Short Communication

Royal Manas National Park, Bhutan: a hot spot for wild felids

Tshering Tempa, Mark Hebblewhite, L. Scott Mills, Tshewang R. Wangchuk, Nawang Norbu, Tenzin Wangchuk, Tshering Nidup Pema Dendup, Dorji Wangchuk, Yeshi Wangdi and Tshering Dorji

Abstract The non-uniformity of the distribution of biodiversity makes allocation of the limited resources available for conservation of biodiversity a difficult task. Approaches such as biodiversity hotspot identification, endemic bird areas, crisis ecoregions, global 200 ecoregions, and the Last of the Wild are used by scientists and international conservation agencies to prioritize conservation efforts. As part of the biodiverse Eastern Himalayan region, Bhutan has been identified as a conservation priority area by all these different approaches, yet data validating these assessments are limited. To examine whether Bhutan is a biodiversity hot spot for a key taxonomic group, we conducted camera trapping in the lower foothills of Bhutan, in Royal Manas National Park, from November 2010 to February 2011. We recorded six species of wild felids of which five are listed on the IUCN Red List: tiger *Panthera tigris*, golden cat *Pardofelis temminckii*, marbled cat *Pardofelis marmorata*, leopard cat *Prionailurus bengalensis*, clouded leopard *Neofelis nebulosa* and common leopard *Panthera pardus*. Our study area of 74 km^2 has c. 16% of felid species, confirming Bhutan as a biodiversity hot spot for this group.

Keywords Bhutan, biodiversity, camera trap, eastern Himalayas, felid diversity, hotspot, Manas, tiger

This paper contains supplementary material that can be found online at http://journals.cambridge.org

As biodiversity is distributed unevenly around the globe, so are threats to species and vulnerability to extinction. A practical conservation approach is to prioritize the focus of conservation efforts. Approaches that spatially prioritize biodiversity conservation such as hotspots (Myers et al., 2000), endemic bird areas (Stattersfield et al., 1998), crisis ecoregions (Hoekstra et al., 2005), global 200 ecoregion (Olson & Dinerstein, 1998) and the Last of the Wild (Sanderson et al., 2002) are used by international conservation organizations to prioritize and allocate conservation efforts. These approaches have been successful in influencing donors and funding agencies to invest in these regions (Brooks et al., 2006; Grenyer et al., 2006; Wilson et al., 2006). Although each approach uses different criteria, Bhutan, as part of the biodiverse Eastern Himalayan region, has been recognized as a conservation priority area by all these five approaches (Olson & Dinerstein, 1998; Stattersfield et al., 1998; Myers et al. 2000; Hoekstra et al., 2005.

Although Bhutan is recognized as part of most biodiversity conservation priority networks, few efforts have been made to document the country's biodiversity. Most of the existing information, particularly for mammals, is based on historical samples, anecdotal sources and sign surveys carried out in a few protected areas. These methods have detected common and large mammals but missed rare and elusive species such as most wild felids. Breakthroughs in camera-trapping technology have made it possible to study many of these rare and elusive species and the method has become commonplace for the inventory of many terrestrial species (Srbek-Araijo & Garcia, 2005; Azlang & Lading, 2006; Tobler et al., 2008), including felids and other carnivores (O'Connell et al., 2010).

In Bhutan the only previous published camera-trap study was of the tiger *Panthera tigris* and common leopard *Panthera pardus* in the central part of the country (Wang & Macdonald, 2009). Here we report the results of a camera-trap survey, with a focus on wild felids, in the lower foothills of Bhutan, in Royal Manas National Park.

A grid of 2.5 × 2.5 km cells was overlain on our study (Fig. 1) area using *ArcGIS v. 9.3* (ESRI, Redlands, USA). Clusters of 30 cells were systematically sampled close to Manas base camp, taking into consideration logistic and security constraints. Within a cell we set up cameras in locations based on the presence of felid sign (mostly of tiger)

Tshering Tempa* (Corresponding author), Mark Hebblewhite and Scott Mills Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, College of Forestry and Conservation, University of Montana, Missoula, Montana 59812, USA. E-mail t_tempa@yahoo.com

Tshewang R. Wangchuk Bhutan Foundation, Washington, DC, USA

Nawang Norbu and Pema Dendup Ugyen Wangchuck Institute for Conservation and Environment, Bumthang, Lamai Goempa, Bhutan

Tenzin Wangchuk, Tshering Nidup, Dorji Wangchuk, Yeshi Wangdi and Tshering Dorji Royal Manas National Park, Gelephu, Sarpang, Bhutan

*Also at: Ugyen Wangchuck Institute for Conservation and Environment, Lamai Goempa, Bumthang, Bhutan

Received 10 February 2012. Revision requested 10 August 2012. Accepted 24 August 2012.

