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Population Size, Distribution and Conservation Status of Howler Monkeys (*Alouatta coibensis trabeata*) and Spider Monkeys (*Ateles geoffroyi azuerensis*) on the Azuero Peninsula, Panama

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Abstract: The Azuero howler monkey, *Alouatta coibensis trabeata*, and the Azuero spider monkey, *Ateles geoffroyi azuerensis*, are endemic to the Azuero Peninsula, southwestern Panama, Central America and they are considered Critically Endangered. They are threatened by deforestation, poaching, and illegal trade. I carried out population surveys of the two subspecies from April 2001 to June 2009. The study covered potential habitats for these primates in the three provinces where they are believed to occur (Herrera, Los Santos and part of Veraguas). Surveys determined their occurrence and locations in each province. In all, 7,821 hrs were spent in survey activities. I used four methods: 1) Direct observation of presence/absence; 2) triangulations based on vocalizations; 3) strip-transect censuses, and 4) road counts. Forty-five Azuero howler monkey groups were seen and counted, totaling 452 individuals with a mean of 9.6 individuals/group, SE ± 3.3 (range = 3–26). I estimate approximately 322 howler groups and c. 3,092 individuals remaining in the wild in the three provinces. For the Azuero spider monkey, 74 individuals in 10 sub-groups and five complete groups were counted directly, with a mean of 3.8 individuals/subgroup, SE ± 0.6 (range 2–7) and a mean of 12.5 individuals/group, SE ± 3.7 (range 10–22). Overall, I confirmed the existence of approximately 13 spider monkey subgroups and 145 individuals of *A. g. azuerensis* remaining in the wild in the provinces of Veraguas and Los Santos. It is already extinct in the province of Herrera. This study confirms that both subspecies are Critically Endangered. Each appears to have already experienced changes in group composition due to isolation and habitat degradation. Conservation measures based on educational awareness programs have been initiated.

Key words: *Alouatta coibensis trabeata*, *Ateles geoffroyi azuerensis*, Azuero howler monkey, Azuero spider monkey, distributions, conservation status, Azuero Peninsula, Panama

Introduction

This is the first range-wide assessment of the distributions and populations of the Azuero howler monkey, *Alouatta coibensis trabeata*, and the Azuero spider monkey, *Ateles geoffroyi azuerensis*; endemic to the Azuero Peninsula of southwestern Panama (Froehlich and Froehlich 1987). Both are assessed as Critically Endangered on the *IUCN Red List of Threatened Species* (Cuarón *et al.* 2008). Surveys were carried out, using four conventional techniques to assess population parameters of the two subspecies. The aim was to calculate not only total numbers in Azuero but to obtain information on group characteristics, specifically their group structure, relating the findings to habitat size and other environmental variables. These two primates are among the most endangered in Panama, and the information obtained will provide a basis for

the Fundación Pro-Conservación de los Primates Panameños (FCPP) and the Panama Environmental Authority (ANAM) to establish and enforce a conservation program. In this assessment I identify promising localities (e.g., villages, towns, protected areas) and primate populations for the development of long-term conservation projects and environmental education programs for local people (Jacobson *et al.* 2006). As stressed by Godfray and Crawley (2004), to improve conservation prospects of threatened wildlife in deforested regions such as the Azuero Peninsula, the remaining forests that still hold wild populations, need to be assessed to document the extent of environmental change that is taking place and responses to these changes by the endangered primate subspecies.

Methods

Study area

Azuro howler and spider monkeys are endemic to the Azuero Peninsula in the southwest of Panama. Annual average temperature is 28.1°C (range 22.5–33.7°C), and average annual rainfall is 1,410 mm/year (Navas *et al.* 2001). Azuero, encompassing the provinces of Herrera, Los Santos and the eastern part of Veraguas, is severely deforested. There is a dry season from December to April, and a rainy season from May to December (Suárez 1981). The lowlands are quite flat with small hills reaching 90 to 150 m above sea level (Méndez-Carvajal 2001). The El Montuoso Forest Reserve, at 900 m above sea level (Arcia *et al.* 2004), is in the highlands in the north, and the Cerro Hoya Natural Park (Cerro Hoya reaches 1,559 m above sea level) is in the southwest. Forests in the Azuero Peninsula remain mainly on hilltops and along rivers. The lowlands are dominated by pasture interspersed with forest patches that are connected in some areas by gallery forest and living fences. The tallest trees reach 15 to 20 m in the remnant forests and living fences that line the principal and secondary roads, delimiting the cattle ranches and pastures (Méndez-Carvajal 2001, 2008). Vegetation was classified and mapped using satellite data from GH NASA-Tele Atlas 2008 and Garmin Etrex (MapSource 6.15.4), along

with information provided by the Panamanian Environmental Authority (ANAM) and the landowners. Statistical analyses were carried out using Excel, SPSS 16.0. Spearman's tests were applied to evaluate relationships between group size, forest height and the area of the habitat. The study area was divided into five regions (see Fig. 1, Table 1).

