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DIFFERENTIAL EFFECTS OF HUNTING ON POPULATIONS OF HORNBILLS AND IMPERIAL PIGEONS IN THE RAINFORESTS OF THE EASTERN INDIAN HIMALAYA

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ABSTRACT

Responses of hornbills and *Ducula* pigeons to hunting and disturbances to their habitats may help us understand the implications for the regeneration of their dependent tropical forest trees. Moreover, density estimates serve as a gauge of whether some frugivorous birds can potentially substitute for the decline of their functionally-similar competitors. We carried out a year long survey of 24 line-transects distributed across disturbed (2 sites) and undisturbed (4 sites) habitats in the lowland evergreen forests of Pakke wildlife sanctuary and surrounding forests of Arunachal Pradesh. Hornbill and *Ducula* densities were estimated with DISTANCE. While densities of the Great Indian Hornbill, *Buceros bicornis*; Oriental Pied Hornbill, *Anthracoceros albirostris*, and wreathed hornbill, *Aceros undulatus* were substantially reduced in disturbed habitats, densities of the mountain imperial pigeon, *Ducula badia* and the green imperial pigeon, *Ducula aenea* were unaffected. These results suggest that *Ducula* pigeons may potentially provide substitute dispersal services for large-seeded tree species in disturbed sites, but that this response is most likely context driven.

Keywords: Pakke Tiger Reserve, Hornbills, Pigeons, Line Transect, Density and DISTANCE

Introduction

Habitat alteration and loss due to logging and development have intensified in the biodiversity rich forests of Arunachal Pradesh in the Eastern Himalayas of India (Katti *et a*l., 1992; Datta and Goyal, 2008). The Eastern Himalayas biodiversity hotspot (Myers *et al*., 2000) lying at the cusp of two biogeographical realms, the Indo-Malayan and the Paleartic, probably harbours the second highest number of bird species in the world, and twice the number of bird species of the Western Himalayas (Inskipp and Inskipp, 1985). Between 1998 and 2008, at least 353 new species have been discovered in the Eastern Himalayas including Arunachal Pradesh. In the last decade some new discoveries from Arunachal Pradesh include the Arunachali macaque, *Macaca munzala* (Sinha *et al*., 2005) and the bugun liocichla, *Liocichla bugunorum*. The plant life of Arunachal Pradesh is also exceedingly diverse, reported to rank second to Sumatra in Indonesia and greater than Borneo, Brazil and Papua New Guinea. Although forests still cover an area of 80.5% of the state (FSI, 2011) pressures on the forests have simultaneously accelerated and human population densities while still the lowest in India are steadily increasing (Census of India, 2011). Hunting, loss of forests to *jhum* (shifting) cultivation and logging are especially severe in foothill forests (<1200m altitudes) which are easily accessible and often close to villages and roads (Katti *et al*., 1992). Estimates suggest the loss of more than 400 km^2 of forests in the last ten years. This mounting pressure on biodiversity by causing population declines or the local extinction of wildlife threatens to disrupt the many vital ecosystem services they provide including pollination, seed dispersal and forest regeneration.

Large-bodied vertebrates including hornbills and imperial pigeons that may function as 'keystone' (Gilbert, 1980) mutualists in forests are particularly sensitive to both habitat destruction and hunting (Poonswad, 1998; Lambert and Collar, 2002; Fa *et al*., 2005; Hilaluddin *et al*., 2011, 2012). Hornbills are extensively hunted because of the cultural value of their beaks, feathers, casque and meat. Since vertebrate-dispersal is the most common dispersal mode for at least 50% and sometimes more than 90% of tropical trees (Howe and Smallwood 1982; Fleming *et al*., 1987), reduced abundances of frugivores could affect the dispersal, regeneration and ultimately the demographics of their dependent trees. In the present study consequences of disturbance and were assessed on populations of large-bodied frugivorous birds in Pakke Wildlife Sanctuary and contiguous foothill forests of Doimara and Papum reserve forests, one of the last remaining fairly extensive foothill forest landscapes in Arunachal Pradesh (Datta, 2008). This area, probably the best lowland habitat for hornbills in Arunachal Pradesh (Datta, 2008), is subjected to significant hunting pressures apart from some logging and habitat destruction. Exacerbating this is the illegal clearing of abutting forests in the adjoining state of Assam, along the

Hornbills, pigeons and doves are facing survival threats because of hunting in the Rainforests of the Northeast India.

