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Summer Diet and Distribution of the Red Panda (*Ailurus fulgens fulgens*) in Dhorpatan Hunting Reserve, Nepal

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Saroj Panthi, Achyut Aryal, David Raubenheimer, Jennie Lord, and Bikash Adhikari (2012) Summer diet and distribution of the red panda (*Ailurus fulgens fulgens*) in Dhorpatan Hunting Reserve, Nepal. *Zoological Studies* **51**(5): 701-709. The red panda (*Ailurus fulgens fulgens*) is distributed throughout the Himalayas and is found in both protected and unprotected areas of Nepal. Loss and fragmentation of habitat threaten red panda populations throughout its range, and as a consequence, it is listed as vulnerable on the *IUCN Red List of Threatened Species*. Despite this pressing situation, data on the ecology of the red panda in western Nepal are lacking. Our aim in the current study was to determine the distribution, associated habitats, and summer diet of the red panda in Dhorpatan Hunting Reserve (DHR), Nepal. Evidence of red pandas was found in all 6 blocks (except Dogadi block) of the reserve, spanning an area of 345.8 km^2, between elevations of 2800 m and 4000 m and predominantly (> 75%) in forests comprising plant communities dominated by *Abies spectabilis*, *Acer caesium*, *Tsuga domusa*, and *Betula utilis*, with ground cover of *Arundinaria* spp. The dominant plant found in scat of the red panda was *Arundinaria* spp. (81.7%), with *Acer* spp., *B. utilis*, and lichen also frequently present. Livestock grazing and human activities were significantly higher in habitats where signs of pandas were recorded than in areas where they were absent. This habitat overlap between the red panda and livestock potentially poses a major threat to the panda's survival in the DHR, a fact that should be taken into account in devising management strategies for this threatened species.
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Key words: Diet, Habitat, Distribution, Habitat overlap.

The red panda (*Ailurus fulgens*) is associated with the eastern Himalayas, and has a range that extends from eastern Nepal through Bhutan, India, and Burma to southern Tibet and western Yunnan Province of China (Chowdury 2001, Wang et al. 2008). Its habitat is typically characterized by the presence of mixed deciduous and coniferous forests with a bamboo-thicket understory (Roberts and Gittleman 1984, Chakraborty 1999). The loss and fragmentation of this habitat threatens the red panda throughout its range (Pradhan et al. 2001, Wei et al. 1999, Yonzon et al. 1991). It is estimated that there are fewer than 10,000 mature individuals, and populations continue to decline (Wang et al. 2008). For this reason both subspecies (*A. f. fulgens* and *A. f. styani*) are listed as vulnerable in the *IUCN Red List of Threatened Species* (Wang et al. 2008). In Nepal, *A. f. fulgens* is protected by the *National Parks and Wildlife Conservation Act* (1973). Despite this level of protection and increased research efforts on *A. f. fulgens* in Nepal over the last decade (Pradhan et

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al. 2001, Mahato 2003, Williams 2006, Sharma and Belant 2009), detailed information on the status, ecology, and causes of population declines is lacking, particularly for western Nepal and in unprotected areas.

Studies of the habitat use and diet of the red panda have been performed in other regions. In the Dharjeeling area of India, the red panda was found to occur most frequently at sites on steeper slopes, with high densities of fallen logs, tree stumps, shrubs, and bamboo culms (Shrestha 1988, Wei et al. 2000, Wang et al. 2008). In the same region, the diet of red panda was characterized as being largely vegetarian and consisting of young leaves and shoots. Bamboo of the genera *Arundinaria*, *Phyllostachys*, *Thamnocalamus*, *Chimonobambusa*, *Semiarundinaria*, *Pseudosyachyum*, and *Qiongzhuea* were most commonly consumed (Chowdury 2001).

Herein, we report on the ecology of the red panda in Dhorpatan Hunting Reserve (DHR) western Nepal (Fig. 1). The presence of red panda was confirmed in this reserve < 10 yr ago (Sharma and Beltan 2009). However, high rates of poaching, grazing pressures, and habitat fragmentation have also been recorded (Sharma and Beltan 2009, Aryal and Kreigenhofer 2009, Aryal et al. 2010a b, DNPWC 2011). These factors are considered to be the most significant threats to red panda habitat in other areas of Nepal (Thapa 2007, Yonzon et al. 1991, Williams 2006). Our aim was to investigate the distribution, diet, habitat use, and influence of livestock grazing on the red panda in the DHR, with a view to contributing information required to develop a sustainable management plan.

