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COMPOSITION, DISTRIBUTION AND MOVEMENT OF HOWLER MONKEY GROUPS (*ALOUATTA PALLIATA*) IN THE AGRICULTURAL LANDSCAPE OF PITAL, SAN CARLOS, COSTA RICA

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Abstract

Some areas intensively used by humans provide suitable habitat for wildlife, and knowledge of basic population characteristics of wildlife in these areas can help prioritize appropriate actions for their protection. The objective of the present study was to determine the distribution, composition and movement of groups of howler monkeys in an agricultural landscape of 8,400 ha in Pital of San Carlos, Costa Rica. This area contains a total of 115 forest fragments larger than 0.5 ha, of which 103 were evaluated, and 39 were occupied by monkeys. A total of 561 individuals were counted, for an ecological density of 1.44 individuals/ha. On average, groups were composed of 24% adult males, 45% adult females, 24% juveniles, and 7% infants. Most of reported monkey movements (76%) between fragments and through deforested areas covered less than 300 m. There is a positive relationship between increase in size and vegetation quality of the forest fragments with the number of howler monkeys found in the fragments. The high number of individuals encountered in this study compared to that in other areas may be related to the quality of the vegetation in the forest fragments inside the study area and their surroundings.

Key words: Platyrrhini, demography, forest fragments, Central America, group composition

Resumen

Algunas áreas de intensivo uso humano proporcionan hábitat adecuado para la vida silvestre, el conocimiento de las características básicas de la población de vida silvestre en estas áreas puede ayudar a priorizar las acciones apropiadas para su protección. El objetivo del presente estudio fue determinar la distribución, composición y movimiento de las manadas de monos aulladores en un paisaje agrícola de 8.400 ha en Pital de San Carlos, Costa Rica. Esta área contiene un total de 115 fragmentos de bosque mayores de 0,5 ha, de los cuales 103 fueron evaluados y 39 estaban ocupados por monos. Se contabilizaron un total de 561 individuos, para una densidad ecológica de 1,44 individuos/ha. En promedio, las tropas estaban compuestas por 24% de machos adultos, 45% de hembras adultas, 24% de juveniles y 7% de crías. La mayoría de los reportes de movimientos de monos entre fragmentos (76%), a través de áreas deforestadas, cubrieron menos de 300 m de distancia. Existe una relación positiva entre el aumento de tamaño y la calidad de la vegetación de los fragmentos de bosque con el número de monos aulladores encontrados en ellos. El alto número de individuos encontrados en este estudio, en comparación con el de otras áreas, puede estar relacionado con la calidad de la vegetación en fragmentos dentro del área de estudio o sus alrededores.

Palabras clave: Platyrrhini, demografía, fragmentos de bosque, América Central, composición de grupos

Introduction

To succeed in species conservation, protection efforts should not be focused solely on protected areas, which are generally insufficient to maintain stable populations in the long term (Harvey and Sáenz 2008). Areas that are intensively used by humans are also important for the conservation of biodiversity, making it necessary to preserve their native vegetation and establish connections that facilitate movement or that provide suitable habitats for wild species within these modified landscapes (Ranganathan and Daily 2008). These types of landscapes are frequently found in rural areas of Costa Rica, including the area of Pital of San Carlos, where economic growth has been achieved by cattle ranching and the more recent

introduction of crops such as cassava (*Manihot esculenta*) and pineapple (*Ananas comosus*), which has also led to a substantial loss of forest cover (Programa Estado de la Nación 2009).

The mantled howler monkey (*Alouatta palliata*) is a common primate in forest remnants in low and mid-altitude areas in Costa Rica, and is recognizable by its loud calls. Like many other populations throughout the distribution of this species, the howler monkeys in Costa Rica are affected by forest fragmentation and loss (Estrada et al. 1994; Juan et al. 2000; Quan 2008). *Alouatta palliata* is included in Appendix I of CITES (CITES 2017), is listed as Vulnerable on the IUCN Red List (Cortés-Ortiz et al. 2020), and is protected in Costa Rica by the Wildlife Conservation Law No. 7317 and its regulations, as well as by the Environment's Organic Law No. 7554.

Research on *A. palliata* in landscapes that have been extensively modified by human use is vital for the long-term conservation of this species. Any management and protection decisions should be based on knowledge of the basic characteristics of *A. palliata* populations, which can contribute to understanding the prospects of these populations in particular settings. Therefore, the objective of this study was to determine the distribution, group composition, and movement patterns of *A. palliata* in different forest fragments in the district of Pital de San Carlos, as well as the variation in the number of individuals in these groups as a response to the size and vegetation quality of forest fragments in an agricultural landscape.

Methods

Study area

We carried out this study in the district of Pital, canton of San Carlos, province of Alajuela, between the Toro Amarillo and Tres Amigos rivers, approximately 50 km south of the northern border of Costa Rica (Figure 1). The annual average temperature is around 26–27ºC, precipitation ranges between 3,000 and 4,000 mm per year, with a dry season lasting between 0 and 5 months (MAG 2000 climatic map for the Northern Zone, cited by Chassot et al. 2006).

