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## USE OF SPACE BY A PAIR OF SALVIN'S CURASSOWS (*MITU SALVINI*) IN NORTHWESTERN COLOMBIAN AMAZON

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**Resumen.** – Uso y preferencia de hábitats por un grupo familiar de Paujiles Camaranos (*Mitu salvini*) en Amazonia noroccidental Colombiana. – Entre Enero y Julio de 1999 estudiamos el área de rango de hogar, el uso y preferencia de hábitats, y sus relaciones con la disponibilidad de frutos en un grupo familiar de Paujiles Camaranos (*Mitu salvini*) en el Parque Nacional Natural Tinigua, Amazonia noroccidental Colombiana. El grupo de paujiles era seguido continuamente a lo largo del día, mientras registrábamos sus actividades, el tiempo invertido en cada hábitat, y la trayectoria recorrida. El uso de los hábitats fue evaluado mediante el tiempo invertido y el área utilizada de cada hábitat. La disponibilidad de frutos fue estimada por medio de trampas y conteos visuales. La disponibilidad de los hábitats se estimó como la representación proporcional de cada hábitat en el área de estudio y en el rango de hogar. El área del rango de hogar durante el período de estudio fue de 72 ha e incluyó los bosques ripario, inundable, de ladera y maduro. Se presenciaron variaciones marcadas en el uso relativo de los hábitats que estuvieron frecuentemente relacionadas con cambios en la distribución y abundancia de los recursos alimenticios, principalmente frutos en el bosque maduro e inundable, y posiblemente invertebrados en el bosque de ladera y ripario. El tiempo total invertido y el área utilizada en el bosque maduro e inundable estuvieron significativamente correlacionados con cambios en la disponibilidad de frutos. Nuestros resultados sugieren que la búsqueda de alimento, específicamente frutos e invertebrados, es uno de los factores principales en determinar los movimientos de los paujiles. Sin embargo, durante la etapa reproductiva, actividades como defensa del nido y territorio, o proteger y ayudar a alimentar a la hembra, ejercen también influencias considerables. Se comenta acerca de la importancia de cada hábitat para los paujiles y se discuten implicaciones para su conservación.

**Abstract:** – We studied home-range size, habitat-use, habitat preferences, and their relationships with fruit availability by a family of Salvin's Curassows (*Mitu salvini*) between January and July 1999 at Tinigua National Park in the northwestern Colombian Amazon. We followed the group closely throughout the day, registering its activities, the time spent in each habitat, and the trajectory traveled. Habitat-use was evaluated in terms of area used and time spent in each habitat. Fruit availability was estimated in each habitat by

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fruit traps and visual counts. Habitat availability was estimated as the proportional representation of each habitat in the study site and the home range. Home-range size was 72 ha during the study period and it included riparian, flooded, open-degraded, and mature forests. There were marked temporal shifts in the relative use of habitats, often related to changes in the distribution and abundance of food resources, mainly fruits in flooded and mature forests, and possibly invertebrates in open-degraded and riparian forests. Area used and total time spent in flooded and mature forests were correlated with fruit availability on a weekly basis. Flooded forest, where nesting places and some of the most important food items can be found with a relatively high abundance, was the most preferred habitat overall. Our results suggest that the search for food, mainly fruits and invertebrates, plays a determinant role on the curassow's space use. Nonetheless, during the breeding period, activities such as territory and nest defense, or protecting and helping feeding the female may become of high relevance. The importance of each habitat and conservation implications for the curassows are discussed. *Accepted 2 February 2001.*

**Key words:** *Mitu salvini*, *Salvin's Curassow*, *Paujil Camarano*, *home-range size*, *habitat-use*, *habitat selection*, *temporal variation*.

## INTRODUCTION

Knowing the main factors determining the movements of an organism is very useful, since it allows us to make predictions about changes in the behavior of individuals (e.g., Pyke 1983) and changes in the structure of populations (Turchin 1998). Movements can be associated with external and internal factors (Bell 1980, Greenwood & Swingland 1983), whose relative importance can vary in time, space and between individuals (Cody 1981). Despite the difficulty in identifying the actual features used by animals from just the correlates of its distribution (Cody 1985), some general factors have been suggested. Body weight and the distribution and abundance of prey appear to be the main factors associated with home-range and territory size (Schoener 1968, Mace *et al.* 1983). The distribution and abundance of resources (e.g., food, mates, nesting, perch and roosting sites), competition, and predator density are suggested as some of the main factors determining the use and selection of habitats in birds (Cody 1985).

