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Short communication

Empty forests: Large carnivore and prey abundance in Namdapha National Park, north-east India

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ABSTRACT

Illegal hunting poses a dual threat to large carnivores through direct removal of individuals and by prey depletion. We conducted a camera-trapping survey in the Namdapha National Park, north-east India, conducted as part of a programme to evaluate carnivore and prey species abundance. Clouded leopard (*Neofelis nebulosa*) was the only large carnivore detected by camera-trapping. Indirect evidences indicated the presence of the wild dog (*Cuon alpinus*) and leopard (*Panthera pardus*), however, there was no evidence of tigers (*Panthera tigris*), suggesting their possible extinction from the lower elevation forests. Of the major ungulate prey species, sambar (*Cervus unicolor*) and wild pig (*Sus scrofa*) were the only large prey detected, while the Indian muntjac (*Muntiacus muntjak*) was the only small prey species detected. Relative abundances of all species were appreciably lower than estimates from other tropical forests in south-east Asia. We suspect that illegal hunting may be the cause for the low carnivore and prey species abundance. An ongoing community-based conservation programme presents an opportunity to reduce local people's dependence on hunting by addressing their socio-economic needs and for using their skills and knowledge of the landscape for wildlife conservation. However, long-term wildlife monitoring is essential to assess the efficacy of the socio-economic interventions in bringing about wildlife recovery.

1. Introduction

Enforcement of India's laws that entirely prohibit hunting of all wildlife is a challenge, especially in north-east India, where local tribes have a strong tradition of hunting. Although hunting has ritual, recreational and subsistence value (Datta, 2002; Hilaluddin et al., 2005; Mishra et al., 2006), it is also increasingly being driven by high-value markets for derivatives from species such as tigers (*Panthera tigris*) and elephants (*Elephas maximus*). In the Namdapha National Park and Tiger Reserve in Arunachal Pradesh, one of four designated tiger reserves in north-east India, hunting remains a serious threat. We initiated a community-based conservation programme in 2004 in an attempt to progressively eliminate hunting by local communities by addressing their socio-economic needs (Datta, 2007). Abundance and trend estimates for several faunal groups targeted by hunters are needed. Such information is vital, as presently very little is known of the status of large carnivores and their prey from the hill forests of north-east India, particularly when compared to those of peninsular India (Karanth et al., 2004,2004b; Karanth and Nichols, 1998; Karanth and Sunquist, 1995).

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Our research objectives were to (1) develop a large-scale camera-trapping survey in the Namdapha National Park to generate baseline information on the relative abundance of large carnivores and their prey species, (2) compare our results to abundance estimates from similar forests in south-east Asia and (3) examine the current conservation scenario in Namdapha, and explore avenues for making conservation successful in the context of lessons learned from the ongoing community-based conservation programme.

1.1. *Study area*

The study was conducted within the 1985 km^2 Namdapha National Park (27°23′30″–27°39′40″N and 96°15′2″–96°58′33″E; Fig. 1), in Arunachal Pradesh, north-east India. The site harbours extensive dipterocarp forests, the northernmost lowland tropical rainforests in the world (Proctor et al., 1998) and has been identified as a globally high priority landscape for tiger conservation (Wikramanayake et al., 1998). The elevation ranges from 200 m to 4571 m. With increasing elevation, there is a transition in habitat from subtropical broad-leaved forests to subtropical pine forests, temperate broad-leaved forests, alpine meadows and perennial snow. Though primary forests cover most of the park, there are extensive bamboo and secondary forests. The park lies within the Indo-Myanmar global biodiversity hotspot (Myers et al., 2000) at the junction of the Palearctic and Malayan biogeographic realms resulting in a highly diverse species assemblage. The floral and faunal composition is highly similar to adjoining forests in Myanmar and other parts south-east Asia (Mani, 1974; Myers et al., 2000; Rodgers and Panwar, 1988).

Ninety mammal species are reported from the park, including nine species of felids, two bear species, 15 viverrid and mustelid species and seven primate species. Four species of mountain ungulates: red goral (*Nemorhaedus baileyi*), serow (*Nemorhaedus sumatraensis*), takin (*Budorcas taxicolor*) and musk deer (*Moschus* sp.) occur at higher elevations, while the hog deer (*Axis porcinus*) is restricted to the grassland habitat in the river valleys. The main species targeted by hunting are the Indian muntjac (*Muntiacus muntjak*), sambar (*Cervus unicolor*), wild pig (*Sus scrofa*) and gaur (*Bos frontalis*). These four species are among the important prey of the tiger, leopard (*Panthera pardus*) and the wild dog (*Cuon alpinus*) (Karanth and Sunquist, 1995), while primates and smaller mammals constitute important prey for the clouded leopard (*Neofelis nebulosa*) (Rabinowitz et al., 1987).

