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Survey of Three Primate Species in Forest Fragments at La Suerte Biological Field Station, Costa Rica

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Introduction

As habitat destruction continues to threaten the existence of tropical species, it becomes increasingly important to document their numbers as a means of assessing their survival potential. Surveys are a method commonly used to document the status of species such as primates and often serve as a preliminary step to long-term studies of primate populations. Reports of non-human primate surveys are common in the literature (for example, Agoramoorthy and Lohmann, 1999; Cant, 1978; Gonzalez-Kirchner, 1996, 1999; Hashimoto, 1995; Johnson and Overdorff, 1999; Plumptre and Reynolds, 1996; Thomas, 1991; Whitesides *et al.*, 1988; Yamagiwa *et al.*, 1992). However, Peres (1999a) points out the lack of consistency in many studies and makes suggestions for standardizing techniques as a way to ensure the reliability of primate surveys between sites. Many of Peres' (1999a) guidelines were adopted in our study (See 'Methods').

Here we report a survey of the three primate species inhabiting tropical lowland rainforest at La Suerte Biological Field Station (LSBFS) in Costa Rica, and address the difficulty in assessing primate densities using brief contacts with surveyed groups. Although the site has been the focus of numerous primate-oriented field courses, systematic data are lacking on the densities of the primate species occurring at LSBFS. This site provides an ideal setting in which to examine the effects of reforestation efforts on several primate species.

Methods

Study site
La Suerte Biological Field Station is approximately 20 km from the Atlantic coast of Costa Rica, and is home to black-handed spider monkeys (*Ateles geoffroyi*), mantled howling monkeys (*Alouatta palliata*), and white-faced capuchins (*Cebus capucinus*). The LSBFS was purchased by the Molina family in 1987 and is characterized by lowland tropical rainforest, cropland (pineapple, coconut), marshland, and pasture for cattle. The site is a government-protected area and has functioned as a research and teaching facility since 1993.

The three forest fragments at La Suerte are all characterized by some degree of disturbance due to logging. The Small Forest is advanced secondary forest that was last logged in the 1970s (Garber and Rehg, 1999). It was 15 ha in size when the study was conducted but has since been reduced by approximately one-seventh in an area not owned by LSBFS (JDP, pers. obs.). The Large/German Forest was approximately 100 ha in size, 30 ha of which is owned by the LSBFS (Fig. 1). These forest patches are surrounded by either pasture or croplands but are connected to one another and to other forest patches by a narrow strip of riparian habitat (<50 m width on average) that runs along the La Suerte River. A forest fragment that was purchased by LSBFS in 1998 is a 40 ha plot within a 180 ha area of secondary growth, pasture and marshland, which had yet to be surveyed properly at the time of our study. While howling monkeys were seen in this forest in August 1999 (JDP, pers. obs.), based on the degree of disturbance and the lack of many large trees it seemed unlikely that spider monkeys occurred there, although it possibly supported capuchins. A goal in progress is to establish corridors between the fragments (Fig. 1).

The third forested area surveyed in this study was not owned by LSBFS (Fig. 1: Logged Forest). It was included in the survey because spider monkeys were observed, besides the other primates, before it began to be logged very heavily in 1998 (N. Mann, pers. comm. and JDP, pers. obs.). It has been logged since 1997, a practice which continued

