CERC Technical Report No. 8

The High Altitude Wildlife of Western Arunachal Pradesh

A Survey Report

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ISLT WCS NCF

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Cover photographs
Front: A high altitude lake near Kyemnya La, within the proposed wildlife reserve
Back: Large eared pika *Ochotona macrotis*; Wooden mask from Tawang

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By

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The High Altitude Wildlife of Western Arunachal Pradesh: A Survey Report

Abstract

The high altitude wildlife of Arunachal Pradesh, located in the Eastern Himalaya biodiversity hotspot, has remained unexplored and unprotected. Between August and October, 2003, we undertook a biological expedition in the high altitudes (> 3000 m) of Tawang and West Kameng Districts of Western Arunachal Pradesh, with the objective of inventorying wildlife and identifying areas for the establishment of wildlife reserves. The expedition documented the occurrence of a rich mammalian species assemblage (34 species), 12 of which are of global conservation importance. Our discovery of the Chinese goral *Nemorhaedus caudatus* represents a new addition to the list of large mammals of the Indian sub-continent. We also recorded a primate belonging to the *sinica* group of the genus *Macaca,* which is potentially a species new to science. We recorded 150 bird species, identified 140 plant species, and prepared a preliminary description of the high altitude vegetation. We also documented peoples' dependence on natural resources (grazing, collection of timber and medicinal plants), and the threats to the region's wildlife, including widespread hunting, and persecution of the snow leopard *Uncia uncia* and dhole *Cuon alpinus* in retaliation against livestock depredation. Preliminary vegetation maps were prepared using field data in conjunction with satellite imageries. Based on information about the wildlife assemblages, extent of high altitude habitat, and levels of anthropogenic disturbance, we identify and propose an important site (815 km^2) for the creation of a wildlife reserve. Future conservation efforts need to focus on establishing the state's first high altitude wildlife reserve, and garnering the support of indigenous people for wildlife conservation through community-based programs.

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Charu, Aparajita and Madhu
January 2004, Mysore

Chapter 1

A biological expedition in the high altitudes of Western Arunachal Pradesh, Eastern Himalaya

Introduction

A rich diversity of life

The state of Arunachal Pradesh in northeast India is uniquely situated in the transition zone between the Himalayan and Indo-Burmese regions (26°28'– 29°30'N and 91°30'– 97°30'E; 83,743 km²; Fig. 1)[1,2]. Arunachal is located within the Eastern Himalaya global biodiversity hotspot[3] and is also among the 200 globally important ecoregions[4]. The state harbours the world's northernmost tropical rainforests and is estimated to have nearly 50 % of the total flowering plant species in India[5-8]. Of the 1200 bird species in India, nearly 600 have been recorded from the state[9], which is also recognized as an important endemic bird area[10]. Arunachal is also home to fascinating species of large herbivores such as the takin *Budorcas taxicolor*, goral *Nemorhaedus goral*, and serow *Nemorhaedus sumatraensis*, several species of primates, and carnivores such as the common leopard *Panthera pardus*, clouded leopard *Neofelis nebulosa*, and tiger *Panthera tigris*.

The wide altitudinal range (100 m to over 6000 m) within Arunachal has brought about a great diversity of habitat and forest types, and a rich diversity of animal and plant life. Lowland tropical evergreen and semi-evergreen forests occur up to 1500 m, temperate oak and conifer forests up to 3500 m, and alpine areas above 3500 m. Large areas of forest still remain in the state, in part due to its low human population density (13 per km²)[11]. Although Arunachal has the lowest human density compared to other Indian states, its decadal growth rate (1991-2001) of 26% is higher

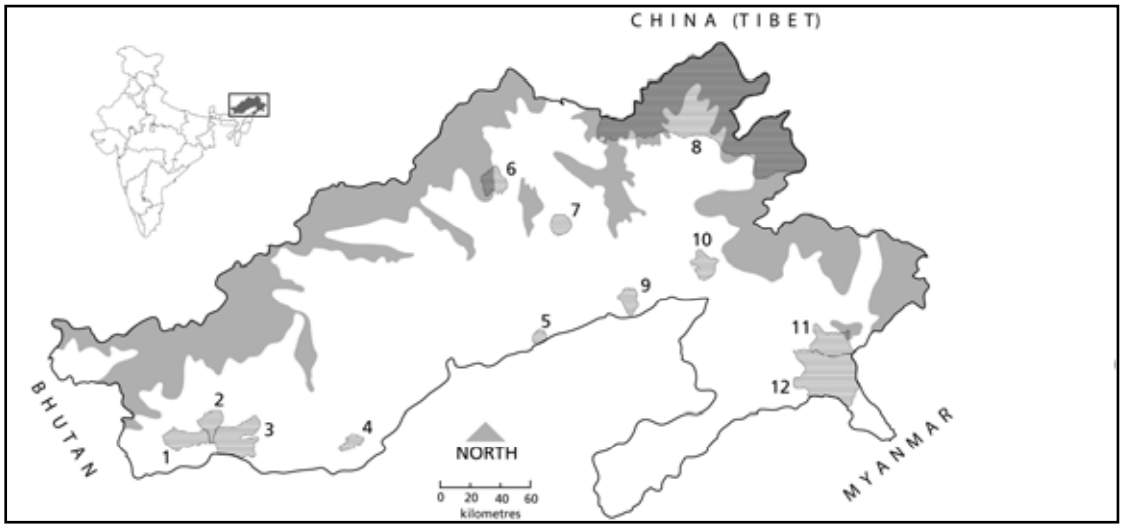

Fig. 1. Map of Arunachal Pradesh, north-east India. Hatched regions represent protected areas. The high altitude region (> 3000 m) of the state is shaded gray. Note the near absence of protected areas in the high altitudes. 1. Eagle's Nest Wildlife Sanctuary 2. Sessa Orchid Sanctuary 3. Pakhui WS 4. Itanagar WS 5. Kane WS 6. Yordi Rabe Supse WS 7. Mouling National Park 8. Dihang Dibang Biosphere Reserve 9. D'Ering WS 10. Mehao WS 11. Kamlang WS 12. Namdapha NP.

Wildlife of Arunachal's high altitudes has remained poorly explored

than the national average[11]. The people are predominantly tribal, with scheduled tribes forming 79% of the population. There are 26 main tribes and numerous sub-tribes, each with a specific geographic distribution and distinct linguistic, cultural and social identities. These tribal groups speak about 50 languages and dialects, belonging mostly to the Tibeto-Burmese branch of the Sino-Tibetan language family. Agriculture is the main occupation (nearly 80%) of the people of Arunachal.

Arunachal's wildlife reserves

Nine wildlife sanctuaries and two national parks covering an area of 9246 km² (11 % of the state) have been established by the Arunachal Pradesh Forest Department (Fig. 1). Another wildlife sanctuary, called Tale Valley, has also been declared recently. Yet, the protected areas of Arunachal largely cover only the low- and mid-elevation forests (Fig. 1). This is despite the fact that 23 % of the area of the state is above 3000 m. Only small parts of Namdapha Tiger Reserve (Changlang District), Kamlang Wildlife Sanctuary (Lohit) and Yordi Rabe Supse Wildlife Sanctuary (West Siang) extend into the high altitude zone. The recently designated Dibang Valley Biosphere Reserve does cover some high altitude regions, but its protected area status is only nominal, with minimal protection infrastructure or inventorying of wildlife.

Wildlife research and exploration in Arunachal

Most wildlife surveys in Arunachal have also been restricted to low and mid elevation forests, and include surveys of rare species[12-16] and avifauna[9,17-20]. Recent herpetofaunal surveys have yielded several new species, range extensions and first records for India[17,20,21]. Our recent discovery of the leaf deer *Muntiacus putaoensis* in eastern Arunachal represents a new addition to the list of large mammals of the Indian sub-

continent[22]. Some research projects[23-26] have also been undertaken in these areas over the last five years. Observations on smaller carnivores, other mammals and turtles in the area have been published[27-30]. These few surveys and ecological studies conducted in the state have yielded important discoveries and information[15,23,25,31], but many areas, especially in the high altitudes still remain unexplored. The only exception is a survey of pheasants in mid elevation forests and alpine areas[15].

The expedition

History

The Nature Conservation Foundation has a high altitude program, which is a conservation partnership with the International Snow Leopard Trust. In response to a questionnaire survey by NCF-ISLT in 2002, Arunachal's Wildlife Department officials (The Chief Wildlife Warden and Mr. Pekyom Ringu, DCF) expressed a strong need for exploring the high altitude wildlife of the state, and identifying areas for conservation. NCF has so far been working in Namdapha National Park in eastern Arunachal. Given the wildlife department's seriousness in conserving Arunachal's high altitude wildlife, and in response to their request, we decided to undertake this biological expedition collaboratively with our partners, the ISLT and the Wildlife Conservation Society (India Program). Two international conservation agencies, The Rufford Foundation and the Van Tienhoven Foundation, came forward to support the bulk of the expedition costs. Arunachal's wildlife department agreed to provide the expedition support in terms of permissions and technical advice.

Objectives

During this expedition, we specifically aimed to:

1. Inventory the occurrence of mammals and avifauna in the high altitudes of Arunachal Pradesh, and map wildlife habitats
2. Assess the status of high altitude wildlife and identify important threats to their conservation
3. Prepare a preliminary profile of the socio-economic status and natural resource use among the resident people in the high altitudes
4. Identify areas with long-term conservation potential for establishing wildlife reserves in the high altitudes of Arunachal Pradesh

The area

The survey was originally planned over three districts, namely, Tawang, West Kameng and East Kameng. However, considering field logistics, we opted to cover the entire high altitude areas of Tawang and West Kameng comprehensively, instead of partially covering all three districts. Tawang District spans over 2172 km^2 with a human population density (16 per km^2) marginally exceeding the average for Arunachal (13 per km^2)[11]. The region is drained by the Tawang Chu, Nyamjang Chu (both of which meet and drain into Bhutan) and their tributaries, and comprises five administrative circles (Tawang, Mukto, Thingbu, Lumla, and Zemithang). The Buddhist *Monpa* tribe is the predominant community inhabiting Tawang. There is a considerable presence

The Buddhist *Monpa*, the main tribe of the high altitudes, are predominantly agropastoralists

of the Indian Army in the district, given that it shares international boundaries with Bhutan and China.

The larger (7422 km^2) West Kameng District has a lower human density (10 per km^2)[11], with the people belonging to 5 tribes: *Monpa, Sherdukpen, Khowa, Aka*, and *Miji*[32]. The region is drained by the Kameng or Bhareli and its tributaries (eventually joining the Brahmaputra), and is divided into six adiministrative circles (Bomdila, Dirang, Kalaktang, Bhalukpong, Nafra, and Thrizino).

These two districts together encompass a wide altitudinal gradient, with the Greater Himalayan Range and the state's highest peaks (Kangto 7090 m, Gorichen 6538 m) forming the northern boundary. People in the relatively low-lying valleys cultivate rice. Other crops include barley, wheat, millet, maize, buckwheat, etc. Livestock include yak, cattle, mithun, and their hybrids, in addition to sheep and horses. They are used for wool, meat, and milk products such as butter and cheese which form the main source of income. Women weave rugs, carpets, clothes and bags from the locally produced wool. Some villages in the higher altitudes are predominantly pastoral, while most are agro-pastoral. Cultivation can be found up to 3000 m. High altitude areas between 3500 m and 5200 m are used for summer grazing (especially by yak, sheep, and yak-cattle hybrids). *Monpa* are the predominant community inhabiting the higher altitudes. Towards the eastern limit of our survey region, the *Miji* of East Kameng sometimes hunt in the same high altitude areas that are used for livestock grazing and hunting by *Monpa*. As a result, there is a certain level of conflict between the two tribes over their hunting and grazing rights in the eastern part of West Kameng's high altitudes.

Methods

Through existing terrain maps, we identified the entire high altitude areas (> 3000 m) in Tawang and West Kameng districts, and for convenience, divided them into six regions: Upper Nyamjang Chu Valley, Lower Nyamjang Chu Valley, Mago Chu Valley, Mukto, PTSO, and the high altitude areas of West Kameng (Fig. 2). All six areas were then surveyed between August and October 2003. We distributed our survey effort (in terms of the number of days) amongst these areas according to the available extent of high altitude habitat. In Upper Nyamjang Chu Valley, we were

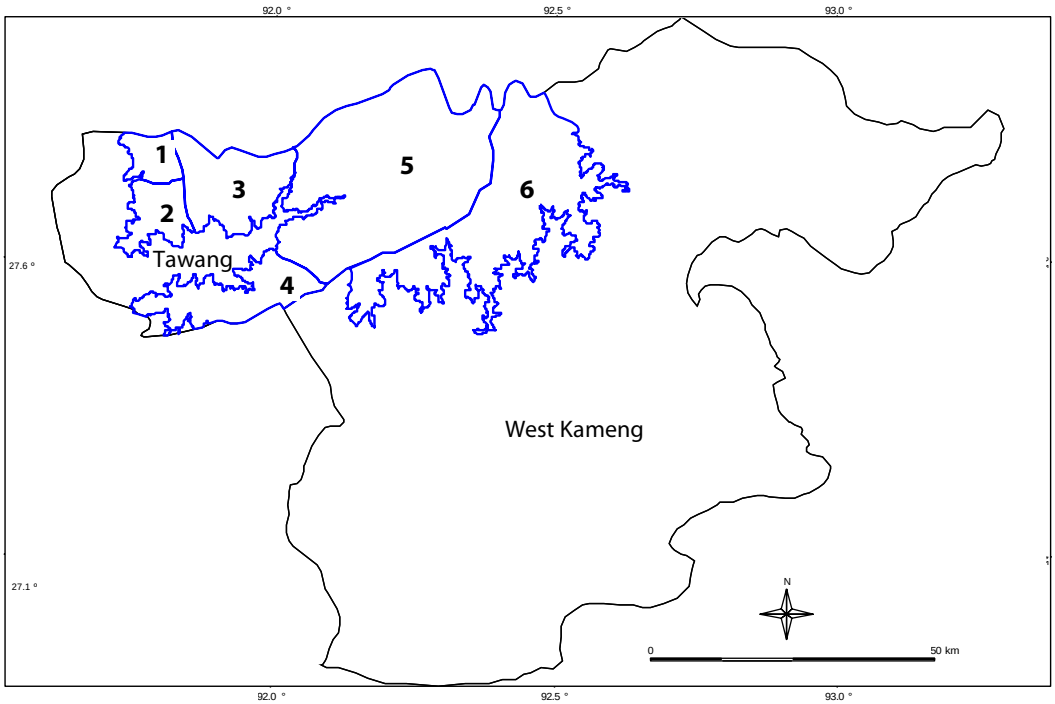

Fig. 2. The six high altitude regions in Tawang and West Kameng districts of Arunachal Pradesh. 1 Upper Nyamjang Chu Valley; 2 Lower Nyamjang Chu Valley; 3 PTSO; 4 Mukto; 5 Mago Chu Valley and 6 High Altitude West Kameng

prevented from going to elevations above 3000 m by the army, and most of the information presented from that region comes from interviews and village surveys.