The high seasonality in fruit, flower, and leaf production in the tropics (Van Schaik *et al.* 1993), makes the study of space use in herbivorous birds very interesting. Small scale

movements are frequently reported for frugivorous and nectarivorous birds and tend to be related with changes in the distribution of food (Loiselle & Blake 1992). Large terrestrial herbivorous birds such as cracids, trumpeters, tinamids, and phasianids, are very suitable study subjects in this area, since they can be followed closely, and detailed and continuous observations can be registered. However, information on these bird's movements is scarce and the few studies reveal no general pattern. Groups of White-winged Trumpeters (*Psophia leucoptera*) defend large territories (72 ha) all the year round. While the size of these territories varies in relation to changes in overall fruit abundance, movements between habitats inside the territory appear to be independent of relative food availability (Sherman & Eason 1998). Home-ranges recorded for individuals of the Boucard Tinamou (*Crypturellus boucardii*) are also large (20 ha in average) and show strong temporal variations associated with breeding condition (Lancaster 1964). During the breeding season, home-range sizes increase, possibly as an adaptation to encounter more mates. Wild Turkeys (*Meleagris gallopavo*) also show considerable seasonal variation in home-range size and habitat-use that appears to be mostly driven by breeding activities, such as the search for

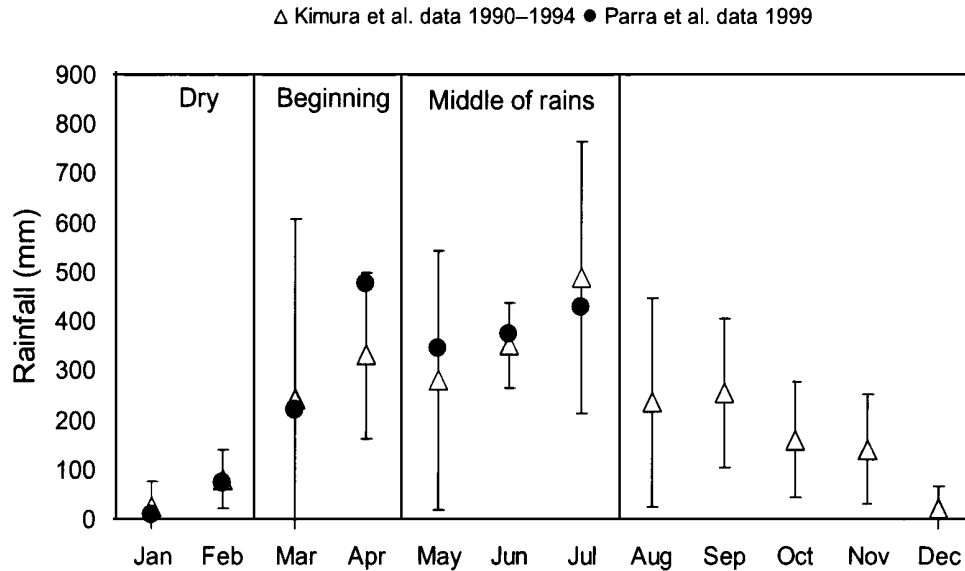


FIG. 1. Annual distribution of rainfall at the Center for Ecological Investigations La Macarena (CIEM) (mean  $\pm$  2 SD,  $n = 4$  years, from Kimura *et al.* 1994). Black dots represent the amounts of rainfall registered during our study period (Jan.–Jul., 1999).

suitable nest habitat (Badyaev *et al.* 1996). Nevertheless, food distribution and abundance were also suggested as important factors influencing space use. Curassows are considered one of the most important terrestrial herbivorous birds in tropical lowland forests, representing a high percentage of the avian biomass (Terborgh 1986) and probably executing an important role in the forest regeneration process through seed predation and dispersal dynamics (Strahl *et al.* 1997b). Little ecological knowledge is available for most of the species. However, movements between habitats have been documented. The Yellow Knobbed Curassow (*Crax daubentonii*) moves from riparian to seasonally dry forests with the onset of rains (Strahl *et al.* 1997a). Apparently, this behavior is associated with the species breeding biology. The Cozumel Curassow (*Crax rubra grisei*) concentrates near water bodies during the dry season (Martinez-Morales 1999). Salvin's (*Mitu sal-*

*vin*), and Black (*Crax alector*) curassows show considerable temporal variation in home-range size and habitat-use, presumably related to changes in fruit availability (Bernal & Mejía 1995, Santamaría & Franco 2000). Although most of these studies document temporal variations in space use, few have simultaneously measure the possible factors driving it. Understanding these factors is essential for a better comprehension of population dynamics, and to improve conservation efforts.

In this paper, we present results on the pattern of space use by a pair of Salvin's Curassows and their two chicks during the first seven months of 1999 in northwestern Amazonia. Our objectives were to 1) estimate the curassows' home-range size, 2) determine which habitats were used by the group, 3) find if the use of habitats reflected their availability, and 4) if changes in habitat-use were related to changes in fruit availability. We also

contrast our results with those obtained in previous studies on the same pair of curassows (Yumoto 1999, Santamaría & Franco 1994, 1996, 2000).

## STUDY AREA

The study took place at the CIEM (Center for Ecological Investigations La Macarena), a biological field station located in the Amazon forests between the eastern Andes and the Sierra de La Macarena. The station lies on the western margin of the Rio Duda, about 13 km from its entrance into the Rio Guayabero (c. 2°40'N, 74°10'W; 420 m.a.s.l.). Annual mean temperature and rainfall are 25°C and 2600 mm respectively (Kimura *et al.* 1994). There is a marked seasonality in rainfall, with a dry season from about December to March, and the rest of the year rainy. Precipitation measured during our study period did not differ from average. We defined three climatic seasons on the basis of the precipitation cycle registered: 1) a dry season (months with less than 100 mm total rainfall), 2) beginning of rains (transition months with more than 100 mm rainfall but without a constant precipitation pattern), and 3) middle of rains (rainy months with a high and similar amount of rainfall) (Fig. 1).