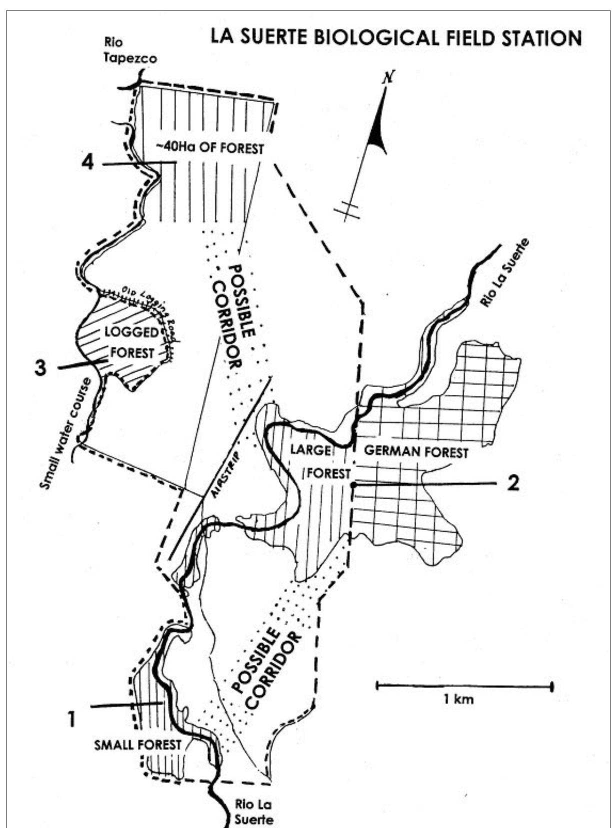

Figure 1. Map of La Suerte Biological Field Station, Limon Province, Costa Rica. 1 – Small Forest, 2 – Large Forest/German Forest, 3 – Logged Forest, 4 – New Forest patch.

during our study and through July 2001 (K. Dingess, pers. comm.). The Logged Forest was approximately 35 ha in size, was adjacent to other forested areas that have not been surveyed, and could be accessed by primates through one or more riparian corridors. The extent and condition of forested areas to the west of LSBFS (and of the Logged Forest) is unknown.

The survey at LSBFS (83°46'15"W, 10°26'30"N) was conducted from 21 June to 18 August 1999. Both line transects and total count methods were used to assess the densities of primates during 318 hours in the field. Primate groups were encountered 152 times. During 98 hours on 19 days we conducted concentrated searches along trails and transects, including fruiting tree vigils at a *Ficus* tree (12 hours over 2 days). Twelve days were spent conducting systematic line transect surveys. Compositions of groups noted during 51 hours of contact by JDP at LSBFS in January 1997 and May-August 1997, as well as published data (Garber and Rehg, 1999), provide some indication of group demographics over a short time-period.

Surveys

From 21 June to 4 July, two observers (JDP and one inexperienced observer), prepared the survey areas by cutting transects through areas previously not marked, marked all transects at 25 m intervals (see Peres, 1999a) and began sampling the vegetation [in prep.]. Existing trails that ran in parallel were used as transects when possible to minimize time spent clearing areas and disturbance of the forest areas, given the narrow width of the fragments. Transects were cut in parallel through most of the length of the German Forest section of the Large/German Forest. Two of the three established trails overlapped and crossed one another at their beginning points, and the presence of natural barriers such as swamps forced observers to place even new transects in overlap in one case. The initial two-week time period for site preparation gave the inexperienced observer the opportunity to become familiar with the primate species at LSBFS. A third observer (HCL), who was familiar with primate behavior in the wild and had worked at this site before, arrived at the field site on 5 July. We began line transect surveys of the forests at LSBFS on 7 July 1999, with three observers. Each of the three forest fragments was surveyed four times. At least one day passed where transects that had been recently cut were avoided by observers before they were systematically surveyed (after Peres, 1999a).