We conducted extensive field surveys in the high altitudes with the assistance of local guides, herders, and hunters, covering 740-800 km by road and at least 211 km on foot. We scanned the slopes from vantage points for large vertebrate wildlife, using spotting scopes and binoculars. Sighting records of all mammal and bird species were maintained, including their location, altitude, and habitat type. Indirect signs of wildlife were also recorded (e.g. faeces, skins, and horns). We recorded GPS locations across the landscape, and made notes on vegetation and habitat. This information was used together with satellite imageries to develop vegetation maps.

We conducted extensive interviews and informal discussions with hunters and herders for information on species occurrence. We showed them photographs and

We collected information on wildlife occurrence through extensive field surveys, by examining wildlife trophies and skins, and also by interviewing villagers, herders and hunters.

drawings of the several mammal species of interest. Their knowledge on the occurrence and natural history of mammal species in the area was recorded. A total of 42 hunters and herders were interviewed. We examined trophies and skins, and photographed live and dead specimens, and body parts of wild animals. Local markets were visited for information on hunting and trade related to wildlife.

Interviews and informal discussions with villagers also yielded information on species hunted and hunting techniques. We also gathered information on peoples' use and dependence on natural resources, and the losses they faced in conflicts with wildlife (via crop damage and livestock killing by wild carnivores).

The report

The main body of this report contains three chapters that detail our expedition findings. The first (Chapter 2) documents the impressive mammalian assemblage that we recorded in Western Arunachal's high altitudes. We detail species occurrence, the main threats they face, and the conservation significance of this rich mammalian assemblage from a global perspective. We also compare the six high altitude regions of Tawang and West Kameng in terms of their species richness, conservation status, the extent of high altitude habitat available, and their overall conservation importance. Based on this information, we identify an important site that is well suited for the establishment of Arunachal's first high altitude wildlife reserve. In Chapter 3, we present details of a preliminary mapping exercise. We map the landscape and vegetation of the entire region, and delineate boundaries for the newly proposed wildlife reserve. In Chapter 4, we revisit the main findings of the expedition, and briefly outline directions for future conservation efforts in the high altitudes of western Arunachal Pradesh.

We have restricted the information presented in the main body of the report to these three chapters. This has been done in order to emphasize the main focus of the report, which is to establish the urgent need for conservation efforts in Arunachal's high altitudes. We have chosen to present several significant findings of the expedition as appendices. Appendix 1 details the expedition's discovery of the Chinese goral *Nemorhaedus caudatus* – this represents the second addition to the list of large mammals of the Indian sub-continent in two years, both from Aruanchal. In Appendix 2, we provide a description of the 'Tawang macaque' *Macaca* sp. recorded during the expedition, which is perhaps a species new to science. Appendix 3 and 4 are check-lists of birds and plants that we recorded during the expedition. Appendix 5 includes the technical and methodological details of our mapping exercise.

References

1. Mani, M.S. (1974) *Ecology and Biogeography in India*. Dr.W.Junk b.v. Publishers, The Hague.
2. 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.
3. 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.
4. 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.

5. Procter, K.H., Haridasan, K. & Smith, G.W. (1998) How far does lowland tropical rainforest go? *Global Ecology and Biogeography Letters*, **7,** 141-146.
6. Rao, R.R. & Hajra, P.K. (1986) Floristic diversity of the eastern Himalaya - in a conservation perspective. *Proceedings of Indian Academy of Scieces (Animal Science / Plant Science) Supplement*, 103-125.
7. Whitmore, T.C. (1998) *An Introduction to Tropical Rain Forests*. Oxford University Press, Oxford, UK.
8. Chowdhury, H.J. (1998) *Orchids of Arunachal Pradesh*. Bishen Singh Mahendra Pal Singh, Dehra Dun, India.
9. Singh, P. (1994) Recent bird records from Arunachal Pradesh. *Forktail*, **10,** 65-104.
10. Stattersfield, J.A., Crosby, M.J., Long, A.J., & Wege, D.C. (1998) *Endemic Bird Areas of the World: Priorities for Biodiversity Conservation*. The Burlington Press Ltd., Cambridge.
11. Government of India. (2003) Census of India - 2001. Available from http://www.censusindia.net/results/popul.html (accessed 21/7/2003).
12. Kaul, R. & Ahmed, A. (1993) Pheasant surveys in Arunachal Pradesh, India. *Pheasants in Asia 1992* (ed D. Jenkins), pp. 50-54. World Pheasant Association, Reading, UK.
13. Athreya, V.R. & Johnsingh, A.J.T. (1995) Survey of the clouded leopard (*Neofelis nebulosa*) in North-east India. -40. Wildlife Institute of India, Dehradun, India.
14. Katti, M., Singh, P., Manjrekar, N., Sharma, D. & Mukherjee, S. (1992) An ornitohological survey in eastern Arunachal Pradesh. *Forktail*, **7,** 75-89.
15. Kumar, S. & Singh, P. (1999) *A Study on Pheasant Distributions in Arunachal Pradesh, Eastern Himalaya, India*. Wildlife Institute of India, Dehradun.
16. Katti, M., Manjrekar, N., Mukherjee, S. & Sharma, D. (1990) Wildlife survey in Arunachal Pradesh with special reference to takin. Unpublished report. Wildlife Institute of India, Dehradun.
17. Athreya, R.M. (1997) *A Faunal Survey of Namdapha Tiger Reserve, Arunachal Pradesh, India*.
18. Datta, A., Singh, P., Athreya, R.M. & Karthikeyan, S. (1998) Birds of Pakhui Wildlife Sanctuary in western Arunachal Pradesh, north-east India. *Newsletter for Birdwatchers*, **38,** 91-96.
19. Singh, P. (1999) Bird survey in selected localities of Arunachal Pradesh, India. Report, Wildlife Institute of India.
20. 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.
21. Captain, A.S. & Bhatt, B.B. (1997) Some snakes of the Itanagar area of Papumpare District, Arunachal Pradesh. *Arunachal Forest News*, **15,** 12-14.
22. Datta, A., Pansa, J., Madhusudan, M.D. & Mishra, C. (2003) Discovery of the leaf deer *Muntiacus putaoensis* in Arunachal Pradesh: an addition to the large mammals of India. *Current Science*, **84,** 101-103.
23. Datta, A. & Goyal, S.P. (1997) Responses of arboreal mammals (primates and squirrels) to selective logging in Arunachal Pradesh, north-east India. Report submitted to the Forest Department of Arunachal Pradesh. -73. Wildlife Institute of India, Dehradun.
24. Padmawathe, R. (2001) *Patterns in species composition and distribution of vascular epiphytes in low-lying semi-evergreen forests of Arunachal Pradesh, India*. M.Sc. dissertation Saurashtra University, Rajkot, India
25. Datta, A. (2001) *An ecological study of sympatric hornbills and fruiting patterns in a tropical forest in Arunachal Pradesh*. Ph.D. Saurashtra University
26. Datta, A. (1998) Hornbill abundance in unlogged forest and a forest plantation in Arunachal Pradesh, India. *Oryx*, **32,** 285-294.
27. Datta, A. (1998) Records of turtles from Pakhui Wildlife Sanctuary, Arunachal Pradesh, Northeast India. *J.Bombay Nat.Hist.Soc.*, **95,** 121-123.
28. Datta, A. (1998) Evidence of clouded leopard *Neofelis nebulosa* in Pakhui Wildife Sanctuary, Arunachal Pradesh. *Journal of the Bombay Natural History Society*, **95,** 498-499.
29. Datta, A. (1999) Pangolin sightings in western Arunachal Pradesh. *Journal of the Bombay Natural History Society*, **96,** 310.

30. Datta, A. (1999) Small carnivores in two protected areas of Arunachal Pradesh. *J.Bombay Nat.Hist.Soc.*, **96,** 399-404.
31. Datta, A. (2000) Pheasant abundance in selectively logged and unlogged forests of western Arunachal Pradesh, Northeast India. *Journal of the Bombay Natural History Society*, **97,** 177-183.
32. Choudhury, S.D. (1996) *Arunachal Pradesh District Gazetteers: East Kameng, West Kameng, and Tawang Districts*. Gazetteers Department, Government of Arunachal Pradesh, Shillong, India.

Chapter 2

Conservation status of the high altitude wildlife of Western Arunachal Pradesh, Eastern Himalaya

In this chapter, we report the occurrence of large mammals in western Arunachal's high altitudes and the threats to their conservation. Based on this information, we also identify areas where a high altitude wildlife reserve could be established. While the main focus of our survey was on areas lying above 3000 m, we have also included information from adjoining habitats at lower elevations (2500-3000 m).

Results

Mammal records

Through interviews, direct sightings and evidences, we recorded the occurrence of a total 34 mammal species, of which we confirmed the occurrence of 27 species through sightings and direct evidences (Table 1). The tiger, which was reported to occur in the past, is now apparently extinct. Twelve of the 34 species recorded are of high conservation importance globally, being listed either as Endangered or Vulnerable in the IUCN's Red List of Threatened Species[1] (Table 2). A total of 19 species recorded during the survey may be considered high altitude mountain fauna, although some of them do occur over a wide altitudinal range (Table 1). Besides the disappearance of the tiger, our interviews indicated that the ranges of bharal and musk deer have shrunk locally over the last 3 decades. Musk deer, for instance, was reported in the

We recorded a rich and fascinating assemblage of mammals. The endangered dhole *Cuon alpinus* (left) is persecuted in retaliation against livestock predation. The Tawang macaque *Macaca* sp. (right) discovered on this survey is perhaps a species new to science. Smaller mammals recorded include the orange-bellied squirrel *Dremomys lokriah* (top inset), Himalayan marmot *Marmota himalayana* (centre inset), and the large eared pika *Ochotona macrotis* (lower inset).

past to occur in the Mukto region. Similarly, bharal was reported to have disappeared from the Lower Nyamjang Chu Valley, as well as from parts of PTSO, where it apparently occurred 5-10 years back.

We sighted eight troops of the 'Tawang macaque' *Macaca* sp. which is perhaps a primate species new to science (Appendix 2). The rhesus macaque *M. mulatta* was seen at a relatively lower altitude area fringing the high altitude areas of West Kameng. One of the pika species we sighted could not be positively identified, though

Table 1. Mammals recorded in the high altitudes of Tawang and West Kameng Districts, Arunachal Pradesh (see Table 4 for scientific names). Species names suffixed with asterisks represent high altitude mountain fauna. The table also indicates the motivations and techniques employed for hunting them in our survey sites.

SPECIES	PRESENCE	EVIDENCE	HUNTING MOTIVATION	MAIN HUNTING TECHNIQUES
Primates				
Tawang macaque	Confirmed	Sightings	Crop damage	Gun, bow-arrow
Slow loris	Reported			
Rhesus macaque	Confirmed	Sighting	Crop damage	Gun, bow-arrow
Ungulates				
Barking deer	Confirmed	Sighting, skins, skulls, antlers	Meat, skin	Gun, bow-arrow, snare
Bharal*	Confirmed	Sightings, skins, skulls, horns	Meat, skin	Gun, baiting-trapping
Chinese goral*	Confirmed	Sighting	Meat, skin	?
Himalayan goral*	Confirmed	Skins, skulls, horns	Meat, skin	Gun, bow-arrow, snare
Red goral*	Confirmed	Sighting	Meat, skin	Gun, bow-arrow, snare
Sambar	Reported	Antlers	Meat	
Serow*	Confirmed	Skins, horns	Meat, skin	Gun, bow-arrow, snare
Musk deer*	Confirmed	Skulls, faeces, tracks, hair	Musk pod, meat	Snare
Takin*	Confirmed	Horns, tracks, bedding sites		Guns, bow and arrow
Wild pig	Confirmed	Tracks, nests, digging signs	Meat, crop damage	Gun
Carnivores				
Clouded leopard	Confirmed	Skin	Skin	
Common Leopard	Reported		Skin	
Himalayan black bear*	Confirmed	Tracks	Gall bladder	Gun
Leopard cat	Confirmed	Sighting, skins	Sport	
Marbled cat	Reported		Sport	
Snow leopard*	Confirmed	Skin	Livestock killing	Gun, snare
Tiger	Extinct			
Wild dog	Confirmed	Skins	Livestock killing	Gun, bow-arrow
Yellow throated marten*	Confirmed	Skin	Skin	
Pale weasel*	Confirmed	Sighting		
Himalayan palm civet*	Confirmed	Sighting		
Common otter	Reported			
Red panda*	Confirmed	Skin	Sport	
Rodents				
Hairy footed flying squirrel*	Confirmed	Skin	Sport	
Himalayan marmot*	Confirmed	Sightings, burrows	Medicinal value	Gun, bow-arrow
Himalayan striped squirrel*	Confirmed	Sightings		
Orange bellied Himalayan squirrel*	Confirmed	Sightings		
Porcupine	Reported			
Lagomorphs				
Moupin's pika*	Confirmed	Sightings, faeces		
Large eared pika*	Confirmed	Sightings, faeces		
Pholidota				
Pangolin	Confirmed	Skin		

its very dark coloration and habitat characteristics suggested that it was the Moupin pika *Ochotona thibetana*.

Hunting

At least 18 of the 34 species we recorded were reported to be actively hunted, mostly for local meat consumption (Table 1). A majority of the people of the dominant *Monpa* tribe do not eat squirrels, red panda *Ailurus fulgens*, other carnivores, or primates, although macaques are frequently killed to prevent crop damage (Appendix 2). Wild pigs *Sus scrofa* are killed for meat, and also to prevent crop damage. Snow leopard *Uncia uncia* and dhole *Cuon alpinus* are killed in retaliation against livestock depredation. Herders in the entire region reported frequent losses of livestock to the dhole. In the Lower Nyamjang Chu Valley, the villagers contribute and pay cash rewards to hunters for killing wild predators. In the Mago Chu Valley and higher West Kameng, people reported livestock losses to the dhole in winter and to the snow leopard in summer, when livestock are taken to the higher altitudes. Carnivore skins were reported to be traded locally. Wildlife trophies are often given away as presents to visiting dignitaries (politicians and bureaucrats), or bartered with the soldiers of the Indian army. Artifacts made from barking deer *Muntiacus muntjak* antlers and serow *N. sumatraensis* horns are being sold in Government-run handicrafts emporia in the district headquarters of both Tawang and West Kameng.