Data collection

I report here on survey data collected over nine years—7,821 hours in the field from April 2001 to June 2009. Surveys were carried out on 121 days (10–15 days per year) (Table 2). Population densities were calculated by the number of individuals found divided by the size of each connected region; providing as such ecological densities, as indicated by Eisenberg (1979), Chapman *et al.* (1988) and Rudran *et al.* (1996).

Areas were selected on the basis of the presence of forest and information provided by the local people. Four methods were used in each survey area: presence/absence recording, strip transect, road count, and listening for calls and locating groups by triangulation. Besides seeing the primates, we recorded their presence through signs, which included smell, feces, tracks, chewed leaves, and calls (Rabinowitz 2003). Twelve strip transects were set up, each at least 1 km long, to cover the entire peninsula, following the recommendations

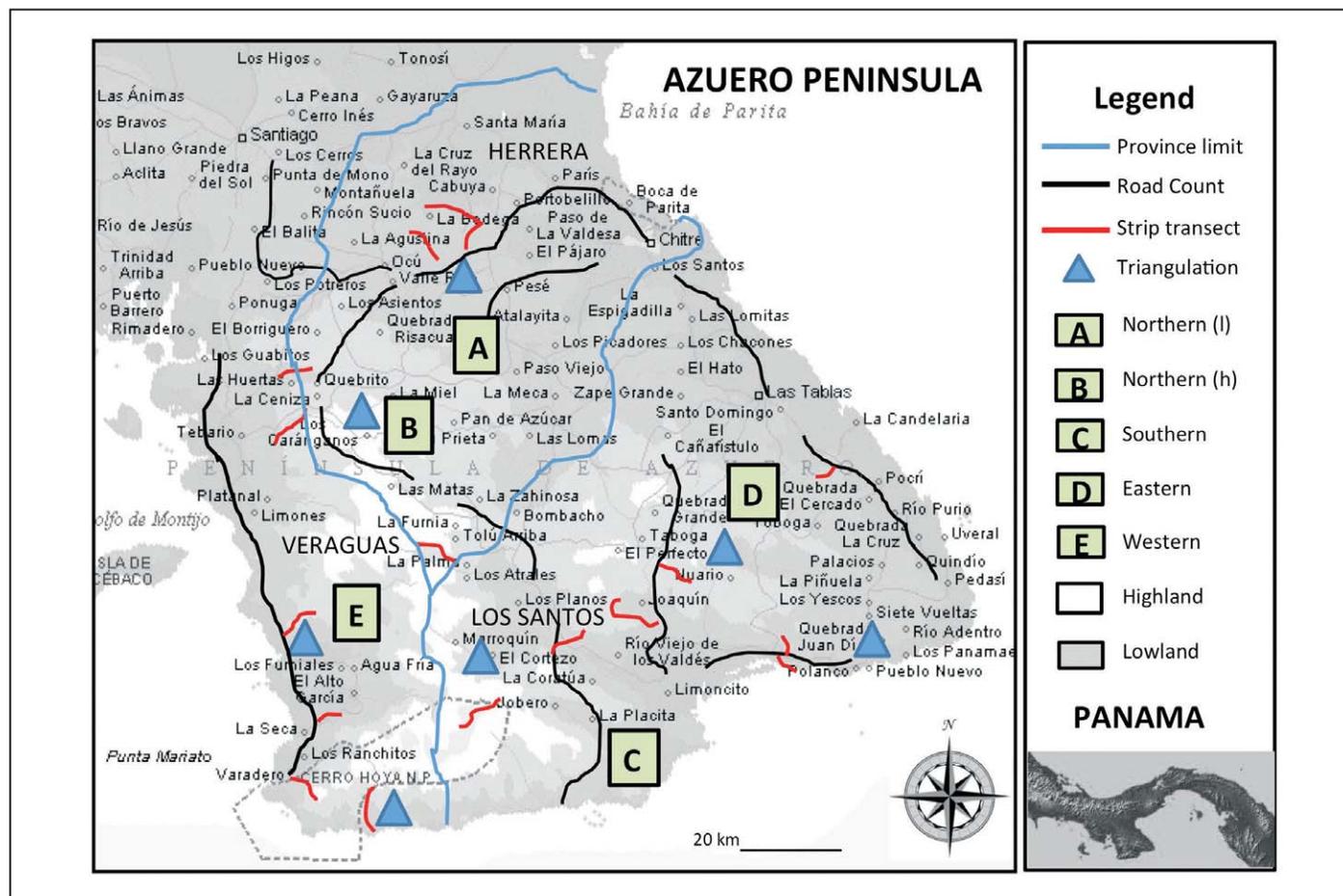


Figure 1. Study site. Location of areas where surveys have been carried out along the Azuero Peninsula.

of Ferrari (2002) and Carvalho-Oliveira *et al.* (2003) (Fig. 1). We carried out strip transects if the forest was at least 40 m wide. This method was used to survey gallery forest, living fences and patches of forest in fragments. Observations were made on foot between 08:00 and 12:00 hr and 14:00 and 18:00 hr. Speed of travel along the strip transects was 1 km/hr by foot. Eleven roads were also surveyed, averaging 26.6 km (range 18–34 km; $n = 11$). Each was surveyed by car twice a year; average speed was 15 km/hr.

