DEMOGRAPHY AND CONSERVATION STATUS FOR THE CRITICALLY ENDANGERED MEXICAN HOWLER MONKEY (*ALOUATTA PALLIATA MEXICANA*) IN THE SOUTHERN PART OF LOS TUXTLAS BIOSPHERE RESERVE, VERACRUZ, MEXICO

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Abstract

The conservation status of the Mexican howler monkey in core zone III of Los Tuxtlas Biosphere Reserve, Veracruz, Mexico, is uncertain. Here, we provide the first set of demographic data of *Alouatta palliata mexicana* in the southern sector of the core zone III by using two different methods: line transect and sweep census. A total of twenty-six individuals divided in 6 groups were registered inhabiting the continuous forest, with a mean group size of 4 (± 0.5) individuals and a range of 3 to 6 individuals. The density of the animals for the study site was 0.04 howler monkeys/ha. Conversely, no individuals were found in any of the fragments surveyed within the buffer zone. Overall, field research showed a much lower density than was expected, suggesting historical and/or contemporary factors may be directly and/or indirectly affecting the persistence of the howlers in the area. New studies focused on the environmental changes caused by natural or anthropogenic factors will be of great aid in future management interventions and viability assessments of the population.

Key words: *Alouatta palliata mexicana*, Tropical rain forest, Demography, Veracruz, Mexico.

Resumen

El estatus de conservación del mono aullador Mexicano en la zona núcleo III de la Reserva de Biosfera Los Tuxtlas es incierto. En apariencia, el área presenta condiciones suficientes para albergar una población robusta de monos aulladores dado su estatus de protección, no obstante no existe investigación de campo para validar esta suposición. Aquí, nosotros proporcionamos el primer compendio de datos demográficos para *Alouatta palliata mexicana* en el sector sur de la zona núcleo III utilizando dos métodos: transecto lineal y censo de barrido. Así, un total de 26 individuos divididos en 6 grupos fueron registrados en el continuo de selva con una media de tamaño grupal de 4 (± 0.5) individuos y un rango de 3 a 6. La densidad de animales para el área de estudio fue de 0.04 aulladores/ha. Al contrario de lo observado en el continuo, ninguno de los fragmentos de la zona buffer fue encontrado habitado por aulladores. En general, la investigación de campo demostró una densidad mucho menor a la esperada lo cual sugiere que factores históricos y/o contemporáneos pueden estar afectando directa o indirectamente la persistencia de los aulladores en el área. Estudios centrados en cambios ambientales causados por factores naturales o antropogénicos serán de gran ayuda en futuras acciones de manejo y análisis de viabilidad de la población.

Palabras Clave: *Alouatta palliata mexicana*, Bosque tropical lluvioso, Demografía, Veracruz, México.

Introduction

The Mexican howler monkey (*Alouatta palliata mexicana*) is a Neotropical primate that occurs from southern Mexico to Guatemala. In Mexico, Los Tuxtlas Biosphere Reserve is one of the largest areas where populations of this subspecies occur. In this protected area, several studies have been carried out concerning the distribution and conservation status of primate populations (Estrada 1982; Rodríguez-Luna 1992; García-Orduña 1996; Canales-Espinosa and García-Orduña 2001; Silva-López and Portilla-Ochoa 2002; Cristóbal-Azkárate et al 2005; Mandujano and Escobedo-Morales 2008). However, there are still areas within the reserve without information on demographic structure, habitat quality and areas of occupancy of these species. In order to contribute to filling in these gaps concerning *A. p. mexicana* status in the tropical region of Los Tuxtlas, here we provide the first set of demographic data for howlers inhabiting the southernmost sector of core zone III within Los Tuxtlas Biosphere Reserve in Veracruz, Mexico, and a discussion of the likely reasons of the current population features in the area.

