Project Update: July 2010

Sixty percent of Asia's forests are under high or moderate threat (Bryant et al., 1997). The main threats for forest loss and degradation are logging, habitat conversion, wildfires, fuel wood collection, overgrazing and plantations. The fundamental triggers behind these activities are probably, increasing human populations, roads penetrating deeper and deeper into the forests and weak economies of respective countries. However, the relative impacts of these factors are still unclear and less apparent. Amongst the causes listed above, logging alone affects a large area of forested tracts in Asia. Logging directly results in change in the structure and composition of forests, in modification of microhabitats and it affects wildlife populations differentially. Responses of different taxa and species within taxa vary to differential pressures of logging.

Another serious threat to wildlife populations is hunting. Hunting is widespread across various areas of South and South-east Asia (Bennett et al., 1997; Kinnaird and O'Brien, 2007; Milner-Gulland et al., 2003; Robinson and Bennett, 2000). Rural tribal communities hunt for various reasons from meeting dietary needs and protein requirements, to hunting specific species for valuable, culturally significant, or medicinally important body parts.

Asian hornbills are a group of large birds, which are restricted to the tropical forests of South and South-east Asia. There are 31 species of hornbills. Hornbills face severe threats from both logging and hunting. Unlike many other hole-nesting birds, hornbills are secondary cavity-nesters, which mean they cannot make their own cavity. They require large cavities on tall emergent large trees especially because the female incarcerates herself in the nest during the breeding season. Hornbills are known to require large trees for nesting. Logging often results in selective removal of these tree species. In South-east Asia, the Helmeted Hornbill *Rhinoplax vigil* and the Red-knobbed Hornbill *Aceros cassidix* nest in cavities of Dipterocarp trees, which are targeted by logging. In such cases, one can expect direct impacts of logging on hornbills. Even if, the specific nest tree species and food species are not targeted by logging, most studies show that even 'selective' logging results in high incidental damage and death of many other trees (various ref). However, there is currently no information on impacts of logging on nesting of hornbills. In addition, logging can also result in removal/loss of important hornbill food plants.

Hunting, on the other hand, poses a more serious threat to hornbills, particularly because it results in direct removal of individuals from the population. The direct loss of adult birds in a hornbill population can have serious consequences as hornbills are large-bodied birds where sexual maturity and pair formation occurs only after the 3rd-4th year, breed once annually, have a long nesting season with extensive and extended parental care with food provisioning by males, small clutch size and possibly low juvenile survival rates.. In addition, due to potential limitation of suitable nest sites and other factors, not all adult pairs may breed each year. Hornbills are hunted for various reasons, for their meat, for their body parts like the tail feathers, casque and body fat. Tail feathers and casque of hornbills, particularly the large and spectacular species like the Great hornbill *Buceros bicornis* and the Rhinoceros hornbill *Buceros rhinoceros* along with other large species, form an important part of the local customs and headdresses of many tribes across South-east Asia. Continuous demand for these body parts of hornbills by the ever-increasing human population has resulted in local extirpation of many hornbill species across their range.

Five species of hornbills are found in Arunachal Pradesh, — the Great hornbill, Rufous-necked hornbill *Aceros nipalensis*, Wreathed Hornbill *Rhyticeros undulatus*, Brown Hornbill *Anorrhinus austeni* and the Oriental Pied Hornbill *Anthracoceros albirostris*. Brown Hornbill is found only in the Tirap, Changlang, and the Lohit Districts of Arunachal Pradesh. In Arunachal Pradesh, like other areas in South-east Asia, hornbills face significant threats from logging and hunting. In 2008, logging was resumed after the removal of the Supreme Court ban for 12 years since 1996. Many tribes in the state like the Nishis, Tangsas, Wanchos use different body parts of hornbills. Nishis use the casque of hornbills in their headdresses, while the Wanchos and Tangsas use the tail feathers of hornbills to adorn their caps. A previous study in western Arunachal Pradesh demonstrated that Great Hornbill was negatively affected by logging (Datta, 1998) and a hunting survey in eastern Arunachal Pradesh suggested some species, particularly the Great hornbill have been locally extirpated (Datta, 2002; Datta, 2009).

