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Effects of habitat disturbance and hunting on the density and the biomass of the endemic Hose's leaf monkey *Presbytis hosei* (Thomas, 1889) (Mammalia: Primates: Cercopithecidae) in east Borneo

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Abstract

Hose's leaf monkey *Presbytis hosei* is endemic to Borneo and occurs only in tall forest. In recent decades Borneo has lost a large part of its forest cover, mostly in low-lying coastal regions. Large intact tracts of forest remain in the interior, but these are by and large inhabited by tribes that subsist in part by hunting. The combined effects of habitat disturbance and hunting on the densities and biomass of Hose's leaf monkey were studied in Kayan Mentarang National Park in Borneo's far interior. Over four months, data on densities and hunting were collected by transect walks in four forest types. Hose's leaf monkeys were hunted to deter crop-raiding, for their meat, and to obtain bezoar stones (visceral secretions used in traditional medicine). Hose's leaf monkeys occurred in single male groups of 7-8 individuals in densities from 0.8 to 2.3 groups km^{-2}. Densities of Hose's leaf monkeys were positively correlated with certain vegetation characteristics, e.g. tree height and height of first bough, and negatively correlated with distance to the nearest village. Biomass of Hose's leaf monkeys declined considerably as a result of habitat disturbance and hunting from 92 kg km^{-2} in primary hill forest inside the reserve to 38 kg km^{-2} in old secondary forest and 31 kg km^{-2} in young secondary forest near villages. A review of the few studies conducted on the effects of habitat disturbance and hunting on Hose's leaf monkeys reveal inconsistent trends in biomass and density responses.

Contents

Introduction

The Sundaic region is recognised as one of the most important global biodiversity hotspots (Myers et al., 2000) and within the region the largest continuous expanse of rain forest is found on the island of Borneo. Until only a few decades ago, the island was almost completely covered in forest. Large-scale exploitation of Borneo's forest for timber began at the end of the 1960's and currently some 90% of the forest (excluding conservation areas) in Sarawak is under logging concession (MacKinnon et al., 1996). The total area of forest under concession in Indonesian Kalimantan is actually larger than that of remaining forest (Rijksen and Meijaard, 1999). Every year vast areas are cleared for agriculture, plantation, human settlements, and timber production. In the last few decades Borneo has become well known for its large forest fires that coincide with the El Niño Southern Oscillation Event (Siegert et al., 2001). Apart from the economic damage the forest fires cause, the loss of forest over large areas has a considerable effect on the wildlife. The forests in the inte-

rior of Borneo have suffered significantly less from the fires than the low-lying, more coastal, parts. This may be explained in part by the low human population density (less chance of ignition), less selective logging (which greatly increases the risk of fire), and a shorter dry season (as a result of orographic rainfall caused by mountain ranges).

The interior is home to a large number of tribes collectively known as Dayak. The Dayak live in villages and practice shifting cultivation. In addition, the interior is the home to the Punan, a group of formerly nomadic tribes that subsisted by hunting and gathering. In contrast to the largely Islamic Malayans that inhabit the low-lying coastal areas, they are skilful hunters. Although the Punan and Dayak occur at low population densities, there are few restrictions on the species that can be hunted and the impact of hunting on a select group of species might be considerable, even leading to (local) extinction (Sumatran rhino *Dicerorhinus sumatrensis*: Rookmaaker, 1977; orang-utan *Pongo pygmeus*: Rijksen and Meijaard, 1999; proboscis monkey *Nasalis larvatus*: Meijaard and Nijman, 2000a).

By virtue of their wide appeal, primates may make ideal flagship species for tropical ecosystem conservation. Borneo is rich in primates with 13 species, of which nine are endemics (Meijaard and Nijman 2003). Most of the endemics and both globally threatened species (orang-utan and proboscis monkey) are vulnerable to the loss of their forest habitat, and site protection is widely seen as the key mechanism in their conservation. The effects of hunting on primates in Borneo are poorly known (Nijman, 2001).