Methods

Study area

This study was conducted in the southernmost point of the core zone III of the reserve, circumscribed within the municipality of Pajapan, Veracruz, Mexico (Fig. 1). A 1:50,000 topographic map (INEGI 1999) and a LANDSAT-TM image (NASA 2003) were used to define the polygon of the site. The sector corresponding to core zone III within Pajapan's territory that consists of tropical rain forest was digitized using the ArcMap application from ArcGIS program version 9.2. Finally, during the census period, each tropical rainforest fragment visited (each with different degrees of degradation/disturbance), was mapped and georeferenced. Spatial information was downloaded into MapSource program version 6.11.6 and then imported to ArcMap for further analysis.

Field protocol

Censuses were conducted in continuous forest and forest fragments during the months of May and June 2009. Initially, in order to determine howler monkey abundance and absolute density, we used the line transect census method which has been widely applied in surveys of primates and other mammal species (NRC 1981; Chapman et al 1988; Buckland and Turnock 1992; Peres 1999). This method assumes that all individuals on a transect are detected at their initial location. Moreover, distance measurements of each individual from the observer must be accurately recorded and sighting events must be large enough to estimate the absolute density (Buckland et al 2001; Thomas et al 2002). Second, a sweep census was carried out using pre-existing trails and traversing the entire forest in a more systematic survey, attempting to determine the howler monkeys' true abundance in the study site. Although the "sweep" serves to determine abundance, it does not consider any distance measurement and therefore does not provide data to estimate absolute density as with the line transect method (Thomas et al 2002). Alternatively, density can be calculated by taking the total number of individuals censused and dividing it by the total area surveyed, an approach that has shown to be effective in similar studies (Estrada 1982 and references therein). For the fragments in the sector within the buffer zone, the sweep census method was applied as well.

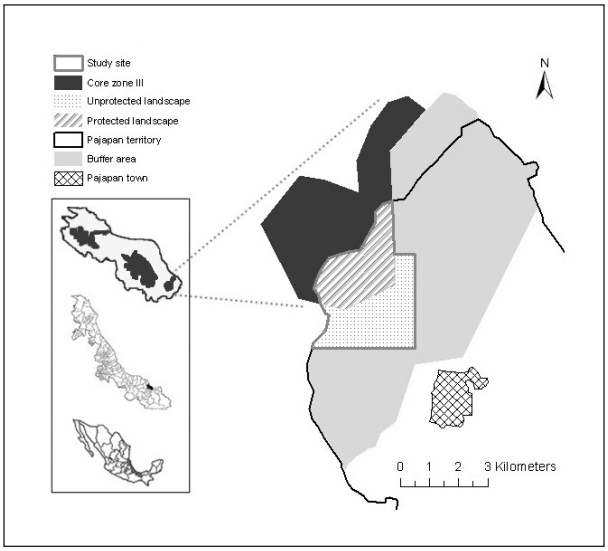

Figure 1. Study site within the municipality of Pajapan, which includes part of the protected (core zone III) and unprotected (buffer area) landscapes in the southern part of "Los Tuxtlas" Biosphere Reserve (illustrated at the top of the inner map) located in the state of Veracruz, Mexico.

Line transect census

Eight linear transects (±1 km long) were randomly selected within the study site (ranging from 300 to 500 m between them and from ± 500 m to ± 1,000 m above sea level). Although a minimum of ten is recommended (Buckland et al 2001), more survey lines within the study site could cause an overlapping of home ranges, compromising the accuracy of both the abundance calculation and the estimate of absolute density. During the first half of May researchers walked slowly along the transects twice a day from 0500 h to 1800 h, and stopped occasionally in order to detect any sign of howlers' activities (Peres 1999). When a group was detected, individuals were counted and classified as adults (large body size and fully developed genitalia), juveniles (individuals half the size of the adults independent of the mother) or infants (individuals carried by the mother) for further demographic analysis (NRC 1981). Number of males and females were registered for each class except infants. The, radial distance from the observer to each howler and the sighting angle of the observation from the transect line were also recorded (Buckland et al 2001). No more than 20–30 minutes were spent in counting the groups and acquiring demographic data. It was assumed that sighting events per transect were independent provided that vocalizations of the group previously detected were heard occasionally during the survey in the same or following transects. Additionally, particular body features were used to differentiate individuals of a particular group to help prevent counting the same individual twice.