Four types of habitats have been described at the study site (Hirabuki 1990): 1) Riparian forest: located on recently formed sand beaches, involving from the earliest stands of succession, dominated by graminoids (*Gynerium* sp.) and bushes (*Tessaria integrifolia*), to older stands, dominated by young *Cecropia* trees and a variety of “platanillos” (mostly *Heliconia* spp.); 2) Flooded forest: Localized on flatlands that are partially inundated seasonally. The seasonally flooded part is dominated by *Laetia corymbulosa* and *Heliconia marginata*. The rest of the forest is characterized by a higher diversity, mostly *Guarea guidonia*, *Ficus* spp. and old *Cecropia* trees in the

canopy, and some Rubiaceae (*Psychotria* spp.) and “platanillos” (*Heliconia* spp.) in the understory; 3) Open-degraded forest: Localized on steep slopes and erosion fronts. This forest is notably heterogeneous, but can be characterized by the high diversity of vines, lianas, and bamboos, and by the presence of some distinctive plants like *Carludovica palmata* and some Melastomataceae; 4) Mature forests: Localized on high flatlands and hill ridges. This forest contains the most diverse flora. The canopy is continuous with emergent trees reaching 30 m. The understory is relatively clear. Distribution of the habitats in the study area can be seen in Figure 2.

Previous studies on fruit phenology in the study site (Stevenson *et al.* 1998) showed fruiting peaks at the beginning of the rainy season (Mar.–May) and during the dry season (Dec.–Feb.). Fruit production declines between these two peaks reaching to a minimum at the end of the rainy season (Sep.–Nov.).

## METHODS

*Study subject.* The Salvin's Curassow inhabits lowland tropical forests east of the Andes (Delacour & Amadon 1973). Since 1990, at CIEM, a curassow couple was habituated to human presence, allowing detailed observations of several ecological aspects for long and continuous periods of time (Santamaría & Franco 2000). Salvin's Curassows have a complex diet including fruits (35–45%), seeds (15–25%), flowers (1–3%), leaves (10–15%), invertebrates (5–15%), soil (3–4%) and others (4–6%) (Agudelo 2000). Consumption of these food categories shows considerable temporal variations, sometimes coupled with variations in habitat-use (Santamaría & Franco 2000). Their breeding period starts in the beginning of the dry season (Dec.) and can last until May if the first reproduction trials are unsuccessful (Santamaría & Franco 1994). We believe curassow behavior is little

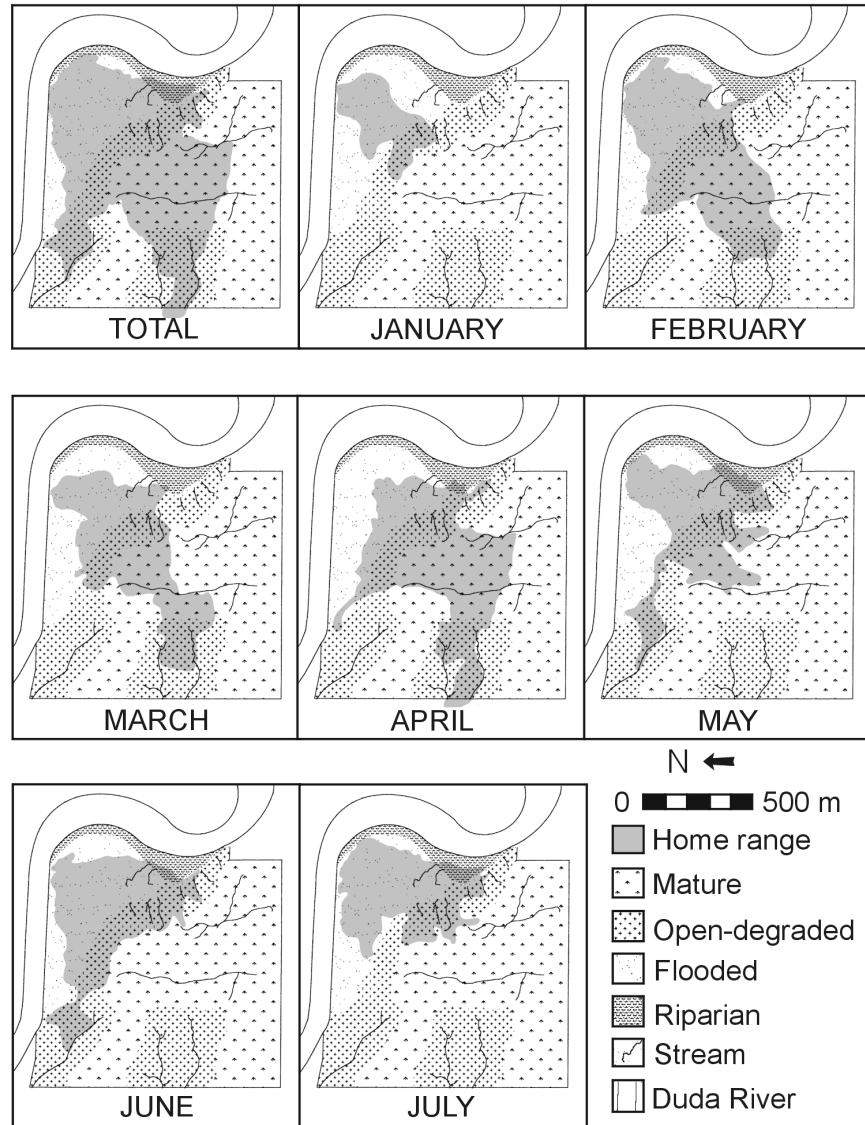


FIG. 2. Temporal variation of the home-range areas used by the Salvin's Curassows through the study period. First illustration (Total) represents total home range area. Boundaries of the study site were arbitrarily defined.

