Short Communication

Effects of livestock on occurrence of the Vulnerable red panda *Ailurus fulgens* in Rara National Park, Nepal

HARI P. SHARMA, JERROLD L. BELANT and JON E. SWENSON

Abstract The Vulnerable red panda *Ailurus fulgens* is endemic to the Himalayas. Anthropogenic activities, including deforestation, have degraded the species' habitat but the effects of livestock have not been examined. We assessed the effects of illegal livestock activity on the presence of the red panda in Rara National Park, Nepal. The probability of detecting red panda faecal pellets decreased with livestock occurrence but not with elevation or aspect. The presence of bamboo and proximity to water are important to red pandas but did not influence their habitat use at the spatial resolution evaluated. Livestock grazing in Rara National Park appears to adversely affect the presence of the red panda within its habitat. To reduce illegal livestock grazing we recommend enforcement of existing regulations, that training workshops be held for herders, and awareness-raising and dialogue with residents.

Keywords *Ailurus fulgens*, conservation, grazing, habitat, Nepal, red panda, threatened species

The red panda *Ailurus fulgens*, endemic to the Himalayan areas of Bhutan, China, India, Myanmar and Nepal (Roberts & Gittleman, 1984), inhabits evergreen, deciduous, and mixed evergreen–deciduous forests with dense understories (Yonzon & Hunter, 1991) at elevations of 1,500–4,800 m (Choudhury, 2001). Red pandas require fallen logs for resting and feeding, bamboo or fruits for forage, and open water (Wei et al., 2000). The red panda is categorized as Vulnerable on the IUCN Red List (Wang et al., 2008) and in Nepal is a protected priority species (Jnawali et al., 2011) under the National Parks and Wild Conservation Act 1973. Range-wide threats include killing by poachers and dogs, and habitat loss (Wei et al., 1999; Williams, 2003). Livestock grazing and collecting livestock feed (Sharma & Belant, 2010) may further reduce the quality of habitat for the red panda. Understanding habitat selection by the red panda, especially any effects of anthropogenic activities on such selection, is important for the conservation of the species.

Livestock grazing is considered a major threat to wildlife in protected areas in Nepal, including in Langtang National Park, Dhorpatan Hunting Reserve and Koshi Tappu Wildlife Reserve (Berkmueller et al., 1990; Yonzon & Hunter, 1991; Sharma & Belant, 2010), and elsewhere (e.g. Bhutan; Dorji et al., 2012). Livestock, particularly cattle and buffalo, can damage habitats, compete with native species for food and introduce diseases (Jolles et al., 2005; Schmidt et al., 2005). Consequently, we considered it relevant for red panda conservation generally to assess the effects of livestock use on red panda habitat selection in Rara National Park.

We collected data on presence of livestock sign and red panda faecal pellet groups in Rara National Park (Fig. 1) during May–July in 2011 and 2012. The study area is at altitudes of 2,754–4,097 m and is dominated by blue pine *Pinus wallichiana* up to 3,200 m, with rhododendron *Rhododendron arboreum*, black juniper *Juniperus indica*, west Himalayan spruce *Picea smithiana*, oak *Quercus semecarpifolia*, and Himalayan cypress *Cupressus torulosa*. Mixed forests of blue pine, west Himalayan spruce and fir *Abies spectabilis* occur over 3,200–3,550 m, and above 3,350 m there is coniferous–broadleaf forest of fir, oak, birch *Betula utilis*, Indian horse-chestnut *Aesculus indica*, walnut *Juglans regia* and Himalayan poplar *Populus ciliata*. The Park is surrounded by nine Village Development Committees (administrative units within a district), which were declared a buffer zone to increase people's participation in conservation and minimize their conflict with the Park (Budhathoki, 2004). The buffer zone and the Park together comprise 304 km^2. Livestock grazing occurred in the Park and buffer zone before its establishment in 1976 but is now illegal in the Park but not in the buffer zone. The Park is unfenced.

We delineated 25 linear transects at 500-m intervals in the forest around Rara Lake within the Park and established 10×10 m plots along each transect. Mean transect length

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Received 7 July 2013. Revision requested 3 September 2013.
Accepted 1 October 2013.