Bears *Ursus thibetanus* and musk deer *Moschus chrysogaster* are actively hunted for gall bladders and musk pods respectively, apparently catering to the larger illegal market in wildlife products. The trade in wildlife products has local links with middle-men from Assam, as well as from Bhutan and China, though we were unable to assess the magnitude of this trade. We recorded two instances where hunters we interviewed had sold a common leopard *Panthera pardus* skin to traders in China, and another hunter reported selling bear gall bladder to traders in Bhutan. Most ungulate

We recorded widespread hunting of wildlife, including the endangered snow leopard *Uncia uncia* (left), musk deer *Moschus chrysogaster* (centre, above), and serow *Nemorhaedus sumatraensis* (centre, below). Hunters use arrows (right) tipped with poison from *Aconitum* sp., an alpine herb.

Table 2. A comparison of mammalian species richness (see Table 4 for scientific names) in the six high altitude regions of Tawang and West Kameng Districts, Arunachal Pradesh. The table also indicates the global importance of the species in terms of their conservation status in the IUCN's Red List of Threatened Species.

SPECIES	IUCN RED LIST STATUS	UPPER NYAMJANG CHU	LOWER NYAMJANG CHU	PTSO	MUKTO	MAGO CHU	HIGH ALTITUDE WEST KAMENG
Barking deer		+	+	+	+	+	+
Bharal*		+	-	+	-	+	+
Chinese goral*	Vulnerable	-	-	.	-	+	.
Chinese Pangolin	Low risk near threatened	.	.	.	.	.	+
Clouded leopard	Vulnerable	.	.	.	.	.	+
Common Leopard		+	+	+	+	+	+
Hairy footed flying squirrel*	Low risk near threatened	.	.	+	.	.	.
Himalayan black bear*	Endangered	+	.	+	+	+	+
Himalayan goral*	Low risk near threatened	+	+	+	+	+	+
Himalayan marmot*	Low risk conservation dependent	+	+	+	-	+	.
Himalayan palm civet*		.	+	.	.	.	.
Himalayan striped squirrel*		+	+	.	+	+	+
Large eared pika*		.	+	.	.	+	+
Leopard cat		+	+	.	.	.	.
Macaque		+	+	.	+	+	+
Marbled cat	Vulnerable	.	.	.	.	.	+
Moupin's pika*		.	.	.	.	+	+
Musk deer*	Low risk near threatened	+	+	+	-	+	+
Orange bellied Himalayan squirrel*		.	+	.	+	+	+
Otter	Endangered	+	.	.	.	.	.
Pale weasel*		.	.	.	-	.	+
Porcupine	?	.	.	.	+	.	.
Red goral*	Vulnerable	.	.	.	-	.	+
Red panda*	Endangered	+	+	+	+	+	+
Rhesus macaque		.	.	.	.	.	+
Sambar		+	+	.	+	+	+
Serow*	Vulnerable	+	+	+	+	+	+
Slow loris	Data deficient	+	.	.	.	.	.
Snow leopard*	Endangered	.	.	+	-	+	.
Takin*	Vulnerable	-	-	-	-	.	+
Tiger	Endangered	-	-	-	-	-	-
Wild dog	Vulnerable	.	+	+	+	+	+
Wild pig		+	.	+	+	+	+
Yellow throated marten*		.	.	.	.	+	+
Total species		**16**	**15**	**13**	**13**	**20**	**24**

skins (especially goral *Nemorhaedus* sp. and barking deer) are traded and used locally by herders as clothing (both trousers and jackets are stitched; Appendix 1). Marmots *Marmota himalayana* are killed for the reported medicinal value of their skin and fat in treating backaches.

In many of the surveyed areas, villagers reported that hunting intensity had declined following the Buddhist spiritual leader, the Dalai Lama's visit to Tawang in May 2003. Although we found widespread evidence of continued hunting (fresh kills of bharal *Pseudois nayaur*, takin *Budorcas taxicolor* and pheasants, a two month old skin of a snow leopard that was caught in a snare, abundant snares for musk deer,

pheasants, etc.), conversations with some villagers suggested that the extent of hunting may indeed have declined.

Human presence and natural resource extraction

In addition to hunting, we found many other forms of natural resource use and extraction among the resident people. A majority of the forest area is under the traditional ownership and *de facto* control of the village councils. On the other hand, individual families or groups of families seem to have usufruct rights over a major fraction of the grazing land, with remaining pastures belonging to the village councils. The high altitude meadows, which are open hill slopes above the tree line at altitudes between 4200 and 5250 m, are used for summer livestock grazing. Further, open alpine grasslands and krummholz *Rhododendron* vegetation occur between 4000 m and 4500 m and are used for summer grazing (see Chapter 3). In areas between 2500 to 4200 m, forests have been cleared in the past to create grazing land. These grassy meadows in forest clearings seem to be maintained by livestock grazing. We found that the practice of cutting and burning forests to create grazing areas continues to the present day. The entire high altitude pastures are used for summer grazing by yak, cattle-yak hybrids and sheep, whereas the lower altitude forests and meadows in forest clearings are mostly grazed by mithun, cattle, mithun-cattle hybrids, and mithun-yak hybrids.

The forests are also used by people to collect fuelwood, timber, bamboo for house-building, and to gather oak leaf litter for manure. In areas such as Mukto and the Lower Nyamjang Chu Valley, timber and firewood are commercially traded, with fir *Abies densa* being the most sought after timber species. This trade is largely unregulated. In the higher areas, *Rhododendron* shrubs and tress are particularly sought-after as fuel-wood since they burn well even when fresh. Leaves and small branches are regularly gathered from *Juniperus*, a plant of ritual significance in local Buddhist culture. In many villages, the village councils locally administer some regulation on collection of bamboo and other forms of extraction.

Collection of medicinal plants from the high altitude meadows, as well as the forests, seems to be an important source of cash income for the villagers, especially in the higher reaches of West Kameng. The main species in trade are *Swertia* sp., *Taxus* sp., *Dactylorhiza* sp., *Cordyceps* sp., *Rubia* sp., and *Picrorrhiza* sp. Villagers reported a rapid decline in the abundance of medicinal plants due to unregulated collection. In particular, *Taxus* sp., an endangered tree, appears to have undergone drastic population decline. *Ilicium griffithi* fruits, used as a spice, also constitute an important source of income for the villagers. Although the forest department does not own most of these forests, it does charge royalties on commercial produce gathered from village/community forests. In the Bomdila Forest Division of West Kameng, such royalty earning from the trade in medicinal plants last year was estimated at about Rs. 4 million (Shambhu, *pers. comm.).* Although recently, the forest department has temporarily stopped issuing permits to traders for transporting medicinal plants, the collection at the local level continues.

We found the existence of very small (< 100 ha) sacred forests near Tawang and Mukto, where no hunting or any other form of resource extraction is allowed.

Comparison of survey areas

Our interviews revealed differences in hunting intensity within the surveyed areas. The Mukto area was the most heavily hunted site, followed by Lower Nyamjang Chu Valley, the PTSO region, the high altitude areas of West Kameng, and then the Mago Chu Valley. The least hunted site was the Upper Nyamjang Chu Valley, where village councils have imposed a ban on killing wildlife. A village called Lumpo was the most exceptional, where the villagers do not kill either wild or domestic animals, and apprehend and fine hunters from outside coming to their village forests. In all areas surveyed, government officials from other parts of Arunachal (belonging to other tribes) and workers of the Border Roads Organization were reported to hunt heavily.

While most of the region has some presence of the army, high altitude wildlife habitats in the PTSO region are perhaps the most heavily disturbed due to the presence of large army establishments and associated activities. Access to the high altitude areas of Upper Nyamjang Chu Valley is restricted by the army. The high altitude wildlife habitats of West Kameng were relatively free from such disturbance, except the areas around Se La (which encompass parts of both Tawang and West Kameng). However, the entire area is subject to livestock grazing, hunting, and medicinal plant collection.

From the viewpoint of high altitude wildlife conservation, we found the contiguous regions of high altitude West Kameng and the Mago Chu Valley to be the most promising (Tables 2, 3). This area has the richest mammalian assemblage (27 species cumulatively), extensive high altitude habitat, and is relatively less disturbed by the army. Of a total of 19 high altitude species that we recorded, the area harbours at least 17 (Table 2). The Himalayan palm civet *Paguma larvata* and the hairy footed flying squirrel *Belomys pearsonii*, which we did not record in this area, are also very likely to occur here given the extent of habitat available. Of the 12 extant species of global conservation importance in the region (Table 1), the highest numbers occur in the high altitude areas of West Kameng (8 species) and the Mago Chu Valley (6) and, and together, these two areas account for 10 of the 12 species (Table 4).

Table 3. A comparison of conservation importance of the six high altitude regions of Tawang and West Kameng Districts, Arunachal Pradesh. Species considered to be of global conservation importance are those listed as 'Endangered' or 'Vulnerable' in the IUCN's Red List of Threatened Species.

ATTRIBUTE	UPPER NYAMJANG CHU	LOWER NYAMJANG CHU	PTSO	MUKTO	MAGO CHU	HIGH ALTITUDE WEST KAMENG
Extent of high altitude habitat (sq. km)	77	116	261	231	968	614
Number of mammal species recorded	16	15	13	13	20	24
Species of global conservation importance	4	3	5	4	6	8
Number of high altitude mammal species	9	9	9	6	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	Habitation	Army bases	Habitation	Habitation	Habitation

Discussion

Our survey has established the presence of a rich mammalian assemblage in western Arunachal's high altitudes, including 12 species of global conservation importance. The survey regions contain a unique assemblage of high mountain fauna, including elements from both the Palearctic and Indomalayan realms. Amongst them, the Chinese goral *N. caudatus* was previously not known to occur in India, and its discovery represents a new addition to the list of large mammals of the Indian sub-continent (Appendix 1). This also makes western Arunachal the only known region in the world today to harbour all three extant species of goral. The pale weasel *Mustela altaica* is also a new record for the state. Our survey also established the presence of the endangered snow leopard in the state.

Hunting is amongst the most serious threats to wildlife throughout Arunachal Pradesh, including our survey sites[2]. This is a traditional practice that has formed linkages with the international illegal trade in wildlife products. Limited awareness of conservation laws has further meant that even Government officials and politicians were commonly reported to hunt across our survey sites, and there is very limited on-ground enforcement of the Indian Wildlife Act. Display and sale of wildlife trophies by Government run handicrafts emporia perhaps best reflect the extent of ignorance of conservation and wildlife laws.

Given that wildlife conservation currently is not a priority with most of the government departments, realistic measures to reduce hunting will require seeking the participation of the local communities. Community based conservation efforts are also needed to provide assistance and incentives that encourage conservation-friendly practices by the local community. To start with, these need to focus on devising means of reducing and off-setting livestock losses to wild carnivores and establishing conservation linked community development programs that provide economic incentives (see Mishra et al.[3]). Community based conservation efforts could take advantage of the predominant Buddhist religion that preaches compassion and tolerance towards all forms of life. At the same time, conservation awareness programs are required not just in schools, but also for politicians, bureaucrats, the judiciary and the army.

We sighted 35 bharal *Pseudois nayaur* (left & inset) in five herds within the proposed wildlife reserve. This expedition also led to the discovery of the Chinese goral *Nemorhaedus caudatus* (right) in India.

Table 4. A comparison of mammalian species richness of the proposed wildlife reserve in relation to two existing reserves of Arunachal, Pakke Tiger Reserve and Namdapha Tiger Reserve. IUCN Red List status is indicated for those species listed as 'Endangered' or 'Vulnerable'.

SPECIES	SCIENTIFIC NAME	IUCN RED LIST STATUS	PAKHUI	NAMDAPHA	PROPOSED RESERVE
Assamese macaque	*Macaca assamensis*	Vulnerable	+	+	.
Barking deer	*Muntiacus muntjac*		+	+	+
Binturong	*Arctictis binturong*		+	+	.
Burmese ferret badger	*Melogale personata*		+	.	.
Capped langur	*Semnopithecus pileatus*	Endangered	+	+	.
Chinese Pangolin	*Manis pentadactyla*		+	+	+
Clouded leopard	*Neofelis nebulosa*	Vulnerable	+	+	+
Common leopard	*Panthera pardus*		+	+	+
Eastern mole	*Talpa micrura*		+	.	.
Elephant	*Elephas maximus*	Endangered	+	+	.
Gaur	*Bos gaurus*	Vulnerable	+	+	.
Himalayan striped squirrel	*Tamiops macclellandi*		+	+	+
Hoary-bellied squirrel	*Callosciurus pygerythrus*	Vulnerable	+	+	.
Hog deer	*Axis porcinus*		+	.	.
Jackal	*Canis aureus*		+	+	.
Large Indian civet	*Viverra zibetha*		+	.	.
Leopard cat	*Prionailurus bengalensis*		+	+	+
Malay tree shrew	*Tupaia glis*		+	.	.
Malayan giant squirrel	*Ratufa bicolor*		+	+	.
Otter	*Lutra sp.*	Vulnerable	+	+	.
Common palm civet	*Paradoxurus hermaphroditus*		+	.	.
Porcupine	*Hystrix sp.*		+	+	.
Red-bellied Pallas squirrel	*Callosciurus erythraeus*		+	+	.
Rhesus macaque	*Macaca mulatta*		+	+	+
Sambar	*Cervus unicolor*		+	+	+
Serow	*Nemorhaedus sumatraensis*	Vulnerable	+	+	+
Slow loris	*Nycticebus coucang*		+	.	.
Small Indian civet	*Viverricula indica*		+	+	.
Small Indian mongoose	*Herpestes auropunctatus*		+	.	.
Tiger	*Panthera tigris*	Endangered	+	+	.
Wild dog	*Cuon alpinus*	Vulnerable	+	+	+
Wild pig	*Sus scrofa*		+	+	+
Yellowthroated marten	*Martes flavigula*		+	+	+
Leaf deer	*Muntiacus putaoensis*		.	+	.
Malayan sun bear	*Helarctos malayanus*		.	+	.
Orangebellied Himalayan squirrel	*Dremomys lokriah*		.	+	+
Stump-tailed macaque	*Macaca arctoides*	Vulnerable	.	+	.
Hoolock gibbon	*Hylobates hoolock*	Endangered	.	+	.
Giant flying squirrel	*Petaurista petaurista*		.	+	.
Hogdgson's flying squirrel	*Petaurista magnificus*		.	+	.
Particolored flying squirrel	*Hylopetes alboniger*		.	+	.
Marbled cat	*Felis marmorata*	Vulnerable	.	+	+
Bamboo rat	*Rhizomys sp.*		.	+	.
Himalayan black bear	*Ursus thibetanus*	Endangered	.	+	+

Table 4. (cont'd)

SPECIES	SCIENTIFIC NAME	IUCN RED LIST STATUS	PAKHUI	NAMDAPHA	PROPOSED RESERVE
Red goral	*Nemorhaedus baileyi*	Vulnerable	.	+	+
Bharal	*Pseudois nayaur*		.	.	+
Chinese goral	*Nemorhaedus caudatus*	Vulnerable	.	.	+
Himalayan goral	*Nemorhaedus goral*		.	.	+
Himalayan marmot	*Marmota himalayana*		.	.	+
Large eared pika	*Ochotona macrotis*		.	.	+
Moupin's pika	*Ochotona thibetana*		.	.	+
Musk deer	*Moschus chrysogaster*		.	.	+
Pale weasel	*Mustela altaica*		.	.	+
Red panda	*Ailurus fulgens*	Endangered	.	.	+
Snow leopard	*Uncia uncia*	Endangered	.	.	+
Takin	*Budorcas taxicolor*	Vulnerable	.	.	+
Tawang macaque	*Macaca sp.*		.	.	+
Total species			**33**	**37**	**27**
Species of global importance			**10**	**14**	**10**

Significant resources and manpower need to be made available to the forest department with a clear mandate of wildlife conservation and implementation of wildlife laws. Presently, in our survey sites, the forest department has a very small presence, with wildlife conservation issues taking a back-seat. The forest department also needs to devise means of regulating timber felling, medicinal plant collection, and the continued cutting and burning of forests.