In Pital, the main productive activities are agriculture and cattle ranching. Cassava, tiquizque roots, yams and plantains have traditionally been cultivated in the area, and more recently some places have been converted into

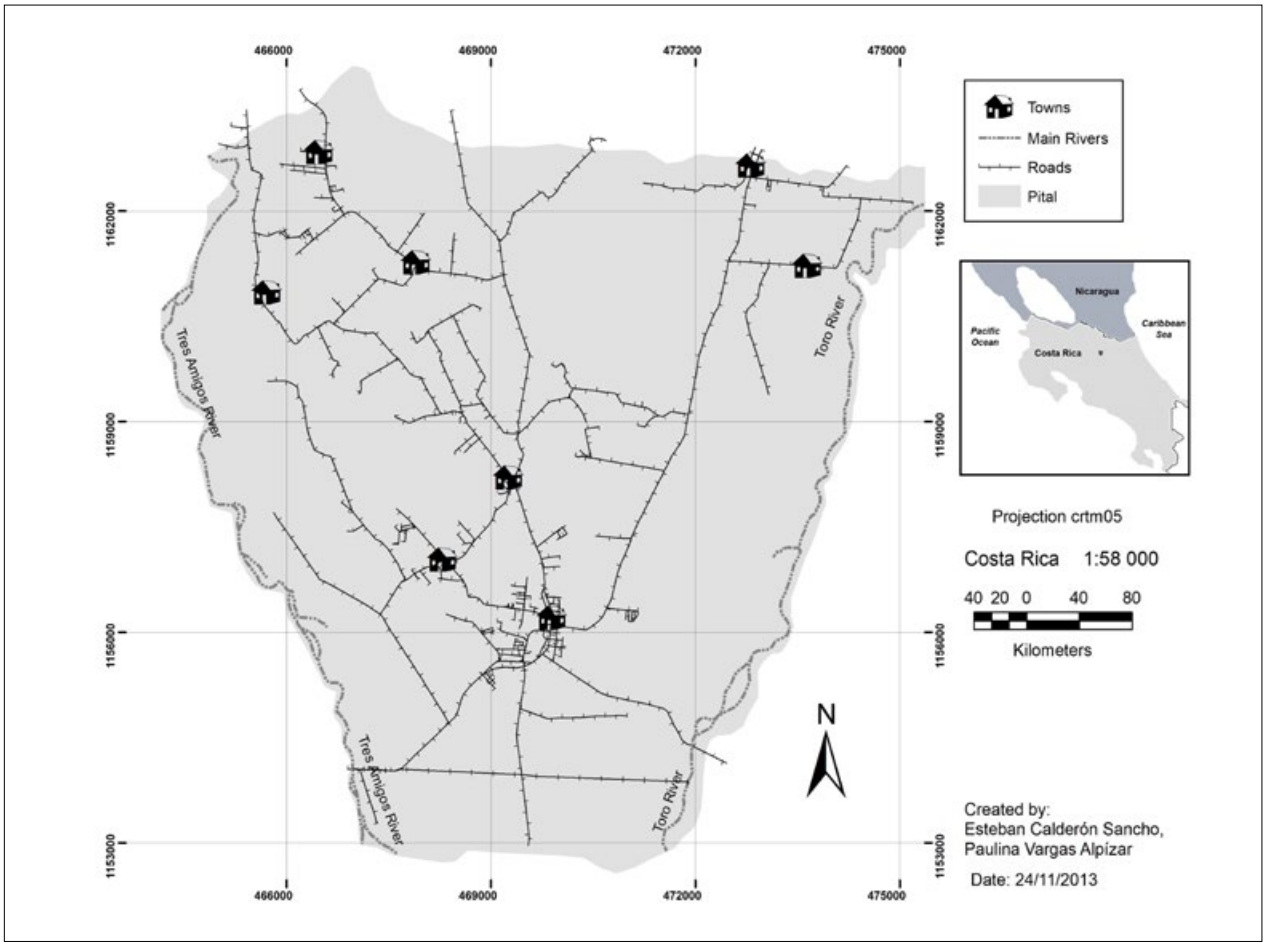

Figure 1. Location of the study area, showing small towns, roads and the two main rivers in Pital, San Carlos, Costa Rica.

monoculture pineapple plantations (Programa Estado de la Nación 2009; Arguedas et al. 2021). The area studied covers approximately 8,400 ha and encompasses a number of private properties used for a variety of purposes, with fragments of humid tropical forest in different stages of regeneration, most of which are found on the banks of streams and rivers, and in flood zones.

Quantity and size of fragments

We detected forest fragments using aerial photographs on the Google Earth Pro program dated April 4, 2010, which were obtained from the map library of the School of Geographical Sciences of the Universidad Nacional de Costa Rica.

We defined a fragment as a forest larger than 0.5 ha separated from other forest patches by a matrix landscape. We considered forest separated by a road as different patches, as long as there was no interconnection between canopies. We determined the area of each fragment (i.e., the fragment size) through photo interpretation and surveying of the forest cover with the ArcGis 9.3 program (ESRI 2008), using the Patch Analyst 3.12 extension for ArcView software (Elkie, Rempel and Carr 1999). Due to the rapid changes in the landscape, we carried out fieldwork to verify current presence of the fragments. Fieldwork was conducted between March and October of 2011. We achieved ~1100 hours of observations, spread over 210 days.

Distribution and group composition of the howler monkey population in Pital de San Carlos

We located howler monkey groups using directions provided by residents, as well as by listening to morning vocalizations by howlers. The daily number of sites sampled and the people participating (2–5) depended on the size and proximity of the fragments. Fieldwork began at 4:30 a.m. and finished when all members of the groups were counted and classified into age-sex categories (Table 1) using binoculars.

To identify the groups of howler monkeys and confirm the accuracy of our observations, we visited most fragments on two occasions on consecutive days. We recorded the geographical location of observed groups and the number of the fragment in which each group was found. We uniquely identified each group based on pelage coloration marks or scars present on the skin of certain group members, as well as by the number of individuals of each sex. Forest fragments that were separated by less than 300 m were visited by different people simultaneously to avoid recounting the same monkey groups in different fragments in case those groups moved from original forest fragment to another nearby.

