CONSEQUENCES OF HORNBILL HUNTING FOR SEED DISPERSAL AND TROPICAL TREE REGENERATION IN THE INDIAN EASTERN HIMALAYAS

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INTRODUCTION

Hunting is rampant throughout the tropics with potentially severe though largely undelineated consequences for plant-animal interactions and forest dynamics (Redford, 1992, Peres 2001). Frugivorous animals by moving seeds to favorable microsites for establishment (Wenny and Levey, 1998, Wenny, 2001), helping them ‘escape’ from zones of density and distance-dependent mortality in the vicinity of parent plants or colonize new habitats have been shown to confer critical survival benefits thereby playing an integral role in tree recruitment (Schupp 1988, Terborgh et al. 1993, Howe et al. 1985, Howe, 1990) and ecological restoration. Because most tropical trees bear fruits that are animal dispersed, the loss of critical seed dispersers may ramify through the ecosystem with profound effects on seedling demography and spatial ecology (Chapman and Chapman, 1995, Harms et al 2000) through severed mutualisms with tropical trees (Cordeiro and Howe, 2003) and hampered plant recruitment (Howe, 1993). In the Indian Eastern Himalayas, intensive hunting of hornbill dispersers by local tribes for meat and ornamentation is predicted to have significant, although largely unquantified consequences for forest regeneration and diversity.

In this study, I propose to test whether tribal hunting of hornbills in the Eastern Himalayas disproportionately impacts the dispersal and regeneration of large-seeded tree species as compared with small-seeded ones, and to identify appropriate ecological restoration measures to prevent large scale alterations in forest diversity. In the Eastern Himalayas, large hornbills are the primary if not exclusive dispersal agent for several large seeded and relatively rare tree species belonging to the families Meliaceae, Myrsticaceae and Lauraceae (Datta, 2001). Since only large birds with large gape widths are in a position to transport large seeds, given the close correlations of body size with gape size (Wheelright, 1985), I expect large-seeded species that are solely reliant on hornbills to be dispersal limited. Furthermore, other large frugivores such as primates, civets or ungulates are unlikely to act as substitute dispersers since they show little dietary overlap with hornbills (Datta, 2001). In contrast, a much wider assemblage of small to medium sized birds including barbets, mynas, bulbuls and the fairy blue bird may compensate for the decline in dispersal services for small-seeded tree species due to their ability to handle small seeds and also because small seeded species are hypothesized to represent a low investment strategy for attracting many, generalist frugivores rather than few, specialized ones (McKey, 1975). Large seeds that have higher nutritional value, however, typify high investment dispersal syndromes for attracting few, specialized frugivores and thus promote tight relationships with few bird species amongst a larger frugivore assemblage (Howe and Vande Kerckhoeve, 1981 and Howe 1993).

Elimination of hornbills may have profound consequences for tropical forests by altering tropical tree diversity in favor of small seeded species. Similar patterns are also likely to result from the elimination of any important large frugivores, whether bird or mammal, suggesting that in the future tropical forests could perhaps be dominated by small-seeded tree species at the expense of large-seeded ones (Peres and Roosmalen, 2002). World-wide, widespread destruction of tropical forests is eliminating seed dispersers some of which play pivotal roles in disperser-tree mutualisms (Cordeiro and Howe, 2003) and are

