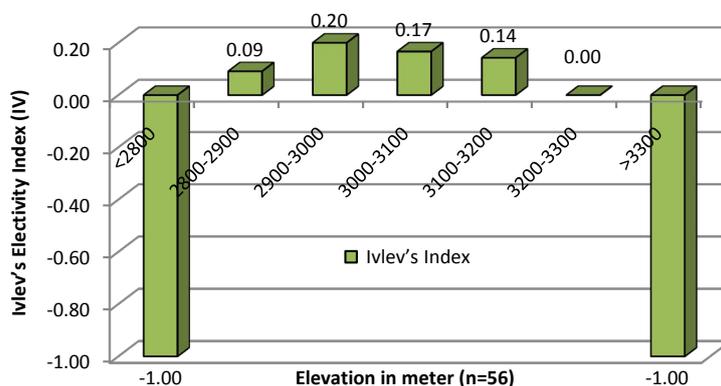


Figure 3. Elevation preference by red panda.

slope (IV = 0.00, 21.43%) and avoided the gentle slope (IV = -0.05, 7.14%). However, red panda completely avoided very gentle slope (3.57%) (Figure 4).

3.2.3. Aspect

Red panda mostly preferred southwest facing slopes (IV = 0.12, 44.64%), moderately preferred northwest facing slopes (IV = 0.07, 26.79%), and randomly used northeast facing slopes (IV = 0.00, 14.29%). However, red panda avoided Southeast facing slopes (IV = -0.50, 14.29%) in the area (Figure 5).

3.2.4. Water Source

Red panda signs were found at the distance of 5 m to 350 m far from the nearest water sources in the study area. The species mostly preferred the distance ≤ 100 m (IV = 0.13) from the water sources followed by distance (101 - 200) m (IV = -0.08) whereas, it avoided the distance greater than 200 m (IV = -0.45), from nearest water sources (Figure 6).

3.2.5. Substrate

The different substrates used by red panda for defecation were fallen logs, ground (forest floor), uprooted trees and rock cliffs. Fallen logs were mostly preferred for defecation (39%) followed by forest floor (25%), uprooted trees (25%) and rock cliffs (11%) (Figure 7).

3.2.6. Floristic Preference

1) Trees

Tree species were examined in 56 plots (28 habitat use plots and 28 habitat availability plots) each 10 m \times 10 m in size. Out of nine tree species recorded, red panda showed higher preference to *Acer* spp. (IVI = 27.14; IV = 0.35) followed by *Betula utilis* (IVI = 26.91; IV = 0.24) and *Quercus semecarpifolia* (IVI = 55.29; IV = 0.13). *Abies spectabilis* (IVI = 54.85; IV = 0.00) was randomly used whereas *Tsuga dumosa*, *Juglans regia*, *Picea smithiana* and *Pinus wallichiana* were avoided by red panda (Table 1).

2) Shrubs

Shrubs were examined in 56 plots (28 habitat use plots and 28 habitat availability plots) each of 4 m \times 4 m area. A total of 19 shrub species found in the red panda habitat, eight species were preferred, two species were randomly used and remaining were avoided by red panda. Red panda highly preferred *Elaeagnus parvifolia* (IV = 0.40) followed by *Drepanostachyum falcatum* (IV = 0.10), *Drepanostachyum intermedium* (IV = 0.06) and *Drepanostachyum khasianum* (IV = 0.04) whereas *Ribes himalense* (IV = 0.00) and *Viburnum cotinifolium* (IV = 0.00) were randomly used. However, shrubs like *Coriaria nepalensi* (IV = -1.00), *Prinsepia utilis* (IV = -0.42), *Salix denticulate* (IV = -0.41) and *Rosa macrophylla* (IV = -0.37) were highly avoided (Table 2).