Group movements

We conducted surveys with people of the local communities to estimate the movement of howler monkey groups.

Table 1. Age-sex categories for the classification of howler monkey individuals in each group in an agricultural landscape in Pital de San Carlos, Alajuela, Costa Rica.

Category	Description
Adult male	Large, with a bushy beard and a visible white scrotum; emit loud vocalizations.
Adult female	Approximately 15% smaller than the adult male, with a small beard; sometimes carry infants.
Juvenile	Smaller and thinner than adults, no development of external sexual characters; independent of the mother.
Infant	Small individual, dependent on the mother and rarely separated from her.

We applied two types of questionnaires to the residents of Pital: A) for owners of properties we asked about the location of howler monkey groups and the benefits they provided or the damage they caused to their farms and/or their productive activities; and B) for members of the community who live or work in the vicinity of the forest patches, we obtained information on group location, movement within and between patches, and in areas without forest cover.

Vegetation quality index

We carried out a rapid vegetation evaluation in the forest fragments inhabited by monkeys. We established one or two plots of 50 x 50 m (depending on the size of the fragment) at the site where the groups were sighted and recorded the following variables: V1 = number of strata present, V2 = percentage of light entering the forest, V3 = number of trees with a diameter at breast height (DBH) greater than 40 cm, V4 = the number of tree species present, and V5 = land use or anthropic damage. To determine V1, we traversed each fragment and recorded the number of forest strata, based on a modification of the classifications of Mostacedo and Fredericksen (2000) by Ochoa et al. (2009) (Table 2).

We used an Importance Value Index, this number is a mathematical weight between 0 and 1 assigned to ranges of each variable in each fragment. The larger the value the greater is the positive influence of that particular variable on the quality of the vegetation as habitat of the monkeys. For V1, we assigned an Importance Value Index to each fragment based on the presence or absence of particular strata. More complex forest structures were assigned with higher values: all strata present = 1; lacking a stratum other than the canopy = 0.5; lacking a canopy, or having no more than one stratum = 0.2. Since the monkeys mainly use the canopy (Field and Carrillo 2002), and the absence of this stratum corresponds to a patch in the initial stages of regeneration, these types of fragments were assigned low Importance Values.

Table 2. Classification of forest strata used to evaluate forest fragments in Pital de San Carlos, Alajuela, Costa Rica.

Forest stratum	Description
Canopy of emergent crowns	Crowns of tall trees (35 to 45 m) protruding from the continuous canopy of crowns. Totally exposed to vertical light and free from lateral competition.
Canopy of continuous crowns	Crowns of trees between 25 and 35 m high intertwined with each other. There is abundant sunlight, with many epiphytic plants growing between branches.
Shrubby	Located totally under the canopy; receive diffuse rather than direct light, but can be exposed to direct lateral light due to a gap or edge of the upper canopy.
Undergrowth	Made up of shrubs, herbs and palms, little light penetrates there.

Source: Modified from Mostacedo and Fredericksen (2000) and Ochoa et al. (2009).

At each corner of the plot we measured the percentage of light penetrating the patch (V2) with a convex spherical crown densitometer (Model A). We obtained averages of the percentage of light and assigned Importance Values between 0 and 1, with higher values given to condition in which there was lower penetration of light corresponding to a more closed canopy. The following criteria were used: 1-10% light penetration = 1.0; 11-30% light penetration = 0.7; 31-50% of light penetration = 0.5; and >51% light penetration = 0.3.

We counted all trees with a diameter at breast height (DBH) greater than 40 cm (V3) and extrapolated that value to the size of the fragment (in hectares). Since the presence of large trees in the fragments suggests greater production of fruits and leaves, and more substrate for the monkeys to rest and perform other activities (Arroyo-Rodríguez and Mandujano 2003), the Importance Value for this variable was assigned as follows considering all trees with DBH >40 cm: from 0 to 10 trees/ha = 0.4; from 11 to 18 trees/ha = 0.6; from 19 to 30 trees/ha = 0.8; and more than 30 trees/ha = 1. Finally, we counted morphospecies of trees present in the fragments (V4) by evaluating which trees looked the same, without identifying them at species level, and a value of importance was assigned as follows: more than 8 morphospecies present = 1; from 6 to 7 morphospecies = 0.8; from 4 to 5 morphospecies = 0.6; and 3 or less morphospecies = 0.4.

Finally, for each forest fragment we recorded signs of land use and anthropic damages (V5) including livestock browsing and trampling by looking for where the understory leaves and branches were nibbled or trampled respectively, and for human firewood extraction, and erosion and sedimentation. We categorized this variable based on how common these anthropic damages seemed to be as: (1) none; (2) low; (3) medium; and (4) high or intense, and assigned Importance Values between 0 and 1 based on the sum of such anthropic damage values: none = 1; damage sum between 1 and 2 = 0.9; damage sum between 3 and 4 = 0.7; damage sum between 5 and 6 = 0.5; damage sum between 7 and 8 = 0.3; and damage sum >8 = 0.1.

We used the Importance Values for each variable in Equation 1 to determine a Vegetation Quality Index for each fragment. Given that variables V3 and V4 have direct positive or negative effects on monkeys, we decided that their contribution to the final Vegetation Quality Index should be double that of the other variables used.

$$Vegetation\ quality\ index = \frac{V1+V2+(2*V3)+(2*V4)+V5}{7} \quad \textbf{Equation 1}$$

Data analysis

All statistical analyses were conducted in R version (3.6.3) (R Development Core Team 2012). We performed Generalized Linear Models (GLM) with Poisson distribution to evaluate the relationship of number of howler monkeys with fragment size and vegetation quality. We used fragment size and vegetation quality as predictor variables, and number of howler monkeys as response variable. Specifically, we used the vegetation quality index as our measure of vegetation quality. We performed one GLM per predictor variable. We log-transformed fragment size to improve normality and tested for statistical significance (χ^2 test.statistic) of the predictor variable in each model using the Anova() function from the R package "car". We visualized the relationship of predictor variables with number of howler monkeys using the R packages "visreg" and "ggplot2".