In this study, I have investigated the relative impacts of logging and hunting on four species of hornbills in eastern Arunachal Pradesh. I was also interested in looking at differences in responses of species, which show strong seasonal movements (Wreathed Hornbill), and resident species (Great Hornbill, Rufous-necked Hornbill and Brown Hornbill) to hunting and logging.

Methods

I established sixteen trails across seven sites (see Table 1 and Fig. 1). These trails were established based on our previous knowledge on hunting and logging pressures in the area. I had a fair idea of hunting and logging pressures in the area because of the previous survey carried out in the area between January and May 2008. The habitats in all the sites would have been primary evergreen forest at one point of time; however, logging had degraded few of the sites into open forests. Namdapha National Park with no logging history acted as our control site. Since hornbills occupy a wide elevation range, I selected sites across the elevation range occupied by hornbills from 150 – 1400 m. Most of the trails were animal trails, which were cut slightly to allow a single person to walk. In Namdapha, I used the already existing trails of the Forest Department for monitoring. The length of the trails varied from 1.3 – 3.0 km. These trails were monitored from November 2008 – April 2009. The trails were walked in mornings (5:30 – 8:00 am) and in the evenings (3:30 – 5:00 pm). Species identity, number and activity (perched, flying, feeding) were recorded. Perpendicular distance of the bird from the trail and the height at which the bird was perched was also recorded. In case, the birds were in a flock, distance to the center of the flock was recorded. Encounter rates of hornbills were estimated for each of the trails. Namdapha experiences no logging pressures; therefore, I expected it to be structurally the most complex thereby having the least detection distances amongst all the sites. I used Program Distance 5.0 to calculate the detection probability function and estimate the distance within which the hornbill detection probability was equal to one in the 'best' forest (Namdapha National Park). Thus, at all the sites, only sightings within this distance (where the detection probability was equal to one) were used to estimate the encounter rates of hornbills. This approach allowed us to control for the varying detection probability across the various sites.

Systematic vegetation sampling was done at each of the sites to estimate total basal area (per hectare). Total basal area was used as an indicator of forest quality with the expectation that logged forest due to loss of big trees will result in lower total basal area as compared to the primary forest. Along all the trails, except in Namdapha National Park and Tengapani Reserve Forest, I used the Point-centered Quarter technique wherein the points were spaced at 100 m distance along the trail. The distance to the nearest trees in each of the quarters was measured. The girth at the breast height (GBH) of each of the trees along with tree height was also measured. In Namdapha National Park and Tengapani Reserve Forest, I used 10 m circular radius plots spaced regularly at every 100 m along the trail. In each of the plots, the number of trees was counted and GBH and tree height of each of the trees was measured. I compared the tree density estimates for two sites using both the methods Point-centered quarter and 10 m circular radius plots (Tengapani RF and Namdapha NP). The tree densities with both the methods yielded comparable densities therefore I decided to use PCQs as a rapid method for assessment of tree density and basal area in the remaining sites.

I interviewed at least two key informants to obtain information on hunting pressures on the trail. The key informants in most cases were resident hunters in the villages nearest to the sampling site. In some remote areas of Namdapha National Park where hunters may go occasionally and were not available, local people with good knowledge of the area were interviewed. At sites, where there were several resident communities, individuals from each community were interviewed. The interviews were carried out as part of informal conversations from which I got answers to specific questions like 1) which species of hornbills were found in the area, 2) did the locals hunt any particular species of hornbills, 3) what were the reasons for which the hornbills were hunted, 4) did they use any of the hornbill body parts in local customs, rituals or traditional attire, 5) did they have any specific hunting taboos, 6) whether the locals frequent the area which were monitoring frequently and, 7) if a particular hornbill species was not sighted when was the last time they had detected the species. This information was used to attempt an objective semi-quantitative assessment of hunting pressures. Based on the information of whether they visited the surveyed area to hunt hornbills often or not and based on the whether the locals used particular body parts of hornbills I ranked the sites into high and low hunting intensity sites.

Table 1. Details of 16 trails that were monitored from November 2008 – April 2009.