  doi:10.1017/S0030605313001403

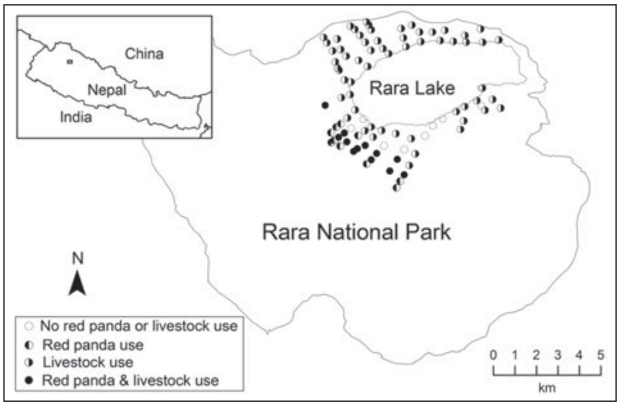

FIG. 1 Distribution of plots (circles) surveyed for signs of the presence of livestock and the red panda *Ailurus fulgens* in Rara National Park, Nepal, during 2011–2012. The inset indicates the location of the main map in Nepal.

was 1.46 ± SD 0.51 km (range 0.6–2.5 km). Transects started within 50 m of the road that circumscribes Rara Lake and plots were placed at each 100-m increase in elevation. At each plot we recorded aspect and elevation, using a global positioning system, measured distance from the plot centre to the nearest open water, using a measuring tape, and recorded any signs of recent livestock occurrence (livestock dung, tracks and trampling of vegetation), bamboo and red panda faecal pellet groups.

We calculated means and standard errors of continuous variables for plots with and without red panda pellets. We used logistic regression to estimate the effects of bamboo presence, elevation, livestock presence, aspect and distance to the nearest water on the presence of red panda faecal pellet groups. Because red pandas are bamboo specialists (Roberts & Gittleman, 1984), we included bamboo presence in all models and ran all combinations of variables without interactions. Before conducting logistic regression we calculated a correlation matrix of the explanatory variables, to exclude those with $|r| > 0.7$ in the same model (Libal et al., 2011). We ranked models using the Akaike information criterion adjusted for small samples (AIC_c; Burnham & Anderson, 2002) and used Akaike model weights to estimate relative strength of evidence for each model. We conducted model averaging using all models, to estimate 95% confidence intervals for each variable, and accepted statistical significance at $\alpha < 0.05$.

We surveyed a total of 106 plots on 25 transects (14 transects on north-facing and 11 on south-facing slopes). We detected red panda pellet groups in 23 plots (43%) on north-facing slopes at 3,185–3,516 m and none on south-facing slopes. Mean elevation of plots with and without red panda pellet groups was 3,166 ± SE 19.7 m and 3,205 ± SE 22.9 m, respectively. Bamboo (*Thamnocalamus* spp.) occurred only in plots on north-facing slopes (62%) at 2,985–3,516 m. Mean distances to nearest open water for plots with and without red panda pellet groups were 60.6 ± SE 4.9 m and 99.6 ± SE 11.3 m, respectively; 79% of plots on north-facing slopes were ⩽ 100 m from water. Livestock presence was documented in 81% of plots (64 and 98% of plots on north-facing and south-facing slopes, respectively) at 2,985–3,600 m.

No pairs of variables were highly correlated ($|r| < 0.7$ for all correlations) and thus all were used for modelling. The best-supported models included bamboo and elevation, followed by the model containing bamboo, elevation and aspect (Table 1). The probability of red panda presence was less in plots with livestock use (Table 2).

The National Park Regulations (HMG, 1979) stipulate that Park authorities can allow livestock grazing if it is important for management (Heinen & Kattel, 1992). Livestock grazing is illegal in Rara National Park but local people can use natural resources, including grazing, within the buffer zone (Durga Poudel, Chief Warden, pers. comm.). Nevertheless, we recorded evidence of livestock in our survey plots within the Park and observed buffalo, cattle, horses, goats and sheep in the Park. Many livestock graze in the Park during spring–autumn (Bir Bahadur Buda, Park Staff, pers. comm.). Park officials gather livestock in the Park and confine them to punish their owners but often the owners do not claim them. The livestock are later released outside the Park but often return shortly afterwards.

Livestock grazing probably reduces bamboo abundance and availability (Williams, 2003). Red pandas may forage in areas livestock cannot access (e.g. on steeper slopes; Wei et al., 2000) but we did not have the data to investigate this. Jotikapukkana et al. (2010) also demonstrated, in Thailand, a negative association between wildlife presence and livestock activity.

Threats associated with livestock grazing, including herders and their livestock-guarding dogs, which chase and kill red pandas, may have a greater effect on red pandas than grazing (Yonzon, 1989). At least six red pandas were killed by hunters and herders near Rara National Park during March–July 2012 (The Kathmandu Post, 2012). Furthermore, dogs may kill red pandas, introduce disease, and reduce the presence of the panda in otherwise suitable habitats (Williams, 2003; Lenth et al., 2008). We observed people collecting bamboo illegally in the Park, for fodder and building materials, as occurs in other protected areas of Nepal (Yonzon & Hunter, 1991; Sharma & Belant, 2010) and Bhutan (Dorji et al., 2012), and such activities may reduce bamboo availability for red pandas.