MATERIALS AND METHODS

Study area

The DHR (Fig. 1) covers approximately 1325 km^2 and is situated in western Nepal within Rukum, Myagdi, and Baglung Districts in the Dhaulagiri Himal range, at 23°30'N-28°50'N, 82°50'E-83°15'E (Figs. 1, 2) (Aryal and Kreigenhofer 2009). It was established in 1987 as the only hunting reserve in Nepal, with the objective of providing an area for sport hunting of blue sheep while simultaneously preserving a representative high-elevation natural ecosystem that ranges 2850-5500 m (Aryal and Kreigenhofer 2009).

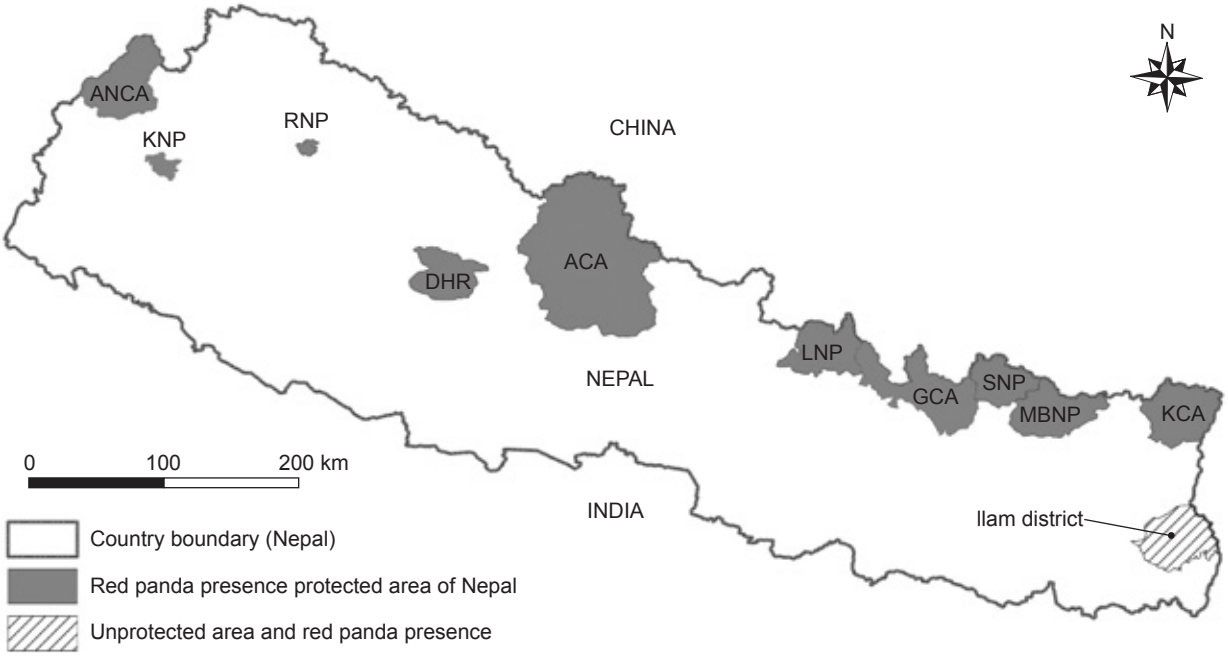

Fig. 1. Protected and unprotected areas of Nepal supporting red panda: ANCA, Appi Nappa Conservation Area; KNP, Khaptad National Park; RNP, Rara National Park; DHR, Dhorpatan Hunting Reserve; ACA, Annapurna Conservation Area; LNP, Langtang National Park; GCA, Gauri Shankar Conservation Area; SNP, Sagarmatha National Park; MBNP, Makalu Barun National Park; KCA, Kanchanjunga Conservation Area. Also shown is the Ilam District; Williams (2006) confirmed the presence of the red panda in its northeastern portion.