integral to ecological restoration of disturbed and fragmented habitats. Evaluating which trees are disperser dependent and which are not is critical to the ecological restoration of an area since it can lead to the design of specific restoration interventions that mitigate profound changes in forest composition and structure. Hornbills are irreplaceable dispersers for trees in Africa (Whitney et al.1998) and Asia (Datta, 2001, Kinnaird et al. 1996), and have been identified as key organisms in rainforest regeneration and restoration since they fly for long distances through rainforests dispersing a great diversity of seeds along the way. Ecological restoration of forests in Asia including India, and Africa may then depend on preserving the seed dispersal capabilities of hornbills in conjunction with plantation of tree species that both provide critical food resources to hornbills and other frugivores as well as contribute to forest diversity. Conservation efforts, however, are only likely to be successful if they are based on a thorough understanding of underlying ecological processes since they can help to target interventions where they are most needed. If this study shows that large seeded species are declining, ecological restoration options could then focus on the plantation of large-seeded species. Therefore, this study by determining the impacts of key disperser loss on forest diversity can pinpoint exact conservation options.
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The Eastern Himalayas provide an ideal system for the test of hunting on seed dispersal mutualisms and the resulting consequences for forest structure. It is recognized as one of the eight ‘hottest hotspots’ of biodiversity in the world (Myers et al. 2000) and among the 200 globally important ecoregions (Olson and Dinerstein 1998).The Indian part of this biodiversity hotspot harbors about 5800 plant species, of which roughly 2000 (36%) are endemic, hosts 50% of India’s 1200 bird species (Singh, 1994), and holds the northernmost rainforests In India. The Eastern Himalaya is also a prime ecosystem for evaluating restoration measures since the fragile and unique biodiversity of this region is impacted by extremely high human population densities, necessitating the design of appropriate restoration measures that both prevent further degradation and maintain and enhance existing biodiversity.

PROJECT DESIGN AND METHODOLOGY

This study attempts to determine how loss of dispersers may differentially impact the dispersal and regeneration of large and small seeded tree species and what this implies for tropical tree regeneration and restoration efforts. Elimination of large frugivores such as hornbills may lead to dense aggregations of undispersed seeds lying below large-seeded parent trees due to reduced disperser visitation, and subsequently enhanced seedling mortality and low regeneration for species susceptible to density dependent mortality. For small-seeded, hornbill dispersed trees, decreased visitation rates of hornbills in hunted areas may result in density compensation (numerical increase) by birds belonging to the small to medium-sized disperser assemblages.

Study area

The study is being conducted in one protected area (the ‘control’ region) Pakke National Park and Tiger Reserve (862 sq. km 26°54′N~ 27°16′N, 92°36′~ 93°09′E) in East Kameng district, located within the priority North Bank Landscape of the Eastern

Himalayas biodiversity hotspot (Fig.1). Three sites within this tiger reserve namely Khari, Seijosa-Ditchu and Tipi have been selected based on preliminary surveys between April to August 2005. The disturbed sites include the Reserve Forests close to the periphery of each park namely Lanka in Papum Reserve Forest (RF) and 2 sites in Doimara RF.

Towards the south and south-east the park adjoins reserved forests and the Nameri National Park (349 sq. km) of Assam. To the east lies the Pakke river and Papum Reserve forest; to the west it is bounded by the Kameng or Bhareli river, Doimara RF and Eagle Nest Wildlife Sanctuary, and to the north again by the Bhareli river and the Shergaon, Forest Division. The sanctuary is delineated by rivers in the east, west and north and is drained by a number of small rivers and perennial streams of the Bhareli and Pakke rivers which are tributaries of the Brahmaputra. The terrain of the study site is hilly and undulating and while the altitude ranges from 100m to over 2000m, the accessible altitude of the study site is only about 100-300m. Both Papum (1064 sq. km) and Doimara RF (216 sq. km) fall in Khellong Forest Division.