Proposed wildlife reserve

The contiguous areas of the Mago Chu Valley and the high altitudes of West Kameng District together harbour the richest mammalian assemblage among our survey sites, and the most extensive high altitude wildlife habitat (Tables 2, 3). Species richness in this area is only marginally lower when compared with the two important wildlife reserves of Arunachal; the low elevation Pakke Tiger Reserve, and the low to mid elevation Namdapha Tiger Reserve (Table 4). In terms of mammalian species of global conservation importance, the region is as rich as Pakke. Establishment of a wildlife reserve in the Mago Chu Valley and adjoining high altitude areas of West Kameng will afford protection to the entire high altitude mammalian fauna of western Arunachal, including 10 species of global conservation importance. This would also make the area the only existing wildlife reserve in the world to harbour all three species of goral, and the only wildlife reserve in Arunachal affording protection to high altitude species such as the snow leopard, the Chinese goral, and the Himalayan marmot.

References

1. IUCN. (2003) Summary statistics for globally threatened species. 2002 IUCN Red List of Threatened Species. Available from http://www.redlist.org/info/tables/table1.html (accessed 15/7/2003).
2. 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, NY, and India-Program and the Forest Department of Arunachal Pradesh.
3. 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.

Chapter 3

Vegetation and wildlife habitat mapping in the high altitudes of Western Arunachal Pradesh, Eastern Himalaya

Vegetation and topography together make up the basic ecological template defining the distribution and abundance of wildlife. In this chapter, we use ground data in conjunction with satellite imageries for the survey region to map different vegetation types represented in the higher elevations (> 2750 m) of Tawang and West Kameng districts. We also use these vegetation maps together with the information on mammal species richness (Chapter 2) and topography to delineate the tentative boundaries of the proposed high altitude wildlife reserve. We have provided the details of the field-methods, analytical techniques, and technical results of the mapping exercise in Appendix 5.

Vegetation types and mapping

Based on broad structural and compositional characteristics, the vegetation and landscape of the survey sites (elevational range < 2750 m) was classified into the following broad types:

a) Permafrost (PMF): An elevation of 5250 m largely represented the upper limit for vegetation growth. Most areas above this elevation consisted of barren rocky or scree slopes and glaciers, and were classified as permafrost in our mapping exercise.

We obtained locations using a GPS (top left) and took detailed notes on the vegetation. The higher elevations were dominated by High Altitude Grassy Meadows (top right) and Dwarf *Rhododendron* Meadows (below).

Vegetation types identified and mapped included (clockwise, from top left) *Rhododendron* Scrubland, Forest Clearings, Broadleaved Forest including *Rhododendron* (right centre) and oak *Quercus* spp. (right below), and Conifer Broadleaved Forest.

b) High-altitude Grassy Meadows (HGM): High-altitude grassy meadows occurred between 4350 and 5250 m. These were open, rocky areas with graminoids and forbs as the dominant life form. The woody vegetation was very restricted, and trees were absent. Towards the higher altitudes, the landscape was relatively drier. These high altitude meadows are used extensively for sheep grazing in summer. Plants include species such as *Stipa*, *Saxifraga*, *Artemesia*, *Leontopodium*, restricted dwarf *Rhododendron*, etc.

c) Dwarf Rhododendron Meadows (DRM): These meadows with graminoids and forbs, but dominated by a mat of very dwarf *Rhododendron* sp. (rarely exceeding a height of 0.5 m) occurred between 4200 and 4600m. Other plants included species of *Anaphalis*, *Fagopyrum*, *Juncus*, *Aster*, and *Anemone*. These meadows are used for summer grazing by sheep and yaks.

d) Rhododendron Scrubland (RSL): *Rhododendron* scrubland, forming a *Krummholz* vegetation fringing the tree line, occurred between 4000 and 4300 m. This included large patches of *Rhododendron* interspersed with alpine meadows. The *Rhododendron* layer varied between 1 m at higher altitudes to 3 m in the relatively lower areas. The

species composition was variable, including plants such as *Berberis*, *Rosa*, *Fagopyrum*, *Anaphalis*, *Allium*, *Pedicularis*, *Potentilla*, *Bistorta*, *Rheum* etc. Many open areas had a mat of moss. This vegetation zone is used for summer grazing by yaks, cattle, and cattle-yak hybrids. *Rhododendron* is heavily used as fuel-wood by the herders.

e) Conifer Broadleaved Forest (CBF): Conifer-broad leaved forests were distributed across a wide elevational range from 3000 to 4200 m. This forest type was variable in species composition and appearance, ranging from open fir *Abies densa – Juniperus* patches to closed, homogenous stands of fir. While fir was the predominant conifer, other species included *Larix*, *Tsuga*, *Picea*, *J. recurva*, and *J. indica*. The broad leaved tree species were dominated by *Rhododendron*, but also included *Acer*, *Quercus*, etc. The understorey included species of bamboo, *Daphne*, *Rubus*, and several ferns. The tree branches were covered with a thick mat of moss. These forests are used for collection of bamboo, *Illicium griffithi* fruits, and for timber extraction (mainly fir, but also some *Juniperus*). In relatively lower altitudes, they are grazed by mithun, mithun-yak hybrids, and mithun-cattle hybrids.

f) Broadleaved Forest (BLF): Broad leaved, oak dominated forests occurred mostly below 3000 m. Other tree species included *Rhododendron*, *Acer*, etc. Most of the forests were degraded due to human use, as most villages in the region lie within this altitudinal zone. The tree branches are often moss covered. These forests are used for grazing cattle, mithun, and cattle-mithun hybrids. People also collect oak leaf-litter for manure, as well as extract bamboo and timber from these forests.

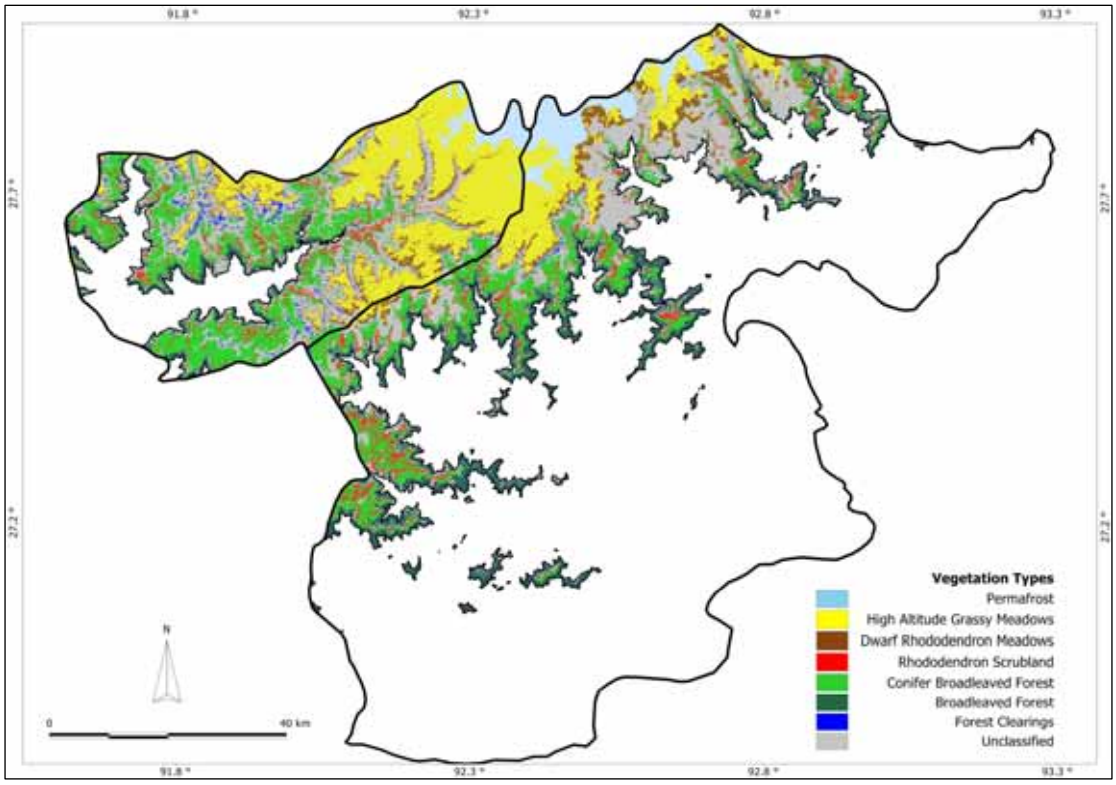

Fig. 1. A map showing vegetation types found at elevations above 2750 m in Tawang and West Kameng Districts, Arunachal Pradesh.

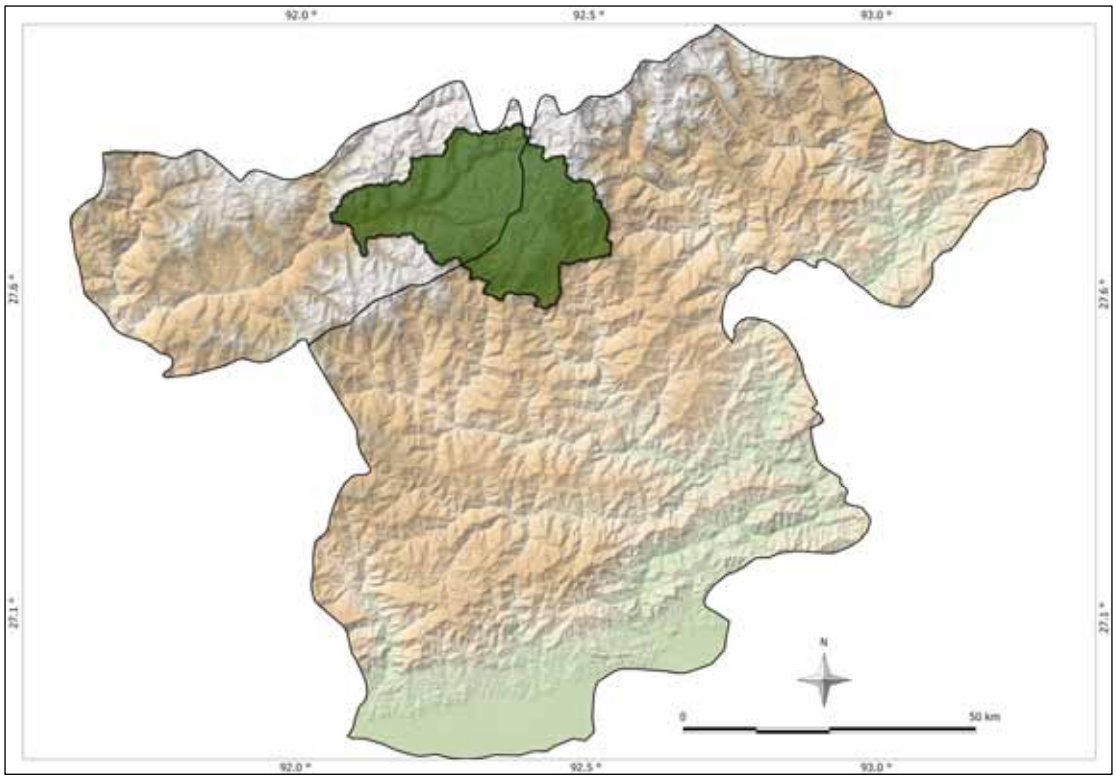

Fig. 2. The proposed high altitude wildlife reserve (shaded region) covering parts of Tawang and West Kameng districts, Arunachal Pradesh.

g) Forest Clearings (FCL): Large areas of CBF and BLF have been cleared and burnt to create grazing land. These meadows and scrubland in forest clearings seem to be maintained by livestock grazing. They are grazed by cattle, mithun, cattle-mithun hybrids, and cattle-yak hybrids. These clearings contain several graminoids and forbs, as well as shrubs such as *Rosa* and *Berberis*. Herbs include *Anaphalis*, *Potentilla, Sambucus, Rumex, Senecio* etc.

Vegetation map

A map of the vegetation in areas > 2750 m is shown in Fig. 1. HGM (21 % of the area) and CBL (20 %) were the most extensive vegetation types. Permafrost (above 5250) constituted 5 % of the total area mapped. Vegetation in a significant proportion of the area (30 %) remained unclassified. The areas covered by the other vegetation types included DRM at 5 %, RSL 1%, BLF 11 %, and FCL 6 %. Problems are evident in the classification of FCL, which appears to encompass a wide range of disparate habitats ranging from settled agriculture and cut-and-burned pastures in forests to naturally-open riverine stretches. A ground truthing of this map is essential before it is further refined.

Proposed wildlife reserve

A total of 474 basins, ranging in size from 0.6 ha to 7294 ha, upstream of Mago Chu and Gorja Chu, were identified for inclusion in the proposed protected area (Fig. 2). This area totals 815 km² and encompasses an elevational range of 2400 m to > 6400 m. Indeed, the conservation importance of one part of the proposed reserve (Mago Chu)

was expressed more than a decade back by Singh, who had recorded 48 bird species and 10 mammal species in the area during a short visit[1].

References

1. Singh, P. (1991) A preliminary faunal survey in Thingbu Circle Towang District, Arunachal Pradesh. *Arunachal Forest News*, **9,** 13-22.

Chapter 4

Conserving high altitude wildlife in Western Arunachal Pradesh

In this chapter, we will briefly outline the follow-up efforts that will be required to safeguard the future of Arunachal's high altitude wildlife. We first briefly revisit the significant findings of our biological expedition in the high altitudes of Tawang and West Kameng Districts. The expedition resulted in:

1. Documentation of 34 mammalian species, 12 of which are of global conservation importance (listed as Endangered or Vulnerable in the IUCN's Red List of Threatened Species; Chapter 2).
2. Discovery of the Chinese goral *Nemorhaedus caudatus* – a mountain ungulate previously not known to occur in the Indian sub-continent (Appendix 1).
3. Discovery of the Tawang macaque *Macaca* sp., which is perhaps a species new to science (Appendix 2)
4. A check list of 150 bird species (Appendix 3).
5. Understanding of the threats to the region's wildlife, and of peoples' dependence on natural resources (including widespread hunting; Chapters 1 and 2).
6. Preliminary vegetation and habitat maps (Chapter 3 and Appendix 5).
7. A check list of 140 plant species (Appendix 4)
8. Identification of a suitable site for the creation of a wildlife reserve that would protect the entire assemblage of high altitude wildlife species in western Arunachal (Chapters 2 and 3).

