

Mammals of the high altitudes of western Arunachal Pradesh, eastern Himalaya: an assessment of threats and conservation needs

Charudutt Mishra, M.D. Madhusudan and Aparajita Datta

Abstract The high altitudes of Arunachal Pradesh, India, located in the Eastern Himalaya biodiversity hotspot, remain zoologically unexplored and unprotected. We report results of recent mammal surveys in the high altitude habitats of western Arunachal Pradesh. A total of 35 mammal species (including 12 carnivores, 10 ungulates and 5 primates) were recorded, of which 13 are categorized as Endangered or Vulnerable on the IUCN Red List. One species of primate, the Arunachal macaque *Macaca munzala*, is new to science and the Chinese goral *Nemorhaedus caudatus* is a new addition to the ungulate fauna of the Indian subcontinent. We documented peoples' dependence on natural resources for grazing and extraction of timber and medicinal plants. The region's mammals are threatened by widespread hunting. The snow leopard *Uncia uncia* and dhole *Cuon alpinus* are also persecuted in retaliation

for livestock depredation. The tiger *Panthera tigris*, earlier reported from the lower valleys, is now apparently extinct there, and range reductions over the last two decades are reported for bharal *Pseudois nayaur* and musk deer *Moschus* sp.. Based on mammal species richness, extent of high altitude habitat, and levels of anthropogenic disturbance, we identified a potential site for the creation of Arunachal's first high altitude wildlife reserve (815 km²). Community-based efforts that provide incentives for conservation-friendly practices could work in this area, and conservation awareness programmes are required, not just amongst the local communities and schools but for politicians, bureaucrats and the army.

Keywords Dhole, Eastern Himalaya, human-wildlife conflict, hunting, India, *Macaca munzala*, snow leopard.

Introduction

The state of Arunachal Pradesh (83,743 km², Fig. 1) in north-east India is uniquely situated in the transition zone between the Himalayan and Indo-Burmese regions (Mani, 1974; Rodgers & Panwar, 1988). Arunachal falls within the Eastern Himalaya global biodiversity hotspot (Myers *et al.*, 2000) and is also among the 200 globally important ecoregions (Olson & Dinerstein, 1998). It harbours the world's northernmost tropical rainforests and is estimated to contain nearly 50% of the total flowering plant species in India (Rao & Hajra, 1986; Procter *et al.*, 1998; Whitmore, 1998).

Arunachal has a wide altitudinal range (100–7,090 m). The nine existing wildlife reserves (total area 9,246 km²), however, largely cover the low and mid elevation forests. This is despite the fact that 23% of Arunachal lies above 3,000 m. Only small parts of some of the existing reserves extend into the high altitude zone. Ecological studies

and wildlife surveys have also been largely confined to low and mid elevation forests (Katti *et al.*, 1992; Kaul & Ahmed, 1993; Singh, 1994; Datta, 1998; Datta, 2001; Pawar & Birand, 2001), and most of the high altitude areas of the state remain unexplored zoologically.

In this paper, we (1) summarize the results of wildlife surveys in hitherto zoologically unexplored high altitudes (2,500–5,000 m) of western Arunachal Pradesh, (2) detail species occurrence, the threats they face, and their global conservation significance, (3) document natural resource use by the local inhabitants, and (4) identify and demarcate a potential site for establishing Arunachal's first high altitude wildlife reserve.

Study area

The people of Arunachal Pradesh are predominantly tribal, with scheduled tribes forming 65% of the population. There are 26 main tribes and numerous subtribes, each with a specific geographic distribution and distinct linguistic, cultural and social identities. Nearly 80% of people are involved in agriculture. Large forested areas still remain in Arunachal, in part because of its low human population density (13 km⁻², compared to a national average of 324 km⁻²; Government of India, 2003). Nevertheless, Arunachal's decadal (1991–2001) growth

Charudutt Mishra¹ (Corresponding author), M. D. Madhusudan and Aparajita Datta Nature Conservation Foundation, 3076/5, 4th Cross Gokulam Park, Mysore 570002, India. E-mail charu@ncf-india.org

¹Also at: International Snow Leopard Trust, 4649 Sunnyside Avenue N., Suite 325, Seattle, Washington 98103, USA.