Although bamboo can comprise > 90% of the red panda's diet (Wei et al., 1999) bamboo alone did not influence red panda occurrence (Table 2). Although bamboo is important for the red panda, this may not have been detected at the fine spatial resolution we evaluated. Elevation did not influence red panda occurrence, probably because

TABLE 1 Logistic regression models describing the occurrence of the red panda *Ailurus fulgens* in Rara National Park (Fig. 1) during 2011–2012, ranked according to the Akaike information criterion adjusted for small sample size (AIC_c). Model parameters include Bamboo (bamboo presence), Elevation (m), Aspect (north or south), Water (distance to nearest open water), and Grazing (presence of livestock grazing). K is the number of parameters, ΔAIC_c is the difference between the AIC_c value of the best-supported model and successive models, and w_i is the Akaike model weight.

Model	*K*	loglink	AICc	ΔAICc	w_i
Bamboo + Elevation	4	−8.89	26.18	0.00	0.45
Bamboo + Elevation + Aspect	5	−8.58	26.47	1.58	0.21
Bamboo + Elevation + Water	5	−8.82	28.23	2.05	0.16
Bamboo + Elevation + Aspect + Water	6	−7.95	28.74	2.56	0.13
Bamboo + Elevation + Grazing	5	−10.54	31.67	5.49	0.03
Bamboo + Elevation + Aspect + Grazing	6	−10.36	33.57	7.39	0.01
Bamboo + Elevation + Aspect + Water + Grazing	7	−9.47	34.09	7.91	0.01
Bamboo + Grazing	4	−26.19	60.78	34.59	0.00
Bamboo + Water + Grazing	5	−25.88	62.35	36.17	0.00
Bamboo + Aspect + Grazing	5	−26.19	62.98	36.79	0.00
Bamboo + Aspect + Water + Grazing	6	−25.87	64.59	38.41	0.00
Bamboo	3	−29.79	65.81	39.62	0.00
Bamboo + Water	4	−29.69	67.79	41.60	0.00
Bamboo + Aspect	4	−29.74	67.87	41.68	0.00
Bamboo + Aspect + Water	5	−29.67	69.93	43.75	0.00
Null	2	−40.18	84.48	58.30	0.00

TABLE 2 Model-averaged parameter estimates and 95% confidence limits (CL) describing red panda occurrence in Rara National Park (Fig. 1) during 2011–2012. Model parameters include Bamboo (bamboo presence), Elevation (m), Aspect (north or south), Water (distance to nearest open water), and Grazing (presence of livestock grazing). Estimates were averaged from all models.

Parameter	Estimate	SE	Lower CL	Upper CL	*z*	P
Bamboo	9.20	8.80	−8.034	26.443	1.047	0.295
Elevation	0.06	0.03	−0.007	0.126	1.752	0.080
Aspect	2.24	2.78	−3.700	7.692	0.803	0.422
Water	0.02	0.03	−0.037	0.071	0.620	0.535
Grazing	−5.30	2.33	−9.86	−0.742	2.279	0.023

our entire study area was within the typical elevational range reported for this species (Choudhury, 2001). The climate on north-facing slopes at these elevations provides more suitable conditions for bamboo than do south-facing slopes (Numata, 1979; Yonzon et al., 1991). The absence of bamboo and red pandas on south-facing slopes suggests that bamboo was more important than elevation for determining the species' occurrence. Although red pandas drink water soon after eating (Yonzon, 1989), distance to water did not influence red panda presence, probably because most of the survey plots were ≤ 100 m from water.

Based on our findings we make three recommendations: (1) enforcement of existing regulations regarding livestock grazing in Rara National Park (if livestock use cannot be restricted we suggest that grazing zones, where livestock can be monitored by herders, be restricted to south-facing slopes where red pandas do not occur); (2) that training workshops be held for herders, to encourage them to develop husbandry practices that include individual or communal livestock corralling, and establishment of areas with supplemental fodder within the buffer zone, to reduce grazing within the Park; (3) dissemination of pamphlets and dialogue with residents of the Village Development Committees and visitors, to inform all users of the Park of the threats of livestock to the red panda, and associated regulations. Reducing the use of Rara National Park by livestock, to enhance the conservation of the red panda, will require increased public awareness, community support, and enforcement of regulations.

Acknowledgements

The Rufford Small Grant Foundation, Norwegian University of Life Sciences, International Fur Trade Federation, and Mississippi State University provided funding. The Department of National Parks and Wildlife Conservation, Nepal, permitted this research. We thank

Dr Mahendra Maharjan, Ravi Sharma, Bir Bahadur Buda, Raju Rimal and Rara National Park staff for their support. The comments from two anonymous reviewers helped to improve the article; we appreciate their time and effort.