3) Herbs

Herbaceous plants were observed in 56 plots (28 habitat use plots and 28 habitat availability plots) each 1 m \times 1 m in area. A total of 17 herbaceous plants were observed in these plots, eight of them were preferred by red panda. *Polygonatum cirrhifolium* (IV = 0.32) was most preferred species followed by *Fragaria nubicola* (IV =

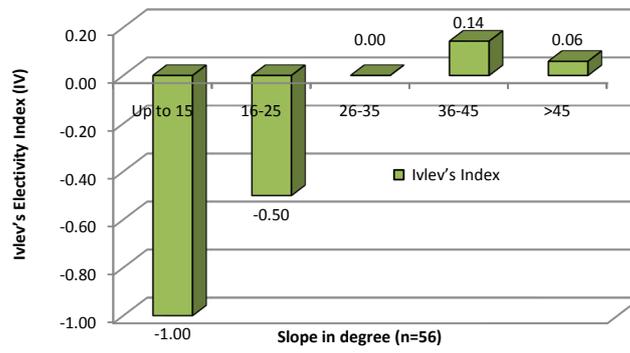


Figure 4. Slope preference by red panda.

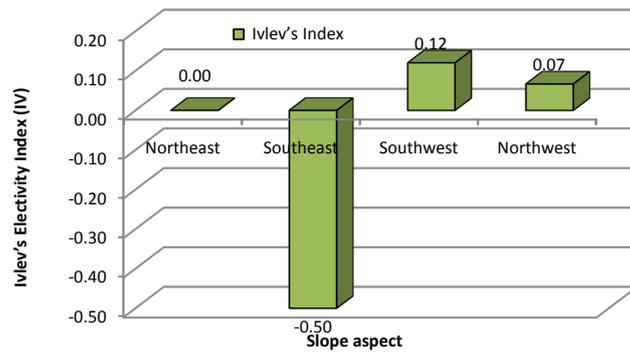


Figure 5. Aspect preference by red panda.

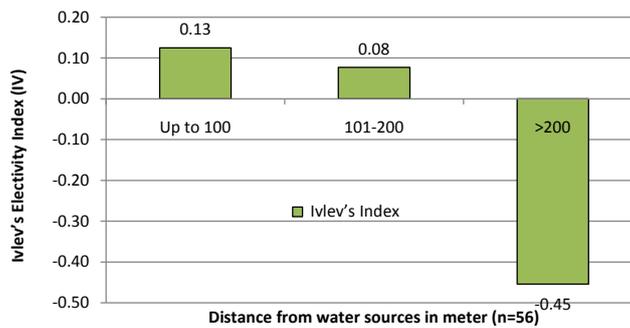


Figure 6. Preference of distance from water sources by red panda.

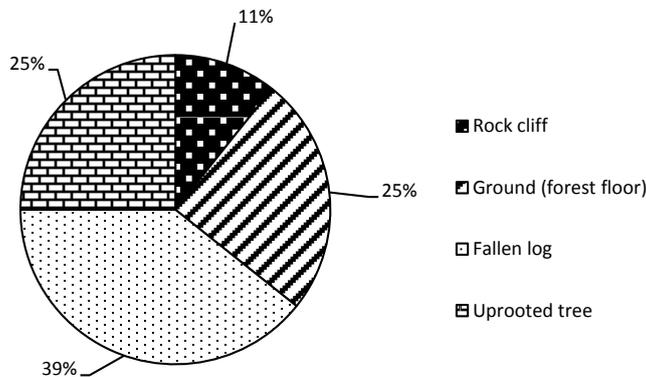


Figure 7. Percentage of substrate used by red panda for defecation (n = 28).

Table 1. Tree species according to preference by red panda.