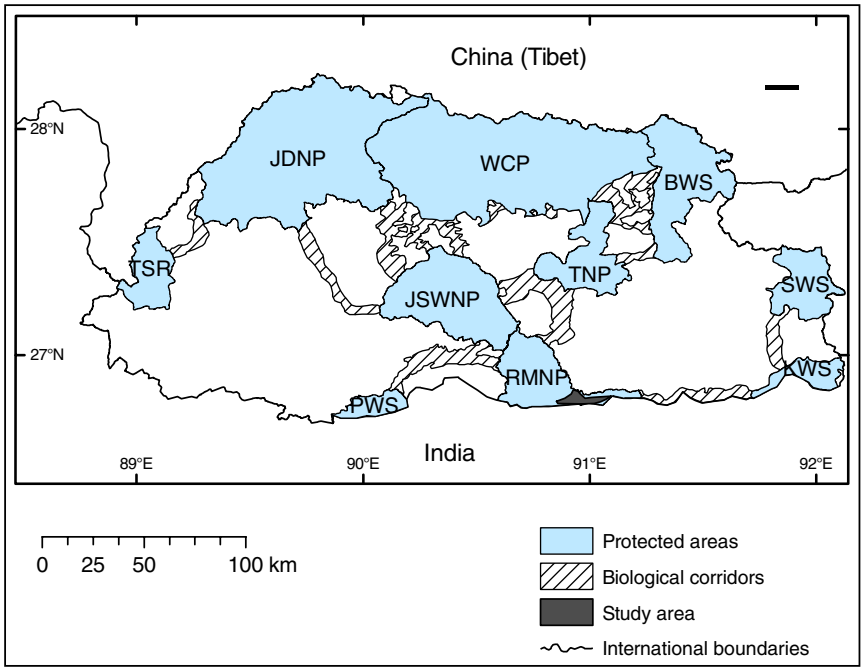

FIG. 1 Bhutan, showing the protected area network, including designated biological corridors and the study area in Royal Manas National Park (RMNP). BWS, Bumdeling Wildlife Sanctuary; JDNP, Jigme Dorji National Park; JSWNP, Jigme Singye Wangchuck National Park; KWS, Khaling Wildlife Sanctuary; PWS, Phibsoo Wildlife Sanctuary; SWS, Sakteng Wildlife Sanctuary; TNP, Thrumshingla National Park; TSR, Torsa Strict Nature Reserve; WCP, Wangchuck Centennial Park.

TABLE 1 The six species of wild felid photographed by camera trap (Supplementary Plate S1) in Royal Manas National Park (Fig. 1), with their Red List category (IUCN, 2012), number of photographic events, photographic rates (number of independent events divided by total trap nights) and number of days required for one event, ordered by photographic rate.

Species	Red List category*	Number of events	Photographic rate	No. of days required for 1 event
Leopard *Panthera pardus*	NT	107	0.053	19.0
Leopard cat *Prionailurus bengalensis*	LC	48	0.024	42.4
Tiger *Panthera tigris*	EN	40	0.020	52.2
Clouded leopard *Neofelis nebulosa*	VU	18	0.009	113.1
Asiatic golden cat *Pardofelis temminckii*	NT	3	0.001	678.7
Marbled cat *Pardofelis marmorata*	VU	3	0.001	678.7

*LC, Least Concern; NT, Near Threatened; VU, Vulnerable; EN, Endangered

such as pug-marks, scrape marks, scent marks and scats. To maximize the probability of capturing wild felids we placed cameras along trails and river basins and beds that had the highest density of signs within a grid cell. At each station two cameras (passive infra-red Reconyx HC500 Hyperfire; RECONYX, Inc., Wisconsin, USA) were set 6–7 m apart at a height of 45 cm, to photograph both flanks of any passing animal (Karanth, 1995). Camera sensitivity was set very high, to record all species. The first camera trap was established on 7 November 2010 and the last on 17 November 2010, and we used data from 17 November 2010 to 12 February 2011. Camera traps were monitored twice per month, whenever possible, to replace batteries and renew camera memory cards.