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Assam-Arunachal border.

Birds appear to be the most important dispersers in Pakke Wildlife Sanctuary and adjacent forests where just short of 60% of the tree species are dispersed entirely or partially by birds. Of the 128 tree species for which dispersal modes were determined, 54 tree species are dispersed exclusively by birds, 21 by birds and mammals, 25 only by mammals and the remaining abiotically. Some lines of evidence suggest that bird-dispersal may be significant in this part of the world. Fleming *et al*. (1987) suggest that in Southeast Asia, primate and bat species densities are about one-twelfth and one-half the values of bird species density respectively. In Pakke, the flora appears to be dominated by families such as Lauraceae, Euphorbiaceae, Moraceae and Meliaceae which are largely dispersed by birds; moreover the density of bird-dispersed tree species (157 trees/ha) was higher than that of mammal or abiotically dispersed trees. Consequently, decreased avian abundances will impact the dispersal of these bird-dependent trees, and trees with large seeds that can only be handled by declining populations of large frugivores could be the hardest hit.

In these rainforests, large birds such as hornbills and *Ducula* pigeons are the primary dispersers of several large-seeded trees; trees of bird-dispersed families such as Annonaceae, Euphorbiaceae, Lauraceae, Meliaceae and Myristacaceae often produce large, high-quality, fat and protein laden fruits (Leighton and Leighton, 1983). Alternative large-bodied dispersers are few. Primate densities in this area are low; the Capped langur (*Tracypithecus pileatus*) is primarily a folivore, the Assamese macaque (*Macaca assamensis*) is rarely seen and the Rhesus macaque (*Macaca mulatta*) is restricted to the periphery of forest areas. While dispersal of large-seeds by ungulates and bears along with dispersal by smaller carnivores and bats is also important, the former are heavily hunted along with primates. Ungulates also appear to disperse a different suite of tree species and in many parts of Arunachal Pradesh large vertebrates have become exceedingly rare. Thus large frugivorous, 'keystone' birds are probably pivotal to the regeneration and recruitment of several rainforest trees; some of which, e.g., trees belonging to the Meliaceae and Myrsticacae may themselves function as 'keystone 'resources (Leighton and Leighton, 1983). Elimination of these large avian frugivores could lead to alteration in the composition and diversity of forests with a decline of trees bearing large–seeds that are often characteristic of primary forest species (Foster and Janson, 1985).

In this paper, the authors try to ascertain the consequences of disturbance for populations of hornbills

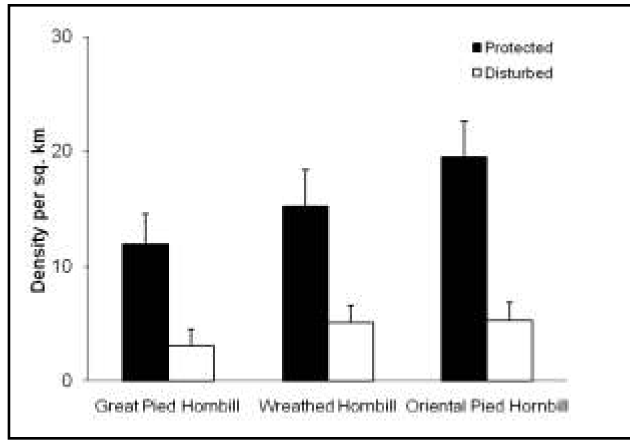

Fig. 1 : Differences in densities (mean ± S.E.) of three hornbill species in hunted and protected habitats. Densities were significantly different between hunted (2 sites) and protected sites (4) for all three species (95% CI are presented in Table 3).