Results

Number and size of fragments

We recorded a total of 115 forest fragments representing 10.25% of the total study area (Fig. 2). Of these, only 103 fragments were visited because some owners of lands dedicated to pineapple production did not grant permission to enter their properties. 80.5% of the visited fragments had an area smaller than 10 ha, one had an area of 120 ha, and the rest had areas between 10 and 51 ha.

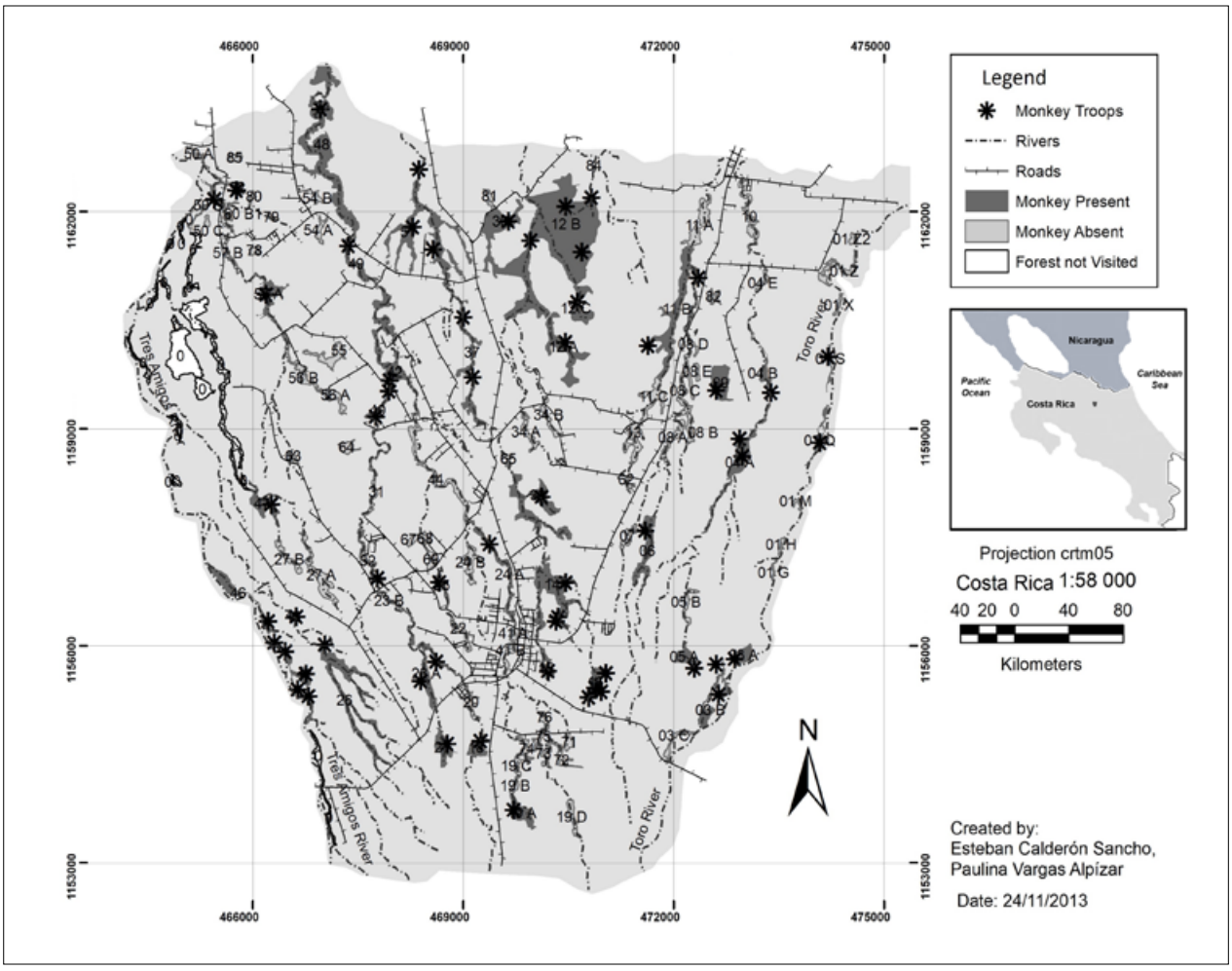

Figure 2. Fragments of forest and distribution of howler monkey groups in the study area in Pital, San Carlos, Costa Rica. Numbers for each fragment are consistent with those presented in Table 3.

Distribution and composition of the howler monkey population

We recorded the presence of howler monkeys in 39 fragments (37.86% of visited fragments), and 12 fragments were inhabited by more than one group. In total, we observed 576 howler monkeys in 59 groups (Table 3). The average group size was 9.76 individuals, and the average ecological density was 1.23 individuals/ha. Of the total number of individuals, 139 were adult males, 255 were adult females, 138 were juveniles, and 44 were infants. The average troop composition was 34.27% males, 40.13% females, 19.37% juveniles, and 6.23% infants. The average ratio of juveniles and infants to adult females was 1:0.8, ranging from 1:0.3 to 1:2.0.