No.	Site	Elevation (m)	Status	Administration	Transect length (km)	Total effort (km)
1	C	209	RF	Tengapani RF	1.5	33
2	D	225	RF	Tengapani RF	1.5	31.5
3	E	233	RF	Tengapani RF	1.5	34.5
4	F	201	RF	Tengapani RF	1.5	30
5	Turung	299	RF	Turung RF	3.0	27
6	Rima	549	RF	Rima RF	2	34
7	Miao	576	RF	Miao RF	2	42
8	Manmao	808	CF	USF	1.7	25.5
9	Yakhulo	1394	CF	USF	1.3	20.8
10	Haldibari	599	PA	Namdapha NP	2	46
11	Bulbulia	683	PA	Namdapha NP	2	48
12	Ranijheel	848	PA	Namdapha NP	1.7	45.9
13	Rajajheel	918	PA	Namdapha NP	2	50
14	65 mile (above M-V Road)	1119	PA	Namdapha NP	2	18
15	75 mile (above M-V Road)	1210	PA	Namdapha NP	1.8	25.2
16	Waa-si	1348	PA	Namdapha NP	1.5	33

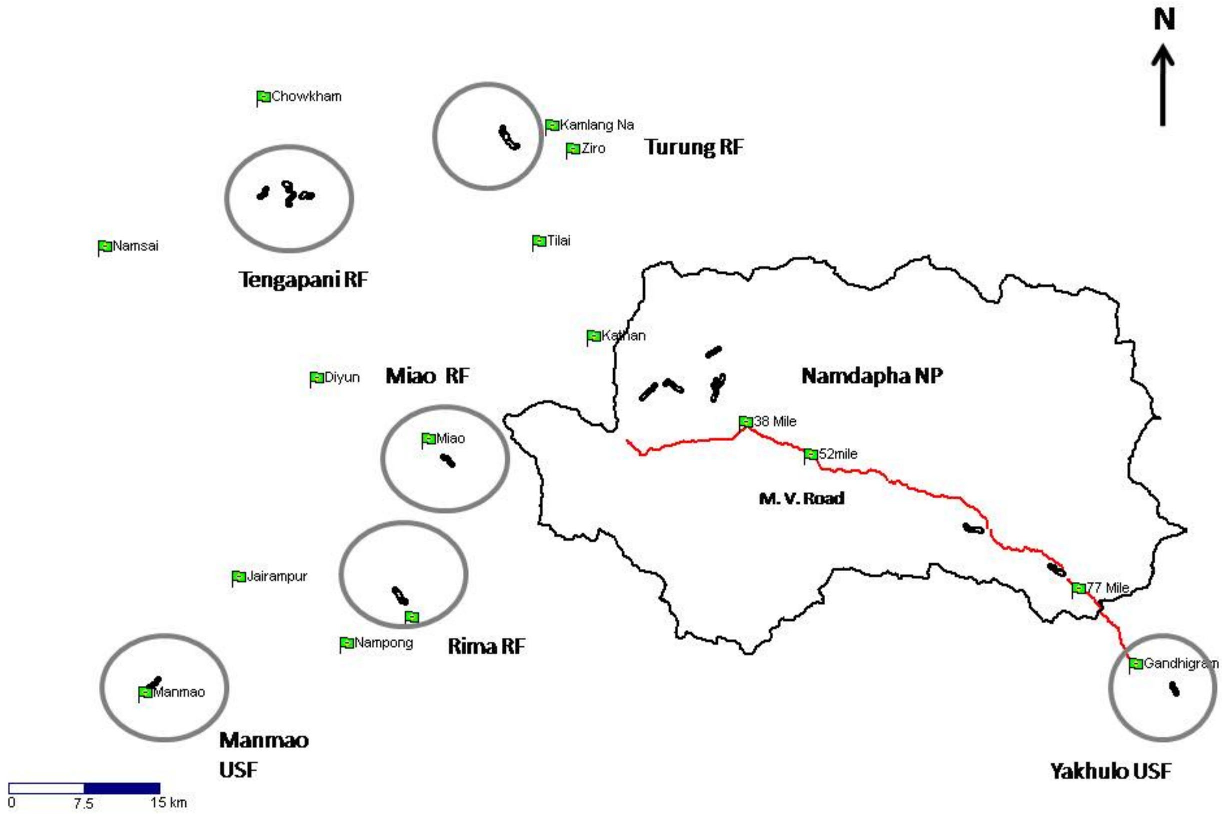

Figure 1. Map depicting the location of trails (black lines) at each of the sites. The area enclosed by the black line is the Namdapha National Park. The grey ellipses are the Reserve Forests and the Community Forests.