(Bucerotidae) and imperial pigeons (Columbidae), which show broad dietary overlaps. Several studies suggest that *Ducula* pigeons, like hornbills, are important dispersers for a variety of tree species in forests of the Asian, Australasian, and Pacific regions (Leighton and Leighton, 1983; Ganesh and Davidar, 2001). Like hornbills, they regurgitate and defecate intact seeds and can handle large seeds, swallowing seeds twice the width of their normal gape (Meehan *et al*., 2002). Also like hornbills they are highly mobile, dispersing seeds over long distances (Holbrook *et al*., 2002; Sethi and Howe, 2009). Despite these functional similarities, hornbills and imperial pigeons may not be equally susceptible to disturbance leaving open the important possibility that one or the other taxa may continue to provide essential dispersal services for several rainforest trees. Because hunting appears to be the most proximate threat to

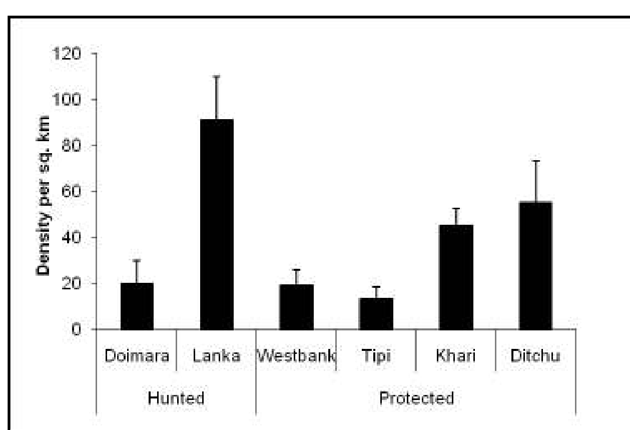

Fig. 2 : Densities (mean ± S.E.) of the Mountain Imperial Pigeon at sites in hunted and protected habitats. A hunted site (Lanka) had higher densities than all the other sites. The 95% CI are presented in Table 4.

Table 1 : Details of site and sampling effort

Site	Location	Habitat	Transect length and number of transects per site	Sampling effort	Number of replicates
Doimara	Doimara RF	Hunted	1.2 km, 4 transects	34.45 km	30
Lanka	Papum RF	Hunted	1.2 km, 4 transects	36.8 km	33
West Bank	Pakke Tiger Reserve	Protected	1.2 km, 4 transects	39.6 km	33
Khari	Pakke Tiger Reserve	Protected	1.2 km, 4 transects	38.4 km	32
Ditchu	Pakke Tiger Reserve	Protected	1.2 km, 4 transects	37.2 km	31
Tipi	Pakke Tiger Reserve	Protected	1.2 km, 4 transects	33.6 km	28

hornbill populations (Datta, 1998) unlike for imperial pigeons which are not preferred game and rather more difficult to hunt, imperial pigeon abundances may be less affected in disturbed sites. They could even exhibit numerical compensation if they compete with hornbills for similar fruit resources.

The main objective of this study were : a) to obtain density estimates of large frugivorous birds using DISTANCE estimates; b) to determine if population densities of hornbills are lower at disturbed sites than undisturbed ones; c) to determine if both, frugivorous pigeons and hornbills are equally vulnerable to disturbance; d) to try and assess whether disturbance or hunting are the most proximate threat to populations of hornbills and imperial pigeons, and e) to compare the effects of disturbance on hornbills with effects documented from other parts of the world in a variety of disturbance contexts (hunting, logging and fragmentation).