Troop movement: survey data

We conducted a total of 73 interviews. Most respondents agreed that the monkeys traveled mostly within forested areas. However, 45% of the respondents also reported that they moved through areas without forest cover. In these cases, 76% of the reported movement involved distances of less than 300 m, indicating that most of these groups were crossing bridges, streets and roads to neighboring fragments. Reporting of movement of more than 300 m was rare, and associated mostly with solitary individuals. No respondent reported howler monkeys causing damage to their productive activities or their properties. We observed other species of primates, white-faced capuchins (*Cebus imitator*) and black-handed spider monkeys (*Ateles geoffroyi*), in four of the forest fragments visited (see Table 3).

Vegetation quality (Vegetation Quality Index)

We only calculated the Vegetation Quality Index for fragments inhabited by howler monkeys. The obtained values ranged between 0.44 and 0.89, and the majority (65%) of the fragments had indices higher than 0.70. No groups or solitary individuals were observed in fragments that did not have a canopy layer. The most common anthropogenic damage observed in the fragments were trampling by cattle and accumulation of sediments from agricultural fields.

Relationship between number of monkeys with fragment size and vegetation quality

We found a significant relationship between number of monkeys and fragment size (χ^2 = 188.97, df = 1, p <

Table 3. Howler monkey groups and forest fragments in Pital, San Carlos, Costa Rica. "Other species" refers to the presence of other primate species (*Cebus imitator* or *Ateles geoffroyi*) in the same fragment. Fragment ID is the same as in Figure 2.

N	Fragment ID	Area (ha)	N° groups	Group size	AGE CLASSIFICATION				Ecological Density	Other species present
					Males	Females	Juveniles	Infants		
1	01 G	0.59								
2	01 H	0.89								
3	01 M	0.69								
4	01 Q	4.12	1	7	2	4	1		1.70	
5	01 S	2.20	1	8	2	4	1	1	3.64	
6	01 X	0.84								
7	01 Z	4.67								
8	01 Z2	0.87								
9	03 B	9.26	2	9	2	4	3		2.37	
				13	3	5	3	2		
10	03 C	2.58								
11	03 A	5.12	1	11	3	4	3	1	2.15	
12	04 A	16.52	2	17	6	10	1		2.30	
				21	3	12	6			
13	04 B	6.40	1	4	1	3			0.63	
14	04 E	1.61								
15	05 A	6.00	1	11	2	5	4		1.83	
16	05 B	2.91								
17	06	14.23	1	12	3	4	3	2	0.84	
18	7	2.85								
19	08A	4.38								
20	08B	2.19								
21	08C	7.59								
22	08D	1.04								
23	08E	0.90								
24	09	10.85	1	6	1	3	1	1	0.55	
25	10	6.97								
26	11A	9.11								
27	11 B	31.41	2	3	1	1		1	0.60	
				16	4	7	3	2		
28	11 C	7.30								
29	12 B	120.47	4	16	7	6	3		0.56	*C. imitator*
				23	6	11	5	1		
				22	6	8	4	4		
				6	6					
30	12 A	17.24	1	18	3	11	3	1	1.04	
31	12 C	10.29	1	10	1	5	2	2	0.97	*C. imitator*
32	13	7.22								
33	14	28.38	3	5	1	3		1	1.09	
				9	1	5	2	1		
				17	2	8	5	2		

N	Fragment ID	Area (ha)	N° groups	Group size	AGE CLASSIFICATION				Ecological Density	Other species present
					Males	Females	Juveniles	Infants		
34	15	5.34	1	4	1	1	2		0.75	
35	16	7.86	4	15	6	7	1	1	2.54	
				3	2	1				
				1	1					
				1		1				
36	17	9.09	4	4	1	2	1		1.43	
				1	1					
				7	3	2	2			
				1	1					
37	18	5.70	1	5	1	3	1		0.88	
38	19 A	7.83	1	7	2	3	2		0.89	
39	19 B	1.48								
40	19 C	1.66								
41	19 D	3.67								
42	20	2.80								
43	21	7.62	1	13	2	5	5	1	1.71	
44	22	3.10								
45	23A	16.33	2	3	1	1	1		0.49	
				5	1	3	1			
46	23 B	1.78								
47	24B	6.02								
48	24A	11.51	1	1	1				0.09	
49	25	3.85	1	1	1				0.26	
50	26	30.22	1	9	2	4	2	1	0.30	
51	27 A	10.33								
52	27 B	3.77								
53	31	2.86								
54	32	6.47	1	12	3	6	3		1.86	
55	33	25.95	1	6	1	3	2		0.23	
56	34 A	3.80								
57	34 B	3.00								
58	36	14.18	1	24	4	13	7		1.69	
59	37	18.31	2	7	2	3	2		1.53	
				21	3	9	7	2		
60	40	7.68	2	18	3	9	4	2	3.91	
				12	4	4	3	1		
61	41 A	1.35								
62	41 B	2.11								
63	42	25.51	1	16	2	6	8		0.63	
64	43	1.62	1	2	2				1.24	
65	44	9.27								
66	46	10.45	2	14	3	5	4	2	1.91	*C. imitator*
				6	1	2	2	1		
67	47	9.87	1	3	1	2			0.30	

