

RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 18

WINTER 1984

No. 4

RAPTOR COMMUNITY STRUCTURE OF A PRIMARY RAIN FOREST IN FRENCH GUIANA AND EFFECT OF HUMAN HUNTING PRESSURE

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ABSTRACT - The diurnal raptor community of a primary rain forest in French Guiana was studied, both around a small isolated village and far from any human settlement. Twenty species were found in large areas of unbroken forest and 6 additional species only near edges and clearings around the village. The comparison between hunted and non-hunted patches of otherwise similar virgin forest showed that even a moderate hunting pressure (i.e., for food by few people) significantly reduces both mean species richness of sample counts and density of most primary forest raptors. The largest species may eventually disappear.

Other than regional avifaunas and local annotated lists, including birds of prey, I found no studies on any entire raptor community of a particular primary Neotropical rain forest. Most papers are restricted to short observations on feeding (Haverschmidt 1962; Greenlaw 1967; Smith 1969; Lamm 1974; Lemke 1979; Boyce 1980; Fontaine 1980) or breeding behavior (Laughlin 1952; Smith 1970; Strauch 1975). Very few are longer, behavioral (Peeters 1963; Fowler and Cope 1964; Skutch 1965; Rettig 1968; Gochfeld et al. 1978), or ecological studies (Vooous 1969; Smith and Temple 1982).

The number of falconiform species is much higher in tropical American forests than in similar forests of other continents (Thiollay 1984). However, their overall density does not seem to be higher (pers. obs. in Africa, Asia and Central America). Tropical forest raptors are exceedingly difficult to see in their natural habitat, so much so that only one nest of *Micrastur* (5 species), probably the most widespread genus of Neotropical rain forest raptors, has ever been found (Mader 1979).

The avifauna of French Guiana is poorly known (see Tostain 1980), though type specimens of many species (including raptors) coming from this country were described nearly 200 y ago. This paper presents the preliminary results of a larger study designed for a rain forest national park in French

Guiana, and the effect of human hunting pressure on the non-game bird community of primary forest. The objectives were to determine: (1) the composition of the diurnal raptor community of a truly virgin Neotropical rain forest, (2) the closest estimate of the structure (relative abundance of species) of such a community, (3) the forest species occurring only near the edge of large clearings or associated secondary forest and not around smaller natural opening in otherwise unbroken forest, and (4) the result of a moderate human hunting pressure (mostly on non-raptor species) on the raptor community richness and species' abundance.

STUDY AREA AND METHODS

The study site was in south central French Guiana ($3^{\circ} 35'N$ - $53^{\circ} 10'W$) near the small village of Saul (50 inhabitants, mainly goldminers). There are no other settlements or clearings within a 100 km radius. The country was hilly (200 to 500 m) and completely covered with high, dense, primary rain forest. The rich flora (ca. 500 tree species) was described by Granville (1978) and the forest structure by Oldemann (1974). The mean canopy height was 30-40 m with the highest trees up to 60 m. Numerous treefall gaps and small streams (but no large rivers) increase habitat diversity. Mean annual rainfall was 2400 mm, occurring mainly from December to February and April to July. Precipitation was 96 mm in November (17 d) and 206 mm (24 d) in December 1983.

The village was surrounded by about 150 ha of plantations, old re-growth, secondary forest and an airfield. A network of 120 km of small trails helped when searching the forest within about 5 km around the village. Local people hunted there for food. Nearly all

medium-size or large mammals and birds were hunted. The following raptors were killed during my 6 wk study: 1 Harpy Eagle (*Harpia harpyja*), 1 Ornate Hawk Eagle (*Spizaetus ornatus*), 1 White Hawk (*Leucopternis albicollis*), 2 Red-throated Caracara (*Daptrius americana*) and 1 Bat Falcon (*Falco rufigularis*). According to the villagers, about 50 raptors/yr are killed. Hunting has begun there since the first gold miners settled less than 50 y ago.