Study site

We carried out this study in 2008 in the lowland, semievergreen foothill forests of the Pakke Wildlife Sanctuary (PWS) and its adjoining reserve forests. Assam Valley Tropical semi-Evergreen Forests (Champion and Seth, 1968) lie in the East Kameng district of Arunachal Pradesh, India within the Eastern Himalayas, one of the eight 'hottest' biodiversity hotspots (Myers *et al.*, 2000.) Four protected sites were in PWS (26°54'N- 27°16'N, 92°36'- 93°09'E, 862 km^2) and two hunted sites lay in adjoining Papum Reserve Forest (RF) (27° 00' N, 93°10'E; 1064 km^2) and Doimara RF (27° 00' N, 92°00'E) of the Khellong Forest Division. Protected sites included Westbank, Seijosa (26° 56' N, 92° 58'E), forests near Khari (26°59' N, 92° 54'E), Ditchu (26° 59' N, 93°00'E) and Tipi (27°01' N, 92° 36'E), where hunting bans were in effect. Two hunted sites were Doimara (27° 00' N, 92°00'E) in Doimara RF and Lanka (27°01' N, 93°02'E) in Papum RF. The local people had completely logged one of our original 2006 hunted sites, which was not included in the current analysis. Additional details of the study area, the terrain, climate and non-disperser frugivores are given in Sethi and Howe (2009).

Methods

Bird censuses

We used line-transects to gather data for density estimates. Censuses of hornbills and imperial pigeons were conducted in the morning soon after sunrise. Upon each visual detection, the species was identified, the number of individuals counted and perpendicular distance from the transect line to the birds was measured with a laser rangefinder. At each site, four line transects of 1.2 km each were laid systematically with a random start and marked at 50 m intervals for a total of 24 lines across six study sites (4 protected and 2 hunted). At some sites, because of difficult terrain we used a segmented line-transect approach. The lines were approximately 1 km apart. Each line was monitored between 6-10 times from November 2007 to November 2008. A total of 220.05 km was walked over the course of the bird census and the distances walked were similar across all sites (Table 1). On some occasions due to river flooding or disturbance by the local people we were not able to walk the entire 1.2 km length of transect. The length of transect at such places was terminated and the census was then recorded and adjusted for in the analysis. Sampling effort was approximately evenly spread across all sites, and protected and hunted habitats were censused at similar times during any particular census period. The same transects were never walked on the same day so as to avoid temporal autocorrelation and in most cases several days elapsed before transects were walked again.

Data analysis

To assess the impacts of hunting on the population sizes of hornbills and imperial pigeons we used the software DISTANCE 5.0 (Thomas *et al.*, 2006) to generate

Table 2 : Results of a nested-crossed ANOVA of perpendicular distance to each hornbill cluster.

Factor	F	df	P
Habitat	0.055	1	0.82
Species	0.0597	2	0.55
Habitat* Species	1.745	2	0.18
Site (Habitat)	1.478	4	0.21

density estimates. We restricted the analysis only to perching birds and did not include flying birds in the density estimates in accordance with Lloyd *et al*. (1998). Density estimates were restricted to perched (visually detected) birds since a) distances to birds that were seen could be accurately measured with a laser rangefinder and b) in the case of large-bodied birds like hornbills and imperial pigeons it is likely that all birds near the centre line are visually detected, a key assumption of distance sampling, i.e. g(0) = 1.

For perching birds, we plotted a frequency distribution of perpendicular distances. The shape of the histogram suggested that evasive movements occurred as suggested by more individuals seen away from the transect line than on it. We compensated for this evasive movement by binning the distances into 4 distance categories (0-40m, 41-60, 61-80 and 81-100) for hornbills and 4 distance categories for imperial pigeons (0-32m, 33-50, 51-75 and 76-100). We truncated the detection distances at 100m to improve the fit of the detection functions. This led to our discarding 6 (2% of all perching birds) and 20 (3.5% of all perching birds) observations beyond 100m for hornbills and imperial pigeons respectively.