The monsoon season in this area occurs between June and Oct., with annual precipitation of < 1000 mm (Aryal and Kreigenhofer 2009). Higher elevations are subject to strong winds throughout the year, and snow usually lasts, even at lower elevations, until early Apr. (Aryal et al. 2010b). During the dry season, the weather is dry and cold, with light snow in midwinter and unpredictable heavier snowstorms into late spring (Wegge 1976). The reserve is characterized by alpine, sub-alpine, and high-temperate vegetation. Common plant species include fir (*Abies spectabilis*), blue pine (*Pinus wallichina*), birch (*Betula utilis*), rhododendron (*Rhododendron* spp.), hemlock (*Tsuga domusa*), oak (*Quercus semicarpifolia*), juniper (*Juniperus indica*), spruce (*Picea smithiana*), maple (*Acer caesium*), juglans (*Juglans regia*), taxus (*Taxus bacata*), and chirpine (*P. roxburghii*) (Aryal and Kreigenhofer 2009, Aryal et al. 2010a b). The reserve supports red panda and also blue sheep (*Pseudois nayaur*), leopard (*Panthera paradus*), goral (*Naemorhedus goral*) serow (*Capricornis sumatraensis*), Himalayan thar (*Hemitragus jemlachicus*), Himalayan black bear (*Ursus thibetanus*), barking deer (*Munticus muntjak*), wild boar (*Sus scrofa*), rhesus macaque (*Macaca radiata*), and wolf (*Canis lupus*) (Aryal and Kreigenhofer 2009, Aryal et al. 2010a b).

There are human settlements inside the DHR of different castes including Bishowkarma, Magar, Nauthar (Chhetri), Chhantyal, Thakali, Bhotias (Tibetan refugees), and Brahmin. People are dependent on traditional agricultural practices in the southern part of the reserve. In the northern, higher-elevation parts of the reserve, animal husbandry and trans-boundary trade are the major sources of livelihood (Aryal 2008, Aryal and Kreigenhofer 2009, Aryal et al. 2010).

Distribution of the red panda within the DHR

Between Dec. 2010 and Oct. 2011, local residents (n = 119) were interviewed to identify potential and confirmed red panda habitat. A map of the area (1: 50,000) (provided by the Department of Survey, Government of Nepal, Katmandu) was used in the interviews; interviewees were requested to indicate the locations of any evidence of red panda presence (direct observation, scat, nesting site, and footprints). Evidence was noted in all 6 blocks within the DHR, and field surveys were subsequently conducted in these blocks to

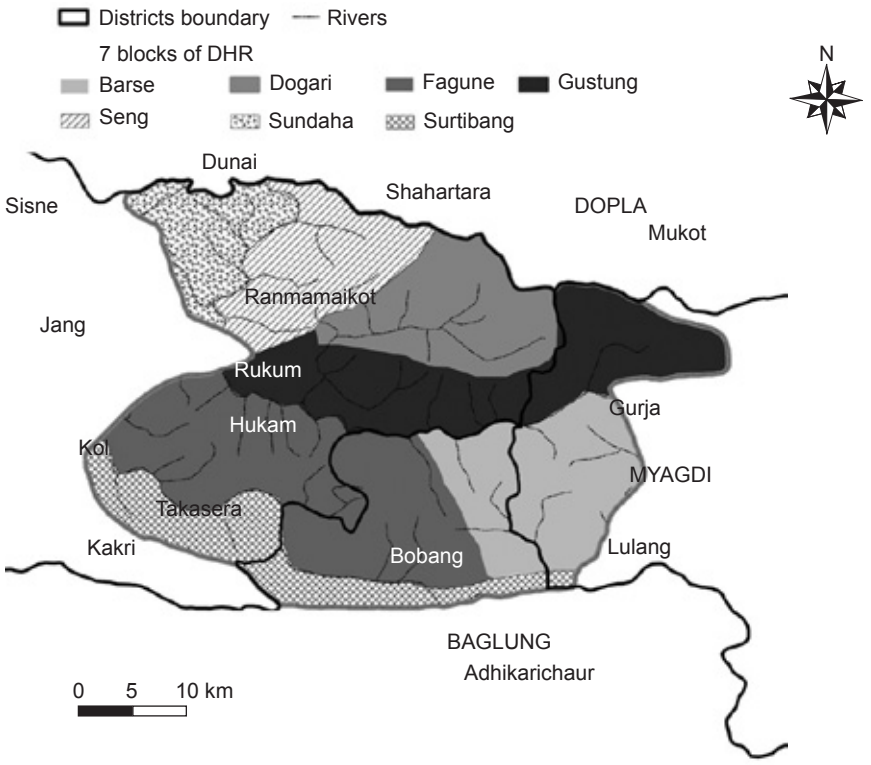

Fig. 2. Demarcation of the districts, surrounding villages, and 7 blocks of the Dhorpatan Hunting Reserve (DHR).

corro-borate the interview information. During the surveys, existing manmade trails were walked, and the traversed habitat was examined for red panda signs. In total, 342 GPS points were recorded, indicating the locations of observed evidence of red panda, and these were uploaded into Arc GIS-9.3 (ESRI). This information was overlaid on a vegetation-type layer (http://geoportal.icimod.org) and distribution map, from which the size of the area was calculated.