affected by observer presence although we cannot discard the possible influence on the behavior of potential predators and other interacting species. The group was followed continuously from 06:00 to 18:00 h, seven

days a week, from 18 January to 24 July (187 days) 1999.

*Home-range and habitat-use.* Habitat-use was evaluated on the basis of two measurements:

time spent and area used by the group of curassows in each habitat. We followed the curassows closely (3–5 m), noting the time of entrance and departure from any habitat. Each habitat was delimited by a forest trail, except for riparian forest, delimited by a conspicuous depression in the soil level and a marked change in vegetation structure and composition. We also recorded information about the trajectory traveled by the curassows, i.e., we noted trail crossings, visits to fruit patches, streams, and any place, which location was previously known by us. The study site counts with an elaborated trail system, each trail marked every 25 m, which allowed us to determine the location of the birds. We used the information gathered to outline the daily trajectory of the group on detailed maps of the study site. The area used by the group was estimated by overlapping the daily trajectories and taking the peripheral trajectories (or parts of a trajectory) as the boundaries of the area used. Then, using the Sigma Scan Image software, we obtained the areas used by the group. Home-range was defined as the area used by the curassows during their foraging, rest, parental care and vigilance activities (Burt 1943), and was calculated using all daily trajectories registered.

*Habitat preferences.* Habitat selection can be viewed as a hierarchical process, in which animals must make decisions at various stages or scales (Johnson 1980). Measurements of habitat-use, availability, and the criteria on which decisions are taken, can vary at different scales (Sodhi *et al.* 1999). For instance, one of the decisions the group of curassows must make is which areas to include in their home-range, and how to distribute their time among the available habitats in the study site (first order of selection *sensu* Johnson 1980). At this scale, curassows must take into account that their home-range includes areas with suitable nesting sites, where food can be harvested

throughout the year, not just for the adults, but also for their chicks during the parental-care period. At a minor scale, thus being dependent upon the previous decision, the group of curassows must decide how to use the available habitats within their home-range (second order of selection *sensu* Johnson 1980). At this scale, decisions need not to be influenced by all the factors taken into account previously. In fact, decisions at this scale could be based on entirely different reasons. An approximation to visualize how habitats are selected within the home-range is to analyze habitat-use at a smaller time-scale, for example weeks. We obtained the weekly proportions of time spent in and area used of each habitat, and contrasted them with the proportions available in the home-range.

For the first order of selection, we graphically contrasted the proportions of area of each habitat in the home-range with the proportions of area of each habitat in the study site. Boundaries of the study site were arbitrarily defined by us, based on the range covered by the trail system. Assuming curassow movements were at random and that they showed no preference for any habitat, the proportion of time spent in each habitat should be proportional to the area occupied by that habitat in the study area or home-range. We contrasted the proportions of time spent in each habitat (total time in habitat/<sub>i</sub> total observation time) with habitat availability, estimated as the proportional representation of each habitat in the study site.

For the second order of selection, we obtained the mean and 95% confidence intervals (CI) for the proportions of area of each habitat used weekly, and contrasted them with the proportions of area of each habitat in the home-range. Using time, we also calculated the mean and 95% CI of the proportions of time invested in each habitat on a weekly basis, and contrasted them with the proportions of habitats in the home-range. To calcu-