Received 29 June 2004. Revision requested 9 November 2004.
Accepted 19 April 2005. First published online 19 January 2006.

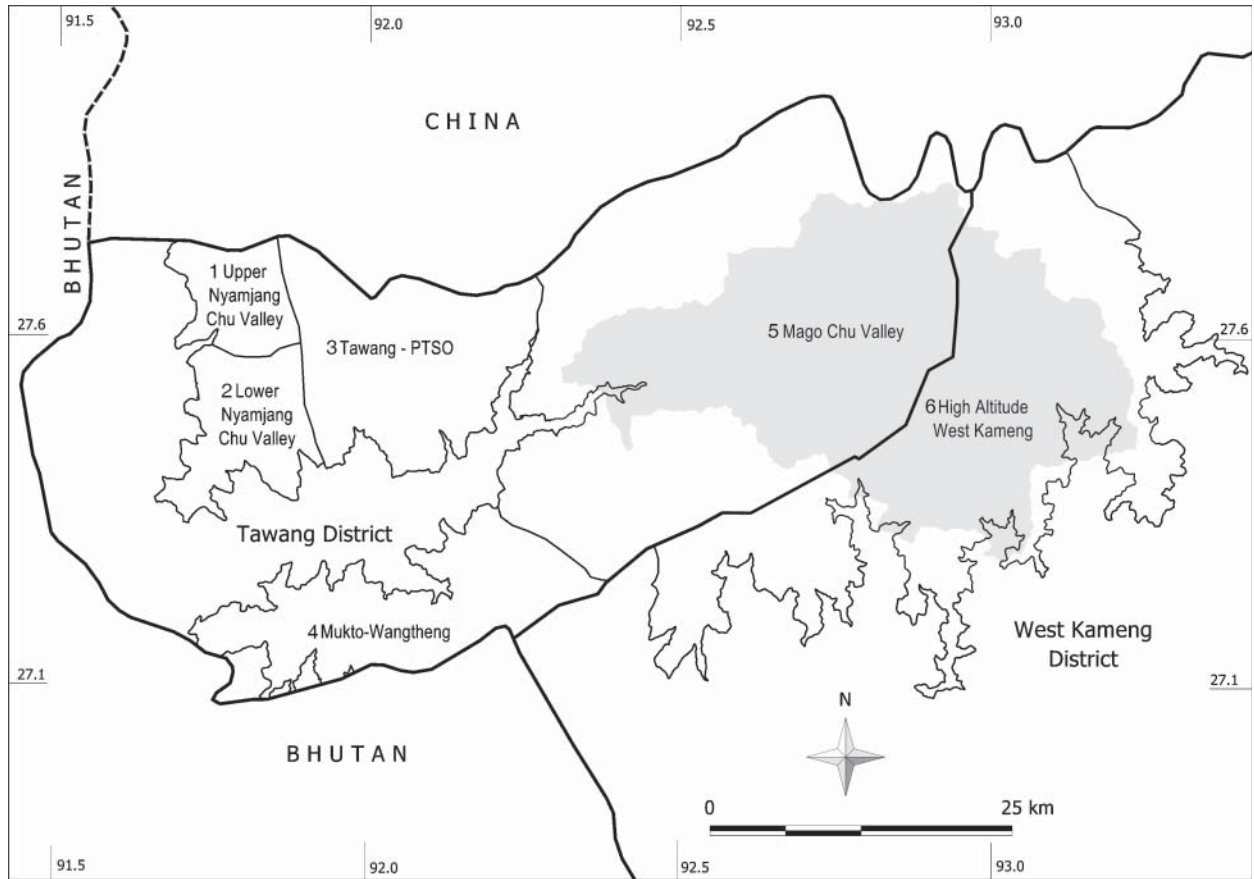


Fig. 1 The six high altitude regions in Tawang and West Kameng districts of Arunachal Pradesh. The shaded area indicates the location of the proposed high altitude wildlife reserve (see text for details).

rate of 26% is higher than the national average (21%; Government of India, 2003).