Images were classified into independent events based on several criteria. If the same animal was captured multiple times within 1 minute then it was classified as a single event. If two or more animals were captured in a single image, all animals were considered independent events. For tigers, common and clouded leopards *Neofelis nebulosa* we identified individuals based on stripe patterns on flanks, head, tail and limbs. For all wild felids we calculated photographic rates as number of independent events divided by total trap nights (Carbone et al., 2001; Rovero & Marshall, 2009).

From a total of 2,036 trap nights we confirmed the presence of six species of wild felids (Table 1, Supplementary Plate S1) and 28 other species of terrestrial mammals (Supplementary Table S1, Plate S2) in our study area of 74 km^2. Of the six species, the common leopard was captured by almost all camera stations and had the highest photographic capture rate (Table 1). Of the smaller felids, leopard cat was the most common. Marbled cat *Pardofelis marmorata* and Asiatic golden cat *Pardofelis temminckii* were the least common. Although, our study was not designed for estimating abundance, we detected 10 individual tigers, 20 individual common leopards and seven individual clouded leopards.

Our study indicates that Royal Manas National Park is a hotspot of wild felid diversity. Comparable wild felid diversity has been documented in the nearby Jeypore-Dehing rainforest in the north-eastern Indian state of Assam (CEPF, 2010) and from the Yungas biosphere of Argentina (Di Bitteti et al., 2011). Both of these studies were conducted in much larger areas (500 km^2 in India, $>$ 1,000 km^2 in Argentina). We consider that the six species of felid detected in the Park is a minimum as we also expect that at least two other species, the jungle cat *Felis chaus* and fishing cat *Prionailurus viverrinus*, inhabit the area because they are known to be in Manas National Park, India, which boarders our study area (Roy, 1992). A camera-trap survey in Manas National Park in India from November 2010 to February 2011 reported five species of felids, including the jungle cat (Borah et al., 2012). Three months after our survey a jungle cat was captured just west of our study area within the Royal Manas National Park. We may not have detected the fishing cat because because we did not place camera trap near their typical riverine habitat.

Conservation organizations and institutions have to allocate their resources to areas where conservation impact can be maximized in terms of number of species conserved per unit cost (Wilson et al., 2006). Our results show that Royal Manas National Park is a diverse hotspot for wild felids. If the objective of conservation is to save the greatest number of species from extinction, then focusing conservation efforts and resources in areas such as Manas will be most effective in meeting conservation objectives.

Acknowledgements

We thank the staff of Royal Manas National Park for field and logistical assistance. Funding was provided by the Bhutan Foundation, and the Jigme Singye Wangchuck Research and Training Fund at Ugyen Wangchuck Institute for Conservation and Environment. Administrative support from the Ministry of Agriculture and Forests facilitated the study, especially assistance from His Excellency P. Gyamtsho, S. Gyaltshen, and K. Drukpa from the Department of Forests and Parks. We also thank colleagues from the Berger/Mills lab for their feedback and suggestions, and the Wildlife Biology Program, International Program Office, and Office of the Provost at the University of Montana.

References

Azlan, J.M. & Lading, E. (2006) Camera trapping and conservation in Lambir Hills National Park, Sarawak. *The Raffles Bulletin of Zoology*, 54, 469–475.

Borah, J., Sharma, T., Das, N., Rabha, N., Kakati, N., Basumatri, A. et al. (2012) Diversity of carnivores in Manas National Park - a World Heritage Site, Assam, India. *Cat News*, 56, 16–19.

Brooks, T.M., Mittermeier, R.A., da Fonseca, G.A.B., Gerlach, J., Hoffmann, M., Lamoreux, J. et al. (2006) Global biodiversity conservation priorities. *Science*, 313, 58.

Carbone, C., Christie, S., Conforti, K., Coulson, T., Franklin, N., Ginsberg, J. et al. (2001) The use of photographic rates to estimate densities of tigers and other cryptic mammals. *Animal Conservation*, 4, 75–79.

CEPF (2010) *World's Highest Number of Wild Cat Species Recorded in Eastern Himalayan Rainforest*. Http://www.cepf.net/news/press_releases/Pages/wild_cats_himalayas.aspx [accessed 18 January 2013].