Several indigenous tribes and other communities reside in and around the park; however those that primarily affect the park are the *Chakma*, *Miju Mishmi* and the *Lisu* (Datta, 2007). The *Chakma* and *Miju Mishmi* enter the park for fuelwood, non-timber forest produce collection (Arunachalam et al., 2004), hunting and fishing. While their impact is restricted

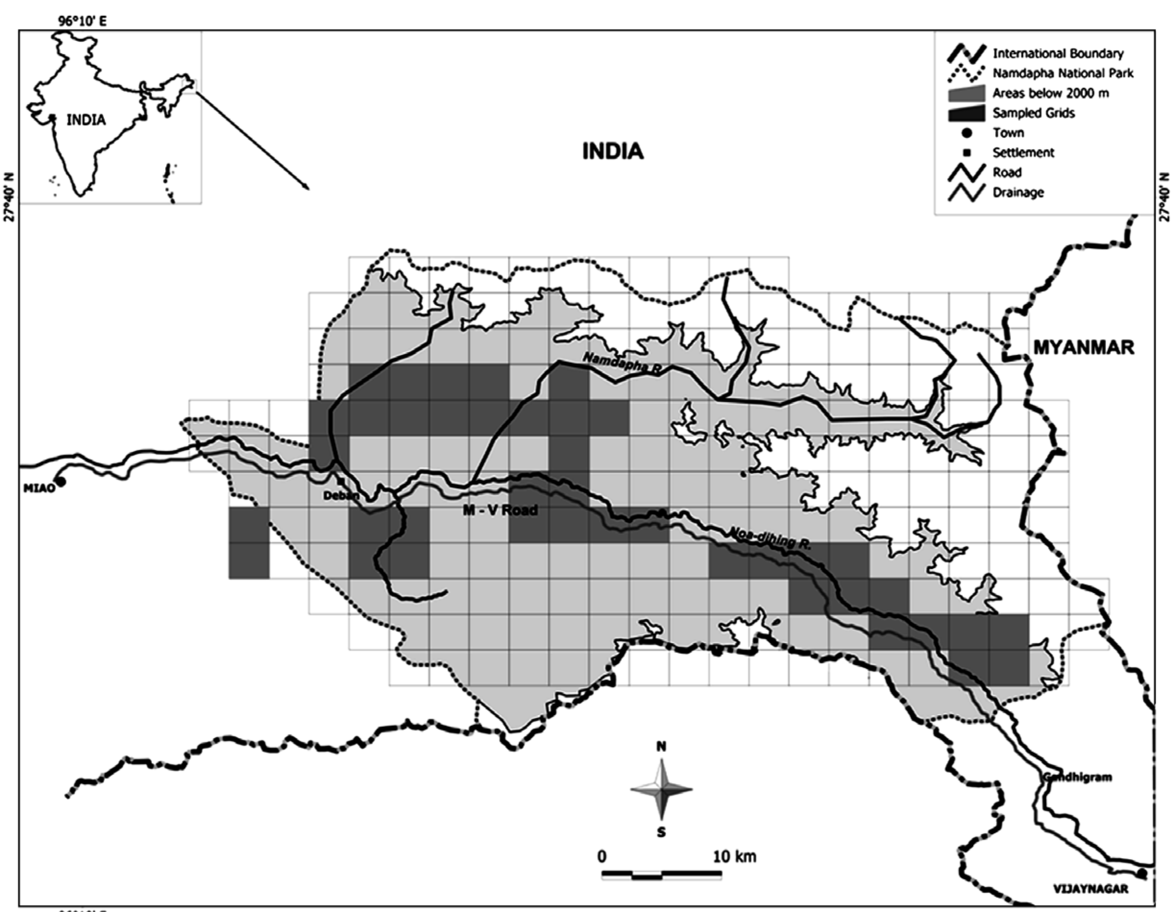

Fig. 1 – Map of Namdapha National Park showing 3 × 3 km grid utilized for sampling. Areas shaded in light grey represent tropical forests below 2000 msl. Dark grey squares represent the 40 sampled grids.

to the western portion of the park, it is members of the *Lisu* tribe that reside along the eastern fringe of the park who access the interior and remote areas. A population of 3988 (Census of India, 2001) reside beyond the south-eastern park boundary in four villages of the *Lisu* tribe and nine villages of the *Nepali* community. Although some *Lisu* households existed within the park earlier, more *Lisu* families have migrated into the park since 1997, as their populations have grown and owing to a serious decline in cultivable land due to erosion by the River Noa-dihing. Currently, 65 such families reside in the park and practice settled rice cultivation in the river valley.