As hornbill species have specific elevational distributions, it was important that I sampled across the entire elevation gradient. I also incorporated elevation of each trail as a predictor variable to investigate the influence of elevation on hornbill distributions.

I was interested in investigating the influence of hunting and logging pressures on the response of each hornbill species in the area. I had a continuous response variable (encounter rate of each hornbill species) and two continuous predictor variables (total basal area and elevation) and a categorical predictor variable (high and low hunting intensity). I therefore used Analysis of Covariance to examine the influences of both continuous and categorical predictor variables on a continuous response variable. I ran 12 different models using single predictor variables and a combination of predictor variables.

Results

The total basal area of the logged sites (37.4 ± 4.5 m^2/ha) was significantly lower than the unlogged sites (53.2 ± 4.6 m^2/ha; t = -2.4456, df = 14, p = 0.028).

The responses of the four species of hornbills were different to hunting and logging. Logging did not seem to affect any of the four species of hornbills. Basal area, which was used as a surrogate for logging impacts, was not significant in explaining the variation in hornbill encounter rates (Table 2). However, Great Hornbill and Rufous-necked Hornbill were negatively affected by hunting. Wreathed

Hornbill and Brown Hornbill were not affected by hunting. Great Hornbill, Rufous-necked Hornbill and Brown Hornbills showed significant associations with elevation. Great Hornbill and Brown Hornbill encounter rates declined with increase in elevation, while Rufous-necked Hornbill encounter rates increased with elevation.

When all the high elevation sites (four sites >1000 m) were dropped (thereby controlling for elevation) and the analysis was repeated, the model with only hunting as the predictor variable came out to be the significant factor explaining 35% of variation in Great Hornbill encounter rates (Table 3). Similarly, for Rufous-necked Hornbill when the lowland sites (five sites < 500 m) were dropped, the model with only hunting as the predictor variable was selected as the best model and it explained more than 38% of the variation in Rufous-necked Hornbill encounter rates (Table 3).

Table 2. Summary of Analysis of Covariance results for the four species of hornbills with the standardized coefficients for the three variables: elevation, total basal area and hunting intensity index.

Species	**Model[a]**	***p***	**Adj. R^2**	**Elevation**	**Basal area**	**Hunting intensity**	**Intercept**
Great hornbill	E+B+H	**0.025**	0.41	**-2.66E-04***	3.50E-03	**-1.75E-01***	**3.99E-01***
Rufous-necked hornbill	E+H	**0.009**	0.44	**7.30E-04****		**-0.45***	0.48
Wreathed hornbill	E+B	0.146	0.14	-5.48E-05	1.44E-03		2.12E-02
Brown hornbill	E	**0.013**	0.32	**-1.436***			**0.18****

[a] E = Elevation; B = Total basal area per hectare; H = Hunting
*** p < 0.05; ** p < 0.01**

Table 3. Analysis of covariance results for the two species of hornbills (with some sites removed from analysis to control for elevation; see text) with the standardized coefficients for the hunting variable.

Species	**Model**	***p***	**Adj. R^2**	**Hunting**	**Intercept**
Great hornbill	Hunting	**0.026**	0.35	**-0.24***	**0.51****
Rufous-necked hornbill	Hunting	**0.025**	0.38	**-0.69***	**1.53****

*** p < 0.05; ** p < 0.01**

Discussion

Logging

The current study did not detect significant trends in impacts of logging on hornbills. One of the main reasons for this could be the fact that currently none of the logged sites is isolated. They are contiguous with pristine forests. Hornbills are fragile birds and are known to cover large distances to track specific food resources (Kemp, 1995). In a matrix of logged and pristine forests, hornbills might continue using logged forests to access key resources. It is difficult to understand the impacts of logging fully as most areas are connected with larger forest patches. While several important food plants of hornbills like *Ficus*, *Dysoxylum binectariferum, Chisocheton paniculatus* are not targeted by logging, species like *Amoora wallichi,* which is one of the most important non-fig hornbill food plants (Datta, 2001), is logged because of its good timber quality. *A. wallichi* is however, classified as Class B-I timber, and is targeted only when the Class-A timber resource is exhausted in the area. One expectation of logging would be reduced fruit abundance, which can have negative influences on frugivores community. Heydon & Bulloh (1997) found lower monthly fruit production in selectively logged forests as compared to logged forests.