S.N.	Scientific name	Family	Local name	IVI	IV	Status
1	<i>Acer</i> spp.	<i>Aceraceae</i>	Paalau	27.14	0.35	Preferred
2	<i>Betula utilis</i>	<i>Betulaceae</i>	Bhuje	26.91	0.24	Preferred
3	<i>Quercus semecarpifolia</i>	<i>Fagaceae</i>	Khasru	55.29	0.13	Preferred
4	<i>Abies spectabilis</i>	<i>Pinaceae</i>	Gobrya	54.85	0	Randomly Used
5	<i>Pinus wallichiana</i>	<i>Pinaceae</i>	Piu Sallo	30.64	-0.17	Avoided
6	<i>Picea smithiana</i>	<i>Pinaceae</i>	Jhulya	35.8	-0.21	Avoided
7	<i>Rhododendron arboreum</i>	<i>Ericaceae</i>	Guraunsh	17.26	-0.27	Avoided
8	<i>Juglans regia</i>	<i>Juglandaceae</i>	Oakhar	23.28	-0.4	Avoided
9	<i>Tsuga dumosa</i>	<i>Pinaceae</i>	Thigo	28.84	-0.52	Avoided

Table 2. Shrub species according to preference by red panda.

S.N.	Scientific name	Family	Local name	IV	Status
1	<i>Elaeagnus parvifolia</i>	<i>Elaeagnaceae</i>	Gunyalo	0.4	Preferred
2	<i>Drepanostachyum falcatum</i>	<i>Poaceae</i>	Malingo	0.1	Preferred
3	<i>Drepanostachyum intermedium</i>	<i>Poaceae</i>	Jurmutho	0.06	Preferred
4	<i>Drepanostachyum khasianum</i>	<i>Poaceae</i>	Deu Ningalo	0.04	Preferred
5	<i>Jasminum humile</i>	<i>Oleaceae</i>	Kali Sanguto	0.04	Preferred
6	<i>Rubus biflorus</i>	<i>Rosaceae</i>	Aainselu	0.03	Preferred
7	<i>Cotoneaster microphyllus</i>	<i>Rosaceae</i>	Ghungyaru	0.02	Preferred
8	<i>Cotoneaster affinis</i>	<i>Rosaceae</i>	Raisya	0.01	Preferred
9	<i>Ribes himalense</i>	<i>Grossulariaceae</i>	Pangro	0	Randomly Used
10	<i>Viburnum cotinifolium</i>	<i>Sambucaceae</i>	Banchhudo	0	Randomly Used
11	<i>Philadelphus tomentosus</i>	<i>Hydrangeaceae</i>	NA	-0.16	Avoided
12	<i>Sabia campanulata</i>	<i>Sabiaceae</i>	NA	-0.25	Avoided
13	<i>Berberis aristata</i>	<i>Berberidaceae</i>	Chutto	-0.27	Avoided
14	Unidentified	NA	Pitaielo	-0.28	Avoided
15	Unidentified	NA	Chellelya	-0.3	Avoided
16	<i>Rosa macrophylla</i>	<i>Rosaceae</i>	Kuiyeshi	-0.37	Avoided
17	<i>Salix denticulata</i>	<i>Salicaceae</i>	Baish	-0.41	Avoided
18	<i>Prinsepia utilis</i>	<i>Rosaceae</i>	Dhatenlo	-0.42	Avoided
19	<i>Coriaria nepalensis</i>	<i>Coriariaceae</i>	Machaino	-1	Avoided

NA = not available.

0.27) and *Galium asperifolium* (IV = 0.22) whereas *Hemiphragma heterophyllum* (IV = -1.00) and *Urtica dioica* (IV = -1.00) were the most avoided herbaceous plant species including *Artemisia dubia* (IV = -0.29) (Table 3).