References

Berkmueller, K., Mukherjee, S. & Mishra, B. (1990) Grazing and cutting pressures on Ranthambhore National Park, Rajasthan, India. *Environmental Conservation*, 17, 135–140.

Budhathoki, P. (2004) Linking communities with conservation in developing countries: buffer zone management initiatives in Nepal. *Oryx*, 38, 334–341.

Burnham, K.P. & Anderson, D.R. (2002) *Model Selection and Multimodel Inference: a Practical Information-theoretic Approach*. Springer Verlag, New York, USA.

Choudhury, A. (2001) An overview of the status and conservation of the red panda *Ailurus fulgens* in India, with reference to its global status. *Oryx*, 35, 250–259.

Dorji, S., Rajaratnam, R. & Vernes, K. (2012) The Vulnerable red panda *Ailurus fulgens* in Bhutan: distribution, conservation status and management recommendations. *Oryx*, 46, 536–543.

Heinen, J.T. & Kattel, B. (1992) A review of conservation legislation in Nepal: past progress and future needs. *Environmental Management*, 16, 723–733.

HMG (His Majesty's Government) (1979) *The Himalayan National Parks Regulation*. Ministry of Law and Justice, Kathmandu, Nepal.

Jnawali, S.R., Baral, H.S., Lee, S., Acharya, K.P., Upadhyay, G.P., Pandey, M. et al. (eds) (2011) *The Status of Nepal's Mammals: The National Red List Series*. Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

Jolles, A.E., Cooper, D.V. & Levin, S.A. (2005) Hidden effects of chronic tuberculosis in African buffalo. *Ecology*, 86, 2358–2364.

Jotikapukkana, S., Berg, A. & Pattanavibool, A. (2010) Wildlife and human use of buffer-zone areas in a wildlife sanctuary. *Wildlife Research*, 37, 466–474.

Lenth, B.E., Knight, R.L. & Brennan, M.E. (2008) The effects of dogs on wildlife communities. *Natural Areas Journal*, 28, 218–227.

Libal, N.S., Belant, J.L., Leopold, B.D., Wang, G. & Owen, P.A. (2011) Despotism and risk of infanticide influence grizzly bear den site selection. *PLoS ONE*, 6, e24133.

Numata, M. (1979) *Ecology of Grasslands and Bamboolands in the World*. Junk, The Hague, Netherlands.

Roberts, M.S. & Gittleman, J.L. (1984) *Ailurus fulgens*. *Mammalian Species*, 222, 1–8.

Schmidt, N.M., Olsen, H., Bildsøe, M., Sluydts, V. & Leirs, H. (2005) Effects of grazing intensity on small mammal population ecology in wet meadows. *Basic and Applied Ecology*, 6, 57–66.

Sharma, H.P. & Belant, J.L. (2010) Threats and conservation of red pandas in Dhorpatan Hunting Reserve, Nepal. *Human Dimensions of Wildlife*, 15, 299–300.

The Kathmandu Post (2012) *6 Red Pandas Killed in 5 Months*. Http://www.highbeam.com/doc/1P3-2705438501.html/print [accessed 17 January 2014].

Wang, X., Choudhury, A., Yonzon, P.B., Wozencraft, C. & Than, Z. (2008) *Ailurus fulgens*. In *IUCN Red List of Threatened Species v. 2012.2*. Http://www.iucnredlist.org [accessed 5 May 2013].

Wei, F., Feng, Z., Wang, Z. & Hu, J. (1999) Current distribution, status and conservation of wild red pandas *Ailurus fulgens* in China. *Biological Conservation*, 89, 285–291.

Wei, F., Feng, Z., Wang, Z. & Hu, J. (2000) Habitat use and separation between the giant panda and the red panda. *Journal of Mammalogy*, 81, 448–455.

Williams, B.H. (2003) Red panda in eastern Nepal: how do they fit into ecoregional conservation of the eastern Himalaya. *Conservation Biology in Asia*, 16, 236–250.

Yonzon, P.B. (1989) *Ecology and conservation of the red panda in the Nepal Himalayas*. PhD thesis. University of Maine, Orono, USA.

Yonzon, P.B. & Hunter, M.L. (1991) Conservation of the red panda *Ailurus fulgens*. *Biological Conservation*, 57, 1–11.

Yonzon, P.B., Jones, R. & Fox, J. (1991) Geographic information systems for assessing habitat and estimating population of red pandas in Langtang National Park, Nepal. *Ambio*, 20, 285–288.

Biographical sketches

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