N	Fragment ID	Area (ha)	N° groups	Group size	AGE CLASSIFICATION				Ecological Density	Other species present
					Males	Females	Juveniles	Infants		
68	48	51.01	1	11	2	4	3	2	0.22	A. geoffroyi
69	49	7.70	1	14	3	7	3	1	1.82	
70	50 A	1.30								
71	50 C	0.93								
72	50 B	7.19	1	1	1				0.14	
73	51	37.16	3	20	3	8	6	3	1.40	
				24	3	11	7	3		
				8	2	3	2	1		
74	52	2.53	1	2	1	1			0.79	
75	54 A	2.23								
76	54 B	1.28								
77	55	6.21								
78	56 A	2.51								
79	56 B	6.18								
80	57 A	11.57	1	10	2	3	4	1	0.86	
81	57 B	2.49								
82	60 B	3.57								
83	62	0.78								
84	63	1.03								
85	64	2.61								
86	65	1.24								
87	67	1.49								
88	68	1.52								
89	69	2.22								
90	71	1.87								
91	72	3.04								
92	73	2.00								
93	74	2.91								
94	75	1.37								
95	76	1.85								
96	78	1.10								
97	79	0.65								
98	80	0.85								
99	81	1.59								
100	82	1.16								
101	84	0.50								
102	85	1.76								
103	86	0.49								

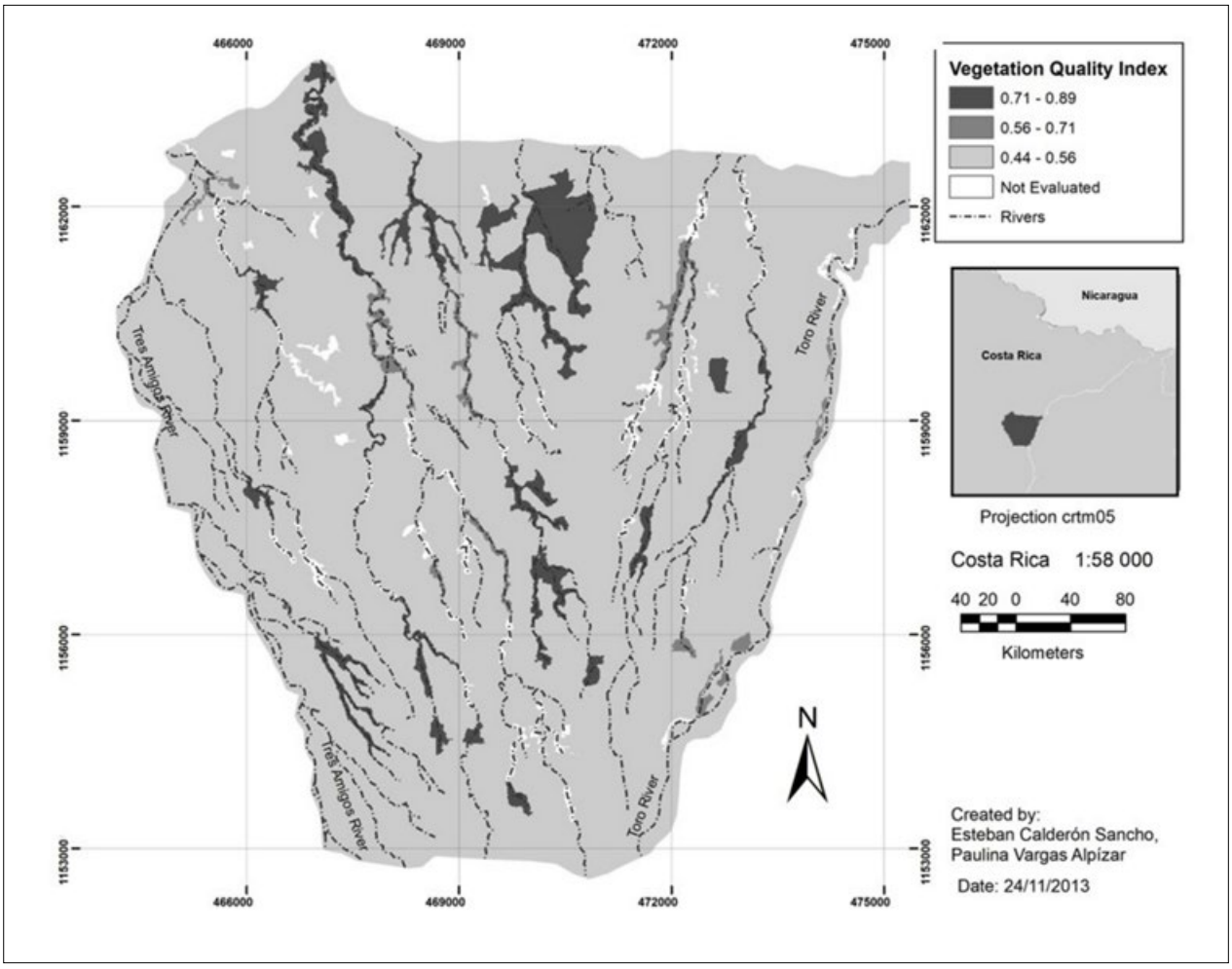

Figure 3. Vegetation Quality Index for all forest fragments evaluated on this study. Pital, San Carlos, Costa Rica.

0.0001). The model estimates indicate a positive relationship between number of monkeys and fragment size, where for each increment of one hectare in the size of the fragment the number of howler monkey individuals increased by a factor of 1.86 (~14%) (Figure 4A). We also observed a significant association between number of monkeys and vegetation quality ($\chi^2 = 18.076$, df = 1, $p <$ 0.0001). The model estimates indicate a positive relationship between number of monkeys and vegetation quality, where for each increment of one unit in vegetation quality the number of monkeys increase by a factor of 3.59 (~41%) (Figure 4B).

Discussion

Forest fragments in the study area were mostly small (>10 ha), with few of intermediate size and only one larger than 100 ha, a pattern typical of areas used for agriculture (Estrada and Coates-Estrada 1996; Quan 2008). Most of the remnant fragments were either strips of trees bordering streams and springs, or swampy areas unsuitable for agriculture and livestock.