Tawang District (2,172 km²; Fig. 1) has a human population density of 16 km⁻² (Government of India, 2003). The region is drained by the Tawang Chu, Nyamjang Chu (both of which drain into Bhutan) and their tributaries. The Buddhist *Monpa* tribe is the main ethnic group. There is a considerable presence of the Indian Army in the district. The West Kameng District (7,422 km²) has a lower human density (10 km⁻², Government of India, 2003), with the people belonging to the *Monpa*, *Sherdukpen*, *Bugun*, *Aka*, and *Miji* tribes (Choudhury, 1996). The region is drained by the Kameng and its tributaries, which join the Brahmaputra.

The two districts together encompass a wide altitudinal gradient, with the Greater Himalayan Range and the state's highest peaks (Kangto 7,090 m, Gorichen 6,538 m) forming the northern boundary. People in the low-lying valleys cultivate rice. Other crops include barley, wheat, millet, maize and buckwheat. Livestock include yak, cattle, the semi-wild mithun *Bos frontalis*, and their hybrids, in addition to sheep and horses. Milk products

such as butter and cheese from yak, cattle and their hybrids form an important source of income. All livestock except horses are used for meat. Yak and sheep are also used for their wool. Women weave rugs, carpets, clothes and bags from the locally produced wool. Villages in the higher altitudes are predominantly pastoral, whereas those lower down are mostly agro-pastoral. *Monpa* is the predominant tribe inhabiting the higher altitudes.

Methods

We identified the high altitude areas (>3,000 m) in Tawang and West Kameng, and divided them into six regions: Upper Nyamjang Chu Valley, Lower Nyamjang Chu Valley, Mago Chu Valley, Mukto, Pankang Teng Tso (also known as PTSO), and the high altitude areas of West Kameng (Fig. 1). All six areas were surveyed in August and September 2003. Parts of the Upper and Lower Nyamjang Chu Valley, Mago Chu Valley, Mukto, and the high altitudes of West Kameng were revisited in April–May 2004. We distributed our survey effort

(in terms of the number of days) according to the available extent of high altitude habitat. Army restrictions prevented us from visiting elevations above 3,000 m in the Upper Nyamjang Chu Valley, and most of the information from there comes from village surveys.

We conducted field surveys with the assistance of local guides, herders and hunters, covering c. 800 km by road and c. 211 km on foot in 2003, and c. 270 km by road and c. 82 km on foot in 2004. We scanned the slopes for large vertebrates, using spotting scopes and binoculars. Indirect signs of wildlife (e.g. faeces, skins and horns) were also recorded.

We conducted interviews and informal discussions with 42 hunters and herders for information on species occurrence. We showed them photographs and drawings of the mammal species of interest and recorded their knowledge on species occurrence and natural history. We examined trophies, skins and body parts of wild animals in homes. Interviews also yielded information on hunting and hunting techniques. Local markets were visited for information on hunting and wildlife trade. We also gathered information on peoples' use and dependence on natural resources, and the losses they faced in conflicts with wildlife.

Results

Mammal records

Through interviews and indirect signs we recorded a total of 35 mammal species, of which we could confirm the occurrence of 30 by sightings and other evidence (Table 1). Of the 35 species recorded, 13 are of high conservation importance globally, categorized as Endangered or Vulnerable on the IUCN Red List (IUCN, 2004). A total of 20 species recorded are characteristically high altitude fauna, although some of them occur over a wide altitudinal range (Table 1). Interviews suggested that the tiger *Panthera tigris*, which was reported from the lower valleys until two decades ago, is now apparently extinct there. The ranges of bharal *Pseudois nayaur* and musk deer *Moschus* sp. have reportedly shrunk locally over the last three decades. There were no recent reports of musk deer from the Mukto region, where it occurred in the past. Similarly, bharal was reported to have disappeared from the Lower Nyamjang Chu Valley and from parts of PTSO, where it apparently occurred until 5–10 years ago.