Habitat availability and use by the red panda in the DHR

Sixty habitat use (U) and 60 availability plots (A) were laid out throughout the study area to estimate habitat selection. U plots were located in areas that contained red panda signs (direct observations, scat, hair, footprints, and resting sites; Fig. 3), as determined from the distribution survey. For each U plot, a paired A plot was laid out at a distance of 100-150 m in a randomly chosen direction (as described by Aryal 2009). Where signs of red panda were observed in the A plots, the status was changed to U. The slope, elevation, percentage crown cover, ground cover, and land features were recorded for these plots.

The quadrate sizes for each plot were as suggested by Schemnitz (1980) for vegetation analysis in both the U and A plots: 10 × 10 m for the tree layer (plants above 3 m high and 5 cm diameter at breast height (DBH)), 4 × 4 m for the shrub layer (woody plants of < 3 m high), and 1 × 1 m for herbs and saplings (plants up to 1 m height). In each plot, the DBH, height, and crown cover of trees were recorded as well as ground cover, the number of trees, the frequency of shrubs and herbs, and signs of other animal species. Any livestock signs (direct observation, dung, and prints) were recorded in each plot to analyze potential habitat overlap between livestock and red panda. A one-way analysis of variance (ANOVA; SPSS vers. 16.0, SPSS, Chicago, IL, USA) was used to compare the following habitat features between U and A plots: vegetation, slope, aspect, and elevation (Aryal et al. 2010c, Aryal 2009).

Habitat overlap of red panda and livestock

Signs of livestock presence, including grazing signs and dung, were noted in our habitat survey. Plots containing signs of red panda but not livestock were defined as 'red panda-only' plots, those containing livestock dung but no red panda were defined as 'livestock-only' plots, and those containing signs of both red panda and livestock were defined as 'shared' plots. The spatial habitat overlap of red panda (A) and livestock (B) was analyzed using Jaccard's similarity index (J) (Real and Vargas 1996, Real 1999) which is expressed as $J = C / (A + B - C)$, where A is the number of plots used by red panda, B is the number of plots used by livestock, and C is the number of plots used by both red panda and livestock. The associated probability for J was calculated to determine if the value for the index differed from what would be expected at random (Real and Vargas 1996, Real 1999), using the formula given below. In this case, the probabilities associated with Jaccard's index depended on the total number of attributes present in either of the 2 habitats compared (N). N was calculated as $(A + B)/(1 + J)$.

Dietary analysis

During the summer of 2011, 61 scat samples were collected from the DHR. Micro-histological fecal analysis was used to estimate the diet of the red panda. This is a widely used method for studying the diet of ungulates (Anthony and Smith 1974, Robbins et al. 1975, Holechek et al. 1982), and is considered the most appropriate method for estimating the diet of wild herbivores (Dearden et al. 1975) where direct observations (Rothman et al. 2011) are not possible.

Samples were dried to constant weight in an oven, then ground and subsequently boiled in a solution of 10% sodium hydroxide (NaOH) until a color change was observed. Samples were washed with distilled water to remove the NaOH, and passed through a series of ascending alcohol solutions before being treated with xylene for complete dehydration. For each sample, 1 slide was prepared (61 in total) for examination. Reference samples were collected from the study area to prepare reference slides. Photographs of each reference slide for each plant species (81 in total) were taken using a microscope (100x and 400x magnifications). Twenty fragments from each slide were observed and compared with the reference slides of vegetation samples (Fig. 3E). Samples were identified under a microscope at 100x or 400x. Finally, the relative frequency (RF) of each species was calculated to estimate the percentage of that species in the diet of red panda (Sparks and Malechek 1968, Metillo 2011, Giri et al. 2011).