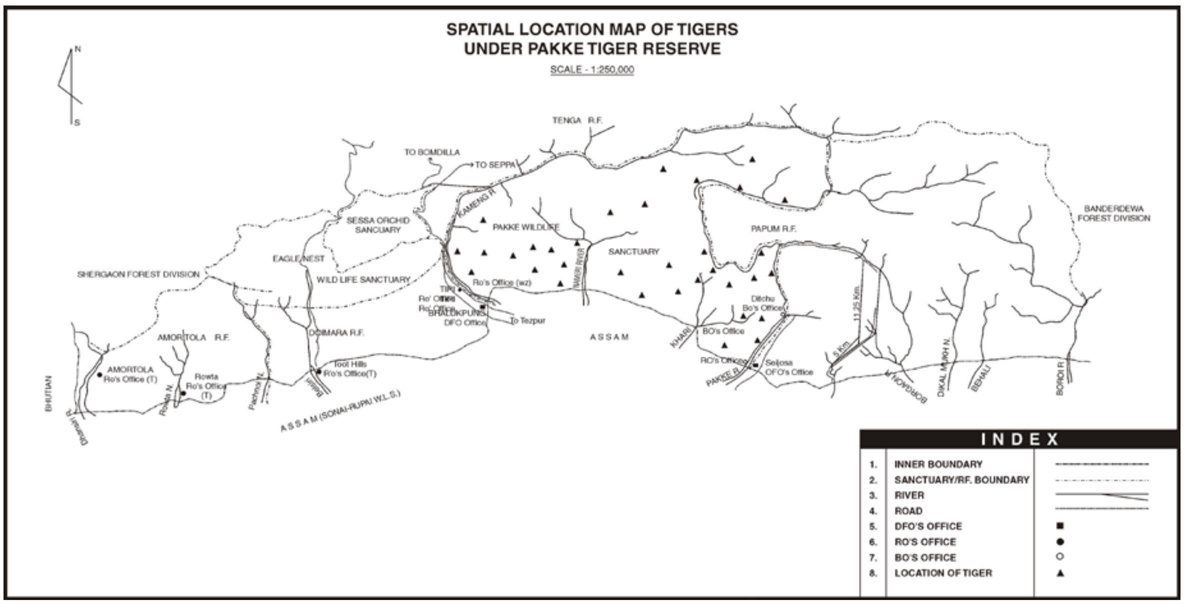

Fig. 1. The main study area of Pakke National Park

PROGRESS MADE IN PROJECT OBJECTIVES TO DATE

Although funding for this project from the Rufford Foundation began in February 2006, preliminary fieldwork had already been conducted during a pilot study in Summer, 2005. This section details the progress made towards project objectives during the pilot study and the months of February and March 2006.

Permission to work in Pakke Tiger Reserve and surrounding Reserve Forests has been given by the forest department and a year long inner line permit has been issued. Two research assistants belonging to the Nishi community were identified and appointed in Summer, 2006 and provided training on census techniques and focal tree watches. In addition, 3 new field assistants are being appointed for the ongoing field season. I am also being assisted in my focal tree watches and censuses by Mr. Hilaluddin Khan, a wildlife biologist who is studying bushmeat extraction patterns in the Himalayas. I will also be joined later this year by a botanist from BNHS, Mr. M. R. Almeida, who will help me with plant diversity studies in the different sites.

Bird census data: Hypothesis 1. The species richness and densities of frugivorous bird guilds is significantly impacted by hunting

While studies of seed dispersal, regeneration and recruitment are central to this study of rainforest regeneration and restoration, bird censuses determine the impact of hunting of large avian dispersers and its correlation with patterns of seed dispersal and recruitment. Bird censuses in hunted and non-hunted sites are therefore being conducted a) to see if hornbill abundance is lower in hunted versus non-hunted sites b) to determine the species richness of frugivores in large and small bodied guilds

Changes in fruit-eating bird species composition (richness and abundance) at three hunted and three non-hunted sites are being evaluated through standardized transects. Two transects of 4 km are being walked in each of the 6 sites, three times a year to record bird densities. This will be sufficient to account for seasonal and phonological fluctuations. Counts are being conducted between 5:30 to 9 am which is the period when hornbills are most active in feeding and calling (Sethi per obs.). The transects are being walked at a slow, uniform rate of 1km/hr while carefully scanning the canopy for bird activity. For each detection, the following observation are being made- the number of hornbills, whether seen or heard, the sex (where possible) and perpendicular distance interval from the transect. The following perpendicular distance intervals (m) are used: 0-10, 10-20, 20-30, 30-40, 40-50, 50-75, 75-100, 100-150. Distance classes further away are wider to minimize for errors in distance estimation. Distances are determined with a range finder or estimated. The data will be analyzed using DISTANCE software using the best fit model for detection probabilities (Laake et al. 1994).