The use of listening posts and triangulation to locate groups proved effective for howler monkeys in seven areas with isolated patches of forest (Fig. 1). Three listening posts were set up and manned from 04:30, for fixed periods in the morning, noon and late afternoon for at least three days in each area. We recorded the time and position of vocalizations using a GPS, and estimated the location of vocalizing groups using a compass-bearing and an estimated distance from the observer (Brockelman and Ali 1987; Aldrich *et al.* 2006). Whenever possible, the groups recorded were verified by direct observation later in the morning. They were counted and recounted at least twice each day while we stayed in the area. This process was repeated several times to ensure accuracy before an average group size and composition could be recorded (Milton 1992; Ferrari 2002). This method helped us to identify new groups unnoticed by our conventional strip transect method. Spider monkeys were detected with this method in previous surveys in the area of Chucantí, Darien (Méndez-Carvajal *et al.* 2010a). Black spider monkeys, *Ateles fusciceps rufiventris*, call almost every day throughout the day, and we expected

the same behavior in Azuero. Azuero spider monkeys were, however, largely silent, probably because people chase them and sometimes shoot them. Azuero spider monkeys always fled when we found them, often subsequently mixing with groups of the similarly colored howler monkeys. They called so infrequently that this method proved impractical for this species in fragmented habitats.

For each group seen we recorded the group size and composition—adult male, adult female, juvenile and infant, following the classifications of Milton (1992) and Campbell and Gibson (2008). The number of groups detected was multiplied by the average group size for each area (Milton 1992). The combination of the four methods maximized our chances of detecting the groups remaining around the non-protected areas. The results from the different methods were analyzed separately but were complementary and allowed us to consolidate our information on the groups at each site.

Data Analysis

I calculated mean group size and composition for each subspecies. To estimate the total number of individuals of a subspecies present in a given area, I calculated densities as follows: Transects and Road counts: $D = N/2WL$; density (D) is found by dividing the number of individuals (N) recorded by twice the estimated detection distance (W) of the forest surveyed, multiplied by the length (L) of the transect.

For triangulation: $D = fn/A$; density (D) is found by multiplying the number of groups located by triangulation in a sampled area (N) by a correction factor for the bias that not

Table 1. Characterization of five Azuero regions divided in this study according to the provinces surveyed (see Fig. 1). Climatic and botanical information from Navas *et al.* 2001, Salazar-Allen (2001), and Arcia *et al.* 2004. Human population data from (González 2002).

Region	Coordinates	Localities	Vegetation	Highest elevation (m)	Annual rainfall (mm)	Forest cover (%)	Canopy height (m)	Temperature (°C)	Forest cover/ Forest surveyed/ Human population
Northern (lowland)	8°00'17"N 80°41'50"W	Ocú, La Polonia, Calabazal, Llano Grande, Llano Hato, Santa Mónica, Pedregoso, Parita, Cabuya, Aguas Buenas	Secondary forest, living fences, gallery forest. Dry forest.	100	1,400	50	15	33	4% (100.5 km ²)/ 42% (76.3 km ²)/ 107,911
Northern (highland)	7°45'17"N 80°45'05"W	Alto del Higo, El Ñuco, Caras Pintadas, Tres Puntas, Sonadora, Chepo de Las Minas. Reserva Forestal El Montuoso (RFEM)	Secondary connected forest, pre-montane, gallery forest, living fences. Montane forest.	1000	2,500	90	25	28	
Southern (Veraguas/ Los Santos)	7°19'01"N 80°27'56"W	Restingue, Cambutal, Tembladera, Güera, Venao, Tonosí, Cañas, SE Cerro Hoya and SW Reserva la Tronosa (RFLT)	Secondary forest, gallery forest, living fences. Dry forest.	1,500	2,000	65	15	30	
Eastern (Los Santos)	7°35'14"N 80°17'51"W	Las Tablas, Oria, La Miel, El Cocal, La Palma, Tonosí and Flores	Secondary forest, living fences, gallery forest. Dry forest.	100	1,500	70	15	33	7% (168 km ²)/ 39% (66.32 km ²)/ 88,487
Western (South-east Veraguas)	07°22'20"N 80°51'44"W	Arenas, Quebro, Flores, Mariato, Torio, Playita, bourder of Parque Nacional Cerro Hoya	Secondary forest, living fences, gallery forest. Dry forest.	500	1,400	65	15	34	8% (250 km ²)/ 36% (90 km ²)/ 4,492

all groups vocalize in the same sample period (f), divided by the study area (A) (Brockelman and Ali 1987).