Hornbills cannot excavate their own nests. They are forced to use naturally existing cavities or cavities created by woodpeckers and barbets. They need large cavities for nesting because they are large-sized birds. Hornbills prefer live, large (GBH > 100 cm and in Arunachal Pradesh GBH ~ 400 cm) and tall emergent trees (35 m) for nesting (Datta and Rawat, 2004; Kinnaird and O'Brien, 2007). In addition, some species like Helmeted Hornbills *Rhinoplax vigil* are known to prefer Dipterocarp trees for nesting. Even in Arunachal Pradesh, hornbills are known to use trees which have high timber value like *Ailanthus grandis* (Borpat), *Terminalia myriocarpa* (Hollock), *Altingia excelsa* (Jutli), *Dipterocarpus macrocarpus* (Hollong) and *Shorea assamica* (Mekai) for nesting (Datta, 2002; Datta and Rawat, 2004). Both *Tetrameles* and *Ailanthus* are Class B timber species and are therefore are not the first species to be targeted by logging. However, in many areas of Arunachal Pradesh, the Class-A timber resource is exhausted due to bad forestry practices and the logging focus has now shifted to Class B timber species. While *Tetrameles* does not occur in eastern Arunachal, some preliminary observations on a few nests shows that large emergent timber species like *Terminalia myriocarpa*, *Altingia excelsa* and two dipterocarps (*Dipterocarpus macrocarpus* and *Shorea assamica* are used in eastern Arunachal or likely to used based on tree characteristics (Datta, 2002; Datta and Rawat, 2004). Logging is targeted mainly for large-sized trees and therefore it can have significant impacts on the nest tree availability for hornbills.

Despite the loss of food and nest trees hornbills continue to use logged forests as is evident from many sites across South-east Asia. Even in sites such as in Turung Reserve Forest, which has extremely low tree density (120 trees/ha) as compared to Namdapha NP (462 trees/ha), I still detected all four species of hornbills. However, this degraded, and heavily logged RF is connected with Tengapani Reserve Forest and Kamlang Wildlife Sanctuary. Thus, logged forests continue to be important habitats for hornbills. Logging especially of important hornbill food plants and nest trees should be banned to ensure persistence of hornbills in these habitats. As hornbills feed on spatio-temporally patchily distributed fruit resources, they need large landscapes for persistence. A matrix of logged forests and contiguous forests possibly will ensure long-term survival of hornbills in the landscape and is the only pragmatic and realistic hope for hornbill conservation.

Often, logging is accompanied by agricultural expansions. With limited opportunities for livelihoods for tribal communities, cash crops such as tea and orange are important sources of revenue, which is resulting in expansions of orange orchards particularly in the Lohit District in areas around Wakro and parts of Changlang District where tea is being planted.

Another reason for loss of primary forests is shifting cultivation. This mode of cultivation is a common method across other parts of Asia and is thought to be a sustainable mode of agriculture in poor tropical soil conditions (MacKinnon et al., 1996). It is characterized by short periods of production followed by long periods of fallow, which results in soil enrichment. Thus, in a landscape with low human population density, shifting cultivation can be sustainable and be less destructive. Fallows more than 25 years old are known to retain bird diversity similar to the primary forest and it needs 50 – 75 years for the fallows for the recovery of woody plants after jhumming (Raman et al., 1998). With the growing population density, there are two consequences of shifting cultivation in Arunachal Pradesh. Firstly, more and more land is probably coming under shifting cultivation and secondly, fallow periods are decreasing and it is rare to find fallows more than 25 years old. Jhum fallows, especially the young fallows are seldom important hornbill habitats because of absence of large trees for nesting and absence of fruiting trees.