3.2.7. Cover

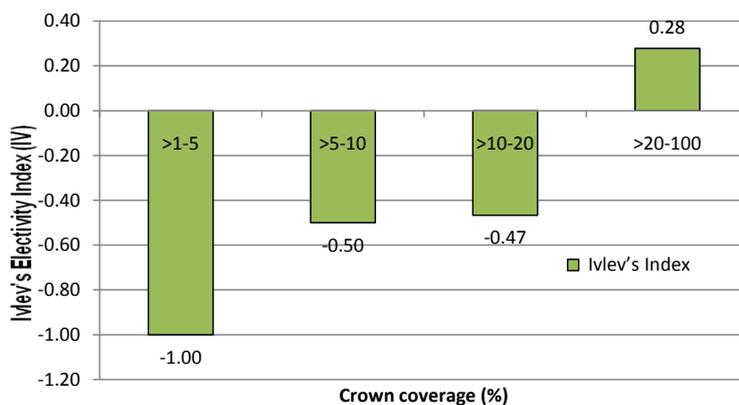
1) Crown cover

Red panda preferred the dense coverage (IV = 0.28) only. A red panda observed during the field work was also in the dense crown coverage category. All other cover classes found in the area *i.e.* sparse (IV = -1.00), open (IV = -0.50) and moderate (IV = -0.47) were found to be avoided by the species (Figure 8).

Table 3. Herb species according to preference by red panda.

S.N.	Scientific name	Family	Local name	IV	Status
1	<i>Polygonatum cirrhifolium</i>	Liliaceae	Khiraunle	0.32	Preferred
2	<i>Fragaria nubicola</i>	Rosaceae	Bhui Kafal	0.27	Preferred
3	<i>Galium asperifolium</i>	Rubiaceae	chittu	0.22	Preferred
4	<i>Rumex nepalensis</i>	Polygonaceae	Halhale	0.16	Preferred
5	Unidentified	NA	Thatar	0.16	preferred
6	<i>Ajuga lupulina</i>	Labiataeae	Bhugelo	0.07	Preferred
7	<i>Dryopteris</i> sp.	Dryopteridaceae	Wunniu	0.07	Preferred
8	<i>Asparagus filicinus</i>	Liliaceae	Kudilo	0.02	Preferred
9	<i>Thalictrum foliolosum</i>	Ranunculaceae	Bansuli	-0.03	Avoided
10	<i>Cirsium verutum</i>	Compositae	Thakailo	-0.05	Avoided
11	<i>Pleurospermum dentatum</i>	Umbelliferae	Gunaino	-0.09	Avoided
12	<i>Girardinia diversifolia</i>	Urticaceae	Allo/Thulo Sisnu	-0.09	Avoided
13	Unidentified	NA	Bina	-0.14	Avoided
14	<i>Lycopodium clavatum</i>	Lycopodiaceae	Ralo	-0.23	Avoided
15	<i>Artemisia dubia</i>	Compositae	Titepati	-0.29	Avoided
16	<i>Hemiphragma heterophyllum</i>	Scrophulariaceae	Nas Jhar	-1	Avoided
17	<i>Urtica dioica</i>	Urticaceae	Sisnu	-1	Avoided

NA = not available.

**Figure 8.** Percentage of crown coverage preference by red panda.

2) Ground cover

Red panda highly preferred 31% - 50% ground cover (IV = 0.09) followed by 51% - 100% ground cover (IV = 0.05). A red panda observed during the field work was in the 31% - 50% ground coverage category. Red panda completely avoided $\leq 10\%$ ground cover (IV = -1.00) and moderately avoided 11% - 30% cover class (IV = -0.20) (Figure 9).

4. Discussion

The occurrence of red panda was found only between 2800 and 3300 m elevation in the study area, whereas it was found between 3000 and 4000 m in LNP [3], between 2800 and 3650 m in KCA [12], between 2800 and 3400 m in SNP [14], between 2600 and 3000 m in Jamuna and Mabu VDC of Illam district in Eastern Nepal [21], between 3000 and 3600 m in DHR [16], between 3117 and 3591 m in RNP [19] and between 2600 and

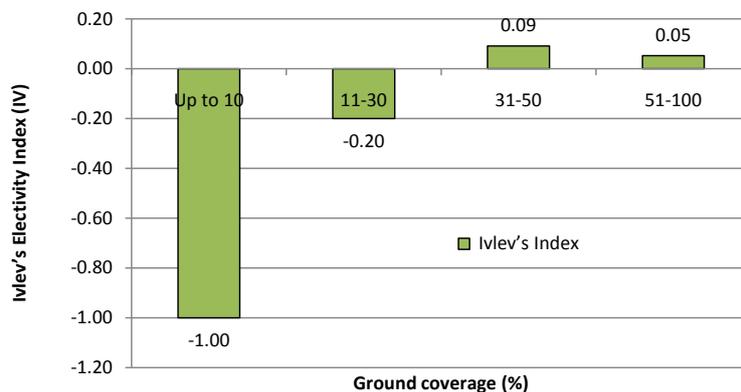


Figure 9. Percentage of ground coverage preference by red panda.