Azuero howler monkey analysis

To estimate of the overall density for *Alouatta coibensis trabeata*, I used results of the two most effective methods applied for this survey: triangulation and strip transects. The total number of individuals was calculated using mean group size multiplied by the number of groups detected in connected forest. Using all relevant data, we tried to estimate the number of groups existing in the more isolated areas. Total population size was calculated using the criteria of Nichols and Conroy (1996). Thus, the equation used to calculate the total population of *A. c. trabeata* was based on a modification of the Eisenberg (1979) ecological formula with a canonical estimator as following:

$$\check{N} = C/\alpha\beta$$

where C is the total number of animals, β =Observation probability expressed as $\beta = \hat{y}/\chi$, \hat{y} is the density of the incomplete population survey (Strip Transect), and χ the most accurate density of the complete survey (Triangulation); α =is the area sampled.

Azuero spider monkey analysis

The *A. g. azuerensis* population was estimated using two of the four methods applied for this survey. The most effective methods to detect Azuero spider monkeys were road counts and presence/absence, considering between them the presence/absence as the more complete and the road count as the less accurate method. We calculate their total population by the number of localities confirmed as “spider monkey present” and then, assuming at least one subgroup per locality, we multiplied the average subgroup size obtained by

direct observations and determine the total population by the equation:

$$\check{N} = C/\alpha\beta$$

where C is the total number of animals, β =Observation probability expressed as $\beta = \hat{y}/\chi$, where \hat{y} is the density of the incomplete population survey (road counts) and the χ the most accurate density of the complete survey (presence/absence); α =is the area sampled.

Results

Total hours/effort invested in presence/absence recording, including informal interviews, for both species was 771.5 hours. Howler monkeys and spider monkeys occurred together in the following locations: Restingue, Cerro Culón, Río Ventana, Tembladera, Punta Blanca, Cerro Hoya National Park, Cerro Moya, Jobero, Cambutal, Altos de Güera, Río Güera, La Tronosa Forestal Reserve, El Cortezo, Quema, Guánico, Tonosí, Cacao, Cañas, Venao, Los Pozos, Macaracas, Las Palmas, Llano de Piedra, Mogollón, Cerro Canajaguas, Cerro El Vijía, Valle Rico, La Miel, Valle de Tonosí, Flores (Los Santos), Oria, Río Purio, Los Ñopos, El Cacarañal, Macaraquitas, La Llanita, Buena Vista, Mariato, Arenas, and Flores (Veraguas) (Méndez-Carvajal 2008) (Table 3).

Populations by region

Northern Region: Herrera Province (lowland). The largest howler population was found in the northern lowland region; 261 howler monkeys in 11 groups. Group size averaged 23 individuals (range 15–39); all in highly fragmented forests. Average group composition was 6.0 males (25%), 7.8 females (32%), 6.6 juveniles (27%) and 3.4 infants (14%). The adult male/female ratio was 1:1.3, female/juvenile 1:0.8, and female/infant was 1:0.4. Densities were

Table 2. Summary of survey activities from 2001 to 2009. Average survey time was 12 hrs/day. P/A: Presence/absence; ST: Strip Transects; RC: Road counts; T: Triangulation. Regions described in Table 1.

Initial date	Final date	Region	No. of observers	Days worked	Survey time (hrs)	Method applied
4/21/2001	4/25/2001	Northern (l)	6	5	360	P/A, ST, RC,T
5/21/2001	5/25/2001	Northern (l)	6	5	360	P/A, ST, RC,T
8/8/2001	8/12/2001	Northern (h)	3	5	180	P/A, ST, RC,T
12/5/2001	12/9/2001	Northern (l)	2	5	120	P/A, ST, RC,T
1/15/2002	1/25/2002	Northern (h)	9	10	1080	P/A, ST, RC,T
2/21/2002	2/25/2002	Northern (h)	2	5	120	P/A, ST, RC,T
4/21/2002	5/1/2002	Northern (h)	9	10	1080	P/A, ST, RC,T
7/11/2002	7/15/2002	Northern (h)	2	5	120	P/A, ST, RC,T
3/7/2003	3/16/2003	Northern (l) & Eastern	3	10	360	P/A, ST, RC,T
1/24/2004	1/2/2004	Eastern	7	10	840	P/A, ST, RC,T
5/1/2005	5/10/2005	Eastern	2	10	240	P/A, ST, RC,T
5/25/2006	6/3/2006	Northern (l) & Eastern	3	10	360	P/A, ST, RC,T
1/5/2007	1/15/2007	Northern (l), Eastern, Western & Southern	6	11	792	P/A, ST, RC,T
5/19/2008	5/29/2008	Northern (l) & Eastern, Western & Southern	8	10	960	P/A, ST, RC,T
4/25/2009	5/25/2009	Northern (l), Eastern, Western & Southern	7	10	840	P/A, ST, RC,T
Total			mean=5	121	7,812	

Table 3. Localities confirmed with presence/absence of *A. coibensis trabeata* and *A. geoffroyi azuerensis*, Azuero Peninsula, Panama. ? = probably present; +? = high probability of presence.