We sighted 14 troops of a previously undescribed macaque, the Arunachal macaque *Macaca munzala* (Sinha *et al.*, 2005). It occurs largely over 2,000–3,500 m. Although it has a distinctive appearance, it shares some morphological features with the Assamese macaque *Macaca assamensis* (which we also recorded) and the Tibetan macaque *Macaca thibetana* (Sinha *et al.*, 2005). We sighted the Chinese goral *Nemorhaedus caudatus* twice

(four individuals), which is a new addition to the known large mammals of the Indian subcontinent. A species of pika *Ochotona* sp. could not be positively identified, although its dark colouration and habitat characteristics indicate that it is the Moupin pika *O. thibetana*. The rhesus macaque *M. mulatta* was seen at a relatively lower altitude, fringing the higher altitude areas of West Kameng. The occurrence of several other species such as the takin *Budorcas taxicolor*, wild dog *Cuon alpinus*, clouded leopard *Neofelis nebulosa* and snow leopard *Uncia uncia* was confirmed from tracks, faeces, skins and trophies (Table 1).

Hunting

At least 23 species were reported to be actively hunted, mostly for local meat consumption (Table 1). Macaques are often killed to prevent crop damage. Carnivores such as the red panda *Ailurus fulgens* and smaller cats such as the leopard cat *Prionailurus bengalensis* and clouded leopard are killed for their skins, which were reported to be traded locally. Wild pigs *Sus scrofa* are killed for meat and also to prevent crop damage. In the Mago Chu Valley people reported a perceived increase in the wild pig population, which is believed to damage pastures. Snow leopard and dhole are killed in retaliation for livestock depredation. In the Lower Nyamjang Chu Valley the villagers pool money to reward hunters for killing wild predators. Wildlife trophies are given away as presents to visiting politicians and government officials, or bartered for fuel or groceries with soldiers of the Indian army. Artefacts made from barking deer *Muntiacus muntjak* antlers and serow *Nemorhaedus sumatraensis* horns were being sold in Government-run handicraft shops in the district headquarters of both Tawang and West Kameng.

Himalayan black bear *Ursus thibetanus* and musk deer are hunted for their gall bladders and musk pods respectively, apparently catering to the larger illegal market in wildlife products. This apparently has links with middlemen from Assam, Bhutan and China. Ungulate skins (especially goral *Nemorhaedus* sp. and barking deer) are locally traded and used by herders as outdoor clothing (Mishra *et al.*, 2004). Marmots *Marmota himalayana* are killed for the reported medicinal value of their skin and fat.

In at least two villages in the surveyed areas people reported that hunting intensity had declined following the visit and preaching of the Buddhist spiritual leader, the Dalai Lama, in May 2003. Nevertheless, in most other areas we recorded widespread evidence of continued hunting (fresh kills of bharal, takin and pheasants, a 2-month old skin of a snow leopard, and abundant snares).

Table 1 Mammals confirmed or reported in the high altitudes of Tawang and West Kameng Districts, Arunachal Pradesh, with their IUCN Red List status, the type of evidence, their occurrence in the six survey areas (1, Upper Nyamjang Chu; 2, Lower Nyamjang Chu; 3, PTSO; 4, Mukto; 5, Mago Chu; 6, High altitude areas of West Kameng; Fig. 1), and the motivations and techniques employed for hunting. Species names prefixed with asterisks indicate high altitude mountain fauna.