In this, I report on the effects of hunting and habitat disturbance on the abundance of Hose's leaf monkey *Presbytis hosei* in the Bahau region, East Kalimantan. This species is restricted to north Borneo: the Malaysian States of Sarawak (northernmost part) and Sabah, the Brunei Sultanate, and the northern half of the Indonesian province of East Kalimantan. It is one of the few species of *Presbytis* leaf monkeys that not have been studied in any detail (but see Rodman, 1978; Mitchell, 1994) although it has been included in a number of wildlife surveys. Hardly any data is available on the species' conservation status and indeed it has been included as Data Deficient on the Red List of Threatened Species (IUCN, 2003).

Methods

Study area and study sites

Data were collected during September-December 1996 in and around the Kayan Mentarang National Park, East Kalimantan, Indonesia. The park is one of Southeast Asia's largest reserves and with adjacent (proposed) reserves it covers an area over 2500 km^2 and is the home of approximately 10,000 people. The study sites were in the Nggeng Bio, Bua Alat and Tebulo river valleys, in Kayan Mentarang's Bahau region [115°50'E, 2°50'N]. The valleys lie between steep hills that are intersected by many small streams. The study sites are at an altitude of c. 300-800 m asl but are mostly below 500 m asl. Forest sites were situated close together (<10 km) and were similar with regards to climate, original forest type, altitude and topography. The area is covered in lowland dipterocarp rainforest, with hill dipterocarp rainforest to submontane forest in the higher parts. True riverine terrace forest is rare or even absent. Secondary forest of different ages is found along the banks of the Bahau River and in the vicinity of the villages, but is usually not found beyond the first mountain ridge from a village. Mature forest is still found close to the major rivers, on steep slopes, and halfway between villages.

The Nggeng Bio river valley has been a 'tana ulen' (restricted forest) of the nearby village of Long Alango for more than 75 years, and is covered with tall primary forest. Most of the Bua Alat river valley is covered in primary dipterocarp rainforest. Near the mouth of the river, however, it is replaced by old secondary forest that was last logged 45 years ago, in 1951. The mouth of the Tebulo river valley comprised mainly cultivated land, including the village of Long Tebulo. Throughout the valley a patchwork of regenerating forest is present, ranging from one to 20 years of age. The study was conducted in forest patches between 10 and 20 years of age, some of which were contiguous with the old secondary forest in the Bua Alat river valley.

Primate censuses and calculation of density

The abundance of Hose's leaf monkeys was assessed using repeated line transect surveys. Transects were situated in primary hill forest (four transects with a total length of 10.75 km), primary riverine forest (one transect of 4.9 km), old secondary forest (one transect of 3.3 km), and young secondary forest (two transects totaling 4.6 km). An average walking speed of c. 1.5 km h^{-1} was maintained. A total of 258 km were thus covered, 119 km in primary hill forest, 29 km in primary riverine forest, 66 km in old secondary forest, and 44 km in young secondary forest.

Densities of leaf monkeys were estimated using the effective distance method of Whitesides et al. (1988):

$$D = \frac{n}{A} = \frac{n}{L(2Ed + S/2)} \qquad \text{(equation 1)}$$

where D = density (groups km^{-2}), n = number of groups seen, A = census area (in km^2), L = length censused (km), Ed = Effective distance (km, estimated in m), and S = mean group spread (km, estimated in m).

Group spread is the diameter of the circle of equivalent area to that occupied, on average, by a primate group. The effective distance is defined as the distance on each side of the transect at which the number of sightings at greater perpendicular distances equals the number missed at nearer distances. There was no significant difference in perpendicular distances between habitats (Kruskall-Walis $H = 2.3$, $p > 0.50$), and the effective distance was determined using a histogram of perpendicular distances from all habitat types combined:

$$Ed = \frac{Nt}{Nf} \times Fd \qquad \text{(equation 2)}$$

where Nt = total number of sightings, Nf = the number of sightings below the fall-off distance, and Fd = fall-off distance, defined as the maximum reliable distance beyond which the number of sightings is reduced by 50% or more.

The density of individuals was calculated using the mean group size, as observed during the transect walks. For estimation of mean group size, only complete counts of all members of the group were used.