Sweep census

In order to refine the findings of the line transect method and detect all the individuals within the study site, two entire weeks were spent in a sweep census with researchers walking along existing trails which overlapped at several points throughout the forest. In order to avoid traversing the same path twice and minimize bias in sighting events, the routes were delineated by marking stems and branches. When a group was detected, the same demographic data was registered as in the line transect method.

Census and mapping of forest cover in fragments

Within the study area, 24 fragments of tropical rain forest with different levels of degradation/disturbance/fragmentation were systematically surveyed. The surveys lasted from 0600 h to 1800 h every day for 2 weeks, with researchers walking through the interior of the fragments until

the entire area was completely surveyed. In order to identify those fragments with potential to promote the flow of howlers in the landscape, positional data for each fragment was recorded to calculate fragment size, edge perimeter, shortest distance to the nearest fragment and shortest distance to the protected forest using the ArcMap application of ArcGIS version 9.2.

Results

Forest cover status

The study site has 1,192 ha and 16.3 km of perimeter (Fig. 2). A total of 25 fragments were mapped and surveyed covering 106.12 ha of tropical rain forest in various degrees of transformation. The largest fragment was considered to be a part of the core zone III with 620.2 ha and 25.4 km of perimeter. The remaining fragments varied in size from 8.8 ha to 0.1 ha with a mean of 1.77 ha. The shortest distance between fragments was 24 m and the largest 115 m. General characteristics of fragments are available by request to the authors.

Howlers' abundance

A total of 20 individuals from 5 groups were censused during the survey in the area corresponding to the core zone III by using the line transect census method. The 20 individuals included; 7 adult males, 9 adult females, 1 juvenile male, 2 juvenile females and 1 infant not sexed. The mean group size was 4 individuals with a range of 3–6 animals. Table I shows the age and sex composition for each of the groups censused.

The adult female-to-male ratio was 1.28:1 ($N_{adult\text{-}females}$ = 9, $N_{adult\text{-}males}$ = 7) and the juvenile female-to-male ratio was 2:1 ($N_{juv\text{-}females}$ = 2, $N_{juv\text{-}males}$ = 1). Overall sex-ratio female-to-male was 1.37:1 ($N_{females}$ = 11, N_{males} = 8). Given the small number of individuals in the area, the estimate of absolute density as described by Buckland (2001) was not performed.

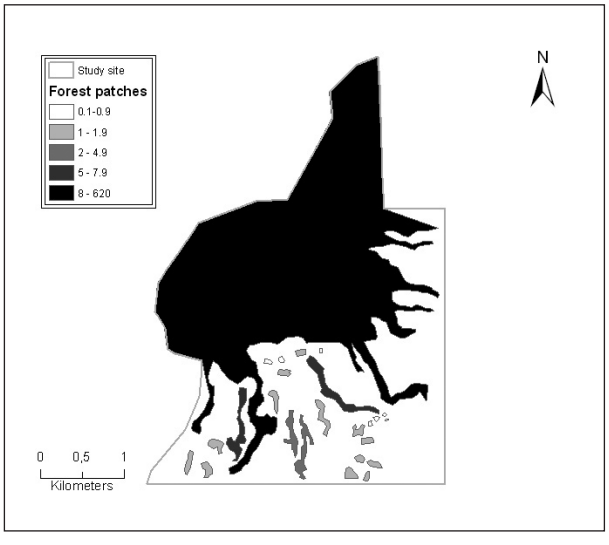

Figure 2. Forest distribution within the study area showing the range of vegetation cover in hectares.