Species	Red List status ¹	Presence ²	Evidence	Occurrence in the 6 survey areas						Hunting motivation	Main hunting techniques
				1	2	3	4	5	6		
Primates											
*Arunachal macaque <i>Macaca munzala</i>		Conf.	Sightings	+	+		+	+	+	Crop damage	Gun, bow & arrow
Assamese macaque <i>M. assamensis</i>	VU	Conf.	Sightings	+	+		+	+		Crop damage	Gun, bow & arrow
Rhesus macaque <i>M. mulatta</i>		Conf.	Sighting						+	Crop damage	Gun, bow & arrow
Capped langur <i>Trachypithecus pileatus</i>	EN	Conf.	Sightings				+		+		
Slow loris <i>Nycticebus coucang</i>	DD	Rep.		+							
Ungulates											
Barking deer <i>Muntiacus muntjak</i>		Conf.	Sightings	+	+	+	+	+	+	Meat, skin	Gun, bow & arrow, snare
*Bharal <i>Pseudois nayaur</i>		Conf.	Sightings	+		+		+	+	Meat, skin	Gun, baiting-trapping
*Chinese goral <i>Nemorhaedus caudatus</i>	VU	Conf.	Sighting						+	Meat, skin	?
*Himalayan goral <i>N. goral</i>	LR: nt	Conf.	Skins, skulls, horns	+	+	+	+	+	+	Meat, skin	Gun, bow & arrow, snare
*Red goral <i>N. baileyi</i>	VU	Conf.	Sighting						+	Meat, skin	Gun, bow & arrow, snare
*Musk deer <i>Moschus sp.</i>	LR: nt	Conf.	Skulls, faeces, tracks, hair	+	+	+		+	+	Musk pod, meat	Snare
Sambar <i>Cervus unicolor</i>		Conf.	Antlers	+	+		+	+	+	Meat	
*Serow <i>N. sumatraensis</i>	VU	Conf.	Skins, horns	+	+	+	+	+	+	Meat, skin	Gun, bow & arrow, snare
*Takin <i>Budorcas taxicolor</i>		Conf.	Horns, tracks, bedding sites						+		Gun, bow & arrow
Wild pig <i>Sus scrofa</i>	VU	Conf.	Tracks, nests, digging signs	+		+	+	+	+	Meat, crop damage	Gun
Carnivores											
Clouded leopard <i>Neofelis nebulosa</i>	VU	Conf.	Skin						+	Skin	
Common leopard <i>Panthera pardus</i>		Rep.		+	+	+	+	+	+	Skin	
Dhole <i>Cuon alpinus</i>	VU	Conf.	Skins			+	+	+	+	Livestock depredation	Gun, bow & arrow
*Himalayan black bear <i>Ursus thibetanus</i>	EN	Conf.	Tracks	+		+	+	+	+	Gall bladder	Gun
*Himalayan palm civet <i>Paguma larvata</i>		Conf.	Sighting			+					
Leopard cat <i>Prionailurus bengalensis</i>		Conf.	Sightings	+	+					Poultry depredation, sport, skin	
Marbled cat <i>Felis marmorata</i>	VU	Rep.							+	Poultry depredation, sport, skin	
Otter <i>Lutra sp.</i>	EN	Rep.		+							
*Pale weasel <i>Mustela altaica</i>		Conf.	Sighting						+		
*Red panda <i>Ailurus fulgens</i>	EN	Conf.	Sightings	+	+	+	+	+	+	Sport, skin	
*Snow leopard <i>Uncia uncia</i>	EN	Conf.	Skin			+		+		Livestock killing	Gun, snare

Table 1 (continued)

Species	Red List status ¹	Presence ²	Evidence	Occurrence in the 6 survey areas						Hunting motivation	Main hunting techniques
				1	2	3	4	5	6		
*Yellow-throated marten <i>Martes flavigula</i>		Conf.	Skin					+	+	Poultry depredation, skin	
Rodents											
*Hairy-footed flying squirrel <i>Belomys pearsonii</i>	LR: nt	Conf.	Skin				+			Sport	
*Himalayan marmot <i>Marmota himalayana</i>	LR: nt	Conf.	Sightings	+	+	+		+		Medicinal value	Gun, bow & arrow
*Himalayan striped squirrel <i>Tamias maclellandi</i>		Conf.	Sightings	+	+		+	+	+		
*Orange-bellied Himalayan squirrel <i>Dremomys lokriah</i>		Conf.	Sightings			+		+	+		
Porcupine <i>Hystrix</i> sp.		Rep.						+			
Lagomorphs											
*Large-eared pika <i>Ochotona macrotis</i>		Conf.	Sightings, faeces		+			+	+		
*Moupin pika <i>O. thibetana</i>		Conf.	Sightings, faeces					+	+		
Pholidota											
Chinese pangolin <i>Manis pentadactyla</i>	LR: nt	Conf.	Skin						+		

¹EN, Endangered; VU, Vulnerable; LR: nt, Lower Risk: near threatened; DD, Data Deficient

²Conf., confirmed; Rep., reported

Natural resource use

We found other forms of natural resource use among the resident people. A majority of the forest area is under the traditional ownership and *de facto* control of the village councils, and families appear to have rights over most of the grazing land (the remaining pastures belong to village councils). High altitude meadows (4,200–5,250 m) and krummholz *Rhododendron* areas (4,000–4,500 m) are grazed by livestock during summer. In areas between 2,500 and 4,200 m forests continue to be cleared to create grazing meadows.