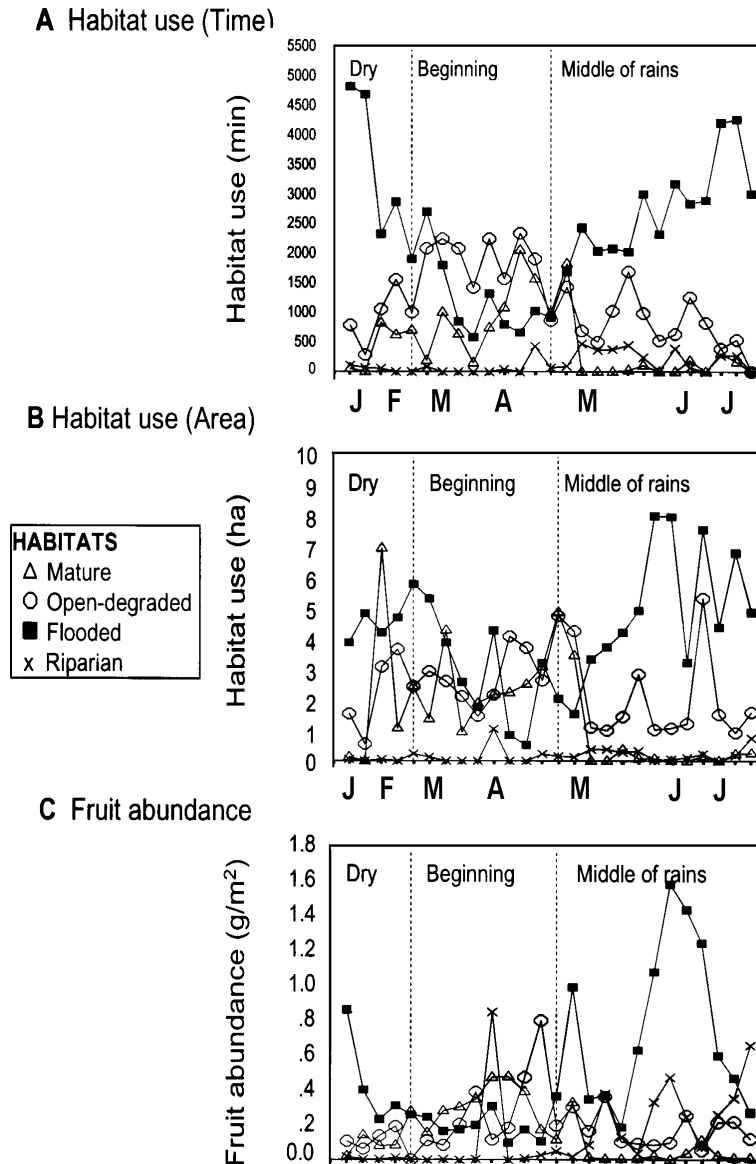


FIG. 3. Temporal variation (A) in habitat use evaluated from the total time spent per week by Salvin's Curassows in each habitat, (B) in habitat use evaluated from the total area used per week in each habitat, and (C) fruit abundance in each habitat.

late mean and CI for the proportions, we performed "arcsine" or "angular transformations" on the proportions:  $p' = \arcsine \sqrt{p}$  (where  $p'$  is the transformed proportion and

$p$  is the actual proportion), so resultant data would have a nearly normal distribution (for details, see Zar 1996). After obtaining the mean and CI for these transformed values,

TABLE 1. Spearman's correlation between habitat use (total time spent, total area used, and average daily time spent foraging per week per habitat) and fruit availability.

	Time	Area	Time foraging
Riparian	0.577* <sup>1</sup>	0.476	0.310
Flooded	0.780**	0.264	0.648*
Open-degraded	0.011	0.473	0.099
Mature	0.617*	0.672*	0.744**

<sup>1</sup>Correlation significance (2-tailed): \* P < 0.05, \*\*P < 0.01.

they were changed back into proportions by the formula:  $p = (\sin p^\circ)^2$ .

When estimating more than two CI simultaneously, the probability that any one interval is incorrect increases beyond  $\alpha$  and is partially dependent upon the number of estimates being made (Hopkins & Gross 1970, *vide* Neu *et al.* 1974). For this reason, it is suggested to use  $t_{(1-\alpha/2k),v}$  values in the construction of the CI for the mean proportions:  $p \pm t_{(1-\alpha/2k),v} s_p$ , where  $p$  = mean proportion,  $t$  = Student's  $t$ ,  $\alpha$  = significance level,  $k$  = number of habitats,  $v$  = degrees of freedom,  $s_p$  = standard deviation. If the proportion available lies below (above) the lower (upper) limit of the CI for the proportion of use, then the conclusion is that the group of curassows is choosing (avoiding) that habitat relative to the others (Cherry 1996). For the analyses, we used only "complete days", defined as those with a minimum observation time of 10 h ( $n = 156$  days).

*Fruit counts.* We estimated the abundance of fruits available for the group of curassows by establishing 0.01 ha plots (50 x 2 m) in each habitat, in a number proportional to habitat area in the study site. Twelve plots were placed randomly in mature forest, and five in each of the rest (we oversampled riparian forest in order to obtain a variability measure within this habitat). Salvin's Curassows typi-

cally consume fallen fruits or fruits from plants within their reach, standing on the ground; they rarely feed while perched on trees or higher than 1.5 m. To estimate the density of fallen fruits, we placed five fruit traps of 1 m<sup>2</sup> systematically (one every 11 m) in each plot. To estimate the density of fruits from plants within the curassow's reach, we counted the number of fruits less than 1.5 m high, within each plot. Each week, the fruits consumed by the curassows were counted and identified with the help of the guide for the fruits of the region (Stevenson *et al.* 2000). Dry weight of the fruits was obtained by drying the fruits in an oven until the weight stabilized. Fruit abundance was expressed as dry weight of fruits/m<sup>2</sup> per week per habitat. This measurement was obtained by taking the means for the plots [ $\Sigma$ dry weights of fruits (g) per trap (m<sup>2</sup>)/ $n$ , where  $n$  = number of traps in the plot] and averaging them for a habitat [ $\Sigma$ mean for a plot (g/m<sup>2</sup>)/ $n$ , where  $n$  = number of plots in a habitat].

To determine if habitat-use was related to fruit availability, we performed Spearman correlation analyses between weekly fruit availability and: i) total time spent, ii) total area used, and iii) average daily time spent foraging for a week in each habitat. To prevent the use of temporal autocorrelated measurements of habitat-use in consecutive weeks, we only used data from interspersed weeks (i.e., weeks 1, 3, 5 and so on), which were not correlated. We used only "complete days" for the analysis.