Timeline: Data was collected from Pakke Tiger Reserve in Summer, 2006 and the field assistants continued to collect data when I returned to Chicago. Currently, I am trying to increase the number of transects walked per site so as to get more accurate estimates of bird abundances in the area. Some new transects have been identified and data collection is progressing.

Hypothesis 2. Hunting of avian dispersers decreases the frequency of large disperser visitation and removal of large seeds

I have already selected four tree species, two large and two small-seeded and conducted preliminary focal tree watches to identify visitation rates. Five individuals of each species have been selected per site. These are *Dysoxylum binectariferum* and *Chisocheton paniculatus* belonging to the Meliaceae and *Horsefieldia kingii*, Myrsticaceae. Amongst small seeded species *Litsea monopetala* (Lauraceae) and *Actinodaphne obovata* have been identified. To get an estimate of total fruit production per tree during the period of fruiting, unripe, ripening and ripe fruits were counted on three to five randomly selected marked branches per tree, averaged per branch and then multiplied by the total number of branches on the tree (Laman, 1996, Clark et al. 2004) Since fruit crop size can influence disperser visitation and seed removal efficiency (Howe and Vande Kerckhove, 1981) crop size will be regressed against number of disperser visits as well as number of fruits taken (Cordeiro and Howe, 2003).

To determine which frugivores eat the fruits of the focal species and the efficiency of seed dispersal, focal watches are being conducted. One 12-hour watch is being conducted at each focal tree. Vertebrate visitors are being identified and classified as dispersers (removed seeds from trees), predators (ate or destroyed seeds) or non-dispersers (dropped all seeds under parent crowns or visited the trees but did not feed on fruit or seeds) and further categorized by body size. Visitation rates combined with seeds removed or dropped near parent trees provide an estimate of removal effectiveness for each frugivore species (Schupp, 1993).

Preliminary results indicate that removal rates of large seeded species (*D. binectariferum* and *C. paniculatus)* are extremely low, even in non-hunted sites. There is no evidence of removal by any other species than hornbills, indicating their critical role in the regeneration of these species. Another, large-seeded, widely distributed species, *Polyalthia simiarum* (Anonaceae), in contrast is widely distributed and appears to be recruiting well. This species' dispersal mode and disperser is also being studied to try and tease out reasons for its success vis-a –vis the species mentioned above.

Focal tree watches have been conducted for *Litsea monopetala.* Although the data has not yet been analyzed, contrary to what was predicted, hornbills particularly the Oriental Pied Hornbill appear to be key dispersers for this species. Although, these trees are visited by numerous avian frugivores (a number of species of bulbuls and barbets), each of these small frugivores disperse only a seed or two at a time. In contrast, OPH's ingest 2-300 seeds per visit. What impact these dispersal rates have on regeneration will be determined in the next phase of study.

Timeline: Preliminary focal tree watches were conducted for *D. binectariferum* and *C. paniculatus,* Polyalthia *simiarum* and *Litsea monopetala* in Pakke. Focal tree watches are currently being extended to trees both within the Park (Hunted) and the Reserve Forests (Non-Hunted). Focal watches will be conducted throughout the year as trees come into fruit. Nonetheless, the peak fruiting period for large seeded species is March-August.

Hypothesis 3. Elimination of large hornbills leads to reduced seed and seedling recruitment for large seeded tree species in hunted versus non hunted sites.
This phase of fieldwork will be undertaken from August onwards, after most of the trees have stopped fruiting.