Forests are also used for collecting fuelwood, timber, bamboo for house-building and oak *Quercus* sp. leaf litter for manure. In some areas timber is commercially traded, with fir *Abies densa* being the most important species. In the higher areas *Rhododendron* shrubs and trees are valued as firewood as they burn well even when fresh. Leaves and small branches are regularly gathered from *Juniperus* spp., a tree of great importance in Buddhist rituals and culture. In many villages the councils locally administer regulations on collection of bamboo and other forms of extraction.

Collection of medicinal plants appears to be an important source of cash for the villagers. The main species in trade are *Swertia* sp., *Taxus baccata*, *Dactylorhiza hatagireia*, *Cordyceps chinensis*, *Rubia* sp. and *Picrorrhiza kurrooa*. Villagers reported a rapid decline in the abundance of medicinal plants because of unregulated collection. Fruits of the star anise *Ilicium griffithii*, sold as spice, are also a source of income. There are two small (<100 ha)

sacred forests near Tawang and Mukto, where no hunting or any other form of resource extraction is allowed. We did not conduct surveys within these sacred forests.

Comparison of survey areas

Mukto was the area most heavily hunted, followed by Lower Nyamjang Chu Valley, the PTSO region, the high altitude areas of West Kameng, and then the Mago Chu Valley (Table 2). The least hunted site was the Upper Nyamjang Chu Valley, where village councils have voluntarily imposed a ban on hunting because of their Buddhist beliefs. In all surveyed areas government officials from other parts of Arunachal and workers of the Border Roads Organization were reported to hunt heavily.

The army is present in most of the region but high altitude wildlife habitats in the PTSO appear to be the most heavily disturbed because of large army establishments. The presence of the army has also led to the creation of a road network, with Tawang having the best road network in the state. The high altitude habitats of West Kameng were relatively free from such disturbance, except areas around the Se La pass, which have high vehicular traffic and army presence. In this high altitude area the army establishments and personnel require a constant supply of fuelwood throughout the year for heating, and also for construction. This has caused considerable forest degradation and loss in parts of both districts.

Table 2 A comparison of conservation importance and potential of the six high altitude regions of Tawang and West Kameng Districts, Arunachal Pradesh (Fig. 1). Species considered to be of global conservation importance are those listed as Endangered or Vulnerable on the IUCN Red List (IUCN, 2004).

Attribute	1, Upper Nyamjang Chu	2, Lower Nyamjang Chu	3, PTSO	4, Mukto	5, Mago Chu	6, W Kameng
Extent of high altitude habitat (km ²)	77	116	261	231	968	614
Number of mammal species recorded	16	15	13	14	19	25
Species of global conservation importance	4	3	5	4	6	10
Number of high altitude mammal species	9	10	9	7	15	15
Present hunting intensity	Low	High	High	Very high	Medium	High
Disturbance level	Low	Medium	High	Medium	Medium	Medium
Main forms of disturbance	Army bases	Human habitation	Army bases	Human habitation	Human habitation	Human habitation

The contiguous area encompassing parts of West Kameng and Mago Chu Valley is the most important for wildlife conservation (Tables 1 & 2), with the richest mammalian assemblage (29 species) and extensive habitat, and is relatively less disturbed by the army. Of the 20 high altitude mammal species recorded, the area harbours at least 18 (Table 1). Although we did not record the Himalayan palm civet *Paguma larvata* and the hairy-footed flying squirrel *Belomys pearsonii* they probably also occur here, given the extent of available habitat. Of the 13 species of global conservation importance in the region (Table 1), 12 species occur in these two areas.

Based on our data we used terrain and vegetation maps (for details, see Mishra *et al.*, 2004) to delineate an area of 815 km² in the upper Mago Chu Valley and West Kameng (altitudinal range 2,400 m to >6,400 m) that is suitable for the creation of a high altitude wildlife reserve (Fig. 1).