Howlers' abundance using sweep census

The sweep census, which required two weeks of intensive field work, detected a total of 24 individuals divided in 6 groups, 5 of them previously detected by the line transect method provided that detections were near to the areas where previous groups were located, and their sex-stage classes were equal except for groups 2 and 5 (Table II) where a juvenile male and an adult female were missing but they were not found either migrating to another area, or dead. Based on the total area surveyed, the density of the animals for the study site was 0.04 howler monkeys/ha. Adult female-to-male ratio was 1.33:1 ($N_{adult\text{-}females}$ = 12, $N_{adult\text{-}males}$ = 9), however, due to absence of male juveniles, no juvenile female-to-male ratio is reported. The sex of the infant was not distinguished. Overall sex-ratio female-to-male was 1.33:1 ($N_{females}$ = 12, N_{males} = 9).

Analysis in fragments

No howlers were detected during the sweep census in the fragments. However, historical incidence was obtained by interviewing local villagers owning the lands where the

Table I. Results of the line transect census in the portion of core zone III within the municipality of Pajapan, Veracruz, Mexico. Abbreviations of age-sex as follows: AM = Adult males; AF = Adult females; JM = Juvenile males; JF = Juvenile females; I = Infants; Sex ratio = Female to Male adults.

Group	AM	AF	JM	JF	I
1	1	1	0	1	0
2	2	3	1	0	0
3	1	2	0	1	0
4	2	1	0	0	1
5	1	2	0	0	0
Totals	7	9	1	2	1
Mean	1.4	1.8	0.2	0.4	0.2
±SD	0.54	0.83	0.44	0.54	0.44

Table II. Results of sweep census at the portion of core zone III within the municipality of Pajapan, Veracruz, Mexico. Abbreviations of age-sex as in Table 1; Statistics of the new group detected are highlighted in bold Individuals observed in the line transect but absent in the sweep census are highlighted within brackets.

Group	AM	AF	JM	JF	I
1	1	1	0	1	0
2	2	3	0 [1]	0	0
3	1	2	0	1	0
4	2	1	0	0	1
5	1	1 [1]	0	0	0
6	2	4	0	0	0
Totals	9	12	0	2	1
Mean	1.5	2.0	0.0	0.4	0.2

fragments are located (supplemental material available in request). Four fragments were reported to previously have been inhabited by howlers (Table III).

In the past, the main cause of forest clearance was to establish grazing lands. This activity often extended fires beyond small forest-cleared spots and resulted in the loss of habitat for many species (Durand and Lazos 2004). Nowadays, fieldworkers know that clearance of forested areas near the reserve can lead to criminal prosecution and therefore they minimize the effect of slash and burn practices within agricultural lands. This supports the claims that recent disappearance of howlers from fragments may be due at least to some extent, to natural fires or other stochastic phenomena that take place periodically in the region (Rodríguez-Luna et al 1996).

Discussion

Howlers' status in continuous forest

Results from the field research within the core zone III, circumscribed to Pajapan, revealed small groups of *A. p. mexicana* ranging from six to only three individuals with a mean group size and sex ratio less than the average reported in other sites of the reserve either with similar (Estrada 1982; Estrada and Coates-Estrada 1996) or different degree of habitat quality (Cristóbal-Azkárate et al 2005) (Table IV). In order to determine abundance in the study two different techniques were carried out: linear transect and sweep census. Although the former was used to estimate abundance by linear sampling only, the latter attempted to count all the individuals present within the study area. The combination of both techniques should provide a robust overview of the demographic numbers and it is unlikely that the small number of individuals reported may be attributed to sampling error. However, the sweep census for the entire core zone III was expected to generate a larger number of howlers: given the protected and well conserved habitat within the reserve, there does not appear to be any impediment to host a larger population. As with other primate populations, the small numbers may be due to historical and contemporary factors working synergistically (Rodríguez-Luna et al 1987; Anderson et al 2007; Struhsaker 2008). Some potential factors are suggested below.