RESULTS

Distribution of red panda in the DHR

Red pandas were found to be distributed in a 345.8-km^2 area of the reserve (Fig. 4). Scat and nesting sites were observed in 6 blocks (Barse, Fagune, Surtibang, Seng, Sundaha, and Ghustang blocks) of the DHR, particularly in the lower belt including parts of the Myagdi, Baglung, and Rukum Districts (Fig. 4), and 4 red pandas (all male) were observed in Barse and Surtibang blocks (Fig. 3).

Fig. 3. (A) red panda (photo by A. Aryal). (B) red panda scat; (C) a red panda in an *Abies spectabilis* tree; (D) *Arundinaria* spp. in red panda habitat (photo by S. Panthi). (E) cellular structure of the leaf of *Arundinaria* spp. (photo by B. Adhikari).

All cases of red panda sign occurred in forests dominated by *A. spectabilis*, *R. arboretum*, and *B. utilis* trees, with ground cover predominantly of *Arundinaria* spp. (Fig. 3). Red pandas were found in the following regions of the reserve: in Khopriban, Sivaodhar area of Baglung and Myagdi Districts of Barse block; in Surtibang and Dija khung of Baglung District of Surtibang block; in Kanga khung, Masa khung, and the Thakur area of Baglung District of Fagune block; on the river side of the Ghustang (Ranma maikot and Gurjakhani VDC of the Rukum and Myagdi Districts) of Ghustung block; in Sengkhola and Dule of Rukum District of Seng block; and in the Sundaha area of the Sundaha block (Fig. 4). The Doghadi block was not considered potential habitat for the red panda, because of the very small amount of forest associated with the higher elevation of the area, and we found no evidence of red panda in this area. However, the lower belt of the forest area (< 10 km^2) of the block was suitable habitat for red panda. The south face of the Surtibang peak of Baglung (Bobang VDC) District and Lalpatan of Rukum (Jhang VDC) District were identified as potential habitat for red panda outside of the reserve, and they were surveyed for signs of red panda and livestock (Fig. 4).

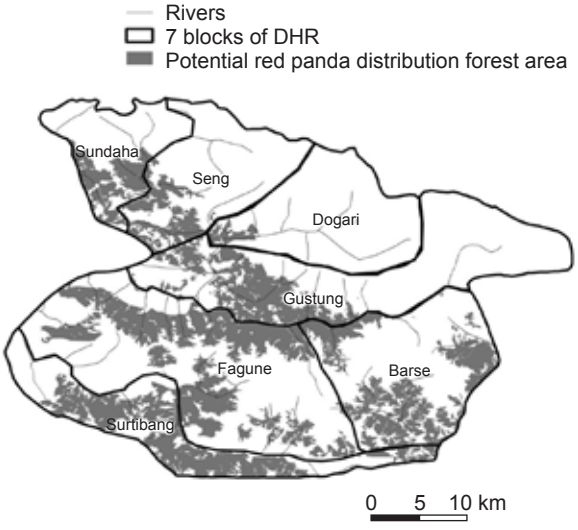

Fig. 4. Forested areas in the Dhorpatan Hunting Reserve identified as potential habitat for the red panda.

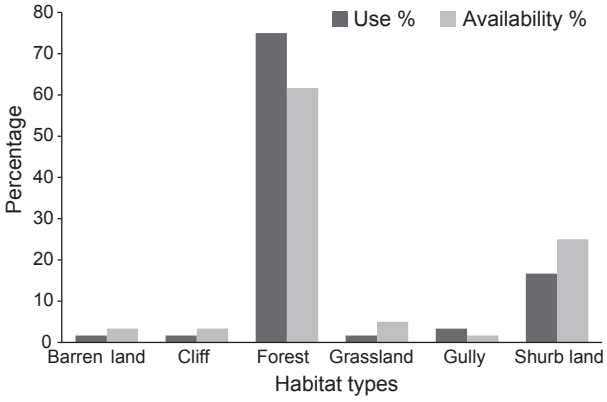

Fig. 5. Availability and use by the red panda of different habitat types in the Dhorpatan Hunting Reserve.

Habitat use and availability

Red pandas were identified in 75% of plots dominated by forests, and 16% of plots dominated by shrub habitat, whereas all habitat types were observed within U plots (Fig. 5).