The percentage of occupied fragments (37.9%) was similar to what was reported in Mexico by Estrada and Coates-Estrada (1995, cited by Escobedo-Morales and Mandujano 2008), who found that 40% of 120 forest fragments visited in their study were occupied by howler monkeys. Escobedo-Morales and Mandujano (2008) reported an average occupation of 18% over three years in 92 fragments in a highly fragmented landscape in Los Tuxtlas, Mexico. These two studies showed similar fragment sizes and number of monkeys, which demonstrates the capacity of fragmented landscapes as habitat to the species, and the ability of the species to survive in highly fragmented areas.

In our study site, we found howler monkeys distributed throughout the area. An understanding of the distribution of the groups is important for future management plans.

Compared to other sites, the area evaluated here has a higher number of individuals. For example, Mandujano et al. (2004) reported from 71 to 76 individuals in 92 fragments of the Mexican region of Los Tuxtlas. The

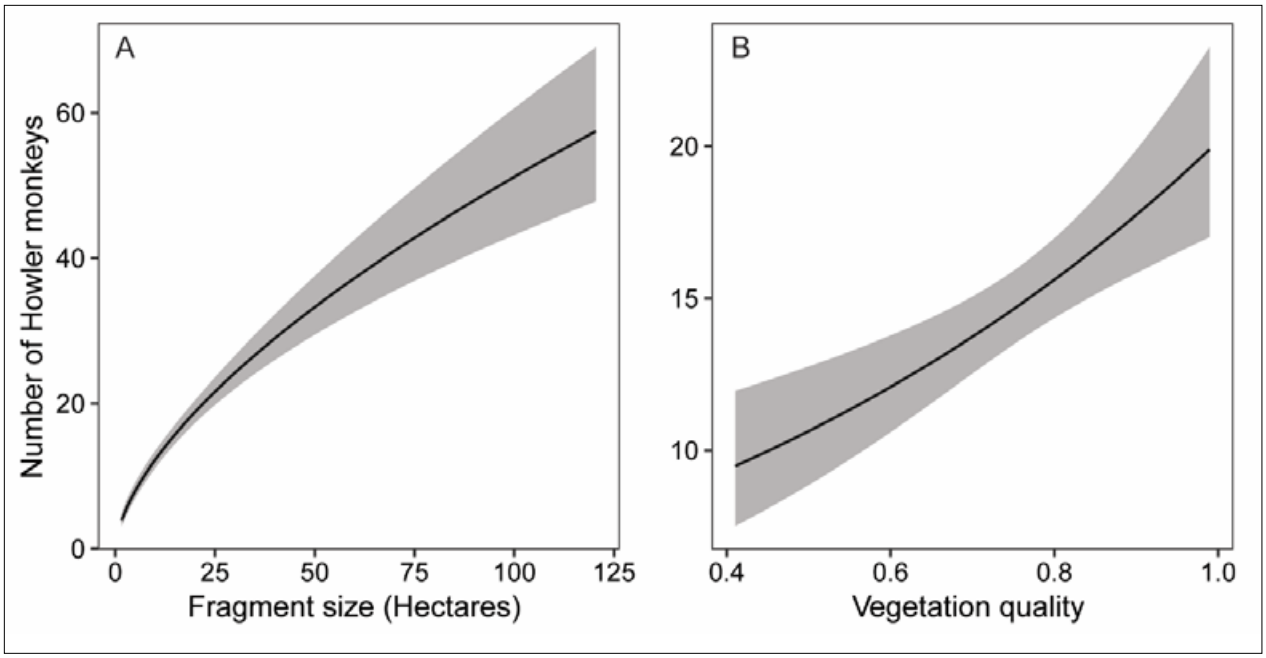

Figure 4. Relationship of (A) fragment size and (B) vegetation quality to number of howler monkeys (*Alouatta palliata*) using a GLM with Poisson distribution. The continuous lines indicate the predicted fit from the model and the dark areas are the 95% confidence intervals.

finding of 576 monkeys in a similar number of forest fragments in our study urges management actions to promote protection and connectivity in this region. The fragmentation and deterioration of the forest in the place of study is very likely to get worse if pineapple cultivation in San Carlos continues increasing as in recent years (Arguedas et al. 2021). Therefore, efforts to maintain that high number of individuals in the population are worth it, assuming that such land use changes would have a significant and negative impact on the survival of monkeys. The number of individuals in this landscape might be the result of a number of factors, such as the quality of forest cover or the proximity of native forest fragments. In addition, the absence of important predators in small patches (González-Solís et al. 2001) or in highly fragmented landscapes facilitates the settlement and persistence of monkey groups.

The proposed vegetation quality index showed that the number of individuals can increase as the quality of the habitat increases. In addition, some authors suggest that many species that are present in a rural landscape can only persist with the presence of native forests in its vicinity (Ranganathan and Daily 2008). In this regard, the area we studied borders the Maquenque Mixed Wildlife Refuge, which still conserves fragments of natural forest that connects with the forests of southern Nicaragua.

The average number of howler monkeys per group (9.76) in our study was on the lower end of reports for *A. palliata* in other locations. For example, Chapman and Balcomb (1998) reported an average of 10.7 individuals per group from a census of Guanacaste National Park, Costa Rica and a literature review characterizing 80 howler monkey populations. In Costa Rica, Zucker et al. (1996) reported an average group size of 14.9 at Hacienda La Pacífica, and Rosales (2008) reported an average group size of 18.0 ± 2.9 individuals per troop. In another Costa Rican dry forest site, Fedigan et al. (1998) revealed that group sizes may change over time showing that the average group size in her study site fluctuated from 10.9 to 17.6 individuals over 8 years of sampling. Estrada et al. (2001) reported an average troop size of 14 individuals for Yunká Park in Tabasco, Mexico.