According to field workers of Pajapan, there are individuals from other towns that sporadically visit the reserve in search of white-tailed deer (*Odocoileus virginianus*), armadillo (*Dasypus novemcinctus*) and paca (*Agouti paca*); howler and spider monkeys may be hunted opportunistically in these cases. In addition field workers argued that they have never seen a forest guard patrolling the area while working in their parcels near the forest. During our own study, we never observed any guard patrols, which, together with the empty shotgun cartridges that were found discarded far into the forest, suggests a potential hunting threat in the area.

A less likely cause for the low abundance may be food scarcity. Although howlers show preference for some tree species (Estrada 1984; Silva-López 1987; Jímenez-Huerta 1992), they can feed from a wide variety of fruits, leaves and flowers from alternative species due to their flexible diet (Rodríguez-Luna et al 1995; Gómez-Marín et al

Table III. Forest fragments reported as occupied by howler monkeys in the last 20 years.

Fragment ID	Area (Ha)	No. of howlers	Last date seen alive	Cause of disappearance	Current threats
15	2.4	4	8 years	Natural forest fire causing the death of the howlers	Firewood collection
24	8.8	5	5 years	Natural forest fire causing howlers' migration to the continuous	Firewood collection and selective logging
5	1.2	1	20 years	Provoked forest fire by uncontrolled slash and burn agriculture practices	Firewood collection
13	1.8	1	20 years	Provoked forest fire by uncontrolled slash and burn agriculture practices	Firewood collection

Table IV. Demographic data of populations of *A. p. mexicana* censused at different sites within the core zones of Los Tuxtlas Biosphere Reserve.

	Estrada 1982	Estrada and Coates- Estrada 1996	Cristóbal - Azkárate et al 2005	This study 2009
	Core zone I	Core zone I-II	Core zone I	Core zone III
Mean group size	9.12	14.62	7.09	4.00
Population density (ha)	0.23	0.52	1.33	0.043
Sex ratio	1.37	2.34	1.47	1.33

2001; Cristóbal-Azkárate and Arroyo-Rodríguez 2007). In consequence, variety, density, quality and availability of either kind of resources may influence howlers' population growth. Although the analysis of food availability was beyond the scope of this study, it is very unlikely that a large and presumably undisturbed habitat was unable to provide an adequate source of food. However, assuming scarcity of resources, in theory there should be individuals or groups migrating in search of food from the study site to the north part of the reserve. Further research on the distribution, abundance and availability of food resources within the core zone III may clarify this.

A third explanation may come from the history of the area. Los Tuxtlas was declared as a natural protected area in 1998, while the first records of intensive human colonization in the region originate in the late 1960's and early 1970's (Durand and Lazos 2004). Moreover, Lazos and Paré (2006) as part of compilation of historical transformation processes within Pajapan and the adjacent municipality Tatahuicapan, reported encounters of villagers with primates as early as 1930 and a reduction of primate abundance due to primates being utilized as food resource. Unfortunately this study did not provide rates at which the animals were persecuted for this use.

Fragments' status

Although previous surveys have found individuals in forest fragments in the buffer zone in the northern part of the San Martín Pajapan Volcano (Solórzano 2010), no howlers were detected in any fragment within the buffer zone around Pajapan, the southernmost point of the reserve: this was true regardless of fragment size, fragment shape or current conservation status. Nevertheless, a dataset with the profiles of forest fragments was built to facilitate further investigation and management actions.

Summary and conclusions

Results of the census indicated a very low abundance of howler monkeys in the area despite its apparently well-conserved status; in fact, no howlers inhabit the various fragments within the buffer zone. Before any attempt is made to promote fragment occupancy by howlers, it is imperative to take actions towards determining those landscape attributes that act as constraints on the howlers' persistence. Probably, the current groups are a remnant of a once robust population. Although findings reported here are insufficient to prove this, further research on natural and anthropogenic changes in the area as well as historical howlers' occupancy will help to reveal both patterns of habitat transformation and howlers' population trends. This would be of great importance in developing viability assessments and in turn, management plans to guarantee the persistence of howlers for the future. Otherwise, fragments will continue to be reduced and the fate of the howlers will remain uncertain.

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