Hunting

Great Hornbill and Rufous-necked Hornbill were negatively affected by hunting. The Brown Hornbill and the Wreathed Hornbill however did not exhibit significant trends with hunting intensity. Brown Hornbill is a small-sized species (750 gm), is also less colorful than other species, and is therefore not targeted by hunting. Some tribes like the Tangsa opportunistically hunt Brown Hornbills for their meat and sometimes keep their heads as trophies in their houses, while feathers of the species are occasionally kept by Wanchos for use in traditional ceremonies, mainly for children (Datta, 2002).

The three other large-sized hornbills, on the other hand, face differential hunting pressures with the Great Hornbill being the most preferred. Tangsas also use paper feathers in case of non-availability of Great Hornbill tail feathers. The other species of hornbills are hunted opportunistically. It was however, of interest to note that the two resident species of hornbills were affected by hunting and the Wreathed hornbill, which exhibits strong seasonal movements, was not affected by hunting.

Great Hornbill and Rufous-necked Hornbills both are resident species. Thus, one would expect them to be exposed to hunting for a longer duration of time. Wreathed Hornbill on the other hand shows strong seasonal movements and visits most of these sites only for 2 – 4 months in the winters. It is therefore exposed to hunting for a shorter duration of time, assuming they are not hunted in some of their breeding sites. At least in Tengapani RF (which is the last remaining lowland site in the Indian side) where Wreathed Hornbills breed (based on presence of these species in this area in the breeding season and based on indications by locals in the area that they breed) hunting pressures are low. Tengapani RF is relatively a large RF (385 km^2) and only part of the RF around the Madhuban camp experiences heavy logging pressures. Wreathed Hornbills visiting the Namdapha National Park could also be breeding in the lowland forests in Burma. Currently, our knowledge about the breeding localities of Wreathed Hornbills is poor. I might need to take help of newer and better technology like Satellite Telemetry to pin down the precise breeding localities of these species in the landscape.

The seasonal movement of Wreathed Hornbills, however, also poses serious challenges to determine the effects of hunting on Wreathed Hornbills. One might require monitoring their populations over a wider landscape over successive years to actually determine the trends in Wreathed Hornbill populations and thereby determine impacts of hunting on them.

A single Great Hornbill tail feather can cost anywhere between Rs. 250-1000. The rates of the tail feathers vary from place to place and are probably a function of presence or absence of the species in the area. One would expect that the rarer the hornbill become in the area, greater would be the price of the tail feathers. In Manmao, the local hunter indicated that people from other parts of the state who sometimes visit the area often buy hornbill casques for as much as Rs. 500. In different areas of the state, different tribes attribute values to different body parts. Nishis use the casque of the hornbills, which is of not so great an importance to a Tangsa tribesman who uses the tail feathers. Tangsa tribesman may keep the head of the Great Hornbill as a trophy on a wall in his house. In areas around Itanagar, the casque of the Great Hornbill may cost up to Rs. 4000. When people in one area, start realizing that they might get the body parts they want from other areas of the state at cheaper prices, that might trigger an increase in hunting pressures on hornbills at a larger scale, which can potentially have catastrophic effects on hornbills.

I was also interested in looking at whether any level of hunting is sustainable for hornbills or not. I estimated densities of Great Hornbill (1.2 individuals/km^2) and Rufous-necked Hornbill (6.5 individuals/km^2) in Namdapha National Park. I used the Robinson & Redford model to estimate the sustainable harvest rates for the two species of hornbills (Robinson and Redford, 1991). The harvest rates were just 2.5 – 3% of the population, which translates to 3 – 5 Great Hornbills and 17 – 20 Rufous-necked Hornbills per year per 100 km^2 even in the best habitats like Namdapha. Hornbills are slow breeders, take at least 3 – 4 years to reach sexual maturity and raise only one chick per year. In addition, they naturally occur at low densities which rules out sustainable hunting as an option. Hornbills can be expected to be extremely sensitive to hunting. Robinson & Bennett (2000) estimate that the "typical" forest ecosystem may support subsistence hunting if the human population density does not exceed 1 person/km^2. In most areas in eastern Arunachal Pradesh, the human population densities are much higher than 1 persons/km^2.

I did not detect Great Hornbill and Rufous-necked Hornbill at one of the sites (Manmao) in spite of 25.5 km of effort. In addition, the local hunters indicated that the last Great Hornbill was spotted by the key informants two years ago and the Rufous-necked Hornbill has not been detected for more than ten years now. The two species have probably gone locally extinct in the area. Manmao is dominated by Tangsas who use tail feathers of Great Hornbills.