The second area was located in the Massif des Emerillons, 50 km south of Saül. It is uniformly covered by a strictly virgin rain forest, similar to that of Saül but completely devoid of any human settlement (the nearest is Saül), even of nomadic Indians, and never hunted. The study site was around a bare rocky outcrop which provided the only opening in the forest. Only faint markings were made along line transects which radiated in every direction.

In both areas, only primary, structurally intact forest was considered, but tracks, small openings and edges, from which soaring birds were searched, were included. In Saül this had an influence on the species composition since wider ranging soaring raptors coming from neighboring secondary habitats were recorded above the primary forest canopy.

After a preliminary survey in December 1981—January 1982, counts were made from 22 November 1983 to 2 January 1984. The Saül area, studied in 31 d, extended over about 100 km², against less than 10 km² in the Massif des Emerillons, which was surveyed during 11 d. This period covered the end of the dry season and the beginning of the rainy season and little time was lost because of afternoon rains.

In spite of numerous attempts in other tropical forests, I have found no single method which can give an accurate figure of a whole tropical forest raptor community. Therefore, the following two complementary methods were used:

1 - The number of birds seen or heard within < 100 m on each side of the line transect, per 2 h spent slowly walking with frequent stops inside the forest, was recorded. Very noisy flocks of caracaras were more often heard than seen, and their flock size could not always be accurately assessed. Therefore, only the number of flocks was computed, irrespective of the actual number of individuals. No significant differences were found among times of day, so all hours have been lumped (rainy periods excluded). This careful search is the only way to detect all the non-soaring species, although more specialized methods (tape records, traps) may help to detect a higher proportion of some species.

2 - From edges, natural gaps on ridges or rocky outcrops dominating the forest, the minimum number of different individual birds seen flying over the canopy, or even sitting on exposed branches, was recorded during 2-hr periods, spent on the same spot in non-rainy weather. To account for the hourly variation of the species' soaring activity, the day was divided into 4 periods. Only birds within < 1 km (the range of visibility of a small raptor to the naked eye) were recorded.

Pooling the data from the 2 methods does not give an accurate figure of the entire community because of very different degrees of conspicuousness, and hence detectability, among species, hours, weather, etc. In spite of this, a rough and tentative estimate of the numerical proportion of each species in the raptor community will be made. The percentages were calculated on the maximum frequency recorded in any of the 2 methods (i.e., mean number of individuals seen per 2-hr period, either under or above the canopy, during the most favourable time of day). Such a treatment obviously underestimates the relative importance of inconspicuous species which rarely, if ever, soar (forest falcons (*Micrastur* sp.), Black-faced Hawk (*Leucopternis melanops*), etc.).

RESULTS AND DISCUSSION

The first striking result was the higher mean species richness per sample count and abundance of raptors in non-hunted vs hunted areas, even when the natural primary forest in hunted area suffered no other disturbance than the occasional presence of a few hunters and goldminers. From the hunted to the non-hunted forest, the mean number of species per 2-hr sample increased both under (+ 53.6%, Table 1) and above the canopy (+ 40.9%, Table 2). The frequency of encounters with caracara flocks was 69.4% higher in non-hunted vs hunted area (Table 1). Similarly, the abundance of other raptors increased from the hunted to the protected forest by 46.6% (Table 1) to 93.9% (Table 2). This change in mean number of individuals seen/

Table 1. Mean number of individuals (or whole flocks of *Daptrius*) and species seen/2-hr periods of careful search within a 200 m wide strip under the primary rain forest canopy in hunted (Saül) and not hunted (Emerillons) areas. Vultures and kites seen soaring above the canopy are not included.

	2-HR COUNTS	FLOCKS (\bar{x}) OF <i>Daptrius americanus</i>	INDIVIDUAL (\bar{x}) RAPTORS OTHER THAN <i>Daptrius</i>	SPECIES (\bar{x}) INCLUDING <i>Daptrius</i>
Hunted	128	0.36	0.15	0.56
Not hunted	28	0.61	0.22	0.86

Table 2. Mean number of individuals and species of raptors seen/2 hr period sitting in the upper canopy (excluding *Daptrius*), or most often soaring. Observations are within 1 km of the still observer, during the 4 periods of the day in hunted (Saül) and not hunted (Emerillons) areas.