Nested-crossed Anovas on log-transformed detection distances indicated that there were no significant differences between hunted and protected habitats in the detection function for all the hornbill species (Table 2). However, we did not obtain a single detection function across all sites, because this would result in a loss of independence in the data and therefore invalidate statistical comparisons. We therefore attempted to produce independent estimates for hunted and non-hunted sites. To do this, because the number of observations for each species of hornbill at the two hunted sites was less than the required 60-80 detections required for a robust Effective Strip Width (ESW) estimate (Buckland *et al*., 2001), we screened the data to see if the data could be pooled across hornbill species, sites or habitats in order to obtain the detection functions. This we did by comparing values of the Akaike Information Criterion (AIC) for the global and stratified data. Data pooling is allowed if the AICs of the pooled data are less than the sums of the AICs for the stratified data (Buckland *et al*., 2001). We pooled the data for the 3 hornbill species and the two sites in the hunted habitats as sample size in hunted site was not enough to obtain separate density estimates for each species, and AIC values suggested no difference in the detection curves of the three hornbill species. In contrast, for the protected habitats, we pooled the sites but kept the species separate.

We used AIC as implemented in DISTANCE to select the detection function that best fitted the distribution of observed detection distances. Initial models included a half normal and uniform models with cosine and hermite adjustments. We did not consider the hazard-rate model, as it assumes a broad flat “shoulder” with uniform detection around the transect line, which does not seem realistic in our case, as we have reason to suspect that some evasive movements occurred (see above). The final models selected for protected sites included a half-normal for the great pied hornbill and for the oriental pied hornbill. For the wreathed hornbill we selected a uniform + cosine model. For the hunted sites, the final models selected were the uniform with a 2nd order polynomial adjustment for the great pied hornbill, the oriental pied hornbill and for the wreathed hornbill.

For imperial pigeons, we had only 32 detections of the Green Imperial Pigeon (GIP) across all sites. Therefore we pooled detections of the GIP with the much commoner but similar-sized Mountain Imperial Pigeon (MIP) and obtained detection functions that were stratified by habitat and by site. Preliminary ANOVAS on detection distances of GIP and MIP suggested no difference in the detection distances between the two species. Mean cluster sizes were different for each species. The models fitted to each site were the uniform

Table 3 : Summary of density estimates for three species of hornbills

Species	Habitat	Number of detections	Encounter rate (individuals per km)	Average cluster size	Density (individuals per km^2)		
					Estimate	Lower 95% CI	Upper 95% CI
Great Pied Hornbill	Hunted	9	0.13	1.89	3.10	1.34	7.18
	Protected	77	0.52	1.84	11.95	7.90	18.10
Wreathed Hornbill	Hunted	19	0.27	1.88	5.11	2.90	9.02
	Protected	105	0.71	2.26	15.14	10.00	23.00
Oriental Pied Hornbill	Hunted	16	0.23	2.99	5.32	3.03	9.34
	Protected	74	0.50	1.47	19.48	14.20	26.72

CI is the 95% confidence interval of the estimates. This data is for perched birds only.

Table 4 : Summary of density estimates for two species of imperial pigeons

Species	Habitat	Site	Number of detections	Encounter rate (individuals per km)	Average cluster size	Density (individuals per Km^2)		
						Estimate	Lower 95% CI	Upper 95% CI
Mountain Imperial Pigeon	Hunted	Doimara	47	1.33	1.85	20.00	8.06	49.65
		Lanka	66	1.79	2.65	91.33	6.88	137.02
	Protected	West Bank	30	0.76	2.97	19.32	9.99	37.32
		Khari	58	1.51	2.05	44.80	32.15	62.45
		Ditchu	38	1.02	3.34	55.05	29.19	103.85
		Tipi	20	0.60	1.65	13.41	6.31	28.51
Green Imperial Pigeon	Hunted	Doimara	1	0.03	2.00	0.45	0.09	2.24
		Lanka	5	0.14	2.00	5.22	2.28	11.93
	Protected	West bank	1	0.03	3.00	0.65	0.13	3.34
		Khari	6	0.16	2.33	5.27	2.11	13.16
		Ditchu	7	0.19	2.57	7.79	3.43	17.66
		Tipi	12	0.36	2.17	10.57	2.96	37.68

CI is the 95% confidence interval of the estimates. This data is for perched birds only.

with a simple 2nd order polynomial adjustment for Doimara, Khari and West Bank, half normal for Lanka and Ditchu, and half normal with 2 cosine adjustment for Tipi.