A 157 km road (from Miao on the west to Vijaynagar on the east) that cuts through the park was built in 1972 (Fig. 1) and is now only motorable for 16 km within the park. Access to facilities in Miao is on foot through the park for *Lisus* and *Nepalis*, while other tribes access the park when carrying food and supplies to Vijaynagar in winter.

Illegal hunting is a serious threat to wildlife in the park, and is prevalent among all tribal groups. At least 34 species of mammals are hunted as evidenced by skins and skulls seen in villages in the area (Datta, 2002). The main targets of subsistence hunting are ungulates and primates, and dried wild meat and fish are sold in the villages. There is also illegal hunting for tiger, elephant, musk deer, bears, otters and other cats (Datta, 2002, 2007). Hunting is mainly carried out with guns, cross-bows and a variety of indigenous traps, while metal foot snares are used for tigers. Reliable information suggests that there were at least 90–100 active hunters among the *Lisu* in 2003–2004. No data exists on the extent of hunting by other tribes in the park, although there is evidence of localised hunting by these tribes.

2. Materials and methods

Prior work at Namdapha (only 17 detections of two ungulate species over 740 km walked) suggested that conventional sighting-based transect methods may not be feasible for monitoring terrestrial mammal populations in these forests (A. Datta, *unpubl. data*). Therefore, we employed camera-trapping for large and medium-sized mammals, and pellet and track plot surveys for indirect evidences of large herbivores and ungulates. Camera traps were preferred because collecting reliable data based on indirect evidence such as tracks and scats for indices of carnivore abundance is not feasible in the study area, due to problems in distinguishing signs given the presence of several similar-sized sympatric felids (Silveira et al., 2003). In addition, there are hardly any trails or roads in the study area and the dominant soil stratum is covered with leaf-litter.

2.1. *Camera-trapping*

The study focused on an area of 1200 km^2, roughly encompassing the moist evergreen habitat within the Namdapha National Park below 2000 m. We imposed a uniform grid (3 km × 3 km) on a map of the area, the scale of which was selected to match other camera-trapping surveys in south-east Asia (Grassman Jr, 2003; Johnson et al., 2006; Kawanishi and Sunquist, 2004; O'Brien et al., 2003). Of the 130 grids covering the study area, we randomly selected 80 grids for sampling. However, given the logistical difficulties in the hilly terrain, limitations of time, manpower and equipment, we only sampled 40 of the 80 randomly selected grids between October 2006 and January 2007 covering 30% of the study area (Fig. 1). In some instances, we sampled grids adjacent to a randomly selected grid where accessing the grid was impractical. With only 16 km of motorable road, all field work was carried out on foot.

We surveyed large carnivores and prey species using 42 passive infra-red camera trap units (38 DEERCAM-300 camera trap units from Forestry Suppliers Inc., USA and 4 units made by the Centre for Electronic Design and Technology, Indian Institute of Science, Bangalore). In each of 40 sampled grids, two or three camera traps were deployed. Traps were deployed along animal trails, streambeds, wallows and ridgelines, in locations with evidence of animal movement, as identified by expert *Lisu* trackers. We recorded the GPS location, altitude and other habitat parameters at each trap site. A group of highly skilled *Lisu* trackers assisted in identifying suitable locations for deploying camera traps. At every location, one passive infra-red camera trap was placed perpendicular to the expected direction of animal movement at a height of 30–40 cm from the ground. We maintained a minimum distance of 400–500 m between trap locations. However, on two occasions we placed traps at a distance of 200 m apart, due to inaccessible terrain and lack of suitable sites. The traps operated continuously and were removed after a period of 15 days. The number of camera trap-days was calculated from the date of deployment till the date of retrieval (if film was not used up) or till the date of the final photo.

2.2. *Pellet and track plots*

Within 38 of the 40 grids in which camera traps were deployed, we searched for pellets, dung groups and tracks of elephants and ungulates in 10 50 m × 2 m plots. These plots were located at intervals of 100 m perpendicular to a 1 km-long trail. These 380 plots were each intensively searched once by two observers.