	0600 H - 0900 H		0901 H - 1200 H		1201 H - 1500 H		1501 H - 1800 H		
	COUNTS	INDIVIDUALS	SPECIES	INDIVIDUALS	SPECIES	INDIVIDUALS	SPECIES	INDIVIDUALS	SPECIES
		(\bar{x})	(\bar{x})		(\bar{x})		(\bar{x})		(\bar{x})
Hunted	33	2.20	1.24	11.90	7.18	4.33	3.25	2.02	1.55
Not hunted	12	1.50	1.50	20.33	9.33	6.83	3.80	11.00	4.00

2-hr period is the closest estimate available of actual density fluctuations. All the differences were statistically significant (Mann Whitney U-test, $P < 0.01$) for both the pooled four hourly periods (as above) and when computing them separately (except for the 6-9 hr period of Table 2). Such a constant trend, whatever the method used or the set of species considered, strongly suggests that a "normal" human hunting pressure from a small isolated village on both raptors (which are killed for food or fun) and more traditional game animals may deeply impoverish the raptor fauna.

Table 3 gives a tentative figure of the whole raptor community in the 2 forest areas. Table 3 takes into account only the highest value of the mean number of individuals recorded for each species either under or above the canopy in any set of the same 2 h samples. Indeed, highly conspicuous soaring species recorded over a 1000 m radius are mixed with smaller, very inconspicuous species of the understory, detectable over a much shorter range. Therefore, percentages cannot be representative of the actual relative densities and they are given only as long as better estimates are not available. The main goal was to compare two areas with the same methods in similar habitats at the same season. In this respect Table 3 shows that all species, except the *Accipiter-Micrastur* group (rarely soaring and thus badly sampled), reach a higher abundance in non-hunted than in hunted areas. However, excluding 4 species linked to secondary habitats (see below) and 4 species not recorded in the virgin forest (probably because of too short a survey or too small an area studied). The 2 communities have a rather similar diversity ($H' = 2.37$

in non-hunted vs 2.28 in hunted zone) and equitability index ($J' = H'/H'_{\max} = 0.59$).

Among the 26 species identified, 6 were associated with clearings and secondary growths around Saül and 4 occurred in the samples when soaring (Black Hawk Eagle (*Spizaetus tyrannus*), Tiny Hawk (*Accipiter superciliosus*) or hunting Plumbeous Kite (*Ictinia plumbea*), Bat Falcon) over the unbroken primary forest, but never far from its edge. The last 2 species of this group, the Crane Hawk (*Geranospiza caerulescens*) and the Gray Hawk (*Buteo nitidus*) have only been recorded at the edge of the primary forest and hence are not included in any count. The lack of species around Saül such as the Roadside Hawk (*Buteo magnirostris*) or the Laughing Falcon (*Herpetotheres cachinnans*), common in secondary habitats at the northern edge of the Guianan forest, reflects the small size of the local clearing and the absence of other gaps over a huge surrounding area. Hereafter, all species will be typical of the undisturbed primary forest, even if most of them also occurred elsewhere in secondary habitats.

Three species continuously soaring high above the forest have a relative density obviously overestimated. The Greater Yellow-headed Vulture (*Cathartes melambrotus*) is the only *Cathartes* identified within the vast expanses of unbroken virgin forest. The two other congeneric species are common in northern Guiana around clearings, savannas and marshes. The King Vulture (*Sarcoramphus papa*) is as widespread as the previous species but it is proportionally more abundant in non-hunted areas (ratio *Cathartes/Sarcoramphus* = 1.1 vs 1.9 in hunted forest). The last very conspicuous species is

Table 3. Relative abundance of raptors in hunted (Satil) and not hunted (Emerillons) primary forests. N max = highest frequency (mean number of individuals seen/2 h) obtained in any method and time period. % = proportion of the species in the community (percentage of the total number) computed from the above frequency. Names are from the A.O.U. checklist, 1983.