The taboos, which villagers follow for not hunting hornbills during the breeding season is extremely interesting because it has strong conservation implications. Hunting a male hornbill during the breeding season will inadvertently lead to the death of the chicks and in cases even of the incarcerated female, which is completely dependent on the male for food. Taboos like these therefore are the first steps in the conservation of hornbills in the landscape where hornbills form an important component of the local traditions. However, these taboos are slowly fading and interviews with villagers suggested that the younger generation is slowly forgetting this taboo. Loss of simple taboos like this can exacerbate the process of extirpation of the hornbills.

With large mammals like deer and primates having declined drastically in most areas, the focus of hunting is likely to shift to these large birds, which offer 2.5 – 3 kg of meat. Hunting pressures on hornbills and on their habitats is likely to increase with the increasing population in the state. Conservation of hornbills in eastern Arunachal Pradesh is thus precariously placed. Unless strong interventions in the form of conservation education along with law enforcement and alternative sources of hornbill tail feathers (artificial tail feathers or moulted feathers of captive hornbills) are introduced in the area in immediate future, we might lose hornbills from many Reserve Forests and Community Forests in the near future.

Literature Cited

Bennett, E.L., Nyaoi, A.J., and Sompud, J., 1997. Hornbills *Buceros spp.* and culture in northern Borneo: can they continue to co-exist. Biological Conservation 82, 41-46.

Bryant, D., Nielsen, D., and Tangley, L., The last frontier forests: Ecosystems and economies on the edge, World Resources Institute, Washington D. C., USA 1997.

Datta, A., 1998. Hornbill abundance in unlogged forest, selectively logged forest and a forest plantation in Arunachal Pradesh, India. Oryx 32, 285-294.

Datta, A., An ecological study of sympatric hornbills and fruiting patterns in a tropical forest in Arunachal Pradesh, Vol. PhD. Saurashtra University, Rajkot 2001, pp. 245.

Datta, A., Status of hornbills and hunting among tribal communities in eastern Arunachal Pradesh. Report submitted to the Wildlife Conservation Society, New York and WCS-India Program, Bangalore, 2002, pp. 70.

Datta, A., 2009. Observations on Rufous-necked *Aceros nipalensis* and Austen's Brown *Anorrhinus austeni* Hornbills in Arunachal Pradesh: natural history, conservation status and threats. Indian Birds 5, 108-117.

Datta, A., and Rawat, G.S., 2004. Nest-site selection and nesting success of three hornbill species in Arunachal Pradesh, north-east India: *Buceros bicornis*, *Aceros undulatus* and *Anthracoceros albirostris* Bird Conservation International 14, 249-262.

Heydon, M.J., and Bulloh, P., 1997. Mousedeer densities in a tropical rainforest: The impact of selective logging. Journal of Applied Ecology 34, 484-496.

Kemp, A.C., 1995. The Hornbills. Oxford University Press, Oxford, England.

Kinnaird, M.F., and O'Brien, T.G., 2007. The Ecology and Conservation of Asian Hornbills: Farmers of the Forest. The University of Chicago Press.

MacKinnon, K., Hatta, G., Halim, H., and Mangalik, A., 1996. The Ecology of Kalimantan, Indonesian, Borneo. Periplus Editions, Singapore.

Milner-Gulland, E.J., Bennett, E.L., and Group, S.A.M.W.M., 2003. Wild meat: the bigger picture. Trends in Ecology & Evolution 18, 351-357.

Raman, T.R.S., Rawat, G.S., and Johnsingh, A.J.T., 1998. Recovery of tropical rainforest avifauna in relation to vegetation succession following shifting cultivation in Mizoram, north-east India. Journal of Applied Ecology 35, 214-231.

Robinson, J.G., and Redford, K.H., Sustainable harvest of Neotropical forest mammals, in: Robinson, J. G. and Redford, K. H., Eds.), Neotropical Wildlife Use and Conservation, University of Chicago Press, Chicago, USA 1991.

Robinson, J.G., and Bennett, E.L. Eds.), 2000. Hunting for Sustainability in Tropical Forests. Columbia University Press, New York.