Biomass

Davies and Payne (1982) report 6.3 kg and 6.0 kg for an adult male and female Hose's leaf monkey, respectively and 3.0 kg for an immature. Davies (1994) estimated 4.5 kg for an average leaf monkey, irrespective of the group size in which it occurs. Davies and Payne (1982) estimate 30 kg for a group of 7 individuals and Suzuki (1992) at 56 kg for a group of eleven individuals. Given that Hose's leaf monkeys occur in single-male, multiple-female groups, biomass was calculated using average group mass following:

$$M_{group} = 6.5 + (N - 1 \times 4.8) \qquad \text{(equation 3)}$$

where M_{group} = the average group mass (in kg), N = total group size, and 6.5 (kg) the average weight of an adult male and 4.8 (kg) the average weight for females and offspring.

Vegetation sampling

Vegetation characteristics were recorded at sampling stations established every 150 m along transects. Data were collected from 47 sampling stations: 13 in primary forest, 12 in old secondary forest, 13 in young secondary forest and 9 in riverine forest. Inspired by the work of Torquebiau (1986) and Jones et al. (1995), an indication of the recent history of each sampling station was gained by recording the tree 'architecture'. The height of the first major branching, combined with the presence or absence of large scars on the trunk below this first bough, provide information on the growth conditions of the tree. In general, a tree with branches above half its height will have grown up under a closed canopy and may be considered probably a 'primary forest' tree, and those branching below half their height have usually grown up in a cleared areas (a 'secondary growth' tree). Following the method described in Nijman (1998), at each sampling station four trees (>10 cm dbh) were selected, the height and height of the first bough was estimated and the girth and distance to the sampling station's centre point measured. Vegetation cover

was estimated to the nearest 5% at ground, low (2.0 m above ground), and canopy level.

Analysis

Each transect (apart from two of the transects in primary hill forest from where not all vegetation data were collected) was characterised by the following variables: average tree distance, tree diameter, tree height and height of the first bough; average vegetation cover at ground, low and canopy level; average altitude (range 325-450 m a.s.l.); shortest straight line distance to the nearest village (range 0.5-5.0 km) and to the nearest river (range 25 m-2.0 km). A multiple linear regression model was fitted on the (normalised) data to determine the best sub-set of predictors for the observed variation in leaf money densities. The effects of collinearity were reduced by simply omitting predictor variables that correlated highly with the other predictor variables that remained in the model (Quinn and Keough, 2002). Means are reported ± 1 standard deviation, and all tests are two-tailed with significance assumed when $p < 0.05$.

Results

Vegetation

Primary forest has a much more open understory than secondary forest, yet no significant differences were found between forest types in the average distance from the nearest tree (>10 cm dbh) to sample plot's centre (Table 1). This is mainly due to the fact that a great number of the trees in secondary forest had a diameter of <10 cm dbh and thus were not included in sampling. Primary forest and old secondary forest differed significantly in average height of the first bough and their diameter (Mann Whitney U $n_1 = 13$, $n_2 = 12$, $p = 0.03$, and $n_1 = 13$, $n_2 = 12$, $p = 0.05$, for height of first bough and diameter, respectively). Average tree height did not differ between these two forest types, although the range of values was smaller in old secondary forest (10.4-18.6 m) than in primary forest (10.5-20.8 m). Average tree height and height of the first major branch at the sample stations was smaller in young secondary forest than in old secondary forest (Mann Whitney U, both $n_1 = 12$, $n_2 = 13$, $p < 0.01$). Vegetation cover at low and ground level was highest in riverine and young secondary forest, and lowest in primary and old secondary forest (Kruskall-Wallis one-way analysis of variance, $H = 13.3$, $p < 0.01$ and $H = 19.0$, $p < 0.001$, for ground and low level cover, respectively). Conversely, estimated canopy cover was higher in primary and old secondary forest, and lowest in young secondary and riverine forest, the differences between forest types however being not significant (Kruskall-Wallis, $H = 5.0$, $p > 0.1$). Not unexpectedly, vegetation variables were highly correlated with one another (Kendal Correlation Coefficient, $t > 0.67$, $p < 0.05$) except for distance to the nearest tree.