	HUNTED		NOT HUNTED	
	N MAX	%	N MAX	%
Greater Yellow-headed Vulture, <i>Cathartes melambrotus</i>	1.66	13.6	3.00	14.0
King Vulture, <i>Sarcoramphus papa</i>	0.88	7.2	2.66	12.5
Gray-headed Kite, <i>Leptodon cayanensis</i>	0.11	0.9	?	a
Hook-billed Kite, <i>Chondrohierax uncinatus</i>	0.44	3.6	?	a
Swallow-tailed Kite, <i>Elanoides forficatus</i>	1.60	13.2	4.00	18.7
Double-toothed Kite, <i>Harpagus bidentatus</i>	1.66	13.7	2.00	9.4
Rufous-thighed Kite, <i>Harpagus diodon</i>	0.22	1.8	0.33	1.5
Plumbeous Kite, <i>Ictinia plumbea</i>	0.90	7.4	?	b
Tiny Hawk, <i>Accipiter superciliosus</i>	0.11	0.9	?	b
Bicolored Hawk, <i>Accipiter bicolor</i>	0.22	1.8	0.08	0.4
White Hawk, <i>Leucopternis albicollis</i>	0.99	8.1	1.33	6.2
Black-faced Hawk, <i>Leucopternis melanops</i>	0.04	0.4	?	a
Great Black Hawk, <i>Buteogallus urubitinga</i>	0.33	2.7	2.00	9.4
Crested Eagle, <i>Morphnus guianensis</i>	0.11	0.9	0.50	2.3
Harpy Eagle, <i>Harpyia harpyja</i>	?	c	1.00	4.6
Black and White Eagle, <i>Spizastur melanoleucus</i>	0.88	7.2	1.33	6.2
Black Hawk Eagle, <i>Spizaetus tyrannus</i>	0.44	3.6	?	b
Ornate Hawk Eagle, <i>Spizaetus ornatus</i>	0.33	2.7	1.33	6.2
Red-throated Caracara, <i>Daptrius americanus</i> d	0.44	3.6	1.66	7.8
Barred Forest Falcon, <i>Micrastur ruficollis</i>	?	a	0.03	0.2
Lined Forest Falcon, <i>Micrastur gilvicollis</i>	0.22	1.8	0.07	0.4
Slaty-backed Forest Falcon, <i>Micrastur mirandolleti</i>	0.01	0.1	?	a
Collared Forest Falcon, <i>Micrastur semitorquatus</i>	0.02	0.2	0.03	0.2
Bat Falcon, <i>Falco rufigularis</i>	0.55	4.5	?	b

a = may exist but not identified

b = not seen and probably lacking

c = formerly known, but now a rare vagrant

d = number of flocks heard within a 1 km radius from vantage points used for the census of soaring species

the Swallow-tailed Kite (*Elanoides forficatus*) gracefully flying over the forest in flocks of 3 to 8 and roosting in high, emergent dead trees.

Two medium size kites, the Gray-headed (*Leptodon cayanensis*) and the Hook-billed are very local and might be associated with forest openings. The Double-toothed Kite (*Harpagus bidentatus*) is the most likely of all small forest raptors to soar over the canopy or spend long periods in upper exposed branches and it appears much more abundant than other similar sized species. It has certainly a higher

density than the congeneric Rufous-thighed Kite (*Harpagus diodon*) (6-7 times higher in the counts) which has only a slightly less conspicuous behavior. These 2 Kites may co-exist since I have seen them in the same patch of forest at two different localities. On the other hand, the Bicolored Hawk (*Accipiter bicolor*) is probably commoner than suggested by the results (see Table 3) since it rarely soars and is restricted to low levels of the understory.

The White Hawk is mostly found on the edge of clearings or natural gaps and often soars, whereas

the congeneric Black-faced Hawk has only been seen in dense undergrowth at medium height. Their conspicuousness is very different and their actual relative frequencies might be closer to each other than suggested by Table 3. The Great Black Hawk (*Buteogallus urubitinga*) is a conspicuous raptor (pairs often perform noisy displays) but patchily distributed along some forest streams or rocky openings.