All line transect surveys began between 0500 and 0600 hours. Observers started at the same time, using synchronized watches, and walked slowly along marked transects at a speed of approximately 1.5 km per hour (see Peres, 1999a). Observers stopped every 100 m to search the surrounding area for a duration of two minutes before proceeding. Surveys were not conducted on rainy days (see Peres, 1999a). In the Large/German Forest, transect length ranged from 2.7 to 3.7 km. Here, observers completed a survey in one direction (NW-SE or SE-NW) during a single morning. In the two smaller forest fragments, short transect length (range: 663 m - 1500 m) enabled observers to complete two surveys of the same transect in one morning. Upon reaching the end of a transect observers backtracked to the starting point. In all forest patches observers alternated the starting point of a survey each time a survey was conducted. Observers surveyed a different transect each time in order to minimize observer bias (Peres, 1999a). A contact time with primate groups of 30 minutes was targeted during line transect censuses because we reasoned that a lengthier amount of time spent in contact with primate groups would provide for more reliable counts. The small areas surveyed enabled us to use such a contact time without sacrificing survey time during periods when primates were most active. Data recorded when primates were encountered included: (1) location (transect and meter marker), (2) species, (3) distance (m) from observer to monkey, (4) perpendicular distance (m) from monkey to transect, (5) height of monkey in the trees, (6) activity, (7) habitat type, (8) mode of detection (sound or sight), (9) number of individuals in group, (10) ages of individuals seen (adult, infant, other immature) and (11) sex and (12) time of day. Infants were defined as those dependent on adults for travel (i.e., carried). Observers were tested for the reliability with which they recorded distances (see Peres 1999a) by having each record their estimation of the distance to the nearest half-meter between pairs of flags set into the ground at varying distances apart (usually 20 pairs per test, N=6 tests).

The Large/German Forest was the focus of concentrated searches by JDP for spider monkeys. Once a primate group was encountered, a total count (Srivastava *et al.*, 2001) was obtained. Intense searches were made in areas where spider monkeys had been seen before. All primate species were recorded during these searches.

Analyses

We first analyzed the accuracy of observers' estimates of group sizes recorded during line transect surveys by comparing these figures to known group sizes of primates in the Small Forest. In the Small Forest, primate group sizes were known from approximately 37 hours of contact time during the study, and from conferring with teaching assistants and instructors at LSBFS after our study. Since group sizes were greatly underestimated during line transect surveys (see Fernandez-Duque *et al.*, 2001; Table 1), we decided to use line transects mainly to establish group density and not individual primate density (see Peres, 1999b). We also examined the effect that the duration of contact time had on group size counts using data from concentrated searches in an analysis of variance test. Individual primate densities were calculated using a combination of line transect surveys and surveys concentrated in areas where groups had been seen. Averages of group counts recorded during line transect surveys were used when a complete group count could not be recorded.

The size and composition of approximately one-third of the howling and capuchin monkey groups estimated to inhabit LSBFS was known (n = 6 of 17–18 groups). The number

Table 1. Primate group sizes in Small Forest.

Species	Average group size: line transect census	Known group sizes	Difference
Alouatta palliata	6.5 (N=6) range 4-10	12 individuals (Group 2)	46%
Cebus capucinus	6.5 (N=2) range 4-9	9 individuals	28%

of capuchins living in the Logged Forest was based on the maximum number of individuals recorded during any one observation, since we could only reliably say that one capuchin group lived there (Table 1). For two of the three howling monkey groups observed in the Logged Forest, the discontinuity of the canopy allowed JDP to make reliable group counts as individuals moved along a single pathway. The size of the third group was based on the average size of howler groups observed in this forest (i.e., 4.4 individuals, Table 1). Data on the howling monkey and capuchin groups inhabiting the Small Forest that were collected in this study, in 1997 by JDP and in 1995 by Garber and Rehg (1999) were compared over a four-year period.

JDP was able to obtain a full count of the "big" howling monkey group (n = 21 individuals) in the Large/German Forest as the group entered and then left a large fruiting *Ficus* tree during a tree vigil. For howling monkey groups other than the "big" group in the Large/German Forest (n = 7), averages from line transect surveys were used to estimate group sizes. This method was also used to estimate the sizes of capuchin groups observed in the Large/German Forest (n = 3). For spider monkeys, minimum community size was based on data from simultaneous observations of *A. geoffroyi* during sweep transect censuses.