## RESULTS

*Home-range and habitat-use.* The group of curassows used 72 ha during the seven months of observation. This area included all habitats defined for the study site: riparian (3.5%), flooded (35.6%), open-degraded (28.8%) and mature (32.1%) forests (Fig. 2). There were considerable changes, both in the use among

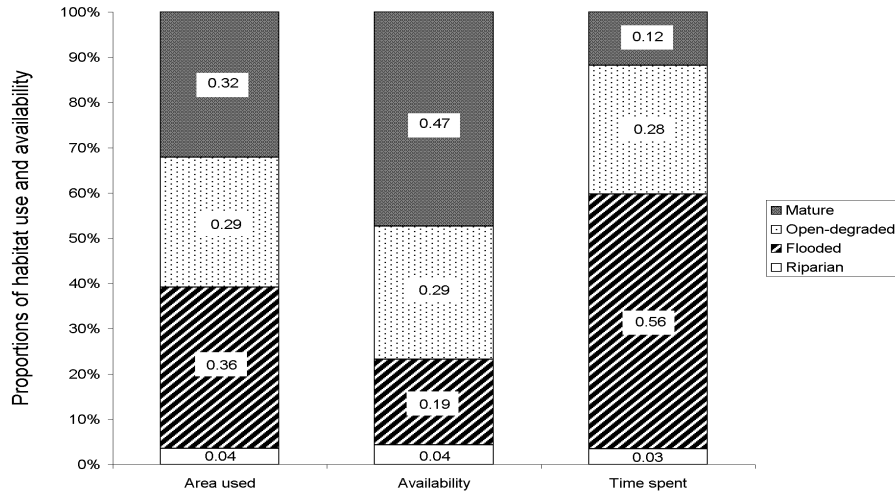


FIG. 4. Contrast between proportions of use (evaluated from the area used and time spent in each habitat in the total home range by Salvin's Curassows) and proportions available in the study site (first order of selection).

habitat types and in the use of each habitat through time (Fig. 2). The overall pattern of habitat-use based on area used per habitat was, in general, very similar to the one encountered with time spent per habitat (Figs 3A and 3B). Most or all measurements of habitat-use were statistically correlated to fruit availability in flooded and mature forests, while none or just one in open-degraded and riparian forests (Table 1, Figs 3A–3C).

*Habitat preferences.* At both orders of selection, curassows spent a greater proportion of time in and used a larger proportion of area of flooded forest than expected by its availability, but spent a lesser proportion of time in and used a smaller proportion of area than expected in mature forest. Open-degraded forest was used in proportions according to its availability at both orders of selection. The proportion of area used weekly of riparian forest was smaller than expected by its availability in the home range. Nonetheless, the proportion of area used of this forest in the

home range did not differ from the proportional representation of this habitat in the study site. Results are presented in Figure 4 (first order) and Table 2 (second order). Notice that results for the first order of selection were only evaluated graphically.

*Fruit counts.* Fruit availability varied through the study period with a pattern similar to the one encountered in previous studies including all fruits (Stevenson *et al.* 1998). Results must be compared with caution, since our results only include fruits consumed by the curassows. There were two peaks in fruit availability including all habitats: one in late March–early April (beginning of rains), followed by the major peak in June–July (middle of rains). Nevertheless, the peak in number of species in fruit was recorded in late March and April (24–27 spp.). Relative fruit availability between habitats is shown in Figure 3C. A total of 70 species of fruits were recorded by the fruit counts out of a total of 93 species of fruits consumed by the curassows during the study period (Agudelo 2000).

TABLE 2. Proportions and 95% confidence intervals of time spent and area used weekly by a pair of Salvin's Curassows and their chicks in relation to the proportions available in their home range.

Habitat	Area		Availability	Time	
	Used proportion (%)	95% confidence interval	Available proportion (%)	Used proportion (%)	95% confidence interval
Mature forest	0.111*	(0.066–0.167)	0.321	0.085*	(0.051–0.126)
Open-degraded	0.262	(0.219–0.309)	0.288	0.263	(0.203–0.328)
Flooded forest	0.557*	(0.465–0.647)	0.356	0.571*	(0.482–0.659)
Riparian forest	0.021*	(0.015–0.029)	0.035	0.030	(0.020–0.041)

\*Selected habitats (preferred or avoided).

## DISCUSSION

*Home-range size.* The group of curassows used fairly large areas, as expected by their size, weight and mostly herbivorous diet (Schoener 1968, Mace *et al.* 1983). Previous studies on the same group of curassows (1990–1994) (Santamaría & Franco 2000), and on a group of Black Curassows (Aug. 1993–Jan. 1994) (Bernal & Mejía 1995) registered even larger areas: 150 and 185 ha, respectively. Differences in home-range sizes found between these studies and ours seem to reflect our lack of observations between August and December, a transition period between the rainy and the dry season, characterized by an overall fruit scarcity and a highly clumped distribution of the fruits available (Stevenson *et al.* 1994, 1998). Curassows movements during this period appear to be the most extensive, as the birds visit new places in search for the few fruit patches available (Santamaría & Franco 2000), sometimes wandering out of their usual home-range limits (X. Bernal, pers. com.). Unlike White-winged Trumpeters, whose territory boundaries are inflexible, thus not permitting expansions during food-scarcity periods, curassow's home-range boundaries appear to be fairly flexible, allowing the group to stretch or expand its home-range limits according to external conditions and their internal requirements.