2.3. *Data analysis*

Based on photo capture rates of large carnivore and prey species, we calculated an index of relative abundance (RAI) as the number of days required for obtaining a photo capture of a species (Carbone et al., 2001). Only independent pictures of a particular species were counted as valid to estimate RAI. We defined independence following O'Brien et al. (2003) where each photo was identified to species and rated as a dependent or independent event, with an 'independent capture event' defined as (1) consecutive photographs of different individuals of the same or different species, (2) consecutive photographs of individuals of the same species taken more than 0.5 h apart and (3) non-consecutive photos of individuals of the same species. Relative abundance values from the current study were also compared to those obtained from studies in geographically and climatically similar forests in six sites in south-east Asia which face lower or comparable hunting

Table 1 – Relative Abundance Indices (number of trap-days required to get a single photo capture of a species) derived from camera trap surveys for large carnivores and prey species in Namdapha National Park and six other protected areas in south-east Asia

Location	Namdapha National Park, north-east India	Hukawng Valley Tiger Reserve, north Myanmar	Hkakaborazi National Park, north Myanmar	Taman Negara National Park, Peninsular Malaysia	Nam Et-Phou Louey National Protected Area, Laos	Bukit Barisan Selatan National Park, Indonesia	Phu Kheio Wildlife Sanctuary, Thailand
Reference	Present study, 2006–2007	Lynam (2003)	Rao et al. (2005)	Kawanishi and Sunquist (2004)	Johnson et al. (2006)	O′ Brien *et al.* unpublished data (1998–2006)	Grassman (2003)
Type of camera trap	Passive	Passive	Passive	Active and Passive	Passive	Passive	Active and Passive
Effort (number of trap-days)	1537	8836	1238	14 054	3588	24 045	1224
Tiger *Panthera tigris*	–	2945	–	230	417	481	408
Leopard *Panthera pardus*	–	–	–	94	144	–	–
Wild dog *Cuon alpines*	–	4418	29	878	359	6024	111
Clouded leopard *Neofelis nebulosa*	768	4418	16	878	Present, but data not available	587	612
Indian muntjac *Muntiacus muntjak*	22	184	6	25	36	26	15
Sambar *Cervus unicolor*	512	192	–	44	400	89	34
Wild pig *Sus scrofa*	512	1767	9	28	250	39	31
Gaur *Bos frontalis*	–	2945	–	1562	1250	–	35
Serow *Naemorhedus sumatraensis*	–	–	20	270	326	4007	Not present?
Porcupines (2 species)	40	1104	6	95	55	43	122
Primates	37	1767	8	351	23	20	153 21
Hog badger *Arctonyx collaris*	–	–	179	–	163	Not present?	408

pressures (O'Brien et al., unpubl. data; Grassman Jr, 2003; Johnson et al., 2006; Kawanishi and Sunquist, 2004; Lynam, 2003; O'Brien et al., 2003; Rao et al., 2005). RAI is negatively correlated to species abundance (Carbone et al., 2001; O'Brien et al., 2003) and is a useful tool to compare relative abundances of species, particularly when individuals of these species cannot be distinguished from each other.

Although, we did not detect tigers with a trapping effort of 1537 days, we used the equation derived by Carbone et al. (2001) – where tiger density (y) is a function of RAI_1 (x) such that $y = 133.89x^{-0.971}$ – to approximate the maximum possible tiger density in Namdapha, had a tiger photo been obtained on the 1538th trap day.

As tigers select large prey when available, we separated the prey species as large (>100 kg) and small (<100 kg) to determine the relative abundance of these prey size categories in the area (Johnson et al., 2006; Karanth and Sunquist, 1995).

Pellet and track plot data were summarized as the mean number of plots per trail in which a species was encountered and used to supplement camera trap data on species presence in the area.

3. Results

We used 1537 trap-days of data for analysis, after deducting trap-days where cameras malfunctioned and where the film was finished before the end of a 15 day sampling session. There were no detections of tigers, leopards and wild dogs (Table 1). The only large carnivore detected was the clouded leopard. Other carnivores photographed included marbled cat (*Pardofelis marmorata*), golden cat (*Catopuma temmincki*), leopard cat (*Prionailurus bengalensis*), small-toothed ferret badger (*Melogale moschata*), yellow-throated marten (*Martes flavigula*), large Indian civet (*Viverra zibetha*), common palm civet (*Paradoxurus hermaphrodites*), Himalayan palm civet (*Paguma larvata*) and crab-eating mongoose (*Herpestes urva*). There were no detections of large herbivore species such as Asian elephant, gaur or serow. With the exception of the Indian muntjac, encounter rates of the target species were far lower at Namdapha than at most other sites in south-east Asia.