3600 m in the Singhalila National Park Darjeeling, India [7]. Roberts and Gittleman [1] mentioned red panda's distribution ranging from 2200 to 4800 in the Himalayas. The Tyakot forest of Malikathata VDC possessed highest percentage (50%) of sign evidences followed by Imilchadamar and Bahirepatan of Tamti and Ghodemahadev VDC respectively. This might be due to the less human and livestock disturbances in the Tyakot forest.

One adult red panda was sighted in Tyakot forest (29°08'36.7"N, 82°02'04.0"E; 2894 m) on southwest facing slope; similar observations were also made by Sharma and Belant [16] and Sharma [19]. Sighting of single red panda in the Tyakot forest (21st May 2013) might be due to the post mating period as mating season starts from middle of January and ends to early March [1] and red pandas are solitary outside their mating period [29].

Yonzon [32] mentioned that the single pellet group consisted several pellets. Karki [10] found single dropping of red panda consisted of 10 pellets on average. However, average number of pellets per pellet group was 12 in the present study. The sign encounter rate was considered as the tool for quantifying the abundance by different researchers. This study found average red panda sign encounter rate as 1.04 per hour which is comparable to that reported by Pradhan *et al.* [7] in term of number of sign encountered per 100 hours. They recorded sign encounter rate in Singhalila range; the highest sign encounter rate is 105.06 ± 53.59 (2800 - 3100 m) followed by 20.31 ± 10.05 (2600 - 2800 m) and 85.00 ± 42.00 (3100 - 3600 m) per 100 hours.

Red pandas are known to be habitat specialists, maintain a small home range, and are restricted to small pockets of microhabitat [3]. In this study, red panda were found to be distributed between 2800 and 3000 m elevation with the frequency of the pellet groups increasing markedly from 2800 to 3000 m and then declining gently towards the higher elevation. No evidence of red panda's presence was observed at the elevations <2800 m and >3300 m. Red panda preferred the altitudinal range of 2800 - 3300 m (Figure 3) with higher preference to the narrow elevation range of 3000 - 3100 m (IV = 0.20). In comparison, Pradhan *et al.* [7] found red panda distributed in the entire study area in Singhalila National Park with the mean altitudinal range of 2600 - 3600 m; however distribution was relatively more abundant within an altitudinal range of 2800 - 3600 m. Karki [10] found that the red pandas were mostly distributed within the altitudinal range of 3000 - 3200 m of Cholangpati-Dokachet Area, Langtang National Park. However, contrary to this, Sharma and Belant [16] found that, the most preferable elevation of the red panda was 3500 m and no evidences of red pandas were observed at the elevation above 3730 m. Distribution of the pellet groups within the narrow elevation range found in the present study was possibly due to the availability of habitat requirements, which is supported by the findings of Sharma and Belant [16] *i.e.* distribution of pellet groups appeared positively associated with the abundance of bamboos *Arundinaria* spp. and availability of water sources.