Discussion

Our survey has established the presence of a rich mammalian assemblage at high altitudes in western Arunachal, including 13 species of global conservation importance. This high altitude fauna includes elements from both the Palearctic and Indomalayan realms (Corbet & Hill, 1992). Amongst the species recorded, the Arunachal macaque is a new species, and the Chinese goral was previously unknown in India. Its discovery makes western Arunachal the only region in the world known to harbour all three extant species of goral. The pale weasel is a new record for the state. We were able to confirm the previously unsubstantiated reports of the occurrence of the snow leopard in the area.

Hunting is the most serious threat to wildlife throughout Arunachal Pradesh (Datta, 2002). This traditional practice has formed linkages with the international illegal trade in wildlife products. Furthermore, limited awareness of conservation laws has meant that even Government officials and politicians were commonly reported to hunt across the area, and there is limited

enforcement of the Indian Wildlife (Protection) Act, 1972. Although we did not find wild meat being sold openly, display and sale of wildlife trophies even in Government-run handicraft shops perhaps best reflect the extent of the ignorance of conservation and wildlife laws.

Wildlife conservation is currently not a priority for most government departments, and realistic measures to reduce hunting will therefore require the participation of the local communities. We believe that community-based programmes (e.g. wildlife tourism and conservation-linked handicrafts development; Mishra *et al.*, 2003) that provide incentives for conservation-friendly practices could work in this area. In recent years Tawang has been promoted as an important tourist destination (with the highest number of domestic and foreign tourists in the state), and there is considerable potential for community-based wildlife tourism. Means of offsetting livestock losses to wild carnivores are also required. Conservation programmes could take advantage of the fact that Buddhism, which preaches compassion and tolerance towards all forms of life, is the predominant religion in the area. At the same time, conservation awareness programmes are required not only amongst the local communities and schools but for politicians, bureaucrats and the army. Finally, establishment of the wildlife reserve proposed here (Fig. 1) will afford protection to the entire high altitude mammalian fauna of western Arunachal.

Based on our study, recommendations and continuing technical assistance, the Arunachal Pradesh Forest Department is setting up a biosphere reserve, to be named His Holiness Tsangyang Gyatso World Peace Park. In November 2004, in a public meeting, the state Chief Minister declared the intention of the state to set up this c. 2,000 km² reserve, with the region we have demarcated forming the core area. With support and involvement of the state polity, the Forest Department has forwarded the proposal to the Federal Government, which is expected to approve it shortly (P. Ringu, pers. comm.).

Acknowledgements

This work was undertaken jointly by the Nature Conservation Foundation, the International Snow Leopard Trust and the Wildlife Conservation Society. Financial support came from The Rufford Foundation, UK, and the Van Tienhoven Foundation, The Netherlands. We are grateful to the Arunachal Pradesh Forest Department for inviting us to conduct the survey, and particularly thank S.K. Raha, Pekom Ringu and the District Forest Officers of Tawang and Bomdila for their support and interest. Thanks are also due to Omak Apang, Herbert H.T. Prins, H.P. Noteboom and Josh Cole. Invaluable field-support came from Dorje Norbu and Jimmy Gyatso.