Hunting is the most serious threat to wildlife in this region. Over half of the species that occur in the region are hunted, including the Chinese pangolin *Manis pentadactyla* (left), clouded leopard *Neofelis nebulosa* (centre), and the snow leopard *Uncia uncia* (right).

While the expedition documented the occurrence of a rich wildlife assemblage with several species of global conservation importance, it is also clear that Arunachal's high altitude wildlife faces serious threats. The main threats include:

1. Widespread hunting (both for local consumption and to cater to the larger illegal commercial trade).
2. Retaliatory persecution of the snow leopard *Uncia uncia* and dhole *Cuon alpinus* for livestock depredation.
3. Habitat modification and loss (army establishments, continued creation of grazing land by opening up forests, etc.).
4. Unregulated collection of medicinal plants.
5. Almost complete lack of awareness of conservation issues (including within the local administration), or the implementation of conservation laws.

The road ahead

Against this background, conservation efforts in Arunachal's high altitudes will need to:

1. Garner the support of the indigenous communities for wildlife conservation, and wean them away from hunting.

Securing the indigenous communities' support for conservation will require extensive dialogue to identify the important needs of the people (including educational facilities, healthcare, etc.), and to explore opportunities for establishing community-based conservation programs. Such programs, while addressing peoples' basic needs, will need to aim at making wildlife conservation economically beneficial to them (through programmes such as conservation linked handicrafts development and marketing, wildlife tourism etc., see Mishra et al.[1] for working models). While establishing these will necessarily take time, in the short term, there is an urgent need to set in place mechanisms that share and off-set the losses that people currently face due to livestock depredation by the snow leopard and dhole. Community managed

It is essential to devise ways of offsetting the losses people bear due to livestock predation by wild carnivores. Efforts are also needed to spread conservation education and awareness, and to formulate economic incentive programs such as conservation-linked handicrafts development and marketing to garner peoples' support for wildlife conservation.

livestock insurance programs that we have established elsewhere have effectively offset such losses, and have served as instruments to stop the persecution of wild carnivores[1]. In terms of priority, all these efforts need to be undertaken first in the area of the proposed wildlife reserve.

2. Establish Arunachal's first high altitude wildlife reserve.
Our map of the proposed wildlife reserve is only indicative, and setting up the wildlife reserve will require careful examination and consultation with the village councils before the reserve boundaries are decided upon. The appropriateness of the different categories of wildlife reserves recognized under Indian law also needs to be carefully examined against the local context. It is important that establishing the wildlife reserve, while ensuring wildlife conservation, also benefits the local communities, rather than alienate them, as has happened in the past in India and elsewhere.

3. Spread conservation education and awareness in schools, villages, and in the administration.
Effective implementation of conservation efforts and laws will require conservation education and awareness programs at various levels, and sensitizing the administration (politicians and bureaucrats). Having effective conservation educational programs for children would require developing locally appropriate educational aids. Politicians, bureaucrats and the defence forces must be sensitized about the global significance of the region's wildlife assemblage, and the need for their interest and cooperation in establishing and maintaining the wildlife reserve.
4. Strengthen the local wildlife department in terms of manpower, resources, and training, and underpinning a clear mandate for wildlife conservation.

Emerging conservation effort

As is evident from the above discussion, partnerships between divergent groups—the state and its departments, the army, the local people, donor agencies, conservation and development organizations—will be needed for successful wildlife conservation in Arunachal's high altitudes. Indeed, we believe that such partnerships are both necessary and possible, and would be a central concern in consolidating the future of Arunachal's magnificent wildlife.

References

1. 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.

Appendix 1

Discovery of the Chinese goral *Nemorhaedus caudatus* in Arunachal Pradesh: another addition to the large mammals of the Indian sub-continent

Abstract

The wildlife of the high altitudes (>3000 m) of Arunachal Pradesh has remained poorly explored. We undertook a survey to document the status of high altitude wildlife of Tawang and West Kameng Districts of Arunachal in August-September 2003. Here, we report the discovery of the Chinese goral *Nemorhaedus caudatus* in Western Arunachal, which represents a new addition to the list of large mammals of the Indian sub-continent. This discovery makes our survey area perhaps the only region in the world known to harbour all three extant species of goral (Chinese, Himalayan *N. goral*, and red goral *N. baileyi*). Together with the red goral, the Chinese goral is categorized as 'Vulnerable' in the IUCN's Red List of Threatened Species, and we recommend the inclusion of both these species in Schedule I of the Indian Wildlife (Protection) Act.

Introduction

Ungulates are believed to be amongst the best documented taxa of large wildlife, with only ten new species being described between 1930 and 1994 [1]. Yet, the past decade saw a spate of ungulate discoveries in Southeast Asia, with four species new to science being described between 1994 and 1998[2-5]. These new discoveries reflect the hitherto poor status of exploration and documentation of wildlife in the remote Southeast Asian forests. Within India, the wildlife of the northeastern state of Arunachal Pradesh (26°28'– 29°30'N and 91°30'– 97°30'E; 83,743 km²) has remained poorly documented. One of our surveys in 2002 resulted in the discovery of the leaf deer *Muntiacus putaoensis* in Arunachal, a new species that was first found in the adjoining forests of Myanmar as recently as 1997[3,5,6]. This discovery of the leaf deer in the mid-elevation forests of Eastern Arunachal was so far the only new addition to the list of large mammals of the Indian sub-continent in the last century[6].

Arunachal Pradesh is situated in the transition zone between the Himalayan and Indo-Burmese regions[7,8]. The entire state is featured within the Eastern Himalaya global biodiversity hotspot[9,10] as well as among the 200 globally important ecoregions[11]. Most wildlife surveys in Arunachal so far have been restricted to low- and mid-elevation forests[6,12-16]. Apart from a recent survey of pheasants in mid-elevation and alpine areas that led to the discovery of a possibly new species of pheasant[14], the status and the occurrence of high altitude (> 3000 m) wildlife remains largely unknown. This is so despite the fact that 23 % of the state's land area is at elevations over 3000 m.

We undertook a biological expedition in the high altitude areas of Western Arunachal with the objective of inventorying wildlife, and identifying areas for possible designation as wildlife reserves. This survey, conducted in August-September 2003, covered almost the entire high altitude areas of Tawang and West Kameng Districts. Here, we report a significant finding of the survey: the occurrence of the Chinese goral *N. caudatus* (also called long-tailed goral) in Western Arunachal

Pradesh, which is another new addition to the list of large mammals of the Indian sub-continent. This discovery makes our survey region in Arunachal the only known region in the world to harbour all three extant species of goral.

Goral

The goral is a goat-like animal with sturdy legs adapted for jumping and climbing. The adult body mass varies between 20-30 kg, with a head and body length of 105-150 cm and 58-70 cm at the shoulder[17-21]. Sexes are similar in size and build, and have slender, backward curving, sharp pointed horns with small closely spaced annulations. Average horn length ranges from 11 to 15 cm, and sometimes up to 23.5 cm[18,20,22,23]. Horns of males are slightly thicker at the base and are more divergent compared to those of females. Goral is known to inhabit a wide altitudinal range from sea level up to 4500 m, though it is mostly restricted to relatively steep, open grassy slopes[24].

There was considerable confusion in the taxonomy of goral until Groves and Grubb[25] proposed the currently followed classification[26], which recognizes three extant species based on morphology. The Himalayan goral *N. goral* occurs in the Himalaya and north-east India (spreading over India, Pakistan, Nepal, China, Bhutan, and Myanmar), the red goral *N. baileyi* is restricted to a relatively small area of Arunachal Pradesh, Southeast China, and Northern Myanmar, and the Chinese or long-tailed goral *N. caudatus* is found in China, Myanmar, Thailand, Lao, North and South Korea, and the Russian Federation[27]. Both the Himalayan and Chinese goral are known to feed predominantly on grass[19,28].

Goral in Arunachal Pradesh

The Himalayan goral as well as the red goral are known to occur in Arunachal Pradesh, and during our survey, we found that they are commonly hunted in Tawang and West Kameng. The *Monpa* herders often make coarse jackets and trousers using Himalayan goral hide, which are apparently very effective against rain and cold. Each garment requires skins from two adult goral, which are purchased from hunters for c. Rs. 300 per skin. Although we did not sight the Himalayan goral during our survey (largely because we were surveying areas above 3000 m; the species is relatively more common in lower altitudes), we saw several skins with hunters, and with herders who were wearing them. One of us (CM), accompanied by two hunters, sighted two red goral in an area called

We sighted the Chinese goral *Nemorhaedus caudatus* (inset) in an open patch within coniferous forests (left) in the Mago Chu Valley. Hides of the Himalayan goral *N. goral* (centre & right) are commonly used as clothing by herders in the region.

Phurgang (Fig. 1) in West Kameng District. The goral were seen along a cliff at an altitude of 4100 m. We saw them from below at a distance of 300 m, and since they were silhouetted against the sky, we were unable to ascertain whether they were Himalayan or red goral. However, the hunters accompanying us as guides were positive that they were red goral, having killed one in the same site a few months back. We also saw fresh signs of takin *Budorcas taxicolor* and musk deer *Moschus* sp. in this area.

Two of us (CM and AD) saw the Chinese goral, about 3 km from Thingbu village (Fig. 1), in the Mago Chu Valley of Tawang district, while on the trail between Mago village and Thingbu. We first saw an adult male feeding in an open, steep grassy patch within fir *Abies densa* forest at an altitude of 3000 m. The animal had a very dark chocolate colour, except the lower limbs which were rufous. There was a small but distinct white throat patch. The dorsal side of the neck and shoulder had a black patch, which tapered to become the dorsal stripe, extending till the base of the tail. The tail was longer and relatively bushy compared to Himalayan goral. After about 20 minutes, this animal was joined by a female and young, both of which had a relatively lighter coat colour. We watched this herd for another 15 minutes with binoculars, from a distance of c. 600 m, when they slowly disappeared out of sight behind some fir trees.

Conservation status

The red goral and the Chinese goral are both categorized as 'Vulnerable' in the IUCN's Red List of Threatened Species[29]. Yet, the Indian Wildlife (Protection) Act 1972 does not list the red goral under any of its schedules[30]. The Act, in its Schedule III, lists the Himalayan goral (*N. goral*), and another species called *N. hodgsoni*. The Himalayan goral has two subspecies, and the latter presumably is meant to denote the eastern subspecies

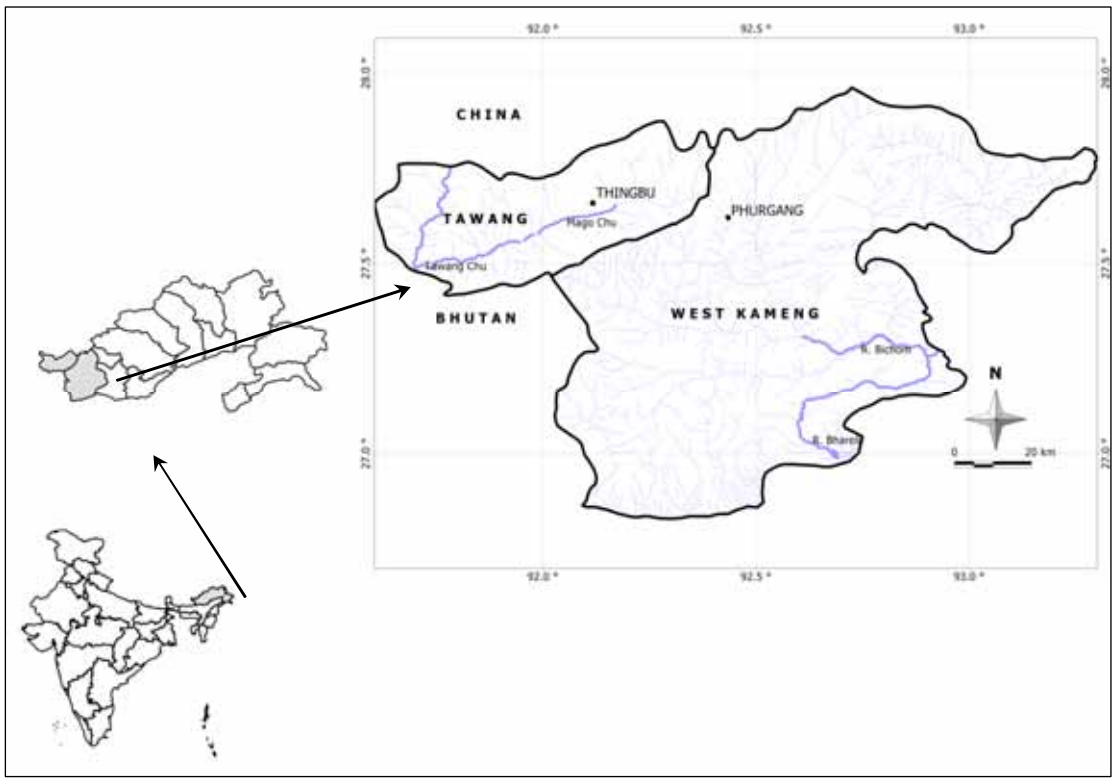

Fig. 1. Map of Arunachal Pradesh, showing the location of goral *Nemorhaedus* sp. sightings. We sighted the red goral *N. baileyi* near Phurgang, while the Chinese or long-tailed goral *N. caudatus* was seen near Thingbu.

N. goral hodgsoni[25]. *N. goral bedfordi* is the Western Himalayan sub-species. In effect, Schedule III of the Indian Wildlife Act covers only the Himalayan goral, and the reference to *N. hodgsoni* can be deleted from it to avoid confusion. More importantly, we recommend the immediate inclusion of the red goral and the Chinese goral in Schedule I of the Indian Wildlife Act. These are species of global conservation concern, and it is only appropriate that they are accorded the highest protection status under Indian law.

The addition of the Chinese goral to the list of large mammals of the Indian sub-continent makes India the only other country apart from China to harbour all three currently recognized species of goral. In fact, the Mago Chu Valley of Tawang, along with adjoining areas of West Kameng District, is perhaps the only known region in the world to have all the three goral species. The area also has two other goat-antelopes – takin *Budorcas taxicolor* and serow *N. sumatraensis*. Our survey has also established the occurrence of other rare and threatened wildlife in this region, such as the snow leopard *Uncia uncia*, dhole *Cuon alpinus*, musk deer *Moschus* sp., bharal *Pseudois nayaur*, and the Himalayan marmot *Marmota himalayana* (Chapter 2). Most of these species are currently hunted in the area. Establishment of community awareness and conservation programmes, and designation of a protected area that is locally appropriate (such as a conservation or community reserve) are required urgently to safeguard the future of this fascinating wildlife assemblage of Western Arunachal Pradesh.