Red panda mostly preferred the steep slopes followed by escarpments/cliffs. Most of the pellet groups were recorded in the steep slope (IV = 0.14, 37.50%) whereas least in the very gentle slope (IV = -1.00, 3.57%). This might be to avoid the competition with the livestock; the very gentle and gentle slopes were mostly used by livestock for grazing in the study area. The signs of red panda presence were recorded mostly in the southwest facing slopes (44.64%) followed by northwest facing slopes (26.79%) indicating that southwest and northwest facing slopes are preferred slope of red panda. This might be due to the presence of habitat requisites specifically food availability for red panda. Our findings are similar to those of Karki [10], who recorded that red panda mostly preferred northwest facing slopes (64%) followed by northeast (29%) while the most preferred slope was

37°. Red Panda Network (RPN)-Nepal [33] found frequency of red panda sign encounter in Sacred Himalayan Landscape (SHL) of Nepal as higher between 30° to 70° slopes accounting for almost 90% of sign encountered with higher preference to steep forested terrain, with high moisture which usually observed on the north and west facing slopes.

The study in Langtang National Park, Nepal by Yonzon and Hunter [29] indicated that proximity to water may be the important habitat requirement because 90% of the droppings were found within 100 m of the nearest water sources. Similarly, Pradhan *et al.* [7] mentioned the water availability as the habitat requisite for red panda, as 79% of the evidences of the red panda were at the distance 0 - 100 m from water bodies which further reflected the importance of water in its preferred habitat sites. This is supported by the observation made by Kandel [15] and Dorji *et al.* [8]. Red panda mostly preferred the distance less than or equal to 100 m (IV = 0.13), moderately preferred the distance of (101 - 200) m whereas mostly avoided the distance greater than 200 m from the water sources in the present study area.

As high as 39% of pellet groups were found on fallen logs followed by forest floor and uprooted tree with 25% each and 11% on the rock cliff. In contrary to this, Pradhan *et al.* [7] found that, during pre-monsoon (March-May), trees (70%) were the most preferred defecation substrate for the species, this is supported by the findings of Williams [21] and Kandel [15]. Most signs observed during the study were old and most of the evidences were found in the fallen logs, forest floors and uprooted trees, probably the substrates were used during post monsoon and winter seasons. Similarly, Pradhan *et al.* [7] suggested that the higher use of forest floor during monsoon was probably because the red panda was seeking bamboo shoots on the forest floors. Besides, pellet groups mostly found on the forest floor, paths on ridges and slopes, could be a mode of communication between the species as winter happens to be its mating season.

The habitat of red panda is associated with the occurrence of subtropical and temperate forests with exceptional case in tropical forest of Meghalaya in India [6]. Based on the vegetation classification given by Shrestha [34], the habitat of red panda in this study area falls within the temperate and subalpine forests.

The preferred habitat of red panda in Dhorpatan Hunting Reserve was dominated by *Abies spectabilis*, *Rhododendron campanulatum*, *Betula utilis*, *Juniperus indica* and *Arundinaria* spp. [15] [16]. In the present study area habitat of red panda was dominated by *Quercus semecarpifolia*, *Abies spectabilis*, *Betula utilis* and *Acer* spp. Furthermore, out of nine species recorded in the study area, red panda preferred *Acer* spp., *Betula utilis* and *Quercus semecarpifolia* where as it randomly used *Abies spectabilis* and avoided *Tsuga dumosa*, *Juglans regia*, *Picea smithiana* and *Pinus wallichiana*. The present study was supported by the study conducted by Panthi *et al.* [17] who reported that the red panda showed higher preference to *Acer caesium*, *Abies spectabilis* and *Quercus semecarpifolia*. The preferred tree species in the study area might be used by red panda for nesting, sleeping and sheltering.

Out of 19 shrubs recorded in the study area, red panda preferred only eight species. Red panda highly preferred *Elaeagnus parvifolia* and *Drepanostachyum* spp. Red panda was found eating the leaves of both species of bamboo, *Arundinaria maling* and *A. aristata* predominantly present as understory in Singhalila National Park [7], similar observation were also made by Yonzon and Hunter [9], Karki [10], Thapa [11] in Langtang National Park, Kandel [15], Sharma and Belant [16], Panthi *et al.* [17] in Dhorpatan Hunting Reserve, Sharma [19] in Rara National Park and Mallick [35] in Neora Valley National Park India. Similarly, three species of bamboo, *Drepanostachyum falcatum*, *D. intermedium* and *D. khasianum* were found most preferred and present as understory in the habitat of red panda in Jumla. Eight herbaceous plants including *Polygonatum cirrhifolium*, *Fragaria nubicola*, *Galium asperifolium* were found to be preferred by red panda. The local villagers mentioned that the study area as most potential area for the medicinal herbs and their exploitation is high.