Density of individuals and total populations sizes for both hornbills and imperial pigeons were calculated by multiplying estimated cluster size by estimates of cluster density (clusters/ha) produced by DISTANCE. The delta method was used to calculate confidence intervals for these values (Seber, 1982). All analyses were conducted using Statistica and DISTANCE 5.0.

Results

Densities of hornbills were significantly higher in protected than in hunted habitats (non-overlapping 95% CI, Table 2). Density estimates for the great pied hornbill was 11.95±2.56 individuals per km^2 in protected forests versus only 3.1±1.39 individuals per km^2 in hunted habitats. Similarly, densities of the wreathed and oriental pied hornbill were 15.14±3.25 and 19.48±3.16 individuals per km^2 in protected habitats which dropped to 5.11±1.51 and 5.32±0.02 individuals per km^2 hunted habitats (Table 3, Fig. 1).

Unlike hornbills, imperial pigeons were not impacted by hunting and even showed weak evidence of an increasing trend at hunted sites in response to reduced hornbill densities, although results varied across sites (Table 4 and Fig. 2). Lanka, a hunted site had the highest densities (91.33±19.1) of mountain imperial pigeons across all sites. This density estimate was significantly higher than that of two protected sites, West Bank (19.32±6.68) and Tipi (13.41±5.36) (non-overlapping 95% CI, Table 3) and almost significant as compared with another protected site Khari (44.8±7.65). Doimara, the second hunted site had an estimated mountain imperial pigeon density (20±9.8) that was higher than Tipi, a protected site, although results were not significantly different.

Estimated densities for the green imperial pigeon were very low as compared with the mountain imperial pigeon and varied from between 0.45 birds per km^2 to 5.22 birds per km^2 in protected habitats and from 0.65 birds per km^2 to 10.57 birds per km^2 in hunted forests. Densities of green imperial pigeons did not vary significantly between hunted and protected habitats (Table 4).

Discussion

This study suggests that the fates of large avian frugivores are appreciably, but differentially altered in over-hunted and disturbed habitats. The estimated hornbill densities were significantly lower in hunted habitats than in not-hunted ones located within the Pakke Wildlife sanctuary. All three species showed a lower encounter rates at the hunted sites, a downward shift from an earlier study conducted at some of the same study sites in 1996-1997 which showed lower encounter rates (hornbill abundance per km) of the great pied hornbill but not of the wreathed hornbill in Doimara area (Datta, 1998). In protected habitats, the smallest-bodied hornbill, the oriental pied had the highest densities followed by the mid-sized wreathed hornbill and then the large-sized great hornbill. In hunted sites, the great pied hornbill which is the most heavily hunted for its beak and casque had the lowest densities, while those of the pied and the wreathed hornbill did not differ.

Encounter rate results for hornbills in protected habitats are broadly comparable with those obtained in another study from trails monitored at the not-hunted sites lying within Pakke wildlife sanctuary encounter rates for the great, wreathed and oriental pied hornbills obtained in that study for 2006-2007 were 0.4, 0.5 and 0.8 birds per km respectively (Datta and Naniwadekar, 2008), while wreathed hornbill encounter rates are higher at 0.71 individuals/km and that of the oriental pied hornbill lower at 0.5 birds/km. No previous density estimates exist for imperial pigeons from this ecosystem; results show that they do not differ significantly between hunted and not-hunted habitats. Lanka area with lower levels of hunting and a small hamlet had the highest densities of *Ducula* pigeons across all habitats while Doimara with higher hunting and disturbance had marginally higher densities than only two protected sites. This was similar to a census conducted during the fruiting season in 2006, where *Ducula* pigeon encounter rates were higher in hunted sites but not significantly different (Sethi and Howe, 2009). Continuous monitoring over several years would definitively ascertain if *Ducula* pigeons are indeed increasing due to density compensation where hornbill competitors are reduced in abundance. Far higher seed removal by *Ducula* pigeons of a large-seeded tree *Dysoxylum binectariferum* (Meliaceae) at hunted habitats suggests behavioral and/or abundance shifts.