Results

Primate density and group sizes at LSBFS
Data on the number of primate groups inhabiting the different forest patches at LSBFS are presented in Table 2.

Contact time and individual primate densities
During concentrated searches, spider monkeys (n = 22 encounters) and capuchin monkeys (n = 19) were encountered relatively more often per survey hour than howling monkeys (n = 38), compared to line transect surveys (n = 10, 10 and 53 times, respectively). Time spent with primate groups averaged 31 minutes (range 1–210 minutes). On average, during group encounters in concentrated searches, capuchins were observed for 30 minutes, and howling monkeys were observed for 38 minutes. For the 79 primate group contacts made during searches, the duration of time with a group significantly affected the number of individuals counted (ANOVA: $F = 12.9$, $df = 46$, $p<0.001$). The number of individuals increased along with duration of time spent with a group up to 120 minutes.

Discussion

In this study, systematic survey measures (i.e., line transects) were supplemented with data on primate group size from total counts to calculate densities of the primate population at LSBFS. Line transect surveys with multiple observers were most useful in estimating the number of primate groups inhabiting a forest patch. The location of groups observed more or less simultaneously could be plotted onto maps so that they could be found later for a more thorough count. Concentrated searches using total counts were instrumental in providing information on group size, since observers were not restricted to a set contact time with groups. The number of individuals counted increased significantly with the time that an observer stayed in contact with the group. Group size was significantly underestimated using line transect surveys, compared to the known number of howling monkeys in the Small Forest. Using data from total counts, where observers spent varying amounts of time with groups, at least two hours were necessary in order to obtain a steady count (i.e., one that no longer increased with time). However, increasing contact time with groups during line transect surveys to such a duration would only be feasible in areas of less than 40 ha in order to survey when primates are most active. Nonetheless, we question the reliability of density estimates for arboreal primates using a 10-minute targeted contact time.

Capuchins and howling monkeys in the Small Forest occurred at higher densities than at most other sites where these primates have been studied (Freese and Oppenheimer, 1981; Freese, 1976). Capuchin numbers in the Large and Logged forests at LSBFS were more similar to capuchin densities elsewhere. Individual howling monkey density was also extremely high per unit area in the Small Forest. Using multiple surveys averaged over time, Chapman and Balcomb (1998) showed that mantled howlers averaged

Table 2. Primate groups inhabiting forested areas at LSBFS.

Species	Small Forest (15 ha)		Logged Forest (35 ha)		Large Forest (100 ha)	
	Indiv. per km²	Groups per forest	Indiv. per km²	Groups per forest	Indiv. per km²	Groups per forest
Alouatta palliata	150	2	41	3	30	7–8
Cebus capucinus	60	1	11	1	15	3
Ateles geoffroyi	0	0	6	1	8–10 (min.)	1

Table 3. Primate group compositions in Small Forest, 1995-1999.

Group	Year	No. of individuals	No. of males	Reference
Tippy's howlers	1997	11	1	JDP unpublished data; this study
	1999	10	2	
2nd howler group	1997	10	2	JDP unpublished data; this study
	1999	12	3	
Small forest capuchins	1995	13		Garber & Rehg 1999; JDP unpubl. data; this study
	1997	12	2–3	
	1999	9	1–2	

48.5 individuals per km² (calculated from Table III: Chapman and Balcomb, 1998). Based on these data, howlers in the Logged and Large/German forest patches at LSBFS approach, but fall below, average population density of mantled howling monkeys, but Small Forest howlers occur at a density approximately three times that of the average (Chapman and Balcomb, 1998). Fashing and Cords (2000) noted the possibility that recent deforestation or other disturbance can result in primate populations that are high in density due to crowding, but that may become significantly lower as the effects of such disturbance become evident. Given the high density of howlers in this forest patch compared to other patches at LSBFS and at other sites where howlers have been studied, this may indeed be the case at LSBFS. Over short periods, howling monkey and capuchin group size in the Small Forest was somewhat stable, with the number of capuchins only slightly decreasing during this time. Additionally, the size of howling monkey groups here was similar to averages taken from a review by Chapman and Balcomb (1998: 12.2 group size based on averages of multiple censuses in different years). If the high densities exhibited by howling and capuchin monkeys in the Small Forest at LSBFS are due to crowding, detrimental effects on group sizes have not become evident in five years. Given the fact that these primate groups are often the focus of study for several primate field courses per year, such information could be gathered for comparison with our data, as well as those from other sites (e.g., Santa Rosa and La Pacifica, Costa Rica).