	Localities	District	Province	<i>A.c. trabeata</i>	<i>A.g. azuerensis</i>
	Northern Region	Ocú	Herrera	Absent	Absent
1	Ocú	Ocú	Herrera	Absent	Absent
2	Las Animas	Ocú	Herrera	Absent	Absent
3	La Polonia	Ocú	Herrera	Absent	Absent
4	El Calabazal	Ocú	Herrera	Present	Absent
5	Camarón	Ocú	Herrera	Present	Absent
6	Tijeras	Ocú	Herrera	Present	Absent
7	Quebrada Limón	Ocú	Herrera	Present	Absent
8	Llano Grande	Ocú	Herrera	Present	Absent
9	Llano Hato	Ocú	Herrera	Present	Absent
10	Santa Mónica	Ocú	Herrera	Present	Absent
11	La Chavarría	Ocú	Herrera	Present	Absent
12	Aguas Buenas	Ocú	Herrera	Present	Absent
13	Cerro Noneca	Ocú	Herrera	Present	Absent
14	Cerro Lavadero	Ocú	Herrera	Present	Absent
15	Cerro Comején	Ocú	Herrera	Present	Absent
16	Los Carates	Ocú	Herrera	Present	Absent
17	El Cercado	Ocú	Herrera	Present	Absent
18	Las Manueles	Ocú	Herrera	Present	Absent
19	Pedernal	Ocú	Herrera	Present	Absent
20	Santo Domingo	Ocú	Herrera	Present	Absent
21	Los Higos	Ocú	Herrera	Present	Absent
22	Potuguilla	Ocú	Herrera	Present	Absent
23	Los Asientos	Ocú	Herrera	Present	Absent
24	Parita	Parita	Herrera	Present	Absent
25	Cabuya	Parita	Herrera	Present	Absent
26	Candelaria	Parita	Herrera	Present	Absent
27	Portobelillo	Parita	Herrera	Present	Absent
28	Cerro Tigre	Parita	Herrera	Present	Absent
29	Queb. Grande	Parita	Herrera	Present	Absent
30	Río Parita	Parita	Herrera	Present	Absent
31	Llano La Cruz	Parita	Herrera	Present	Absent
32	Río Viejo	Parita	Herrera	Present	Absent
33	Las Gardenias	Parita	Herrera	Present	Absent
34	Los Lajones	Parita	Herrera	Present	Absent
35	Queb. Carrizal	Parita	Herrera	Present	Absent
36	Valencia	Parita	Herrera	Present	Absent
37	Chepo	Las Minas	Herrera	Present	Absent
38	El Ñuco	Las Minas	Herrera	Present	Absent
39	Sonadora	Las Minas	Herrera	Present	Absent
40	Tres Puntas	Las Minas	Herrera	Present	Absent
41	Alto del Higo	Las Minas	Herrera	Present	Absent
42	R. Forestal El Montuoso	Las Minas	Herrera	Present	Absent
43	Queb. Chuérala	Las Minas	Herrera	Present	Absent
44	Caras Pintadas	Las Minas	Herrera	Present	Absent
45	Río La Villa	Las Minas	Herrera	Present	Absent
46	Río Tebario	Las Minas	Herrera	Present	Absent
47	Los Pozos	Las Minas	Herrera	?	Absent
48	La Arena	Las Minas	Herrera	?	Absent
49	El Calabacito	Macaracas	Herrera	?	Absent
50	La Mesa	Macaracas	Herrera	?	Absent
	Western Region				
51	Ponuga	Mariato	Veraguas	Present	Absent
52	Tebario	Mariato	Veraguas	Present	Absent
53	Llano de Catival	Mariato	Veraguas	Present	Absent
54	Malena	Mariato	Veraguas	Present	Absent
55	La Loma	Mariato	Veraguas	Present	?