We obtained 156 independent prey photos, of which large prey (sambar and wild pig) comprised only 3.9%. The remaining photos were of small prey; two primate species: stump-tailed macaque (*Macaca arctoides*), capped langur (*Trachypithecus pileatus*), Himalayan crestless porcupine (*Hystrix brachyura*), brush-tailed porcupine (*Atherurus macrourus*) and muntjacs. Muntjacs alone made up 45.5% of the independent photos.

Although we did not detect tigers, we used the equation derived by Carbone et al. (2001) to derive a density estimate, if a tiger were to be detected on the 1538th trap night. Based on this, tiger density in Namdapha would be no more than 0.107/100 km^2. This translates to no more than two tigers in the roughly 1200 km^2 lower elevation forests of Namdapha.

Five species of large ungulates were detected in pellet and track plots. The mean number of plots (±SD) per trail with tracks was 6.68 (±2.14) for muntjac, while it was 2.02 (±1.65) for sambar, 1.27 (±1.64) for wild pig, 0.48 (±1.22) for gaur and 0.18 (±0.8) for serow. Pellet and dung groups of three species were encountered; with 0.34 plots (±0.86) per trail with pellet groups of muntjac, 0.11 (±0.35) for sambar and 0.03 (±0.16) for gaur.

4. Discussion and conclusions

Many important outcomes of the study, unfortunately, centre on the species that were not detected, rather than the ones that were. Although, there were no detections in >1500 camera-days of trapping effort, we conclude that populations of leopard, wild dog, gaur and serow still exist in Namdapha, based on sporadic detections of tracks, scats and droppings. In addition, wild dogs have been sighted on four occasions in grassland habitat in the river valleys in earlier surveys between 2003 and 2005 (A. Datta, *pers. obs.*). However, no primary evidence was recorded to suggest the presence of tigers or elephants within the study area since the winter of 2005 (A. Datta, *pers. obs.*). There are reports of tiger sightings by tourists and of cattle kills by tigers in 2005–2006 near the western boundary of the park, while a single herd of 20 elephants is known to move in the area occasionally (Forest Department staff, *pers. comm.*).

Relative abundance index values from Namdapha of most of the target species are among the lowest in the south-east Asian region, comparable to or lower than other highly-hunted sites (Johnson et al., 2006; Karanth and Nichols, 1998; Rao et al., 2005), and far lower than less hunted sites (Grassman Jr, 2003; Kawanishi and Sunquist, 2004; O'Brien et al., 2003). As is often the case in hunted sites, the only species not showing this pattern was the muntjac (Johnson et al., 2006), encounter rates of which were among the highest in Namdapha. The small-bodied Indian muntjac is likely to be more resilient to hunting pressure and fare better than larger ungulates even in hunted areas. This may result from faster reproductive rates and intrinsic rates of population increase and other factors, as has been demonstrated in other small-bodied cervids such as brocket deer (Hurtado-Gonzales and Bodmer, 2004) and other wildlife species (Bodmer et al., 1997).

A sustained conservation effort would be required for these species to recover to even the low density levels observed in relatively less hunted protected areas in south-east Asia (Kawanishi and Sunquist, 2004; O'Brien et al., 2003). The current status of large mammals in Namdapha is particularly unfortunate, given anecdotal information that even in the early 1990s, Namdapha supported healthy populations of tigers and elephants, among other large mammals. A 451 trap night camera-trapping effort in the western part of Namdapha in 1996 yielded captures of leopard, wild dog and clouded leopard, but none of tigers (Karanth and Nichols, 2000). However, seven scats detected in 363 km walked, as well as pugmarks were noted by Karanth and Nichols (2000), much more than currently seen in the park (a single pugmark seen in 2005). On several visits to the park between 1999 and 2005, with more than 1000 km walked, tiger pugmarks were seen on only 4 occasions (A. Datta, *pers. obs.*). A pilot camera trap survey (364 trap nights) in 2005 also failed to detect tigers, although the clouded leopard and two bear species were detected (A. Datta, *unpublished data*).