Canopy coverage is the important habitat component in the red panda habitat and it prefers forest with greater canopy cover [7] [21]. In the study area, red panda preferred dense crown coverage (>20% - 100%). It was probably due to crown coverage might be used for hiding, resting and thermoregulation; for the protection and maintaining body temperature within narrow tolerable limit. Panthi [36] also found that red panda mostly preferred the crown coverage of 51% - 75% (IV = 0.21) followed by 76% - 100% (IV = 0.08).

Red panda preferred ≥31% - 100% ground coverage, however avoided the ground coverage ≤30%, probably it used dense ground cover for hiding and movements. Panthi [36] mentioned that red panda preferred the moderate ground cover of (26% - 50%) while avoided low ground cover (≤25%) followed by high ground cover (≥51% - 100%).

Although red panda is a carnivore, it is used to pure herbivore diet, primarily consisting of leaves and shoots

of bamboo species. Its other dietary includes berries, fruits, mushrooms, acorns and lichens [7] [9]. In addition, the annual diet of red panda comprises leaves of ringal bamboo (Jhapra and Raate) (68.4%), followed by ringal shoots (14.6%), fruits of *Sorbus cuspidata* (9.23%), berries of *Sorbus microphylla* (6.15%) and mushroom (1.6%) [7]. The villagers and herders of the study area mentioned that red panda mainly feeds on leaves and shoot of *Drepanostachyum* spp. (Jurmutho, Malingo and Deu Ningalo) and partially on fruits of *Rubus biflorus* (Aainselu), *Cotoneaster microphyllus* (Ghungyaru), *Berberis aristata* (Chutto), *Elaeagnus parvifolia* (Gunyalo) and *Fragaria nubicola* (Bhui Kafal). Captive red panda were observed to eat birds and have shown particular interest in sweetened food and readily consumed meat [1], while the herders of study area mentioned that red panda killed and devoured the newly born young of goat and sheep, but this is doubtful and need further verification.

5. Conclusion

The study revealed the presence of red panda in the Bahirepatan, Tyakot and Imilchadamar forests of Godhemahadev, Malikathata and Tamti VDCs respectively. The evidences (pellet groups) of red panda found distributed from the elevation of 2880 m to 3244 m.

Red panda mostly preferred the habitat in the elevation range from 2900 to 3000 m with southwest facing steep slopes (36° - 45°), associated with water availability (at distance ≤100 m). In addition, red panda mostly preferred the tree species of *Acer* spp., *Betula utilis* and *Quercus semecarpifolia*, shrub species of *Elaeagnus parvifolia*, *Drepanostachyum* spp. and *Jasminum humile*, and herbaceous of *Polygonatum cirrhifolium*, *Fragaria nubicola* and *Galium asperifolium*. The red panda preferred the habitat with dense crown coverage (>20% - 100%) and 31% - 50% ground cover. Moreover, fallen logs (39%) were mostly preferred to use by red panda for defecation.

Acknowledgements

We are highly grateful to Red Panda Network (RPN) for financial and equipment support to conduct this study. We are obliged to College of Applied Sciences-Nepal (CAS), Nepal government's Department of National Parks and Wildlife Conservation (DNPWC), Department of Forest (DoF) and District Forest Office (DFO), Jumla for permitting to carry out this study in Jumla district. We are thankful to Mr. Badri Baral for his tireless effort and co-operation throughout the field survey, and to the field guide Mr. Bir B. Rawat, Mr. Padam Budha and Mr. Rabi Thapa and all the local people, respondents, herders and hotel owners for their support and friendly behavior during the field survey.

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