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	Localities	District	Province	<i>A.c. trabeata</i>	<i>A.g. azuerensis</i>
56	Río Varadero	Mariato	Veraguas	Present	?
57	Cerro La Honda	Mariato	Veraguas	Present	+?
58	Río Quebro	Mariato	Veraguas	Present	Present
59	Arenas	Mariato	Veraguas	Present	Present
60	Restingue	Mariato	Veraguas	Present	Present
61	Río Pavo	Mariato	Veraguas	Present	Absent
62	Q. MIDA	Mariato	Veraguas	Present	Absent
63	Playa Malena	Mariato	Veraguas	Present	Absent
64	Torio Arriba	Mariato	Veraguas	Present	Present
65	Changüales	Mariato	Veraguas	Present	+?
66	La Burra	Mariato	Veraguas	Present	+?
67	El Cortezo	Mariato	Veraguas	Present	+?
68	Playa Mariato	Mariato	Veraguas	Present	+?
69	Cerro Culón	Mariato	Veraguas	Present	Present
70	Río Ventana	Mariato	Veraguas	Present	Present
Southern Region					
71	Tembladera	Mariato	Veraguas	Present	Present
72	Punta Blanca	Mariato	Veraguas	Present	Present
73	Parque Nacional Cerro Hoya	Mariato	Veraguas	Present	Present
74	Jobero	Tonosí	Los Santos	Present	Present
75	Cambutal	Tonosí	Los Santos	Present	Present
76	Altos de Güera	Tonosí	Los Santos	Present	Present
77	Río Güera	Tonosí	Los Santos	Present	Present
78	Reserva Forestal La Tronosa	Tonosí	Los Santos	Present	Present
79	El Cortezo	Tonosí	Los Santos	Present	Present
80	Quema	Tonosí	Los Santos	Present	Present
81	Guánico	Tonosí	Los Santos	Present	Present
82	Tonosí	Tonosí	Los Santos	Present	Present
83	Río Agua Buena	Tonosí	Los Santos	Present	+?
84	Río Ojo de Agua	Tonosí	Los Santos	Present	+?
85	Río Cigüa	Tonosí	Los Santos	Present	+?
86	Río de Cañas	Tonosí	Los Santos	Present	+?
87	Cacao	Tonosí	Los Santos	Present	Absent
88	Loma La Zahina	Tonosí	Los Santos	Present	Present
89	Cañas	Tonosí	Los Santos	Present	Present
90	Venao	Pedasí	Los Santos	Present	Present
91	Los Pozos	Tonosí	Los Santos	Present	Absent
92	Macaracas	Tonosí	Los Santos	Present	?
93	Las Palmas	Tonosí	Los Santos	Present	?
94	Llano de Piedra	Tonosí	Los Santos	Present	?
95	Mogollón	Tonosí	Los Santos	Present	?
96	Cerro Canajaguas	Tonosí	Los Santos	Present	?
97	Cerro El Vija	Tonosí	Los Santos	Present	Present
Eastern Region					
98	Valle Rico	Las Tablas	Los Santos	Present	Present
99	La Miel	Las Tablas	Los Santos	Present	Present
100	Oria	Las Tablas	Los Santos	Present	Present
101	Oria Abajo	Las Tablas	Los Santos	Present	Present
102	Queb. Pixbae	Las Tablas	Los Santos	Present	Present
103	Queb. La Palma	Las Tablas	Los Santos	Present	Present
104	Río Purio	Las Tablas	Los Santos	Present	Present
105	Queb. Nuario	Las Tablas	Los Santos	Present	Present
106	Finca Domínguez	Las Tablas	Los Santos	Present	Present
107	Finca Pillo González	Las Tablas	Los Santos	Present	Present
108	Los Ñopos	Las Tablas	Los Santos	Present	Present
109	El Cacarañal	Las Tablas	Los Santos	Present	Present
110	Macaraquitas	Las Tablas	Los Santos	Present	Present

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Table 3. continued from previous page

	Localities	District	Province	<i>A.c. trabeata</i>	<i>A.g. azuerensis</i>
111	Cerro Quema	Las Tablas	Los Santos	Present	Present
112	La Llanita	Las Tablas	Los Santos	Present	Present
113	Buena Vista	Las Tablas	Los Santos	Present	Present
114	Punta Blanca	Las Tablas	Los Santos	Present	Present
115	El Sesteadero	Pocri	Los Santos	?	Absent
116	Rio Mensabé	Pocri	Los Santos	?	Absent
117	La Palma	Pocri	Los Santos	Present	Present
118	Quebrada El Hato	Pocri	Los Santos	?	?
119	Rio Pocri	Pocri	Los Santos	?	?

Table 4. Total individuals detected of *Alouatta coibensis trabeata*, Azuero Peninsula, Panama. Confidence Level (95%), mean = 9.6 individuals/groups (3–26) (SD ±3.3).

Region	Total	Total groups	Density ind./km ²	Density groups/km ²	SD±	Area (km ²)	Vegetation
Northern (lowland)	261	11	40.4	1.7	9.4	6.46	Patches and living fences
Northern (highland)	37	6	0.5	0.08	3.6	69.83	Secondary forest
Southern	35	11	5.1	1.17	5.5	6.78	Secondary forest
Eastern	76	12	42.6	5.5	2.8	1.82	Gallery forest
Western	43	5	17.2	2	5.5	2.50	Gallery forest
Total	452	45	5.2	0.5	4.8	87.39	

Table 5. Total individuals detected of *Ateles geoffroyi azuerensis*, Azuero Peninsula, Panama. Confidence Level (95%) mean = 10.2 individuals/groups (4–22) (SD ±1.5) *See Table 1, **Calculated by locals and environmental authorities.