I expect that reduced seed dispersal of large seeded trees will lead to seeds congregating near the parent tree where they may suffer increased density dependent mortality (Howe, 1993, Harms et al. 2000) either due to enhanced predation (Janzen 1970, Connell, 1971) or due to intra-specific competition (for space, nutrients, etc.). Due to reduction of hornbill populations, I predict high seedling but low juvenile densities immediately under parental crowns and low species richness and diversity of large seeded species in the vicinity of conspecifics. High aggregations of seedlings under the parental crown would suggest dispersal limitation while low juvenile densities would suggest high mortality due to density or distance dependent effects.

Seed, seedling and juvenile densities, richness and diversities

Natural seed fall for the four focal species, seed and seedling densities and survival near parent trees will be estimated at monthly intervals by conducting seed, seedling and saplings counts in wedge shaped transects with a 20-degree angle in a random direction away from focal trees. Wedge shaped transects give a better estimate than linear transects since seeds dispersed increase (π r 2) rapidly with distance (Howe, 1990). If a random degree selected is towards a conspecific neighbor or beyond the forest and into the matrix, then another direction will be selected. Each seed, seedling (<1m tall) and juvenile (>1m tall to < I cm dbh) will be marked and the height and basal diameter measured. Distance from the focal tree will be recorded in 2 m segments and distance to an additional conspecific and the forest edge measured with a range finder. Survival and growth will be monitored on a monthly basis for a year.

Timeline: This phase will be carried out from September to December, 06

Additional activities planned

Some additional activities are being planned if time and resources permit. These are listed belong along with tentative dates for their completion.

1. Assessment of hunting pressure

I will try to obtain a rough idea of the degree of hunting and/or logging pressures at each site. Preliminary observations suggest that hunting is most severe at Doimara followed by Lanka Reserve Forests. This likely gradient in hunting levels may be due to several reasons. Conservation action aimed at local communities to reduce hunting is gaining momentum in Western Arunachal. Since hunting of hornbills for their casques is a traditional cultural practice in the north-east, various conservation agencies such as Arunachal Wildlife and Nature Foundation (AWNF) have begun lobbying with the Nishi tribe in Pakke to switch over to fiberglass replicas of hornbill casques. Some village development councils have also announced a fine of Rs 5,000 ($100) if any person is caught hunting hornbills. These activities, however, tend to be more concentrated near the park headquarters (Seijosa) and the nearby villages. Consequently, Lanka (Papum RF) which is relatively close to Seijosa has been impacted by this ‘conservation message’ and hunting appears to have declined in the recent past. In Doimara, selective logging occurred in the past and hence access to the forests is higher and possibly hunting levels as well.

For this, I will administer a questionnaire to the local people on their levels of hornbill hunting to establish the number of hunters in each region and the size of their ‘kill’. I have already established a rapport with the local people and am currently working with ‘erstwhile’ hunters to collect my data. Therefore, I believe that the local Nishi tribal will be able to give me a fairly, unbiased view of their levels of hunting. This will be supplemented by a count of ‘changes’ or platforms in the forest that are traditionally used for hunting. Other signs of hunting in each area will also be recorded, e.g. number of gunshots heard, and number of traps set, to come up with a rough idea of hunting levels.

2. Assessment of tree diversity, density and disturbance

Since the study will be carried out in areas that are impacted by hunting, I will carry out a quick assessment of tree diversity and density to see if the different sites vary in these parameters. This method may also provide an indication at the community level of whether treatment and control sites differ in the diversities of large and small-seeded tree species. Given that hunting is a traditional practice of tribes in the Eastern Himalayas, it is possible that patterns of decreased recruitment of large-seeded, animal-dispersed, tree species may be evident for juveniles and seedlings and perhaps even for densities of adult trees. In contrast, wind and gravity dispersed species should show no difference in densities between treatment and control areas as should small seeded, animal recruited species. To test this hypothesis, I will establish 100 m vegetation transects at each site (6 sites) and enumerate all juveniles and adults within 5 m of either side of the transect and seedlings in 10, 1 sq. m quadrats on either side of the transect. Tree species will be categorized as animal and non-animal dispersed (wind or gravity dispersed) and then subdivided into large and small seeded species. Further, I will document evidence of felling and logging at each site, e.g. number of felled trees and number of cut stems at each site to provide a qualitative assessment of these pressures at my field sites.