According to recorded sightings of spider monkeys in the Large/German Forest, the spider monkey community is typical of those found elsewhere (Chapman, 1988; Estrada and Coates-Estrada, 1996; Freese, 1976; Cant, 1978; Gonzalez-Kirchner, 1999). The minimum number of individuals in this community is 10, based on simultaneous sightings by observers during line transect surveys. A single sighting of 15 individuals was reported in 1997 (L. Winkler, pers. comm.), so that the size of the community at LSBFS is similar to the mean number of individuals per km² observed at other sites (calculated from Gonzalez-Kirchner, 1999; Chapman, 1988; Estrada and Coates-Estrada, 1996; Freese, 1976; Cant, 1978: mean number of individuals = 14.4).

Table 4. Groups and sizes recorded during line transect censuses.

Species	Forest patch	Average group size	Average no. groups
Alouatta palliata	Small	6.3	1.75
	Logged	4.0	3.75
	Large	4.0	4.75
Cebus capucinus	Small	6.5	0.25
	Logged	3.0	0.5
	Large	6.3	1.75
Ateles geoffroyi	Small	-	0
	Logged	2	0.25
	Large	3.3	0.75

At present, approximately 70 ha of the 100 ha forest fragment surveyed in this study is owned by outside interests (i.e., German Forest). The property was being logged in June 2001 (K. Dingess, pers. comm.). The spider monkey population currently inhabiting it is predicted to suffer a loss in numbers. If clear-cutting occurred, the spider monkey community would not survive, based on estimates of minimum home range size of communities elsewhere. For example, Fedigan *et al.* (1988) found the range size of individual spider monkeys at Santa Rosa, Costa Rica, averaged 62.4 ha, with a range of 37.4–97.9 ha. Four groups of howling monkeys were recorded in this 70 ha area of the Large Forest, as well as two groups of capuchins. The 30 ha forest tract owned by LSBFS would be insufficient to support such numbers of capuchin and howling monkey. The establishment of a corridor between the forest fragments at La Suerte should be beneficial in facilitating dispersal between the spider monkey communities encountered in this study.

Conclusions

Densities of mantled howlers and white-faced capuchins in the Small Forest at La Suerte Biological Field Station are high compared to populations elsewhere. Densities of these species in other forest patches at LSBFS were similar to other sites. The black-handed spider monkey population at LSBFS is similar in its average density when compared to populations elsewhere. Using different survey methods revealed that time spent in contact with primate groups by observers significantly affected the number of individuals counted. Counts of group members increased and then leveled off after observers had been in contact with groups for approximately 120 minutes. This suggests that standard, short time-periods used to determine group size and composition during line transect surveys could result in unreliable density estimates for the primate species surveyed in this study.

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Primates, Lots and Forest Fragments: Ecological Planning and Conservation in the Sierra de Santa Marta, Mexico

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Introduction

Rain forest fragmentation is of particular concern where entire regions are threatened by agriculture and other human activities, constituting as they do some of the most rapidly disappearing habitat on earth. An understanding of processes allowing specific taxa to persist in fragmented habitat is of great importance to conservation programs (Silva-López, 1996; Silva-López *et al.*, 1993a). Resources from forest fragments may play a key role in the domestic economies of local communities (Silva-López *et al.*, 1993b), and community work is as important as research when considering specific conservation measures (Portilla-Ochoa, in press). The management of forest fragments within systems where public land is divided into lots needs to be carefully incorporated into regional and local development plans, and requires a knowledge of the political decisions and socio-economic factors that determine their permanence or state of conservation.