Region	Total	Total groups	Density ind./km ²	Density groups/km ²	SD±	Area (km ²)	Vegetation
Northern (lowland)	–	–	–	–	–	6.46	Patches and living fences
Northern (highland)	–	–	–	–	–	69.83	Secondary forest
Southern	49	4	7	0.6	1.5	6.78	Secondary forest
Eastern	25	1	13.7	0.5	1.5	1.82	Gallery forest
Western	50**	–	20	–	–	2.50	Gallery forest
Total	124	5	1.4	8.4	1.5	87.39	Various*

40.4 individuals/km², and 1.7 groups/km² (n=5; SD ±9.4) for 6.46 km² forest surveyed. This population is not heavily hunted and has no natural predators, and the howlers appear to be overcrowded in the small fragments where they remain, facing, as they do, the difficulties of dispersing over wide expanses of pasture. Azuero spider monkeys were not found in this area.

Northern Region: Herrera Province (highland). The howler population was estimated at 37 individuals in six groups, with an average of 6.1 individuals per group (range 5–12). The six groups averaged 1.83 males (30%), 2.5 females (40%), 1.0 juvenile (16.4%), and 0.8 infants (13.6%). The ratio of adult male/female was 1:1.36, female/juvenile was 1:0.4, and female/infant was 1:0.3. Densities were estimated at 0.52 individuals/km² and 0.08 groups/km² (n=6, SD ±3.6) over an area of 69.83 km² (Table 4). Azuero spider monkeys were not found in this region but interviews assured us of their presence in the past. Locals told us that Azuero spider monkeys were present in the El Montuoso Forest Reserve

about 20 years ago, but disappeared later with other animals such as jaguars; eliminated by poachers (Table 5).

Southern Region: Veraguas and Los Santos provinces – howler monkey population. The howler population was estimated to be at least 35 individuals in 11 groups, with an average of four individuals per group (range 1–12; n=7), with 1.6 males (45%), 1.6 females (45%), 0.7 juveniles (2%) and 0.4 infants (1%). Relative densities were 5.1 individuals/km² and 1.17 groups/km² (SD ±5.5 for 6.78 km²). The ratio of adult males to females was 1:1, juveniles/females was 1:0.46, and females/infants 1:0.23. Densities were calculated based on the size of each patch of forest sampled, with 3.4 individuals/km² and 0.94 groups/km² for the area in the southwest (5.28 km²), and 13.3 individuals/km² and 2.6 groups/km² for the population in the southeast (1.5 km²).

Southern Region: Veraguas and Los Santos provinces – spider monkey population. Anecdotal reports from the communities of Ventana and Tembladera (Veraguas) indicated that spider monkeys occasionally traverse the area through

the gallery forest and forest fragments close to the coast. They reported that spider monkeys inhabit mostly the upper forested slopes of the mountains, and are scarce in the lowlands. People from Ventana and Tembladera (Veraguas) told us that Azuero spider monkeys normally come down near to human settlements during the rainy season (middle of May to December). For Los Santos province, we found a total of 49 spider monkeys in four isolated groups (mean size=10.2; range 4–22). The group composition average was 2 males (SD ± 1.6 ; 40%), 2.2 females (SD ± 1.5 ; 44%), 1.8 juveniles (SD ± 1.5 ; 36%) and 1.5 infants (SD ± 1.5 ; 30%) at Venao, La Zahina, Cañas, Flores of Tonosi and Pedasi District (Los Santos). The ratio of adult males to females was 1:1, and the female/infant ratio was 1:1.5 ($n=4$; 95% confidence). Densities calculated were 7.3 individuals/km² and 0.6 groups/km² in 6.78 km² (Table 5).

Eastern Region: Los Santos Province – howler monkey. Seventy-six howler monkeys were found in an area of 1.82 km². There were 12 groups, and a lone juvenile female. The group composition averaged 1.6 males (21%), 3.8 females (50%), 0.6 juveniles (7.8%) and 1.6 infants (21%), and group size averaged 7.6 individuals (SD ± 2.8 , $n=10$, range 3–12). The ratio of males/females was 1:2.3, juveniles/females 1:2.6, and infants/females with 1:0.42. Relative densities for the Eastern Region for Azuero howler monkeys were 42.6 individuals/km² and 5.5 groups/km².