References

1. Pine, R.H. (1994) New mammals not so seldom. *Nature*, **368,** 593.
2. Schaller, G.B. & Vrba, E.S. (1996) Description of the giant muntjac (*Megamuntiacus vuquangensis*) in Laos. *Journal of Mammalogy*, **77,** 675-683.
3. Amato, G., Egan, M.G. & Rabinowitz, A.R. (1999) A new species of muntjac, *Muntiacus putaoensis* (Artiodactyla, Cervidae) from northern Myanmar. *Animal Conservation*, **2,** 1-7.
4. Giao, P.M., Tuoc, D., Dung, V.V., Wikramanayake, E.D., Amato, G., Arctander, P. & MacKinnon, J.R. (1998) Description of *Muntiacus truongsonensis*, a new species of muntjac (Artiodactyla: Muntiacidae) from Central Vietnam, and implications for conservation. *Animal Conservation*, **1,** 61-68.
5. Rabinowitz, A.R., Amato, G. & Khaing, S.T. (1998) The discovery of the black muntjac, *Muntiacus crinifrons*, in northern Myanmar. *Mammalia*, **62,** 105-108.
6. Datta, A., Pansa, J., Madhusudan, M.D. & Mishra, C. (2003) Discovery of the leaf deer *Muntiacus putaoensis* in Arunachal Pradesh: an addition to the large mammals of India. *Current Science*, **84,** 101-103.
7. Mani, M.S. (1974) *Ecology and Biogeography in India*. Dr.W.Junk b.v. Publishers, The Hague.
8. 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.
9. 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.
10. Mittermeier, R.A., Myers, N., Thomsen, J.B., da Fonseca, G.A.B. & Olivieri, S. (1998) Biodiversity hotspots and major tropical wilderness areas: approaches to setting conservation priorities. *Conservation Biology*, **12,** 516-520.
11. 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.
12. Katti, M., Singh, P., Manjrekar, N., Sharma, D. & Mukherjee, S. (1992) An ornithological survey in eastern Arunachal Pradesh, India. *Forktail*, **7,** 75-89.

13. Katti, M., Manjrekar, N., Mukherjee, S. & Sharma, D. (1990) Wildlife survey in Arunachal Pradesh with special reference to takin. Unpublished report. Wildlife Institute of India, Dehradun.
14. Kumar, S. & Singh, P. (1999) *A Study on Pheasant Distributions in Arunachal Pradesh, Eastern Himalaya, India. Unpublished Report*. Wildlife Institute of India, Dehradun.
15. 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.
16. Athreya, R.M., Captain, A.S. & Athreya, V.R. (1997) A faunal survey of Namdapha Tiger Reserve, Arunachal Pradesh, India. Unpublished Report.
17. Zhang, C. (1987) *Nemorhaedus cranbrooki* Hayman. *The Biology and Management of Capricornis and Related Mountain Antelopes* (ed H. Soma), pp. 213-220. Croom Helm.
18. Roberts, T.J. (1977) *The Mammals of Pakistan*. Ernest Benn, London & Tonbridge.
19. Zhiwotschenko, V. (1990) Gorals (genus *Nemorhaedus*). *Grzimek's Encyclopedia of Mammals. Vol. 5* pp. 506-507. McGraw Hill Publishing Company, New York.
20. Prater, S.H. (1971) *The Book of Indian Animals*. Oxford University Press, Bombay.
21. Corbet, G.E. & Hill, J.E. (1992) *The Mammals of the Indomalayan Region: a Systematic Review*. Oxford University Press, New York.
22. Schaller, G.B. (1977) *Mountain Monarchs Wild Sheep and Goats of the Himalaya*. The University of Chicago Press, Chicago.
23. Mishra, C., Raman, T.R.S. & Johnsingh, A.J.T. (1998) Hunting, habitat and conservation of rupicaprines in Mizoram, northeast India. *Journal of the Bombay Natural History Society*, **95,** 215-220.
24. Mishra, C. & Johnsingh, A. J. T. (*in press*) Goral *Nemorhaedus goral*. .
25. Groves, C.P. & Grubb, P. (1985) Reclassification of the serows and gorals (*Nemorhaedus*: Bovidae). *The Biology and Management of Mountain Ungulates* (ed S. Lovari), pp. 45-50. Croom Helm, London.
26. Shackleton, D.M. & Lovari, S. (1997) Classification adopted for the Caprinae survey. *Wild Sheep and Goats and Their Relatives: Status Survey and Conservation Action Plan for Caprinae* pp. 9-16. IUCN, Gland.
27. Shackleton, D.M. (1997) *Wild Sheep and Goats and Their Relatives: Status Survey and Conservation Action Plan for Caprinae*. IUCN, Gland.
28. Mishra, C. & Johnsingh, A.J.T. (1996) On habitat selection by the goral *Nemorhaedus goral bedfordi* (Bovidae, Artiodactyla). *Journal of Zoology (Lond.)*, **240,** 573-580.
29. IUCN (2000) *2000 IUCN Red List of Threatened Species (With CD-ROM)*. IUCN, Gland.
30. Anon (2003) *The Wildlife (Protection) Act, 1972 As Amended Up to 2003*. Natraj Publishers, Dehradun, India.

Appendix 2

A report on the Tawang macaque *Macaca* sp.

Anindya Sinha, Aparajita Datta, M. D. Madhusudan, and Charudutt Mishra

The high altitude (> 3000 m) wildlife of Eastern Himalayan Arunachal Pradesh has remained largely unexplored and unprotected. All existing wildlife reserves in Arunachal protect low to mid-elevation habitats. Wildlife research and exploration have also been restricted to these habitats, with no comprehensive survey till date of Arunachal's high altitude wildlife.

Three of us (AD, MDM, and CM) undertook a biological expedition between August and October, 2003, to inventory the high altitude wildlife of Arunachal Pradesh, evaluate threats to their conservation, and to identify sites suitable for establishment of high altitude wildlife reserves. We covered the entire high altitude areas of Tawang and West Kameng Districts in Western Arunachal. During the expedition, we had eight sightings of troops of a macaque *Macaca* sp. in different parts of Tawang district (Fig. 1). This primate potentially represents a species new to science. Here, we provide an account of our sightings and morphological notes on the 'Tawang macaque'.

The Tawang macaque

Although the elevation in Tawang district ranges between 2000 to > 6000 m, the macaques were encountered between 2000 and 2700 m. Subtropical broadleaved

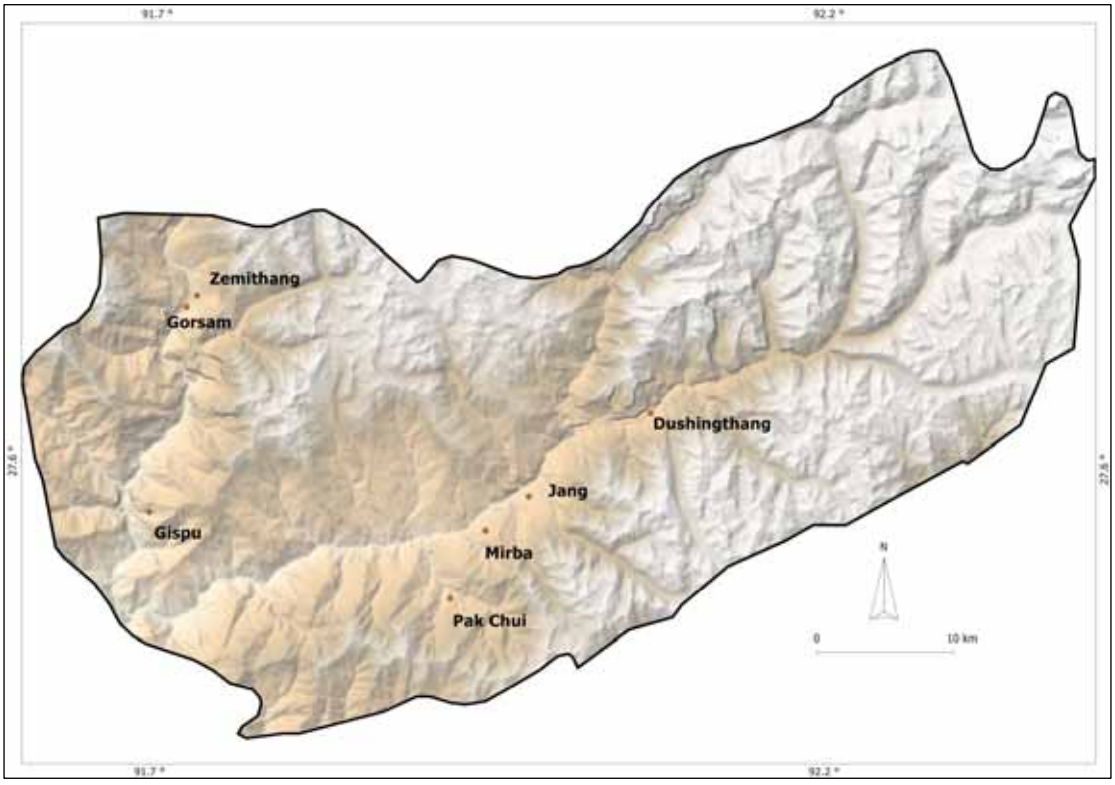

Fig. 1. A map of Tawang district showing sighting locations of the Tawang macaque, *Macaca* sp.

forests dominate the vegetation within this elevation. The region is entirely hilly, with cold winters including snow in the upper reaches. Cultivation is common in areas where the terrain is less rugged. The local people reported that the macaques frequently damage crops, and are killed in retaliation against crop damage. The people of Tawang, belonging predominantly to the Buddhist *Monpa* tribe, in general do not eat primates. However, some hunting of primates for meat is reportedly carried out by government employees belonging to other Arunachali tribes posted in Tawang, and also by the workers of the Border Roads Organization.

We saw the macaques mostly along roads, in patches of degraded broadleaved forests interspersed with crop fields. They seemed fairly terrestrial, with most of our sightings on the ground (Table 1). All our sightings were of mixed troops, each consisting of multiple males and females. We also recorded the presence of at least 2 infants in a single troop of 18+ individuals. The macaques appeared to be relatively tolerant of human presence and habitation, occurring close to villages and crop fields. We were able to photograph and videograph several troops. Nevertheless, they were wary in the presence of people, and in most cases, they moved away when we stopped to observe them (the longest we could observe them from a close proximity of 20 m was 5 minutes). We were not directly threatened by any individual. On one occasion, we observed two adult males and a large juvenile male challenging a feral dog with stares and open-mouth threats. Inside undisturbed forests, however, they seemed extremely shy, rapidly disappearing through the undergrowth as soon as they sensed our presence.

Morphology

Individuals are generally large in size and heavyset in structure. The relative tail length of two adult males, measured (from photographs) as the ratio of the length of the tail to that of the head and body, was 0.39 and 0.45.

Table 1. Sighting records of the Tawang macaque *Macaca* sp. during August-September 2003 in Tawang District, Western Arunachal Pradesh

LOCALITY	DATE	TROOP SIZE	SUBSTRATE	HABITAT DESCRIPTION
Gispu, Lower Nyamjang Chu	19 August	4+	Ground	2230 m, by the roadside in degraded broadleaved forest, close to an isolated crop field
Zimithang, Upper Nyamjang Chu	20 August	6	Ground	2200 m, by the roadside in degraded broadleaved forest, close to crop fields
Gorsam	21 August	18+	Trees 15-20 m	2030 m, seen early in the morning, roosting in the canopy of a riverine forest
Mirba, Mukto	27 August	5	Ground	2620 m, seen on the roof of an abandoned hut in the middle of a crop field
Pak Chui, Mukto	28 August	7+	Ground	2670 m, undisturbed oak forest, heard vocalizing
Jang	1 September	5+	Ground	2120 m, by the roadside in degraded open scrub forest
Jang	23 September	4+	Ground	2470 m, in broadleaved forest
Dushingthang	23 September	8+	Trees 5-10 m	2700, in broadleaved forests by a steep cliff

Most of our sightings of the Tawang macaque *Macaca* sp. (left), which may represent a new taxon, were in relatively degraded forests near habitation (right). For relative body-size measurements, we used profile photographs such as the one shown in the inset.

The body of adults is dark brown to dark chocolate dorsally, with the upper part of the torso and the distal parts of the limbs becoming paler (ranging from light brown to olivaceous). The hands and feet are also pale brown (similar to the upper limbs). The tail is much darker, similar to the dorsal surface of the lower torso and the lower limbs. The ventral part of the trunk is lighter in colour in some individuals, but similar to that of the upper torso in most individuals. The general pelage is long and dense, especially in the upper torso, while the lower torso and ventral part of the trunk have shorter, smoother hairs. Moreover, the underside is hirsute enough for the underlying skin not to be visible – a feature unlike several other species of macaques. The adult males, females and juveniles of both sexes appeared to be similar in colour.

The front of the crown of all individuals had a prominent pale-yellow patch with a central group of dark hairs. In one adult male, this formed an erect tuft, although in every other individual observed, it was more reminiscent of a whorl of hairs. Closer examination should reveal whether this can truly be characterised as a whorl of hairs, as prevails in a certain proportion of Assamese macaques.

The head is very prognathous with the upper part of the face significantly broader than the muzzle, especially in adult males. The facial skin is dark brown (darker than that of the body in several of the adult males). The skin around the eyes is pale in most individuals, producing a spectacled appearance. The nose is similarly lighter in colour in many individuals. In contrast to Tibetan macaques, side-whiskers and beard are not prominently developed, and the ears are, therefore, clearly visible in anterior view.

Discussion

Comparison with the Assamese macaque

Although superficially reminiscent of the Assamese macaque in its general physiognomy, the Tawang macaque is strikingly different from either *M. a. pelops* or *M. a. assamensis* – the western and eastern subspecies of the Assamese macaque, respectively. Its extremely dark coat colour, dark brown facial skin, hirsute underside of the body and the lack of prominent chin and cheek whiskers set the Tawang macaque apart from either of the Assamese macaque subspecies. Further, all

individuals of the Tawang macaque had a prominent pale-yellow patch on the otherwise dark crown. The Assamese macaque, in contrast, has much lighter facial skin and a golden brown coat with plain buff-coloured or whitish hairs ventrally. The undersurface in the Assamese macaque is relatively very sparsely haired, with the pale bluish skin showing through[1]. Further, most Assamese macaque individuals have a smooth crown hair arrangement (with an occasional central parting), although some individuals do have a whorl or tuft of hair in that position[1](A. Sinha *pers.obs.*).