Theoretical and experimental studies have found an inverse correlation between home-range size and food abundance (Hixon 1980, Schoener 1980, Keeley & McPhail 1998). Our results showed that area used by the curassows was positively related to fruit availability in mature forest (Table 1). Nonetheless, if we perform the correlation analysis with the total area used during a week and total fruit availability, we find no relationship between the two variables. Indeed, the correlation coefficient turns out to be negative ( $r_s = -0.214$ ,  $P = 0.482$ ,  $n = 13$ ). Figure 5 shows the relationship between total fruit availability and home range size on a weekly basis. The relationship is not strong or consistent and this might be due to the fact that curassows are not strict frugivores (Agudelo 2000, Santamaría & Franco 2000). More data on the abundance of other food resources, like seeds, leaves and invertebrates are needed to rigorously test this relationship.

*Habitat-use.* The group of curassows showed marked changes in habitat-use over time, which appear to be related in flooded and mature forest principally with changes in the distribution and abundance of fruits. Fruit is the food-category most consumed by this group of curassows (Agudelo 2000), as has been reported for other curassows and ecologically related birds (*Crax alector*: Énard *et al.*

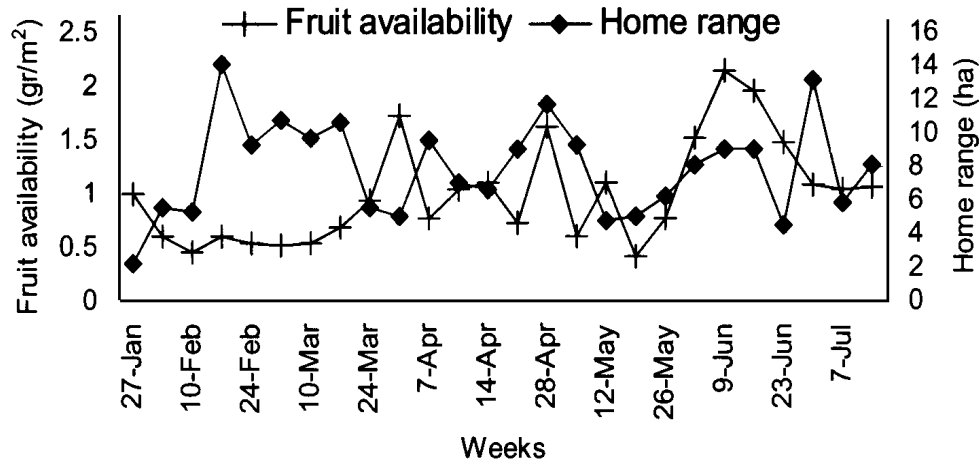


FIG. 5. Relationship between total area used by Salvin's Curassows and total fruit availability on a weekly basis.

1991, Jiménez *et al.* 2001; *Mitu mitu*: Cuadros 1989; *Psophia leucoptera*: Sherman & Eason 1998; *P. crepitans* and *Tinamus major*: Énard *et al.* 1991).

Variation in the use of flooded forest was highly related to changes in fruit availability in this habitat. During the beginning of rains when fruit was scarce in this habitat, the group of curassows spent less time and used less area relative to other seasons when fruit abundance was greater. The fruit most consumed by the group of curassows was *Guarea guidonia*, which is one of the dominant trees in the nonflooded areas of flooded forest (Stevenson *et al.* 1999). The two peaks of fruit production of *Guarea guidonia* (January and May–June) coincide with the peaks of total time spent in and area used of flooded forest.

On the other hand, changes in the use of open-degraded forest were not associated with changes in fruit availability. We rather think these changes are related to shifts in invertebrate availability (pers. observ.). Consumption of invertebrates is very variable on a daily basis, but in average, they are consumed in relatively large quantities among seasons (Agudelo 2000) and being the princi-

pal source of animal protein, should be of high importance in the diet of curassows and their chicks. The group of Salvin's Curassows consume a variety of invertebrates from mollusks to insects (Santamaría & Franco 2000), but they show a conspicuous affinity for crabs (Potamoidea), which can be found readily in streams and small water bodies, specially during the rainy season (pers. observ.). In the dry season (December–February), streams and water bodies are dry. During this period, crabs appear to estivate deep in burrows (Burggren 1988), and are not available to curassows. With the onset of rains, crabs come out of their holes to start reproductive and feeding activities, becoming again available for curassows. A relatively high number of streams are found in open-degraded forest (Fig. 2) where the curassows spent long periods of time searching for crabs from the beginning of the first rains in mid-February until middle of rains, when the streams' water level becomes high, preventing curassows from their use. Curassows used this habitat more than expected during February and the middle of rains when fruit abundance was relatively low (Fig. 3).