Plots ranged in elevation from 2300 to 4380 m with slopes of 1°-78°, whereas red panda signs were recorded only at elevations of 2800-4000 m (Fig. 6). There was a significant difference in the use of different elevations in proportion to their availability, with elevations of 3000-3800 m used the most frequently (F = 3.51, p < 0.05) (Fig. 6).

In total, 10 tree species, 11 shrub species, and 17 herb species were recorded in the 120 sampled plots. Out of 10 tree species, *Ab. spectabilis*, *R. arboretum*, *Acer* spp., and *Q. semicarpifolia* were most commonly found in both U plots and A plots (F = 4.20, p > 0.05) (Fig. 7). Areas dominated by *T. domusa*, *P. wallichiana*, and *J. indica* were used less often by the red panda (Fig. 7).

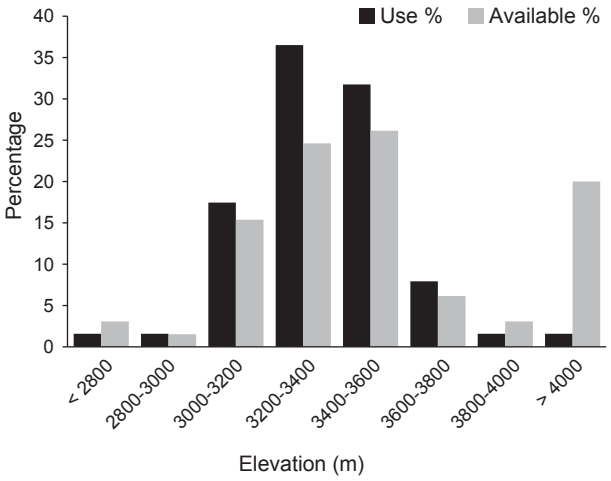

Fig. 6. Availability and use by the red panda of different elevations in the Dhorpatan Hunting Reserve.

Habitat overlap of red panda with livestock

There was appreciable overlap in resources shared by the red panda and livestock in the DHR, with human disturbances and livestock grazing observed in 53% of red panda habitats in the reserve (Jaccard's similarity index, J = 0.22, $n = 86$, $p < 0.001$).

Diet composition of the red panda

Six plants were identified in the scat of red panda, and 2.5% of the diet was unidentifiable (Table 1). From the scat analyses, *Arundinaria* spp. comprised the largest portion (81.7%) of the red panda diet in the DHR. Other plant species present in scat were *Acer* spp. (4.5%), *Q. semicarpifolia* (3.3%), *Berberis* spp. (2.1%), and lichens (2%). *Arundinaria* spp. were found in significantly higher proportion to others species in red panda scat ($\chi^2 = 25.24$, $p < 0.001$). The stem portion of *Arundinaria* spp. was recorded more frequently (58%) than the leaf portion (23.7%) (Table 1).

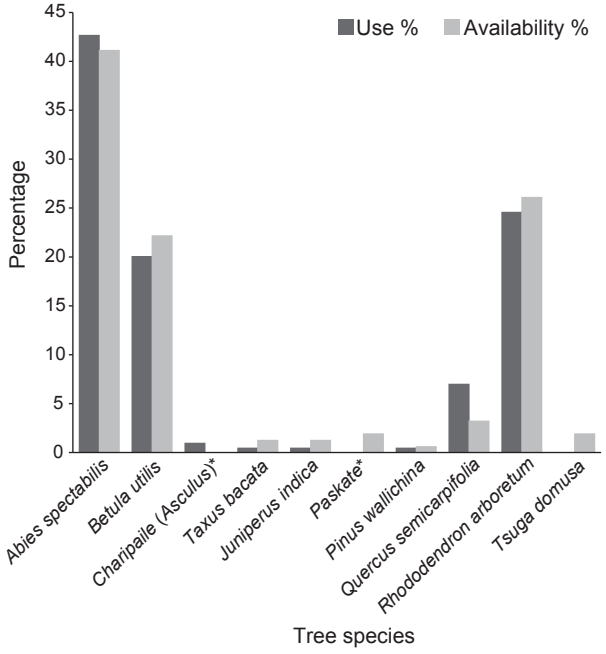

Fig. 7. Availability and use of major tree species by the red panda in the Dhorpatan Hunting Reserve (*local name).