While tiger densities are typically low in 11 other prey-poor rainforest Protected Areas in south-east Asia ranging from 0.53/100 km^2 to 2/100 km^2 as compared to 4/100 km^2–16/100 km^2 in seven prey-rich deciduous forest and grassland Protected Area sites in India and Nepal (Carbone et al., 2001; Karanth et al., 2004b), the failure to detect substantial evidence of the tiger in Namdapha from 2002 onwards points to a serious decline. Even in highly-hunted sites across the border in Myanmar such as the Htamanthi Wildlife Sanctuary and Hukawng Valley Wildlife Sanctuary, estimated tiger densities were 0.49/100 km^2 and 1.1/100 km^2, respectively (Lynam, 2003), though in the Hkakaborazi National Park, tigers are believed to be locally extinct (Rabinowitz and Khaing, 1998; Rao et al., 2005).

Although, there is no reliable evidence suggesting the presence of tigers currently in the lower elevation areas of Namdapha, even higher trapping effort and extensive surveys may be necessary to draw conclusions on the fate of the species in the park. The inability to estimate animal densities reflect the difficulties surrounding the estimation and monitoring of wildlife populations in tropical forests, where cryptic species occur at inherently low densities (Eisenberg and Seidensticker, 1976; Karanth et al., 2004a), rendering most conventional sighting-based sampling techniques inadequate. It is these properties of populations in tropical forests that make them more vulnerable to declines and extinction (Kawanishi and Sunquist, 2004; Kenney et al., 1995) making the monitoring of their populations all the more crucial. Future monitoring efforts must aim to obtain reliable distribution and population density estimates for the target species. Poor detectability may also result from avoidance of humans in areas with high hunting pressures. We stress the need for development of rigorous techniques for population estimation of terrestrial mammals that occur at low densities in tropical forests and long-term wildlife population monitoring programs in the Protected Areas of north-east India.

Although prey depletion is a major threat to tigers (Karanth and Stith, 1999), poaching is believed to be among the primary factors resulting in the current decline. This is particularly true in Namdapha, which is located along the international border with Myanmar and close to hotspots of trade in animal body parts (Banks et al., 2006). In Myanmar, there is a documented decline of tigers due to hunting for trade (Lynam, 2003; Rao et al., 2005). Hunting is a significant threat to the persistence or recovery of tigers and other large carnivores in Namdapha. Reliable information from tribal hunters suggests that a considerable number of tigers (10–15) have been killed for the trade between 1994 and 2002 by professional poachers, mainly from Myanmar. Currently, all available information suggests that Namdapha may soon be the second Indian Tiger Reserve where the tiger has gone extinct, close on the heels of the Sariska National Park in 2004 (Tiger Task Force, 2005). The impending extinction of species from a Protected Area is a serious cause for concern and can only be halted only through more proactive measures and political resolve (Berger, 2003). However, if hunting can be stopped, recovery of tiger and other populations is possible given that Namdapha is contiguous with protected forests on all sides making this amongst the largest contiguous montane forest habitat for tigers in south Asia (Wikramanayake et al., 1998).

4.1. *Making conservation work*

The situation in Namdapha reflects a strong disparity between the law and its enforcement, indicating that legal protected status alone cannot serve to conserve wildlife populations even in a Protected Area. The relatively better status of large mammal populations in two other parks in north-east India – Kaziranga National Park (Chauhan et al., 2006; Karanth and Nichols, 2000) and Pakke Wildlife Sanctuary (Chauhan et al., 2006) – suggests that successful conservation results from dedicated park management coupled with local community support for the park and involvement in its protection. In contrast in Namdapha, an understaffed forest department infrequently patrol no more than 5% of the park; and the *Lisu* community are at odds with park authorities over issues of land rights and road development (Datta, 2007). Timely allocation of funds by the government and increasing staff motivation may improve the situation in Namdapha: however, these measures are dependent on sustained efforts from motivated park administrators. A long-term solution (and the focus of a conservation programme initiated by us) would be to gain the support and co-operation of the *Lisu*, and other tribes in the area.

There is increased awareness and willingness among the *Lisu* to control and reduce hunting since the conservation programme began in 2004 (Datta, 2007), although greater economic benefit to individual households through alternate livelihoods is essential to address the problem entirely. Their knowledge of the landscape, presents an excellent opportunity for the formation of a community protection force, whereby they could undertake park protection in return for monetary and other benefit-sharing schemes. Insights from this conservation programme suggest that judicious settlement of land rights and education and development programmes partly facilitated by park authorities can help reduce the current local antagonism to the park, and result in effective wildlife conservation.

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