Densities, group sizes and biomass

With an effective sighting distance of 24 m for all habitat types combined and an average group spread of 11 m (n=9) the total survey area was 15.2 km^2. Within this area 24 groups were encountered giving an average of 1.6 groups km^{-2}. Although Hose's leaf monkeys were encountered in all forest types, group densities were twice as high in primary forest as in the other habitat types (Table 2). Within the primary forest the monkeys preferred hill forest above riverine forest. Group densities along transects in undisturbed forest types (primary and riverine) were significantly larger than in the secondary forest types (Mann-Whitney U, $n_1 = 5$, $n_2 = 3$, $p < 0.03$). Indeed, densities decreased with increasing levels of forest disturbance. Group sizes of Hose's leaf monkeys tended to be larger in primary forests compared to secondary forests, i.e., 8.3±2.9 (n = 11) and 7.2±1.5 (n = 5) individuals, respectively, but these differences were not significantly different (Mann-Whitney U, $n_1 = 11$, $n_2 = 5$, $p > 0.30$). Combining all habitat types the mean group size was 8.0±3.0 (n = 16) individuals (range 1-11). Most groups consisted of a single adult male, several adult females and their offspring, but an all-male group of four individuals was present in the primary forest and several single individuals, mostly males, were encountered. With an average

Table 1. Vegetation structure in primary, riverine, old secondary, and young secondary, forest in Kayan Mentarang National Park, East Kalimantan, Indonesia. Based upon 13 sampling stations in primary hill forest, 9 sampling stations in riverine forest, 12 sampling stations in old secondary forest, and 13 sampling stations in young secondary forest. s.d.=standard deviation. Values with different letters are significantly different at the 5% level.

	Primary Forest Hill mean (s.d.)		Riverine mean (s.d.)		Secondary Forest Old mean (s.d.)		Young mean (s.d.)	
height of tree (m)	15.2 (3.0)	a	12.0 (2.3)	c	13.5 (2.6)	a	9.9 (1.1)	b
height first bough (m)	11.9 (2.5)	a	7.7 (1.5)	c	9.6 (1.8)	b	6.8 (1.0)	c
diameter (cm)	31.1 (9.8)	a	21.9 (7.2)	b	23.8 (8.8)	b	17.5 (4.0)	b
distance to station (m)	3.5 (1.2)	a	3.4 (1.3)	a	3.5 (0.7)	a	3.4 (1.0)	a
ground cover (%)	16.5 (24.7)	a	54.4 (22.8)	b	17.3 (18.6)	a	45.4 (24.9)	b
low level cover (%)	12.4 (6.2)	a	37.7 (18.3)	b	16.3 (9.1)	a	43.5 (16.4)	b
canopy cover (%)	53.0 (19.6)	a	38.3 (18.7)	b	50 (19.9)	ab	36.6 (20.8)	b

Table 2. Densities of Hose's leaf monkey *Presbytis hosei* in East Kalimantan, Indonesia.

Habitat	No transects (length in km)	Repeats	Census area (km^2)	Groups km^{-2} (s.d.)	Individuals km^{-2} (s.d.)
Primary forest					
Hill	4 (10.8)	44	7.0	2.3 (0.1)	18.9 (22.7)
Riverine	1 (4.9)	6	1.7	1.2	9.5
Secondary forest					
Old	1 (3.3)	20	3.9	1.0	7.4
Young	2 (4.6)	19	2.6	0.8 (0.1)	5.5 (5.2)

group size of 8.0 individuals the average group mass in all forest types combined is 40 kg. This converts to a biomass of 92 kg km^{-2} in primary hill forest, 48 kg km^{-2} in primary riverine forest, and 38 kg km^{-2} and 31 kg km^{-2} for old and young secondary forest, respectively.

Correlations between densities and habitat parameters

Group densities of Hose's leaf monkeys were positively correlated with tree height, height of the first bough, tree diameter, and canopy cover, and negatively with vegetation cover at low and ground level. However, only for the first two mentioned was it significant (Kendall Rank Correlation Coefficient, $t = 0.87$, $p < 0.02$ and $t = 0.73$, $p < 0.04$ for tree height and height of first bough respectively). Hose's leaf monkeys have a preference for tall trees as the height of the tree used upon encounter for 34 individuals in primary and old secondary forest was significantly higher than that of a random sample of 100 trees (dbh >10 cm) in these forest types (Mann Whitney U $n_1 = 100$, $n_2 = 34$, $p < 0.01$). The median altitude of the transects and distance to the nearest village were positively correlated (Kendall Rank Correlation Coefficient, $t = 0.80$, $p < 0.02$), reflecting a preference for establishing villages in valleys. Leaf monkey density was positively correlated with increasing distance from the village (Figure 1) and increasing distance to the nearest river (Kendall Rank Correlation Coefficient, both $t = 0.73$, $p < 0.04$). In a simple linear multiple regression model, tree diameter and distance to a village proved to be the best subset of predictors for the observed variation in densities ($F_{2,} = 33.5$, $p = 0.001$, $R^2 = 0.9$: *Density (in groups km^{-2}) = -0.615 + 0.0682 Tree Diameter + 0.196 Distance to Village*).