Hornbills and imperial pigeons are susceptible to both hunting and habitat change which makes it hard to tease out the relative importance of one vis-à-vis the other. Disturbed forests had reduced tree densities, basal areas and canopy cover (Datta, 1998) all of which influence bird densities. Still, some lines of evidence suggest that hunting may have a greater immediate influence on hornbill populations in the Pakke landscape. First, selective felling stopped eleven years ago, and at least two protected sites were similarly logged or disturbed in the past, West bank and Khari (Datta, 1998). Second, hornbills and imperial pigeons forage over long distances and studies on hornbills suggest that they persist in logged and disturbed habitats as well as large fragments in the vicinity of primary forests (Johns, 1987; Marsden and Pilgrim, 2003; Raman and Muduppa, 2003). Moreover, a study comparing large bird densities in forests before and after logging with varying hunting levels in Sarawak, found depleted densities of hornbills in logged areas with moderate to heavy hunting pressures (Bennett and Dahaban, 1995). Third, abundances of hornbills versus *Ducula* pigeons for the Pakke ecosystem appear to mirror hunting gradients rather than disturbance ones. Great hornbills are most targeted by hunters, and this species showed lower densities than either the wreathed or oriental pied hornbill. As large-bodied frugivorous birds, *Ducula* pigeons may also become vulnerable to population declines resulting from logging and/or disturbance. But *Ducula* pigeons which are not particularly favored by local tribal hunters had densities that were not significantly lower in hunted sites. This suggests that poaching has a more significant impact on hornbill populations than logging or disturbance, at least in the short-term.

Great hornbill population density estimates of the Pakke region (3 to 12/ km^2) are similar to those from the fragmented landscape of the Western Ghats, India, ranging from 3 to 10 birds/ km^2 (Raman and Muduppa, 2003), but higher than the 1.88 birds/ km^2 reported from Central Thailand by Poonswad *et al*., 1988 (as cited in Gale and Thongaree, 2006) or the estimates of 0.12 birds per km^2 in southern Thailand (Gale and Thongaree, 2006). Wreathed hornbill density estimates for Pakke (5-15/ km^2) are also higher than those recorded from Central Kalimantan, Indonesia (0.1 birds/ km^2)-wreathed hornbills only visited the study area in Central Kalimantan when fruit was most abundant (McConkey and Chivers, 2004). Other Wreathed hornbill densities from Southeast Asia ranged from 0.69 individuals/ km^2 in Southern Thailand (Gale and Thongaree, 2006) to 7.5 in Sabah (Angraini *et al*., 2000). However, Leighton's (1982) study from E. Kalimantan (as cited in Kinnaird *et al*., 1996) reported generally higher Wreathed hornbill densities of 10-46/km^2. Density estimates of the Oriental Pied hornbill in Pakke were higher than those observed in Central Kalimantan (0.6 birds/km^2) possibly because they prefer riverine forests which were not well sampled in Barito Ulu (McConkey and Chivers, 2004). In a unique habitat at Narcondam island the density of the endemic Narcondam Hornbill (*Aceros narcondami*) is surprisingly quite high (Yahya, 2003).

This study enlightens illuminates the differential effects of disturbance on different taxa of large frugivorous birds. Results are encouraging as they suggests that some members of large frugivorous avian guilds may be relatively unaffected by disturbance. These guilds could potentially provide substitute dispersal services for several species of large-seeded trees, ensuring their persistence at the local level. This effect is probably highly contextual- studies of disperser visits and seed removal indicated that while *Ducula badia* pigeons provide essential dispersal services for one large-seeded tree at disturbed sites (*Dysoxylum binectariferum*), they fail to do so for another closely related Meliaceae species (*Chisocheton paniculatus*). Moreover, hunter preferences can shift in response to game availability, and imperial pigeons and their dependent trees face an uncertain fate as they are increasingly targeted by hunters.