Timeline: This phase of fieldwork will be conducted after the rains from Oct to Dec. 2006. Help of a botanist will be taken for this purpose. Dr. A. Almeida of the Bombay Natural History Society will help me with plant identification.

3.Disperser guilds differ in their level of specificity and redundancy

Under large-seeded species in control sites, I predict that hornbill visitation will lead to increased seed proportions and seedling and juvenile recruitment of both large and small heterospecific seeds (hornbill visiting large seeded tree species will drop seeds of other species under the crowns while perching or feeding) while there will be fewer conspecific large seeds and consequently lower seedling and juvenile recruitment immediately under the parental crown due to increased dispersal away from the tree by hornbills. I expect these patterns to be reversed in disturbed areas.

Under small-seeded tree species, in control sites I expect an increase in proportions of large and small heterospecific seeds, seedling and juvenile recruitment and a decrease in small conspecific seeds due to intact disperser assemblages. In disturbed sites, I would expect a decrease in the proportions and recruitment of large-seeded heterospecifics due to low hornbill visitation. If redundancy in the small bodied dispersers does not exist, I would expect an increase in small seeded conspecifics due to undispersed seeds accumulating under parents accompanied by low dispersal distances, increased seedling recruitment and low juvenile recruitment if species are density dependent. Small seeded heterospecific proportions and recruitment would be low due to low hornbill visitation. In contrast if redundancy does exist, I would expect to see a converse of these patterns, i.e. small seeded conspecifics would decrease under parent trees as small birds disperse them away while small seeded heterospecifics would increase as many small birds would visit and bring in small seeds.

Methods

Five large-seeded and five-small seeded hornbill dispersed species will be selected for comparative purposes. To determine how con and hetero-specific seed proportions, seedling and juvenile recruitment vary under adult crowns I will count con and hetero-specific seeds, seedlings (<0.5 m high) and juveniles (>0.5 m high to <1 cm dbh) within a 5 m radius circular plot under four adult crowns of each species per site for a total of 240 trees in 6 sites (three hunted and three not-hunted).. Each tree will be selected so that it is at least 100 m from the nearest conspecific. Diameter at breast height will be calculated for each tree and the crown area determined using the average of 4 measures of canopy radius taken at right angles to each other.

Timeline: This phase of fieldwork will be conducted after the rains from Oct to Dec. 2006 with the help of Dr. Almeida.

BIBLIOGRAPHY

Chapman, C. A., and L. J. Chapman. 1995. Survival without dispersers: seedling recruitment under parents. Conservation Biology 9:675-678.

Clark, C. J., Poulsen, J. R., Connor, E. F and Parker, V. T. 2004. Fruiting trees as dispersal foci in a semi-deciduous tropical forest. Oecologia 139:66-75.

Connell, J. H. 1971. On the role of natural enemies in preventing competitive exclusion in some marine animals and in rain forest trees. Pp. 298-312 In Dynamics of populations. P. Den Boer and P. R. Gradwell (eds) pp. 298-312. Wagenengen: PUDOC.

Cordeiro, N. J. and H. F. Howe. 2003. Forest fragmentation severs mutualism between seed dispersers and an endemic African tree. Proceedings of the National Academy of Sciences USA. 100 (24): 14052-14056.

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

Harms, K. E., Wright, S. J., Calderon, O., Hernandez, A., and Herre, E. A. 2000. Pervasive density-dependent recruitment enhances seedling diversity in a tropical forest. Nature 404:493-495.