In 1983, recognizing the need to create a balance between primate conservation and the development of rural areas, the Charles A. and Anne Morrow Lindbergh Fund, Inc., decided to support GSL's project "Rainforest exploitation and efforts to protect the endangered spider and howler monkeys at Sierra de Santa Marta, Mexico." The study´s results not only helped to promote new research and initiatives on behalf of primate conservation in the area but, most importantly, it stimulated the participation of biological and social scientists alike to design new approaches to support the conservation of the Sierra. This paper comments on one such approach and represents a new stage in our research program's vision of the problem. It deals with the fact that *campesinos* have long recognized the agricultural relevance of forest fragments, and examines some of the ways they use these fragments in their daily lives.

The Sierra

Each portion of the Sierra has unique geographic, cultural and biological characteristics. The eastern and southern slopes exemplify this situation, which is closely linked to the presence of the local, Zoque-popoluca people inhabiting the area. This indigenous group is the fourth largest in Veracruz, with about 29,000 people, of which about 60% (some 23,000) inhabit the Sierra and neighboring areas. Most of the Sierra and its area of influence is located in the municipality of Soteapan, where the population density, estimated at 52 inhabitants/km², is nearly half of the 95.4 inhabitants/km² average for the entire state (INEGI, 2000). However, the annual population growth rate in Soteapan has been estimated at 4.47%, almost twice that of the state. Soteapan has more than 40 *ejidos* (public lands) and agricultural communities, which combined represent about 98% of the municipality. Clearly, the Sierra´s portion of Soteapan, with its hilly relief marked by streams and small valleys, its Zoque-popoluca population inhabiting *ejidos* and its flora and fauna largely restricted to small forest fragments, is an example of a unique environment.

Forest Fragmentation

The problems associated with, and derived from, forest fragmentation have been studied by a number of authors (Silva-López, 1995; Kattan, 1993; Robinson, 1993; Kellman, 1993; Murcia, 1993; Harris and Silva-López, 1992) and are not discussed here. However, although we sometimes suggest that the clearing and fragmentation of a rain forest is an irrational act, from the point of view of the stakeholders involved, it is in fact only rarely so (Schelhas, 1993). Only with an understanding of the basis on which an *ejidatario* (a family head of the *ejido*) makes decisions on land use is it possible to change and influence the conditions promoting destructive uses and create incentives to promote sustainable uses.

An *ejidatario* who leaves one or more intact forest fragments in his lot is not being irrational. Our joint study of 67 *ejidal* lots and approximately 50 fragments suggests that these forest remnants are a refuge for the impoverished flora and fauna, including numerous tree species, palms, and spider and howler monkeys, while also providing a number of products for the local economy. A detailed study of the trees in a 10-ha forest revealed that locals use some 12 species for food, 15 as a source of medicinal products, 10 as a source of construction materials and at least 20 for firewood. Combined, they represent about 30% of the species, 40% of the families and approximately 60% of the trees with a diameter of 20 cm or larger in the fragment (Jiménez-Huerta *et al.*, 1993; Silva-López *et al.*, 1993). Fragments also provide ecological services such as windbreaks, the reduction of erosion levels in areas adjacent to cultivations and protection of streams. More than 90% of these fragments are next to rivers and streams on the Sierra´s eastern slope.

There are severe land use restrictions in a hilly terrain such as that prevailing in the Sierra. One of these is related to climate. The strong winds from the south, locally known as *suradas* (Portilla-Ochoa, 1995), are characteristic of the dry season and can be extremely damaging. They may cause fires started by cattle-ranchers to run out of control, resulting in severe and extensive forest fires. These runaway fires are one of the main causes of forest destruction. The loss of