Results also indicate that hornbills persist in logged and hunted habitats, although at far lower densities than undisturbed ones. Hornbills fly long distances tracking fruit resources, and frequently move between hunted and not-hunted habitats (Poonswad and Tsuji, 1994; Datta, 1998). Given their wide ranging patterns in search for food, we will need to manage large tracts of both primary and secondary forests at a landscape level (McConkey and Chivers, 2004; Sitompul *et al.,* 2004) if we are to maintain viable populations of hornbills in the long term. This requires protecting and regenerating the increasingly fragmented and disturbed foothill forests of the Indian Eastern Himalayas.

पूर्वी भारतीय हिमालयों के वर्षा वनों में हार्नबिलों और कबूतरों की आबादी पर शिकार का विभेदी प्रभाव

सौम्या दास गुप्ता और हिलालुद्दीन

सारांश

हार्नबिल और कबूतर पूर्वी भारतीय हिमालयों में अरूणाचल प्रदेश की तलहटी वन आवासों में वृक्षों, विशेषकर बड़े बीज वाले, को फैलाने वाले है। वन शिकार, विक्षोभ, उत्काष्ठन और विकास का भारी दबाव झेल रहे हैं, जिसमें से सभी बड़े शरीर वाले, फलभक्षी पक्षियों की आबादियों पर नकारात्मक प्रभाव डाल सकते है, जो विस्तृत दैनिक आहार और कार्यात्मक अतिव्यापित में सहयोग करते हैं। जबकि अध्ययन हार्नबिल आबादियों पर शिकार और विक्षोभ के प्रतिकूल परिणामों का सुझाव देते हैं, इस बात की अल्प सूचना है कि *डयूकूला* कबूतर इन्हीं आवासों में इसी तरह के दबावों के प्रति कैसी प्रतिक्रिया देगा। शिकार और विक्षोभ के प्रति इनकी अनुक्रियाओं की विभिन्नताओं एवं समानताओं की जानकारी, इन पर निर्भर उष्णकटिबंधीय वन वृक्षों के पुनर्जनन के लिए, जटिलताओं को समझने में हमारी सहायता कर सकती है। इसके अलावा, घनत्व आंकलन इस बात के लिए एक पैमाने के रूप में कार्य कर सकते है कि क्या कुछ फलभक्षी पक्षी अपने कार्यात्मक रूप से समान प्रतियोगियों की अवनति की जगह सक्षम रूप से ले सकते हैं। हमने अरूणाचल प्रदेश के पाक्की वन्यप्राणि अभयारण्य के निम्नभूमि सदाहरित वनों और आस पास के वनों में विक्षुब्ध (2 स्थलों) और अविक्षुब्ध (4 स्थलों) आवासों में फैले हुए 24 लाइन–ट्रान्जेक्ट्स का एक साल सर्वेक्षण किया। हार्नबिल और *ड्यूकूला* घनत्वों का डिस्टेन्स के साथ आकलन किया। जबकि ग्रेट इंडियन हार्नबिल *ब्यूसीरोज, बाइकॉर्निस;* ओरियन्टल पीड हार्नबिल, *एन्थरेकोसीरोज एल्बिरोस्ट्रिस* और रीथ्ड हार्नबिल *एसीरोज अन्डूलेटस* के घनत्व विक्षुब्ध आवासों में पर्याप्त रूप से घटे, माउन्टेन इम्पीरियल कबूतर, *डयूकूला बाडिया* और ग्रीन इम्पीरियल कबूतर, *डयूकूला एइनीया* के घनत्व अप्रभावित रहे। यह परिणाम सुझाते है कि डयूकूला कबूतर विक्षुब्ध स्थलों में बड़े बीजदार वृक्ष प्रजातियों के लिए सक्षम रूप से स्थानापन्न सेवाएं उपलब्ध करा सकता है किन्तु यह अनुक्रिया सम्मिलित हो सकती है।

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