The Harpy Eagle is the only species not recorded from the hunted forest (although one was shot just outside the study area). Thus, it appears to be the species most sensitive to human hunting pressure, directly and through lack of prey. During this study, I have never seen it soaring, unlike *Morphnus*, but adults are easily seen in the morning from granite outcrops dominating the forest, when they perch on exposed branches of the upper canopy. The Crested Eagle (*Morphnus guianensis*) has probably a higher overall density or a wider distribution than the Harpy. One pair of each of these species was followed from a vantage point above the Emerillons virgin area. From the distribution of their perch sites and display flight circuits, their respective territories seemed to be contiguous but not overlapping. No interspecific aggressive behavior was observed.

The Black and White Hawk-eagle (*Spizastur melanoleucus*) is the commonest eagle (but also the one which most often soars). The Ornate Hawk Eagle is the only *Spizaetus* in pure primary forest where it may be more abundant than *Harpia* and *Morphnus* together, but slightly less than *Spizastur*.

The Red-throated Caracara (*Daptrius americanus*) is by far the most noisy and conspicuous raptor, but it never soars. Nevertheless, it actually reaches the highest density of all raptors both in hunted and virgin primary forest, if the number of individuals, and not only flocks, is taken into account. They are always in territorial flocks of 3-9 birds often loosely associated with Toucans (mainly *Ramphastos vitellinus*) and Oropendolas (mainly *Psarocolius viridis*). Around Saül, on 6000 ha intensively surveyed, there were 12 flocks (at least 71 individuals). Elsewhere, the Yellow-throated Caracara (*Daptrius ater*) has been recorded only along rivers, and the lack of any sizeable river in the study area may explain why this species has never been seen there.

The 4 species of *Micrastur* (forest falcons) are exceedingly secretive and inconspicuous (unless

their voices are known). They are probably more abundant than suggested by the results and may be, together, as abundant or more than *Accipiter* and *Harpagus* because, among small raptors, they are the most frequently seen in the understory. The commonest species is the Lined Forest Falcon (*M. gilvicollis*). The Barred Forest Falcon (*M. ruficollis*), if accepted as a separate species (according to the criteria given in Meyer de Schauensee and Phelps [1978] and Schwartz [1972]) was definitely identified only once. The Collared Forest Falcon (*M. semitorquatus*) is widespread and the Slaty-backed Falcon (*M. mirandollei*) seems to be the rarest species of the genus.

CONCLUSION

The virgin state over several million ha of the forest in French Guiana affords a fair opportunity to answer the main question of this study which was to ascertain the influence, on the raptor community, of a small human settlement, with associated clearings and hunting pressure, within a large tract of primary rain forest. Although it is difficult to assess the accurate structure of a rain forest community, because of very different degrees of conspicuousness between species, the results strongly suggest that (1) small clearings of shifting cultivation and secondary growths attracted 6 additional species, apparently very rare and local (large gaps) in natural conditions and thus increased the overall species diversity, and (2) hunting pressure, though mainly on a few game animals, lowers the density of most primary forest raptors, especially the large species, some of which may eventually disappear (Harpy Eagle).

Hunting may depress raptor density both through occasional direct killing of sensitive hawk species (the largest ones which are likely to have the lowest natural density and reproductive rate), through reduction of their food resources (game species as well as other components of the disrupted food chains), or disturbance of shy species. Hunting pressure is the most widespread form of human activity in tropical countries, which usually adds its effects to those of forest destruction (logging, cultivation). Raptors are among the first non-game species to disappear in the process of human population growth and exploitation of the rainforest and are thus suitable indicators of habitat disturbance.

ACKNOWLEDGMENTS

This program was supported by a grant from the French Ministry of Environment and the Ministry of Defense Nationale (helicopter transportation). I am grateful to J.L. Dujardin, experienced ornithologist, for his invaluable help both in the field and in preparing the expedition.

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Received 11 March 1984; Accepted 1 November 1984