The two subspecies of the Assamese macaque are morphologically distinguished from each other only by relative length of their tails[1] (ratio of tail length to head-body length). In *M. a. assamensis*, relative tail length of adult males ranges from 0.26 to 0.44, and in *M. a. pelops* from 0.50 to 0.69. In this regard, the observed relative tail length of the Tawang macaque males overlaps with that of *M. a. assamensis*. Interestingly however, looking at the distribution of the Assamese macaque, the Tawang macaque should be sympatric with *M. a. pelops* (which has a significantly larger relative tail length) that occurs in central Nepal, eastward through Sikkim, northern West Bengal, central Bhutan, and probably western Arunachal Pradesh[1]. On the other hand, the *M. a. assamensis*, whose relative tail length is similar to that of the Tawang macaque, occurs within India in eastern Arunachal Pradesh, Nagaland and Assam[1,2], and is not expected to be sympatric with the Tawang macaque.

We did not sight any Assamese macaque in Tawang or West Kameng during our expedition. The species is largely restricted to a relatively narrow altitudinal zone between 150 and 1900 m asl (although the maximum record for one troop[1] is 2750 m). Thus, the striking morphological differences and the altitudinal specificity of their distributions make it improbable that the Tawang macaque is a subspecies of *M. assamensis*.

Comparison with the Tibetan macaque

The Tibetan macaque is distributed principally in east-central China, at altitudes of 1000-2500 m, south to the Guangxi Province and west to the Yangtze Gorge in western and north-western Szechuan Province. The only report of the macaque outside this distributional range is that of Choudhury in the West Kameng district of Arunachal[3] (see later).

There are some similarities between the Tawang macaque and Tibetan macaque in terms of morphology and altitudinal distribution. These include the large and heavy built of the Tibetan macaque, its dark brown coat, a relatively hirsute underside, and the occasional small whorl on the vertex of the crown with short hairs radiating from it[4]. The Tawang macaque, however, differs from the Tibetan macaque in having a pronouncedly prognathous skull, relatively much darker facial skin, a very prominent and ubiquitous pale-yellow crown patch, and a significantly longer tail (relative tail length of male Tibetan macaques ranges from 0.07 to 0.09)[4]. Further, the Tawang macaque lacks a prominent bushy pale buff-coloured beard and full cheek whiskers found in the Tibetan macaque.

Choudhury[3] reports a troop of macaques from an altitudinal range similar to that of the Tawang macaque in the neighbouring West Kameng district. He

provisionally identifies them as the Tibetan macaque on the basis of their relatively shorter tail compared to the Assamese macaque, more prominent buffy side-whiskers, and differences in their vocalisations[3]. Although Choudhury does not provide measurements or a detailed description, his description somewhat matches that of the Tawang macaque. The Tawang macaque, however, has a remarkably dark pelage and facial skin, and a pale-yellow crown patch shared by all individuals – features not reported by Choudhury.

Conclusion

What then could be the taxonomic identity of the Tawang macaque? Its similarities with the Assamese and Tibetan macaque suggest that the Tawang macaque presumably belongs to the same *sinica* group[5] of the genus *Macaca* as both these species. At the same time, its distinctive features set the Tawang macaque apart from either of them. We therefore believe that the population of the Tawang macaque reported here potentially represents a distinct species within the *sinica* group of the genus *Macaca*. We now propose to conduct more extensive surveys for the taxon and detailed field studies on the demography, ecology and behaviour of different populations in Arunachal Pradesh. In addition, we will attempt to collect specimens for specific morphological and anatomical measurements as well as molecular genetic analyses in order to facilitate more in-depth comparisons with Assamese and Tibetan macaques and determine the exact taxonomic position of the macaque.

References

1. Fooden, J. (1982) Taxonomy and evolution of the *sinica* group of macaques: 3. Species and subspecies accounts of *Macaca assamensis*. *Fieldiana Zoology*, **10,** 1-52.
2. Sarkar, P. (2000) *Ecology and dynamics of social relationships of the Assamese macaque, Macaca assamensis (McClelland, 1839)*. Ph.D. Thesis Gauhati University, Guwahati, India
3. Choudhury, A. (2002) Survey of primates in West Kameng district, Arunachal Pradesh, India. *ASP Bulletin*, **26,** 12.
4. Fooden, J. (1983) Taxonomy and evolution of the *sinica* group of macaques: 4. Species account of *Macaca thibetana*. *Fieldiana Zoology*, **17,** 1-20.
5. Fooden, J. (1976) Provisional classification and key to living species of macaques (Primates: *Macaca*). *Folia Primatologica*, **25,** 225-236.

Appendix 3

Birds of Tawang and West Kameng Districts, Arunachal Pradesh

The avifauna of Arunachal Pradesh is relatively well-documented, especially in the low to mid-elevation areas[1-7]. However, there have been few avifaunal surveys in the high altitudes, especially above 4000 m[4,6,8]. We undertook a biological expedition in the high altitude areas of Western Arunachal with the objective of inventorying wildlife, and identifying areas for possible designation as wildlife reserves. This survey, conducted in August-October 2003, covered almost the entire high altitude areas of Tawang and West Kameng Districts. Here, we report the avifauna recorded during the survey.

Most bird observations were made while walking on existing trails and paths in forest and meadows; a few were recorded while driving along roads or motorable tracks. A total of 150 species were recorded during the survey. We found that pheasants were commonly hunted. We encountered several snares set up for pheasants, and also saw the remains of the blood pheasant *Ithaginis cruentus* in several herder camps. In the following pages is a list of birds recorded during the survey.

References

1. Athreya, R.M., Captain, A.S. & Athreya, V.R. (1997) A faunal survey of Namdapha Tiger Reserve, Arunachal Pradesh, India. Unpublished Report.
2. Choudhury, A. (2003) Birds of Eagle's Nest Wildlife Sanctuary and Sessa Orchid Sanctuary, Arunachal Pradesh, India. *Forktail*, **19,** 1-13.
3. Katti, M., Singh, P., Manjrekar, N., Sharma, D. & Mukherjee, S. (1992) An ornithological survey in eastern Arunachal Pradesh, India. *Forktail*, **7,** 75-89.
4. Singh, P. (1994) Recent bird records from Arunachal Pradesh. *Forktail*, **10,** 65-104.
5. 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.
6. Singh, P. (1999) Bird survey in selected localities of Arunachal Pradesh, India. Report, Wildlife Institute of India.
7. Athreya, R.M. & Kartikeyan, S. (1995) The wildlife sanctuaries in the Dafla Hills of Arunachal Pradesh. Unpublished Report.
8. Kumar, S. & Singh, P. (1999) *A Study on Pheasant Distributions in Arunachal Pradesh, Eastern Himalaya, India. Unpublished Report.* Wildlife Institute of India, Dehradun.

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COMMON NAME	LATIN NAME	TAWANG	WEST KAMENG
Alpine Accentor	*Prunella collaris*		+
Asian Brown Flycatcher	*Muscicapa dauurica*		+
Asian House Martin	*Delichon dasypus*	+	+
Bar-winged Flycatcher Shrike	*Hemipus picatus*	+	+
Beautiful Nuthatch	*Sitta formosa*		+
Black Bulbul	*Hypsipetes leucocephalus*	+	+
Black Drongo	*Dicrurus macrocercus*	+	+
Black Redstart	*Phoenicurus ochruros*	+	
Black-chinned Yuhina	*Yuhina nigrimenta*	+	
Black-faced Laughing Thrush	*Garrulax affinis*	+	+
Black-faced Warbler	*Abroscopus schisticeps*	+	+
Black-lored Tit	*Parus xanthogenys*	+	
Black-throated Tit	*Aegithalos concinnus*	+	+
Blood Pheasant	*Ithaginis cruentus*	+	+
Blue fronted Redstart	*Phoenicurus frontalis*	+	+
Blue Whistling Thrush	*Myophonus caeruleus*	+	+
Blyth's leaf Warbler	*Phylloscopus reguloides*	+	
Broad-billed Warbler	*Abroscopus hodgsonii*	+	
Brown Hawk Owl?	*Ninox scutulata*	+	
Buff-barred Warbler	*Phylloscopus pulcher*	+	+
Chestnut Thrush	*Turdus rubrocanus*		+
Chestnut-bellied Nuthatch	*Sitta castanea*	+	
Chestnut-bellied Rock Thrush	*Monticola rufiventris*	+	
Chestnut-crowned Laughing Thrush	*Garrulax erythrocephalus*		+
Chestnut-crowned Warbler	*Seicerus castaniceps*	+	+
Chestnut-tailed Minla	*Minla strigula*	+	+
Coal Tit	*Parus ater*		+
Common Hoopoe	*Upupa epops*	+	+
Common Iora	*Aegithina tiphia*	+	+
Common Woodshrike	*Tephrodornis pondicerianus*	+	+
Crested Serpent Eagle	*Spilornis cheela*	+	
Crimsonbreasted Woodpecker	*Dendrocopus cathpharius*	+	
Cutia	*Cutia nepalensis*	+	+
Darjeeling Woodpecker	*Dendrocopos darjellensis*	+	
Dark-breasted Rosefinch	*Carpodacus nipalensis*		+
Dark-rumped Rosefinch	*Carpodacus edwardsii*	+	+
Eastern Crowned Warbler	*Phylloscopus coronatus*		+
Emerald Dove	*Chalcophaps indica*	+	+
Eurasian Blackbird	*Turdus merula*	+	+
Eurasian Griffon	*Gyps fulvus*	+	
Eurasian Jay	*Garrulus glandarius*	+	
Eurasian Tree Sparrow	*Passer montanus*	+	+
Ferruginous Flycatcher	*Muscicapa ferruginea*	+	
Fire-tailed Myzornis	*Myzornis pyrrhoura*		+
Fire-tailed Sunbird	*Aethopyga ignicauda*	+	
Goldcrest	*Regulus regulus*		+
Golden Bush Robin	*Tarsiger chrysaeus*	+	+
Golden Eagle	*Aquila chrysaetos*	+	
Golden-spectacled Warbler	*Seicercus burkii*	+	
Golden-throated Barbet	*Megalaima franklinii*	+	+
Gold-naped Finch	*Pyrrhoplectes epauletta*	+	+
Great Barbet	*Megalaima virens*	+	+
Great Tit	*Parus major*	+	

COMMON NAME	LATIN NAME	TAWANG	WEST KAMENG
Green Shrike Babbler	*Pteruthius melanotis*	+	
Green-backed Tit	*Parus monticolus*	+	+
Grey Bushchat	*Saxicola ferrea*	+	+
Grey Sibia	*Heterophasia gracilis*		+
Grey Treepie	*Dendrocitta formosae*		+
Grey Wagtail	*Motacilla cinerea*	+	+
Grey-backed Shrike	*Lanius tephronotus*	+	+
Grey-crested Tit	*Parus dichrous*	+	
Grey-headed Bullfinch	*Pyrrhula erythaca*	+	+
Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	+	+
Grey-hooded Warbler	*Seicerus xanthoschistos*	+	+
Grey-winged Blackbird	*Turdus boulboul*	+	
Hill Pigeon	*Columba rupestris*	+	
Hill Prinia	*Prinia atrogularis*	+	
Himalayan Griffon	*Gyps himalayensis*	+	
Himalayan Monal	*Lophophorus impejanus*		+
House Swift	*Apus affinis*	+	+
Lammergeier	*Gypaetus barbatus*		+
Large-billed Crow	*Corvus macrorhynchos*	+	+
Lesser Necklaced Laughing Thrush	*Garrulax monileger*	+	
Lesser Racket-tailed Drongo	*Dicrurus remifer*		+
Little Forktail	*Enicurus scouleri*		+
Long-tailed Minivet	*Pericrocotus ethologus*		+
Long-tailed Shrike	*Lanius schach*	+	+
Long-tailed Sibia	*Heterophasia picaoides*		+
Long-tailed Thrush	*Zoothera dixoni*	+	
Mistle Thrush	*Turdus viscivorus*	+	
Mountain Imperial Pigeon	*Ducula badia*	+	+
Olive-backed Pipit	*Anthus hodgsonii*		+
Orange-breasted Green Pigeon	*Treron bicincta*		+
Oriental Hobby	*Falco severus*	+	
Oriental Turtle Dove	*Streptopelia orientalis*	+	+
Pale blue Flycatcher	*Cyornis rubeculoides*		+
Plain Mountain Finch	*Leucosticte nemoricola*		+
Plain-backed Thrush	*Zoothera mollissima*		+
Plumbeous Water Redstart	*Rhyacornis fuliginosus*	+	+
Pompadour Green Pigeon	*Treron pompadora*		+
Red-billed Chough	*Pyrrhocorax pyrrhocorax*		+
Red-billed Leiothrix	*Leiothrix lutea*	+	+
Red-headed Bullfinch	*Pyrrhula erythrocephala*	+	
Red-tailed Minla	*Minla ignotincta*	+	
Red-throated Flycatcher	*Ficedula parva*		+
Red-vented Bulbul	*Pycnonotus cafer*	+	+
Rock Bunting	*Emberiza cia*	+	+
Rufous Sibia	*Heterophasia capistrata*	+	+
Rufous-breasted Accentor	*Prunella strophiata*		+
Rufous-breasted Bush Robin	*Tarsiger hyperythrus*		+
Rufous-necked Laughing Thrush	*Garrulax ruficollis*	+	+
Rufous-vented Tit	*Parus rubidiventris*		+
Rufous-vented Yuhina	*Yuhina occipitalis*	+	
Rufous-winged Fulvetta	*Alcippe castaneceps*	+	
Rusty-flanked Treecreeper	*Certhia nipalensis*	+	
Scarlet Finch	*Haematospiza sipahi*	+	+

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COMMON NAME	LATIN NAME	TAWANG	WEST KAMENG
Scarlet Minivet	*Pericrocotus flammeus*	+	+
Silver-eared Mesia	*Leiothrix argentauris*	+	
Slaty-blue Flycatcher	*Ficedula hodgsonii*		+
Snow Pigeon	*Columba leuconota*		+
Spangled Drongo	*Dicrurus hottentotus*		+
Speckled Wood Pigeon	*Columba hodgsonii*	+	
Spotted Dove	*Streptopelia chinensis*	+	+
Spotted Laughing Thrush	*Garrulax ocellatus*	+	+
Spotted Nutcracker	*Nucifraga caryocatactes*	+	+
Spot-winged Grosbeak	*Mycerobas melanozanthos*	+	+
Streak-breasted Scimitar Babbler	*Pomatorhinus ruficollis*	+	
Streaked Laughing Thrush	*Garrulax lineatus*	+	+
Streaked Wren Babbler	*Napothera brevicaudata*		+
Striated Laughing Thrush	*Garrulax striatus*	+	+
Stripebreasted Woodpecker	*Dendrocopus atratus*		+
Stripe-throated Yuhina	*Yuhina gularis*	+	+
Tickell's Leaf Warbler	*Phylloscopus affinis*	+	+
Ultramarine Flycatcher	*Ficedula superciliaris*	+	
Upland Pipit	*Anthus sylvanus*		+
Verditer Flycatcher	*Eumyias thalassina*		+
Wedge-tailed Green Pigeon	*Treron sphenura*	+	
Whiskered Yuhina	*Yuhina flavicollis*	+	+
White Wagtail	*Motacilla alba*	+	+
White-browed Fantail	*Rhipidura aureola*		+
White-browed Rosefinch	*Carpodacus thura*	+	
White-browed Shrike Babbler	*Pteruthius flaviscapis*	+	
White-capped Water Redstart	*Chaimarrornis leucocephalus*	+	+
White-collared Blackbird	*Turdus albocinctus*	+	
White-crested Laughing Thrush	*Garrulax leucopholus*		+
White-naped Yuhina	*Yuhina bakeri*	+	+
White-spectacled Warbler	*Seicercus affinis*	+	
White-tailed Nuthatch	*Sitta himalayensis*	+	+
White-throated Laughing Thrush	*Garrulax albogularis*	+	
Whitewinged Redstart	*Phoenicurus erythrogaster*		+
Winter Wren	*Troglodytes troglodytes*		+
Wood Sandpiper	*Tringa glareola*		+
Yellow Wagtail	*Motacilla flava*		+
Yellow-bellied Fantail	*Rhipidura hypoxantha*	+	+
Yellow-bellied Flowerpecker	*Dicaeum melanoxanthum*	+	
Yellow-billed Blue Magpie	*Urocissa flavirostris*	+	+
Yellow-billed Chough	*Pyrrhocorax graculus*		+
Yellow-breasted Greenfinch	*Carduelis spinoides*	+	+
Yellow-browed Warbler	*Phylloscopus inornatus*	+	+
UID Buzzard			+
UID Forktail		+	
UID Lark		+	
UID Owl		+	
UID Pipit		+	
UID Snipe		+	

Appendix 4

List of plants recorded in the high altitudes of Tawang and West Kameng Districts, Arunachal Pradesh

K. Haridasan, A. Sarmah, Joram Muthu, Singh, Aparajita Datta, M. D. Madhusudan & Charudutt Mishra

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All collected specimens are available with Dr. K. Haridasan, SFRI, Itanagar. Approximately 10 species remain unidentified.