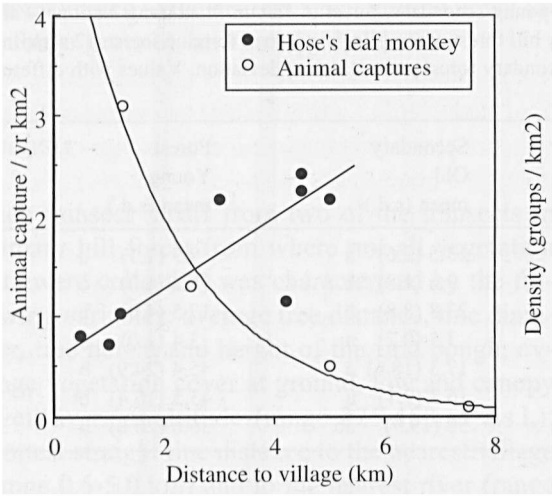

Fig. 1. Animal captures (data from Puri, 1992) and densities of Hose's leaf monkeys in relation to distance to the village in which hunters reside showing an exponential decrease in hunting intensity and a linear increase in leaf monkey density with increasing distance from a village.

Discussion

The effects of habitat disturbance

This is one of few studies to document the effects of habitat disturbance and hunting on Hose's leaf monkeys. Group densities in 45 and 10-20 year old secondary forest were respectively 30% and 40% less than primary forest. The smaller group sizes in secondary forest (albeit not significant) are indicative of an even greater decrease in biomass. These changes have come about as result of a combination of habitat disturbance and hunting, and it is not possible to separate the effects of hunting from habitat disturbance on the species' decline. Given the proximity of the study sites to one another and the homogeneity of the original forest, it is unlikely that other factors (such as spatial differences in number of competitors, the amount of certain food sources, or diseases: reviewed in Davies 1994) are major contributors in these observed differences in density and biomass, other than those induced by habitat disturbance and or hunting, e.g., the amount of certain food sources may change after logging, and other primate species may be more common nearer to villages.

Several studies examined the effects of habitat disturbance (including selective logging, shifting cultivation and hunting) on other colobines in Africa and Asia, but these studies reveal few consistent trends, with some species declining and others increasing (Skorupa, 1986; Davies, 1994; Grieser Johns and Grieser Johns, 1995; Cowlishaw and Dunbar, 2000). Even within species of the genus *Presbytis* few consistent trends emerge, bearing in mind, however, that there have been few diligent studies of this genus. Most species seem to have a clear preference for primary forest (Natuna leaf monkey *P. natunae*: Lammertink et al. 2003; grizzled leaf monkey *P. comata*: Nijman 1997, Nijman and van Balen 1997; red leaf monkey *P. rubicunda*, V. Nijman unpubl. data), and the general trend is that after an initial decrease due to the immediate effects of the logging operation, populations of leaf monkeys quickly recover but to a density below the previous level (Whitten et al., 2000: 373). Payne and Davies (1985) found that Hose's leaf monkeys were less common in a 19-year old logged forest compared to two adjacent unlogged forests, with densities of 1.3 groups km^{-2} compared to 3.6 and 4.3 groups km^{-2} respectively. More generally, they found leaf monkey (Hose's and red) densities were 3-5 times lower in logged forest than in unlogged areas. Mitchell (1994) reported differences in ranging behaviour between two adjacent groups, one of which ranged in a 10-20 year-old lightly logged forest and the other largely in unlogged forest. The group in logged forest had a larger home range and larger day ranges. Mitchell (1994) furthermore reported the absence of Hose's leaf monkey in 15-20 year-old forest that had been heavily logged, suggesting declining densities of Hose's leaf monkey with logging. However, it is not clear if this decline is due to the effects of logging or due to geographical variation in densities. Wilson and Wilson (1975) found Hose's leaf monkey only in primary forest, but indicate that it did also occur in disturbed forests. Bennett and Dahaban (1995) studied the effects of disturbance (including logging and hunting) on densities of four species of leaf monkeys (including Hose's leaf monkey) in Sarawak and Brunei. In general, densities of leaf monkeys differed little between eight primary forest plots