The maximum (24) and minimum (2) numbers of howlers per group reported here are similar to those reported for the same species in different localities in the country – between 1 and 26 individuals in the Palo Verde National Park (Massey 1987); from 2 to 29 individuals in the Cahuita National Park (Perdomo 2003); and groups of 11 and 20 individuals in the La Selva Biological Station (Stoner 1996). In addition, Chapman and Balcomb (1998) reported that group sizes of *Alouatta* spp. vary between 2 and 23 members. We did not find any groups as large as those found by Fedigan et al. (1998, cited by Bezanson et al. 2008), who reported groups of up to 44 individuals in the dry forest of Costa Rica. Groups with a maximum of 15 individuals have been described in fragments of premontane forest (Sánchez 1991), and of 13 individuals in the humid forests of the lowlands (Rodríguez 2007).

Solitary individuals are common in populations of *Alouatta palliata* (Glander 1992; Estrada and Coates-Estrada 1996; Perdomo 2003; Mandujano et al. 2004). In Costa Rica, 79% of the males and 96% of the females of the species leave their native groups, and females and males can live solitarily for 1 and 4 years, respectively (Glander 1992). The extended period of time that males live as solitary individuals is consistent with our observations of more solitary males (6) than solitary females (1) encountered in the current investigation.

The estimates of Chapman and Balcomb (1998) for the density of individuals of the genus *Alouatta* in forested areas range from 0.008 to 1.5 individuals/ha, with an average of 0.49 individuals/ha. The average density calculated for Pital (1.23 individuals/ha) is on the higher end, and is also higher than figures reported for other populations, such as 0.069 individuals/ha on Ometepe Island, Nicaragua (Massey 1987), 0.15 individuals/ha in the Cahuita National Park, Costa Rica (Perdomo 2003), and 0.6 individuals/in Los Tuxtlas, Mexico (Escobedo-Morales and Mandujano 2008). Although density estimates similar to those in our study have also been reported, such as 1.67 individuals/ha in Yunká Park, Mexico (Estrada et al. 2001), a review of different populations of *A. palliata* by Treves (2001) mentions densities ranging from 0.012 to 5.16 individuals/ha, while densities as high as 6.87 or 7.11 individuals/ha are cited for a closed population on a Mexican lake island (Cristóbal-Azkarate and Arroyo-Rodríguez 2007). It is important to note that differences in density of individuals could be due to differences in the estimation methods used in each study, as well as due to calculations made in continuous forest or remnant fragments. However, the plasticity of the species is evident considering the wide range of population densities, therefore it is necessary to study other factors such as the quality of the vegetation of the fragments where the monkeys live. It would also be appropriate to investigate the relationship between population density and health of individuals, so that the estimates of population density may provide more accurate data for future management actions.

Less than half of the interviewees reported movements of the howler monkeys through areas without tree coverage, but when reported the distance was short. This is consistent with the findings of Mandujano et al. (2004), who reported that while movement of individuals between fragments as far as 656 m apart occurred, 70% of movements were of less than 100 m.

We observed a positive relationship between the number of monkeys and the Vegetation Quality Index in the occupied patches, which suggests that the number of individuals present would increase if vegetation quality is improved. The application of this model allows making suggestions about which fragments should be incorporated into a vegetation management and protection system to improve conditions for these groups in the area. Leighton and Leighton (1982) reported that the presence of monkeys has a positive proportional relationship with the abundance of fruits rather than with the fragment size, indicating that improving vegetation conditions can provide benefits for the well-being of this species. Likewise, Arroyo-Rodríguez et al. (2007) show that vegetation quality affected the presence of howler monkeys in small, isolated forest fragments (<10 ha). They also show that variables such as high densities of large trees (DBH > 60 cm), total basal area (sum of all calculated basal area variables), basal area of persistent tree species, and basal areas of species which frequently serve as food, favored the presence of monkeys.

A positive relationship between the size of a forest fragment and the number of howler monkeys living in it has also been reported by Estrada and Coates-Estrada (1996). However, in the area we studied in Pital, San Carlos, it is possible to find medium-sized fragments with high densities of individuals and larger fragments with lower densities. This suggests that other factors may explain the variation in group sizes, such as anthropic pressures or the capacity of the landscape to allow movement of individuals through the landscape matrix. Estrada and Coates-Estrada (1996), for example, reported a negative correlation between the number of monkeys in forest fragments and the distance to the closest forest fragment and isolation time, which can affect the number of individuals per unit of area.

Although some authors consider that exposure to direct conflicts between howler monkeys and people, dogs, or birds of prey may be greater in small patches (Estrada et al. 1994), these previous situations were not documented in our interviews to local people. It seems that the presence of monkeys does not represent a conflict to the types of productive activities in the area, and from the local people's point of view they are not a source of pressure on monkeys because they do not hunt, for example.

Considering the number of howler monkeys present in the study area, the consent of the majority of the owners to study them on their farms, and the fragmented landscape in Pital, we recommend to work together with farmers and landowners to maintain forest strips and/or corridors, which are important for the long-term survival of the howler monkeys, and other primates, in the area. In this regard, Horwich (1998) proposed designing forest areas which could be used for agriculture and silviculture by establishing functional corridors, and increasing the number of plant species that provide food for the howler monkeys, connecting isolated groups with forests, and improving the quality of their habitat.

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