Howe, H.F.1990, Seed dispersal by birds and mammals: implications for seedling demography. Pages 191-218 in K. S. Bawa and M. Hadley, editors. Reproductive ecology of tropical forest plants. Man, and Biosphere series. Vol. 7 UNESCO, Carnforth: Paris and Parthenon Publishing.

Howe, H. F. 1993. Aspects of variation in a Neotropical seed dispersal system. Vegetatio 107/108: 149-162.

Howe, H.F., Schupp, E.W. and L.C. Westley. 1985. Early consequences of seed dispersal for a Neotropical tree (Virola surinamensis). Ecology 66: 781-791.

Howe, H. F. and Vande Kerckhove, G. A. 1981. Removal of wild nutmeg (Virola surinamensis) crops by birds. Ecology 62(4): 1093-1106.

Janzen, D. H. 1970. Herbivores and the number of tree species in tropical forests. American Naturalist 104:501-528.

Kinnaird, M. F., O'Brien, T. B. and Suryadi, S. 1996. Population fluctuation in Sulawesi red-knobbed hornbills: tracking figs in space and time. Auk 113:431-440.

Laake, J. L., Buckland, S. T., Anderson, D. R., Burnham, K. P. 1994. DISTANCE user's guide version 2.1. Fort Collins, CO: Colorado Coop. Fish and Wildlife Research Unit, Colorado State University.

Laman, T. G. 1996. Ficus seed shadows in a Bornean rain forest. Oecologia 107: 347-355.

McKey, D. 1975. The ecology of coevolved seed dispersal systems. In: Gilbert, L.E. and Raven. P. (eds.) Coevolution of animals and plants. University of Texas Press, Austin. Pp. 159-191.

Myers, N. Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G. A. B., and Kent, J. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853-858.

Peres, C.A. 1999. Effects of hunting and habitat quality on Amazonian primate communities. In Primate Communities (J.G. Fleagle, C. Janson and K.E. Reed, eds.). pp. 268-283. Cambridge University Press, Cambridge.

Peres, C. A. 2001. Synergistic effects of subsistence hunting and habitat fragmentation on Amazonian forest vertebrates. Conservation Biology 15 (6): 1490-1505.

Peres, C. A. and van Roosmalen, M. 2002. Primate frugivory in two species-rich Neotropical Forests: Implications for the demography of large-seeded plants in over-hunted areas. (D.J., Levey, W.R., Silva & M. Galetti eds), pp. 407–422. CAB International, USA.

Redford, K. H. 1992. The empty forest. Bioscience 42(6) 412-423.

Schupp, E.W. 1988. Factors affecting post-dispersal seed survival in a tropical forest Oecologia 76: 525-530.

Schupp, E. W. 1993. Quantity, quality and the effectiveness of seed dispersal by animals. Vegetatio 107/108: 15-29.

Singh, P. 1994. Recent bird records from Arunachal Pradesh. Forktail 10:65-104.

Terborgh, J. Losos, E., Rile, M. P., Riley, M. B. 1993. Predation by vertebrates and invertebrates on the seeds of five canopy tree species of an Amazonian forest. Vegetatio 107/108: 375-386.

Wenny, D. G. and Levey, D. J. 1998. Directed seed dispersal by bellbirds in a tropical cloud forest. Proc. Natl. Acad. Sci., 95:6204-6207.

Wenny, D. G. 2001. Advantages of seed dispersal: A re-evaluation of directed dispersal. Evolutionary Ecology Research 3:51-74.

Wheelright N.T. 1985. Fruit size, gape width, and the diet of fruit eating birds. Ecology 66:808–818.

Whitney, K. D., Fogiel, M. K. Lamperti, A. M., Holbrook, K. M., Stauffer, D. J., Hardesty, B.D., Parker, V. T., and Smith, T. B. 1998. Seed dispersal by Ceratogymna hornbills in the Dja Reserve, Cameroon. Journal of Tropical Ecology 14: 351-371.