and two 30-year old secondary forest sites, or between one forest site prior to logging and one year after logging.

In contrast to the above studies that reported either a decrease in densities due to logging or were not able to detect an effect on densities, Johns (1992) reported an increase in density of Hose's leaf monkey after logging, from 2.0 groups km^{-2} in primary forest to 3.6 groups km^{-2} in forest 6 years after logging to 3.9 groups km^{-2} in forest 12 years after logging. Wilson and Johns (1982), using data from East Kalimantan, found that leaf monkeys were able to withstand the pressures imposed by logging.

The effects of hunting

Kuchikura (1988) showed that in peninsular Malaysia two species of leaf monkey (pale-thighed leaf monkey *P. siamensis* and dusky leaf monkey *Trachypithecus obscurus*) were the most profitable primates in terms of rate of energy gain rate for hunters. Nevertheless, primates contribute less than a quarter of the entire mammalian harvest in most hunter communities (Cowlishaw and Dunbar, 2000). Indeed in the Kayan Mentarang area pigs and not primates comprise most of the prey. Still, hunting of Hose's leaf monkeys is a widespread occurrence as five skins were observed mounted on walls in four villages, and an additional three (most likely Hose's) leaf monkey skulls were present in two villages (V. Nijman unpubl. data). On Borneo, hunting of leaf monkeys is often associated with inland settlements, the timber industry and the demand for bezoar stones (visceral secretions used in traditional medicine and sold for high prices). Near villages they are hunted to deter crop-raiding. In West Kalimantan, encounters with primates by Dayak hunters were as likely to result in a capture as encounters with other large mammals, although primates were infrequently encountered (Wadley et al., 1997). In Sarawak, the three leaf monkey species (red, Hose's and white-fronted leaf monkey *P. frontata*) account for at least one percent of all mammals hunted, which may account for some 20 000 monkeys annually (Bennett et al., 1987). However, few studies on Borneo have systematically investigated the effects of hunting on wildlife (cf. Robinson and Bennett, 2000). In Bennett and Dahaban's (1995) study, the effect of hunting on leaf monkeys was considerable (from an average density of 5.1 groups km^{-2} in three sites with a low hunting intensity, to 2.7 and 0.5 groups km^{-2} in four and one forest sites with medium and high hunting intensity, respectively) yet not statistically significant.

Analysis of data on hunting in Kayan Mentarang at a site *c.* 12 km south of my study area presented by Puri (1992) might shed some light on the relationship between hunting intensity and the distance from the village where the hunters live (Figure 1). It shows an exponentially decreasing relation between hunting intensity and distance to a village at a scale very similar to the observed increase in densities of Hose's leaf monkey with increasing distance to a village found in the present study. A significant correlation was demonstrated between Hose's leaf monkey densities and distance to villages and rivers, and distance to villages was included in the best subset of variables explaining variation in Hose's leaf monkey densities. Although these data provide only circumstantial evidence and are by no means conclusive, it does indicate that hunting (perhaps in combination with habitat disturbance) has an impact on population numbers of Hose's leaf monkeys. Other primates, especially those occurring at low densities or whose behaviour makes them susceptible to hunting might be more affected than Hose's leaf monkey. MacKinnon (1992) suggested the almost total absence of orangutans in north-east Kalimantan, including the Kayan Mentarang area, is caused by hunting. The same might explain the scarcity of proboscis monkey in the area (Pfeffer, 1958; Meijaard and Nijman 2000a).