Table 1. Plants identified in the red panda fecal pellets (diet composition of red panda)

Scientific name	Frequency (%)
Arundinaria spp.	81.7
Acer spp.	4.5
Betula utilis	3.3
Quercus semicarpifolia	2.9
Berberis spp.	2.1
Lichens	3
Unidentified	2.5

DISCUSSION

We recorded the presence of red pandas in 6 blocks of the DHR, and further detailed studies should be carried out in Dogadi block for the presence or absence of red panda. Red pandas are known to be habitat specialists, maintain a small home range, and are restricted to small pockets of microhabitat (Yonzon et al. 1991). In our study, red pandas were distributed in specific forest habitats (i.e., those dominated by *A. spectabilis*, *R. arboretum*, and *B. utilis*), within an elevation range of 2800-4000 m. However, in the Langtang region of Nepal and in India, red pandas were recorded across a broader range of 2200-4800 m (Roberts and Gittlemen 1984, Yonzon and Hunter 1989). Previous studies showed the red panda to utilize areas of steep slopes with bamboo and fallen logs (Wei et al. 1999 2000, Zhang et al. 2002).

Our survey revealed the presence of red panda in areas outside of the conservation area (the southern part from the Sundaha block of the DHR), and Williams (2006) similarly recorded this species outside of a protected area in the Ilam district of Nepal. Conservation of pandas outside of protected areas is challenging, and requires specific conservation measures at the local level to motivate villagers to conserve this species in those areas.

Our study recorded that red pandas used several tree species (*A. caesium*, *A. spectabilis*, *B. utilis*, and *Q. semicarpifolia*), shrubs (*Urtica dioica*, *R. campanulatum*, and *Rubus* spp.), and herb species (*Artemosia* spp., *Bistorta amplexicaulis*, *Duschesnea indica*, and *Arundinaria* spp.). As in our study, Sharma and Belant (2009) reported that *A. spectabilis* was the main species occurring in red panda habitat in Nepal, whereas in India, red panda habitats were typically characterized by the presence of mixed deciduous and coniferous forests with bamboo-thicket understory (Roberts and Gittleman 1984, Chakraborty 1999). Several tree species found in red panda habitat, including

A. spectabilis, *B. utilis*, and *Q. semicarpifolia*, are harvested to fulfill the needs of local communities. Studies revealed a preference of red pandas for forests with fallen logs and tree stumps (Zejun et al. 2006), but in our study area, fallen logs and trees stumps are removed for firewood and other purposes by the local people. A conservation strategy should consider managing this situation to balance the needs of local villages and the habitat requirements of the red panda.

In China and India, the main food resources for red pandas are bamboo (Wei et al. 1999 2000, Pradhan et al. 2001). Pradhan et al. (2001) reported that the bamboo species *Arundinaria maling* and *Aru. aristata* constituted 68.4% of the total diet, followed by berries of *Sorbus cuspidata*, *Sorbus microphylla*, *Actinidia strigosa*, and *Rosa sericera*. In contrast, our results showed the diet of the red panda in DHR to be dominated by *Arundinaria* spp. (> 81%). The reason for this difference might be that our survey was conducted in the rainy season (summer) when buds of *Arundinaria* spp. were abundant. *Arundinaria* spp. is heavily used by red pandas, and also by local villagers in the study area: the buds are eaten as a vegetable, the leaves are used as fodder, and the bark (locally known as "choya") is used for making baskets. The harvesting of this species for local use and sometimes for commercial purposes poses a serious threat to the survival of the red panda in the DHR.

Through much of its distribution, the red panda is threatened by habitat loss and fragmentation, poaching, and inbreeding depression (Wei et al. 1999). The same is true in our study area, where each year herders graze their livestock inside the DHR, which constitutes a substantial source of disturbance to red panda habitat. The ultimate cause of this and the aforementioned threats to the red panda are the high growth rate of human populations within the species' range and surrounding areas (Choudhury 2001), and the associated growth in livestock populations. In our study, the magnitude of this effect is underscored by the finding that > 53% of red panda habitat significantly over-lapped with livestock grazing and indicators of human disturbance. This should be an immediate cause of concern for managing red panda populations in Nepal.

The present study provides information on current distribution patterns, habitat characteristics, and diet of the red panda in the DHR and surrounding area. However, further information is needed on the population distribution and total population size in Nepal. An approach that shows particular promise for such studies is a genetic-based population survey method (Wang et al. 2008, Gomerčić et al. 2010, Chu et al. 2012).

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