1. *Abies densa*
2. *Acer sp.*
3. *Aconitum fletcherianum*
4. *Aconitum hookerii*
5. *Agrimonia nepalensis*
6. *Allium wallichii*
7. *Anaphalis busua*
8. *Anaphalis contorta*
9. *Anaphalis nubigena*
10. *Anaphalis sp.*
11. *Anemone sp.*
12. *Anemone vitifolius*
13. *Anthogonium gracile*
14. *Artemisia sp.*
15. *Arundinaria sp*
16. *Aster himalayicus*
17. *Berberis sp.*
18. *Bistorta affinis*
19. *Bistorta calostachyum*
20. *Buddleja sp.*
21. *Calamintha umbrosa*
22. *Campanula pallida*
23. *Carlamenia griffithii*
24. *Cassiope fastigiata*
25. *Chirita pumila*
26. *Cirsium sp.*
27. *Coptis teeta*
28. *Cortia depressa*
29. *Corydalis siberica*
30. *Cotoneaster sp.*
31. *Crotalaria mysorensis*
32. *Crotalaria mysorensis*
33. *Cryptomeria japonica*
34. *Cyananthus lobatus*
35. *Cyanotis vaga*
36. *Cynanthus lobatus*
37. *Cynoglossum furcatum*
38. *Cynoglossum zeylanicum*
39. *Daphne sp.*
40. *Desmodium sp.*
41. *Disporum sp.*
42. *Dumasia sp.*
43. *Eerigeron alpinus*
44. *Epilobium brevifolium*
45. *Eupatorium revesii*
46. *Fagopyrum sp.*
47. *Fragaria sp.*
48. *Frittillaria cirrhosa*
49. *Galinsoga ciliata*
50. *Gentiana capitata*
51. *Gentiana sp.*
52. *Gentiana tianschaica*
53. *Gentiana veitcheriflorum*
54. *Gentianella sp.*
55. *Geranium sp.1*
56. *Geranium sp.2*
57. *Helinia elliptica*
58. *Houttuynia cordata*
59. *Hypericum hookerianum*
60. *Hypericum patulum*
61. *Illicium griffithi*
62. *Impatiens sp. (longipes)*
63. *Indigofera sp.*
64. *Inula sp.*
65. *Juncus grasebachii*
66. *Juncus himalaicus*
67. *Juncus thomsoni*
68. *Juniperus indica/wallichii*
69. *Juniperus recurva*
70. *Jurinea sp.*
71. *Leontopodiun sp.*
72. *Leucas cephalotes*
73. *Lichen*
74. *Lomatogonium sp.*
75. *Lycopodium clavatum*
76. *Melastoma sp.*
77. *Nepeta sp.*
78. *Osbeckia stellata*
79. *Oxalis sp.*
80. *Parnasia wightiana*

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81. *Parochetus sp.*
82. *Pedicularis carnosa*
83. *Pedicularis gracilis*
84. *Pedicularis purpuracea*
85. *Picea sp.*
86. *Picrorrhiza kurroa*
87. *Pimpinella sp.*
88. *Pinus wallichiana*
89. *Plectranthus sp.*
90. *Polygala arillata*
91. *Polygonum bistorta*
92. *Polygonum capitatum*
93. *Polygonum rude*
94. *Polygonum runcinatum*
95. *Polygonum sp.*
96. *Polygonum vaccinifolium*
97. *Potentilla fulgens*
98. *Potentilla sp.*
99. *Praenanthus sp.*
100. *Primula denticulata*
101. *Quercus sp.*
102. *Ranunculus cantonensis?*
103. *Rheum emodi*
104. *Rhododendron anthopogon*
105. *Rhododendron lepidotum*
106. *Rhododendron spp.*
107. *Rosa sp.*
108. *Rubia cordifolia*
109. *Rubus sp.*
110. *Rumex nepalensis*
111. *Sambucus javanica*
112. *Sanicula europea*
113. *Satyrium nepalensis*
114. *Saussaurea kunthiana*
115. *Saxifraga strigosa*
116. *Sedum multicaule*
117. *Sedum sp.*
118. *Seigesbeckia sp.*
119. *Selinum*
120. *Selinum tenuifolium*
121. *Senecio chrysanthemoides*
122. *Senecio sp. 1*
123. *Senecio sp. 2*
124. *Senecio volubilis*
125. *Smilax sp.*
126. *Spiranthes sinensis*
127. *Spirea callosa*
128. *Spirea japonica (Spirea callosa)*
129. *Stellaria media*
130. *Stellaria uliginosa*
131. *Stipa sp.*
132. *Swertia sp.*
133. *Tanacetum rubigenum*
134. *Taxus wallichiana*
135. *Thalictrum foliosum*
136. *Trillidium govanianum*
137. *Tsuga dumosa*
138. *Valeriana wallichiana*
139. *Viburnum simonii*
140. *Viola biflora*

Unidentified bamboos

Appendix 5

Vegetation and habitat mapping: technical details

Data

Digital data

We used orthorectified cloud-free satellite images from the 7-band sensor of LandSat TM. The study region straddled two adjacent paths (137 & 136) for which the available imageries were acquired on 7 November 1990 and 25 October 1988, respectively. These dates represented the best cloud-free period for which data were available to us within the end-monsoon/autumn season when our survey was carried out. Although the imageries are about 15 years old, we do not expect major shifts in the vegetation boundaries, except, perhaps, in the lower-elevation valleys, where agricultural settlements may have expanded. The spatial resolution of the images was 29 m. Topographic data were obtained from the global 89-metre SRTM dataset[1]. 'Holes' in the SRTM data were filled using BlackArt software, employing interpolation procedures described by Childs[2]. The images were processed using ERDAS Imagine and ArcGIS Desktop software.

Field data for decision tree classification and identification of vegetation classes

A total of 128 point locations were recorded during the survey using a global positioning system. Of these, only 92 fell above an altitude of 2750m and were used in the analysis. We marked an additional 32 locations on the map, which we were able to assign to vegetation types based on our field surveys. Together, these 124 points covered all the important vegetation physiognomies occurring above 2750 m elevation. These points were superimposed on the satellite image and the terrain model, and a region of 30 m radius was sampled in these layers to obtain mean values of reflectance in Bands 1 to 7, NDVI from the Landsat TM image, and elevation from the SRTM DEM. These metrics were chosen because of the strong relationships they were expected to bear with the vegetation of an area. We used field observation and videography to gather detailed descriptive information on the vegetation around each of these points. Subsequently, based on broad structural and compositional characteristics, the vegetation at these points was classified into 7 types (see Chapter 3).

Obtaining classification rules using a binary decision tree

A decision tree was used to classify the vegetation class membership of each point (dependent variable) using the independent variables, which were metrics derived from the Landsat TM image and the SRTM DEM. Decision tree theory[3] has previously been used to obtain classification rules for remotely sensed data sets[4,5]. Trees are non-parametric, hierarchical classifiers which predict class membership by recursively partitioning the data into relatively homogeneous subsets. We used the S-Plus statistical package for this analysis. This employs a deviance measure to split data into nodes which are more homogeneous with respect to class membership than the parent

node[6]. Besides their ability to uncover structure in the data, tree analysis allowed us to choose appropriate variables and devise prediction rules that can be rapidly and repeatedly evaluated. Decision trees thus offer a significant advantage over other classification methods, particularly in situations where prior data from the field are strong.

First, decision trees were obtained using only spectral data and their derived indices (reflectance in bands 1-7 and NDVI) for ground points had been assigned to the above *a priori* vegetation classes. This analysis helped identify the essential set of spectral variables based on which vegetation classes could be obtained. Subsequently, for the same set of points, we also obtained a decision tree based on elevation.

Vegetation Classification

We used a hybrid rule-based classification procedure, whereby an integrated set of rules was obtained from the two decision trees (spectral and altitudinal). These rules were then transferred to the Knowledge Engineer module of ERDAS Imagine and cross-checked for conflicts before being implemented under its Knowledge Classification system. A majority filter was applied on the resulting image to remove specks. The pixels remaining unclassified (due to cloud-cover and shadow) were retained and are reported as such.

Delineation of proposed wildlife reserve

We used topographic features to delineate the boundaries of the proposed wildlife reserve in the region identified in Chapter 2. This was done by first marking out individual basins in the Mago Chu Valley and higher West Kameng survey regions. We then added a set of adjacent basins, taking care to minimize protruberances and invaginations into the boundary. We chose to leave out as much of the permafrost areas as possible owing to their low biological significance, and because of the intrinsic protection due to their remoteness and hostile conditions.

Decision tree outputs

The decision tree based on elevation produced a first-level split at 4049 m, which effectively was the tree-line, with closed-canopy forested habitats falling below, and open scrub-grassland habitats falling above it (Fig 1). The reported misclassification rate was 25%. Conifer-Broadleaved forests (CBL) were the most variable class even in

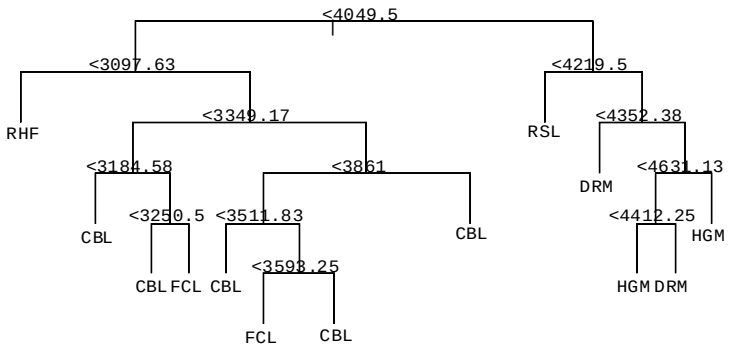

Fig. 1. Binary decision tree showing the different elevation levels at which vegetation classes separate.

terms of altitude, appearing in four terminal nodes between elevations of 3097 m and 4049 m. The decision tree model on spectral characteristics of the ground data points was constructed using Bands 1 through 6, and NDVI (Fig 2). The misclassification rate reported was 23%. Three terminal nodes of Conifer-Broadleaved forests (CBL) were identified, making them spectrally the most variable vegetation class.

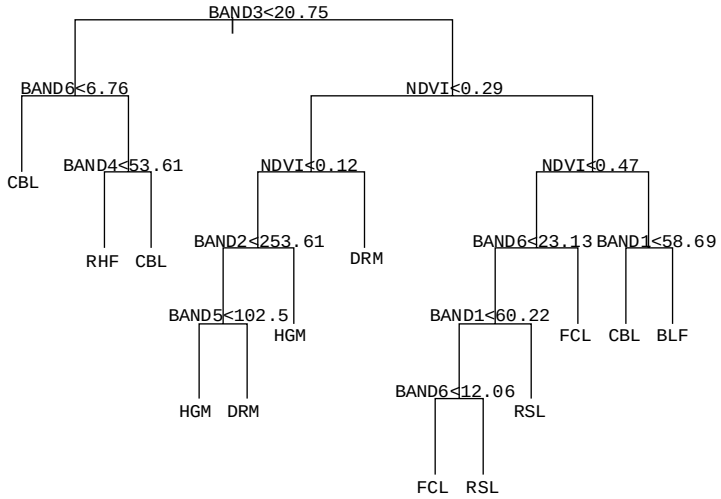

Fig. 2. Binary decision tree showing the levels of different spectral characteristics at which vegetation classes separate.

References

1. USGS. (2003) Shuttle Radio Topography Mission (SRTM) data. Available from http://edcftp.cr.usgs.gov/pub/data/srtm/Eurasia/ (accessed 13/12/3 A.D.).
2. Childs, J. (2004) Using BLACKART to repair SRTM and ASTER DEMs. Available from http://www.terrainmap.com/rm38.html#srtm_repair (accessed 16/1/2004).
3. Venables, W.N. & Ripley, B.D. (1994) *Modern Applied Statistics With S-Plus*. Springer Verlag, New York, USA.
4. Hansen, M.C., Defries, R.S., Townshend, J.R.G. & Sohlberg, R. (2000) Global land cover classification at 1 km spatial resolution using a classification tree approach. *International Journal of Remote Sensing*, **21,** 1331-1364.
5. Krishnaswamy, J., Kiran, M.C. & Ganeshaiah, K.N. (2003) Tree model based eco-climatic vegetation classification and fuzzy mapping in diverse tropical deciduous ecosystems using multi-season NDVI. *International Journal of Remote Sensing*, **24,** 1-21.
6. S-Plus (2001) Classification and regression trees. *S-Plus 6 for Windows Guide to Statistics, Volume 2* pp. 1-37. Insightful Corporation, Seattle, USA.

The high altitude wildlife of Arunachal Pradesh, Eastern Himalaya, has remained unexplored and unprotected. This report summarizes the results of a comprehensive biological expedition in Western Arunachal's high altitudes, and lays down the foundation for establishing the first high altitude wildlife reserve in this global biodiversity hotspot.

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