Conservation prospects in the interior of Borneo

Despite the gazetting of several large (>1000 km^2) protected areas in Indonesian Borneo, due to a combination of mismanagement, poorly integrated planning, institutional deficiencies, and misconceptions on ecological issues, virtually all forest in protected areas have been affected by logging, burning and conversion (Meijaard and Nijman 2000b; Fredriksson & Nijman, 2004). The only large undisturbed

forest areas on Borneo are in the island's far interior. Probably more due to luck and (as yet) poorly developed infrastructure, so far these regions have more or less escaped and, in comparison with low-lying coastal areas, wildlife seems to thrive. Large sections of the remaining forest in Borneo's interior are included inside logging concessions or are scheduled for conversion. The two largest areas that are, at least on paper, adequately protected are the Kayan Mentarang and the Betung-Kerihun / Lanjak Entimau transboundary reserves in West Kalimantan and Sarawak (MacKinnon et al., 1996). Although this may secure the rain forest, it does not exempt wildlife from the dangers of hunting. In Indonesian reserves, law enforcement is virtually absent and in and around both reserves there are numerous villages and settlements that depend for part of their livelihood on subsistence hunting. It is almost impossible and perhaps not even desirable, to prevent these communities from hunting inside the reserves. In the absence of long-term data on the effects of hunting on wildlife, it might be best to follow a pragmatic approach in which more attention is paid to a selected group of species that are most likely to be negatively affected by hunting and that without protection inside reserves run a high risk of extinction in the medium long term. The present study suggests that Hose's leaf monkey might make a good candidate.

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References

Bennett EL, Dahaban Z. 1995. Wildlife responses to disturbances in Sarawak and their implications for wildlife management. In Primack RB, Lovejoy TE, eds. *Ecology, conservation and management of Southeast Asian rainforests.* New Haven and London: Yale University Press, 66-86.

Bennett EL, Caldecott J, Kavanagh M, Sebastian A. 1987. Current status of primates in Sarawak. *Primate Conserv.* 8: 184-187.

Cowlishaw G, Dunbar RIM. 2000. *Primate conservation biology.* London and Chicago: University of Chicago Press.

Davies AG. 1994. Colobine populations. In Davies GA, Oates JF, eds. *Colobine monkeys: their ecology, behaviour and evolution.* Cambridge: Cambridge University Press, 285-310.

Davies AG, Payne J. 1982. *A faunal survey of Sabah.* Kuala Lumpur: World Wildlife Fund Malaysia.

Fredriksson GM, Nijman V. 2004. Habitat-use and conservation of two elusive ground birds (*Carpococcyx radiatus* and *Polyplectron schleiermacheri*) in Sungai Wain Protection Forest, East Kalimantan, Indonesian Borneo. *Oryx* 38: 297-303.

Grieser Johns AD, Grieser Johns BD. 1995. Tropical forest primates and logging: long-term coexistence? *Oryx* 29: 205-211.

Johns AD. 1992. Vertebrate responses to selective logging: implications for the design of logging systems. *Proc. Royal Soc. London Series B* 335: 437-442.

Jones MJ, Linsley M, Marsden SJ. 1995. Population sizes, status and habitat associations of the restricted-range bird species of Sumba, Indonesia. *Bird Conserv. Intern.* 5: 21-52.

IUCN 2003. *IUCN Red List of Threatened Species* [www.redlist.org, accessed 18 December 2003].

Kuchikura Y. 1988. Efficiency and focus of blowpipe hunting among Semaq Beri hunter-gatherers of peninsular Malaysia. *Human Ecol.* 16: 271-305.

Lammertink M, Nijman V, Setiorini U. 2003. Population size, Red List status and conservation of the Natuna leaf monkey *Presbytis natunae*, endemic to the island of Bunguran, Indonesia. *Oryx* 37: 472-479.

MacKinnon J. 1992. Species survival plan for the orangutan. In Ismail G, Mohamed M, Omar S, eds. *Forest biology and conservation in Borneo.* Kota Kinabalu: Center for Borneo Studies, 209-219.

MacKinnon K, Hatta G, Halim H, Mangalik A. 1996. *The ecology of Kalimantan.* Singapore: Periplus.

Meijaard E, Nijman V. 2000a. Distribution and conservation of the proboscis monkey (*Nasalis larvatus*) in Kalimantan, Indonesia. *Biol. Conserv.* 92: 15-24.