Di Bitteti, M.S., Albanesi, S., Foguet, M.J., Cuyckens, G.A.E. & Brown, A. (2011) The Yungas biosphere reserve of Argentina: a hot spot of South American wild cats. *Cat News* 54, 25–29.

Grenyer, R., Orme, C.D.L., Jackson, S.F., Thomas, G.H., Davies, R.G., Davies, T.J. et al. (2006) Global distribution and conservation of rare and threatened vertebrates. *Nature*, 444, 93–96.

Hoekstra, J.M., Boucher, T.M., Ricketts, T.H. & Roberts, C. (2005) Confronting a biome crisis: global disparities of habitat loss and protection. *Ecology Letters*, 8, 23–29.

IUCN (2012) *IUCN Red List of Threatened Species v. 2012.2*. Http://www.iucnredlist.org [accessed 17 October 2012].

Karanth, K.U. (1995) Estimating tiger *Panthera tigris* populations from camera-trap data using capture–recapture models. *Biological Conservation*, 71, 333–338.

MacKenzie, D.I., Nichols, J.D., Hines, J.E., Knutson, M.G. & Franklin, A.B. (2003). Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. *Ecology*, 84, 2200–2207.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A. & Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*, 403, 853–858.

O'Connell, A.F., Nichols, J.D. & Karanth, U.K. (2010) *Camera Traps in Animal Ecology: Methods and Analyses*. Springer, New York, USA.

Olson, D.M. & Dinerstein, E. (1998) The Global 200: a representation approach to conserving the Earth's most biologically valuable ecoregions. *Conservation Biology*, 12, 502–515.

Rovero, F. & Marshall, A.R. (2009) Camera trapping photographic rate as an index of density in forest ungulates. *Journal of Applied Ecology*, 46, 1011–1017.

Roy, D.S. (1992) *Manas—A World Heritage Site*. A Report to the 4th World Congress on Protected Areas, Caracas, Venezuela.

Sanderson, E.W., Jaiteh, M., Levy, M.A., Redford, K.H., Wannebo, A.V. & Woolmer, G. (2002) The human footprint and the last of the wild. *Bioscience*, 52, 891–904.

Srbek-Araujo, A.C. & Chiarello, A.G. (2005) Is camera-trapping an efficient method for surveying mammals in Neotropical forests? A case study in south-eastern Brazil. *Journal of Tropical Ecology*, 21, 121–125.

Stattersfield, A.J., Crosby, M.J., Long, A. & Wege, D. (1998) *Endemic Bird Areas of the World: Priorities for Biodiversity Conservation*. BirdLife Conservation Series No. 7. Bird Life International, Cambridge, UK.

Tobler, M., Carrillo-Percastegui, S., Leite Pitman, R., Mares, R. & Powell, G. (2008) An evaluation of camera traps for inventorying large- and medium-sized terrestrial rainforest mammals. *Animal Conservation*, 11, 169–178.

Wang, S.W. & Macdonald, D.W. (2009) The use of camera traps for estimating tiger and leopard populations in the high altitude

mountains of Bhutan. *Biological Conservation*, 142, 606–613.
Wilson, K.A., McBride, M.F., Bode, M. & Possingham, H.P. (2006) Prioritizing global conservation efforts. *Nature*, 440, 337–340.

Biographical sketches

Tshering Tempa is interested in predator–prey dynamics in the subtropical and temperate forests of Bhutan, with a special focus on tigers and their prey and human wildlife conflicts. Mark Hebblewhite focuses on wolves and their ungulate prey. L. Scott Mills carries out research in applied population ecology, using population models and genetic tools, with field experiments, to understand population and community-level effects of human stressors. Tshewang R. Wangchuk works on snow leopards and communities in Bhutan. Nawang Norbu is interested in the movement ecology of high altitude birds and mammals. Tenzin Wangchuk is interested in protected area management. Tshering Nidup is interested in surveying and monitoring ungulates and other prey species in montane and forested landscapes. Pema Dendup is interested in the application of technology in environmental management. Dorji Wangchuk is interested in the application of camera traps for monitoring wildlife in protected areas. Yeshi Wangdi studies small mammals. Tshering Dorji is interested in protected area management and the use of captive breeding programmes for Critically Endangered species.