References

- Choudhury, S.D. (1996) *Arunachal Pradesh District Gazetteers: East Kameng, West Kameng, and Tawang Districts*. Gazetteers Department, Government of Arunachal Pradesh, Shillong, India.
- Corbet, G.E. & Hill, J.E. (1992) *The Mammals of the Indomalayan Region: A Systematic Review*. Oxford University Press, New York, USA.
- Datta, A. (1998) Hornbill abundance in unlogged forest, selectively logged forest and a forest plantation in Arunachal Pradesh, India. *Oryx*, **32**, 285–294.
- Datta, A. (2001) *An ecological study of sympatric hornbills and fruiting patterns in a tropical forest in Arunachal Pradesh*. PhD thesis, Saurashtra University, Rajkot, India.
- Datta, A. (2002) *Status of Hornbills and Hunting of Wildlife in Lohit, Changlang and Tirap Districts of Eastern Arunachal Pradesh*. Report submitted to the Wildlife Conservation Society India-Program, New York, and the Forest Department of Arunachal Pradesh.
- Government of India (2003) *Census of India – 2001*. <http://www.censusindia.net/results/popul.html> [accessed 21 July 2003].
- IUCN (2004) *IUCN Red List of Threatened Species*. IUCN, Gland, Switzerland [http://www.redlist.org, accessed 15 July 2003].
- Katti, M., Singh, P., Manjrekar, N., Sharma, D. & Mukherjee, S. (1992) An ornithological survey in eastern Arunachal Pradesh. *Forktail*, **7**, 75–89.
- Kaul, R. & Ahmed, A. (1993) Pheasant surveys in Arunachal Pradesh, India. In *Pheasants in Asia 1992* (ed. D. Jenkins), pp. 50–54. World Pheasant Association, Reading, UK.
- Mani, M.S. (1974) *Ecology and Biogeography in India*. Dr. W. Junk b.v. Publishers, The Hague, The Netherlands.
- Mishra, C., Allen, P., McCarthy, T., Madhusudan, M.D., Bayarjargal, A. & Prins, H.H.T. (2003) The role of incentive programs in conserving the snow leopard *Uncia uncia*. *Conservation Biology*, **17**, 1512–1523.
- Mishra, C., Datta, A. & Madhusudan, M.D. (2004) *The High Altitude Wildlife of Western Arunachal Pradesh: A Survey Report*. CERC Technical Report No. 8. Nature Conservation Foundation, International Snow Leopard Trust & Wildlife Conservation Society India Program, Mysore, India.
- Myers, N., Mittermeier, R.A., Mittermeier, C.A., da Fonseca, G.A.B. & Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*, **403**, 853–858.
- 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.
- Pawar, S.S. & Birand, A. (2001) *A Survey of Amphibians, Reptiles, and Birds in Northeast India*. CERC Technical Report No. 6. Nature Conservation Foundation, Mysore, India.
- Procter, K.H., Haridasan, K. & Smith, G.W. (1998) How far does lowland tropical rainforest go? *Global Ecology and Biogeography Letters*, **7**, 141–146.
- Rao, R.R. & Hajra, P.K. (1986) Floristic diversity of the eastern Himalaya – in a conservation perspective. *Proceedings of Indian Academy of Sciences (Animal Science / Plant Science)*, **Supplement**, 103–125.
- Rodgers, W.A. & Panwar, H.S. (1988) *Planning a Wildlife Protected Area Network in India, Volume I & II. A Report Prepared for the Department of Environment, Forests & Wildlife, Government of India*. Wildlife Institute of India, Dehradun, India.
- Singh, P. (1994) Recent bird records from Arunachal Pradesh. *Forktail*, **10**, 65–104.
- Sinha, A., Datta, A., Madhusudan, M.D. & Mishra, C. (2005) The Arunachal macaque *Macaca munzala*: a new species from western Arunachal Pradesh, northeastern India. *International Journal of Primatology*, **26**, 977–989.
- Whitmore, T.C. (1998) *An Introduction to Tropical Rain Forests*. Oxford University Press, Oxford, UK.

Biographical sketches

Charudutt Mishra studies grazing systems, pastoralism, large herbivore community ecology, carnivore ecology and human-wildlife conflicts, focusing in particular on high altitude ecology and conservation. He also runs community-based conservation programmes and is Director of the India Program of the International Snow Leopard Trust.

M.D. Madhusudan's work broadly aims to identify limits and opportunities to reconcile human resource use with the goals of wildlife conservation in India. He studies large mammal ecology in south India and works on conservation projects for high altitude wildlife in the Himalaya.

Aparajita Datta has been involved in research on hornbills in Arunachal Pradesh and her interests include frugivory and seed dispersal. Her work has led to the discovery of large mammal species new to the Indian subcontinent. She presently leads a community-based Hornbill Conservation Program that aims to secure the cooperation of tribal communities to conserve Arunachal's rainforests and their wildlife.

Postscript

Confirmation has now been received that the biosphere reserve described in the last paragraph of the Discussion has been approved by the central Government (P. Ringu, pers. comm., 7 December 2005).