Meijaard E, Nijman V. 2000b. The local extinction of proboscis monkey *Nasalis larvatus* in Pulau Kaget Nature Reserve, Indonesia. *Oryx* 34: 66-70.

Meijaard E, Nijman V. 2003. Primate hotspots on Borneo: predictive value for general biodiversity and the effects of taxonomy. *Conserv. Biol.* 17: 725-732.

Mitchell AH. 1994. *Ecology of Hose's langur (*Presbytis hosei*) in logged and unlogged Dipterocarp forest of northeast Borneo.* Ph.D. dissertation. New Haven: Yale University.

Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858.

Nijman V. 1997. On the occurrence and distribution of *Presbytis comata* (Desmarest, 1822) (Mammalia: Primates: Cercopithecidae) on Java, Indonesia. *Contrib. Zool.* 66: 247-256.

Nijman V. 1998. Habitat preferences of Great Argus Pheasant *Argusianus argus* in Kayan Mentarang National Park, East Kalimantan, Indonesia. *J. Ornithol.* 139: 313-323.

Nijman V. 2001. *Forest (and) primates: conservation and ecology of the endemic primates of Java and Borneo.* Wageningen: Tropenbos International.

Nijman V, van Balen S. 1997. A faunal survey of the Dieng Mountains, Central Java, Indonesia: distribution and conservation of endemic primate taxa. *Oryx* 32: 145-156.

Pfeffer P. 1958. Situation actuelle de quelques animaux menacés d'Indonesie. *La Terre et la Vie* 105: 128 - 145.

Puri RK. 1992. *Mammals and hunting on the Lura River: recommendations for management of faunal resources in the cagar alam Kayan-Mentarang.* Samarinda: WWF-Indonesia.

Quinn GP, Keough MJ. 2002. *Experimental design and data analysis for biologists.* Cambridge: Cambridge University Press.

Rijksen HD, Meijaard E. 1999. *Our vanishing relative. The status of wild orang-utans at the close of the twentieth century.* Dordecht: Kluwer.

Rookmaaker LC. 1977. The distribution and status of the rhinoceros, *Dicerorhinus sumatrensis*, in Borneo – A review. *Bijdr. Dierk.* 47: 197-204.

Robinson JG, Bennett EL. 2000. *Hunting for sustainability in tropical forests.* Vancouver: Columbia University Press.

Rodman PS. 1978. Diets, densities and distribution of Bornean primates. In Montgomery GG, ed. *The ecology of arboreal folivores.* Washington: Smithsonian Institute Press, 465-478

Siegert F, Ruecker G, Hinrichs A, Hoffmann AA. 2001. Increased damage from fires in logged forests during droughts caused by El Niño. *Nature* 414: 437-440.

Skuropa JP. 1986. Responses of rainforest primates to selective logging in Kibale forest, Uganda: a summary report. In Benirschke K, ed. *Primates: the road to self sustaining populations.* New York: Springer-Verlag, 57-70.

Suzuki A. 1992. The population of Orangutans and other non-human primates and the forest conditions after the 1982-83's fires and droughts in Kutai National Park, East Kalimantan, Indonesia. In Ismail G, Mohamed M, Omar S, eds. *Forest biology and conservation in Borneo.* Kota Kinabalu: Center for Borneo Studies, 190-205.

Torquebiau EF. 1986. Mosaic patterns in Dipterocarp rain forest in Indonesia and their implications for practical forestry. *J. Trop. Ecol.* 2: 301-325.

Wadley RL, Colfer CJP, Hood IG 1997. Hunting primates and managing forests: the case of the Iban forest farmers in Indonesian Borneo. *Human Ecol.* 25: 243-271.

Whitesides GH, Oates JF, Green SM, Kluberdanz RP. 1988. Estimating primate densities from transects in a West African rain forest: a comparison of techniques. *J. Animal Ecol.* 57: 345-367.

Whitten T, Damanik, SJ, Anwar J, Hisyam N. 2000. The ecology of Sumatra, 2nd ed. Singapore: Periplus.

Wilson WL, Johns AD. 1982. Diversity and abundance of selected animal species in undisturbed forest, selectively logged forest and plantations in East Kalimantan, Indonesia. *Biol. Conserv.* 24: 205-218.

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