Use of mature forest showed marked changes that seem to have been influenced by variations in fruit availability. In the dry and middle of rains seasons, use of this habitat was minimal. In contrast, during the beginning of rains, when fruit and possibly crab availability were at peak, curassows spent large amounts of time in this habitat. However, based on our observations, we think that the group of curassows used this habitat principally to obtain fruits which could be easily found in known patches that were visited repeatedly.

Although total time spent in riparian forest was related to fruit availability in this habitat, we think that major changes in the use of this forest were in response to changes in invertebrate availability. In the middle of rains, streams coming from open-degraded forest formed a large pool in riparian forest where the curassows invested large amounts of time looking for dead invertebrates and crabs. Nevertheless, we cannot discard the possibility of the important influence of fruits in determining the use of this habitat.

Relative use of habitats was also related to relative fruit availability among habitats. In the dry and middle of rains seasons, when flooded forest was the habitat most used (Figs 3A and 3B), fruit availability in this habitat was the highest relative to others (Fig. 3C). At the beginning of the rainy period, when the most used habitats were open-degraded and mature forests (Figs 3A and 3B), relative fruit availability in these habitats was the highest (Fig. 3C). Shifts in habitat-use by this group of curassows appear to be a strategy to maintain the consumption of fruit and invertebrates constant throughout the year. Fruits and invertebrates might be the principal sources of energy and animal protein for these birds (Jiménez *et al.* 2001). Relationships found between fruit availability and average daily time spent foraging within habitats support the notion that curassows are

able to track short term variations in the abundance and distribution of different resources and that the group might be showing an optimal foraging behavior, assuming that time spent foraging is positively related to the rate of energy gain (Stephens & Krebs 1986).

Other factors also appear to have a strong influence on curassow movements. In January, although most of the time was spent in flooded forest, a relatively small area was used (Figs 3A and 3B). During this month, the female was incubating in flooded forest and the male remained close to the nest, booming, resting, and feeding. It is possible that during this month, use of space was principally determined by breeding activities, like defending the territory, and protecting and feeding the female in the case of the male, or incubating and defending the nest in the case of the female.

Other factors such as predator density and competition for other resources could also influence habitat-use at smaller or greater time scales.

*Habitat preferences.* Although the group of curassows showed a marked preference for flooded forest, this does not mean that other habitats were less important. Our study has demonstrated that all habitats play an important role on the curassows movements, at least during some periods of the year. The flooded forest is a key habitat for this group, not only because it provides suitable nesting sites, but also because some of the most important food items, including fruits (i.e., *Gnarea guidonia*, *Trichilia pleeana*, *Costus spiralis*, *Psychotria psychotriaefolia*), leaves (i.e., *Cratereva tapia*, *Trichanthera gigantea*) and invertebrates (i.e., earthworms, leaf-litter spiders, coleopteran larvae, millipedes) are found in relatively high abundance.

The group of curassows spent a lesser proportion of time and area than expected in

mature forest. Santamaría & Franco (1996) found that this habitat was one of the most used aside from the flooded forest. Although use was not compared to availability in the Santamaría & Franco study, we believe that observed inconsistencies are due to a change in the distribution of habitats. Part of the areas of mature forest in the Santamaría's study did in fact belong to open-degraded forests as reported in other studies (e.g., Stevenson 1994). This situation could have led to an overestimation of mature forest use, and could also have been the cause of the minimal use of open-degraded forests registered by them. However, mature forest was the most used habitat during some periods (April), and it is also possible that we underestimated its use by not taking into account the August–December period. We also cannot discard the possibility of different patterns of habitat-use between years.

*Conservation implications.* Distinctive features of this group's use of space, like the use of large areas including diverse habitats, and the seasonal shifts in habitat-use and habitat preferences, set considerable complications for its conservation. Protecting small isolated forest fragments, one of the most popular "conservation strategies" nowadays, seems not to be a good alternative for these birds. Although some curassows, such as *Crax globulosa* (Bennett 2000) and *Crax mitu* (Karr *et al.* 1990), appear to use a single habitat, the exclusive nesting requirements and the complex diet of Salvin's Curassows make this possibility remote. Small scale movements, such as those exhibited by this group of curassows, have been poorly documented. Species with low tolerance of habitat disruption that undergo seasonal movements are likely to be more susceptible to forest fragmentation (Stotz *et al.* 1996). It is of great concern to examine if groups of Salvin's

Curassows are capable of surviving within a single habitat, and if so, what characterizes this habitat.

At our study site, the flooded forest seems to be the only habitat providing suitable nest sites for the curassows. If flooded forests are indeed necessary habitats for the curassows' successful breeding, more attention should be focused on this species, and its conservation status should be revalued, at least regionally. Although the Salvin's Curassow is not considered a threatened species, mainly because a large part of available habitat is presumed to be still intact (del Hoyo *et al.* 1994), flooded forests, at least in northwestern Amazonia, are rapidly being colonized (Hilty 1985).

Until now, we only dealt with implications for the species in concern. We still do not have the information to speculate on implications for the ecosystem function and stability. Although curassows appear to be very poor seed dispersers (de los Rios 1997, Yumoto 1999, Santamaría & Franco 2000), their role as seed predators might be fundamental in maintaining plant community structure and diversity. Loss of these birds could have great consequences, not only in the composition of avian communities, but also in some important ecological processes.

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