Eastern Region: Los Santos Province – spider monkeys. We found one group composed of three subgroups of Azuero spider monkeys in this region with 25 individuals seen, in the area of La Miel, Las Tablas, and the Tonosi Valley, about 2 km from the town of Flores. Average group size was 12, and subgroup size 6.2, sharing the same area with Azuero howler monkey groups. The density in the three locations was 13.7 individuals/km², 0.5 groups/km², and 2.2 subgroups/km², respectively. Subgroup composition averaged 2.0 adult males, 2.3 adult females, 1.3 juveniles, 1.3 infants (range 3–14, SD ± 1.5 , $n=3$) for a total area of 1.82 km². These monkeys are indirectly connected between the Río Oria Arriba and Oria Abajo via the La Palma Bridge as far as the forest of Cerro El Montuoso, Las Tablas District.

Western Region: Southern Veraguas Province. We observed 43 Azuero howler monkeys in five groups. The groups averaged 1.5 males (13.9%), 5.2 females (48.8%), 3 juveniles (13.9%) and 2.5 infants (23.2%). The adult male/female ratio was 1:3.5, female/juvenile 1:0.4, and females/infant 1:0.5. Densities calculated were 17.2 individuals/km² and 2 groups/km² ($n=4$; SD ± 5.5) in 2.5 km². Spider monkeys were reported by the locals, and around 50 individuals were confirmed for Cerro Hoya National Park, Arenas, Quebro and Restingue including Cerro Culón (Table 5).

Total population of the Azuero howler monkey

We recorded 433 Azuero howler monkeys from 87.39 km² of fragmented forest from 2001 through 2009 (Table 4). Forty-three groups provided an overall density of 5 individuals/km² and 0.5 groups/km² for the entire forested area of the

Azuero Peninsula ($n=32$, SD ± 2.4). Overall, group composition averaged 2.5 adult males, 4.3 adult females, 1.92 juveniles and 1.88 infants. The mean group size was 9.6 (range 3–26). According to the equation, $\hat{N}=433/(1)0.14$, we estimate a total of 3,092 individuals remaining in the wild.

Total population of the Azuero spider monkey

We recorded 74 Azuero spider monkeys, with five groups detected and/or counted directly, and six indirectly (Table 5). There are evidently no spider monkeys remaining in Herrera province, the northern part of the Azuero Peninsula, but remnant and diminished populations survive in the southern (southeastern and southwestern) parts of the peninsula (Méndez-Carvajal and Ruiz-Bernard 2009). The Cerro Hoya National Park is their main stronghold (Rowe 2000; Cuarón *et al.* 2008), and our efforts were concentrated mostly in remnant forests. We found the Azuero spider monkeys surviving in the remnant patches close to the Cerro Hoya National Park and La Tronosa Forest Reserve, and we also confirmed their presence in the surrounding secondary forest, living fences and forest patches throughout the southeastern part of the peninsula, including the gallery forest and coastal forests (Fig. 1). The spider monkeys were difficult to observe in the wild, but using presence/absence detection we obtained a total of 13 localities where their presence was confirmed; in seven of them we obtained direct counts. Conservatively, we can assume at least one subgroup is present in each of the other six (widely separated and isolated) areas. Adding 50 to the number of individuals recorded in the southeastern gallery forested areas (74 individuals), 124 individuals was the number detected during our surveys. Applying the formula $\beta=124/(1)0.85$, I estimate a total of 145 Azuero spider monkeys remaining in the wild.

Discussion

Distribution

Cattle pasture and farmland dominate the landscape of the Azuero Peninsula, largely replacing the original forest (Heckadon-Moreno 2001). The most heavily disturbed parts are in central and northern Azuero, with urbanization more widespread and large areas of monoculture crops, besides cattle ranching (Suárez 1981). Despite this, *Alouatta c. trabeata*, generally scarce by any standards, was found to be widespread and occupied several different habitat types, from sea level to 1500 m. My results show evidence of a significant presence of Azuero howler monkeys and spider monkeys in forest patches with such as *Anacardium excelsum*, *Bursera simaruba*, *Cecropia* spp., *Ceiba pentandra*, *Enterolobium cyclocarpum*, *Ficus* spp., *Manguijera indica*, *Inga vera*, *Pachira* spp., and *Spondias mombin* (see Table 6); species that are generally conserved by the Azuerense campesinos as living fences on their cattle ranches (Méndez-Carvajal 2008). Previous reports of *A. c. trabeata* and *A. g. azuerensis* (Brandaris 1983; Rowe 2000) also found them surviving in extensively deforested areas of cattle ranches and gallery forest.

Alouatta c. trabeata is not restricted to the Cerro Hoya National Park. It would seem, on the other hand, that *A. g. azuerensis*, no longer occurs in El Montuoso Forest Reserve (EMFR), thought to be an important protected area for this species by Cuarón *et al.* (2008). The Azuero howler monkey is common in riparian forest and is often sighted moving through gallery forest, living fences and patches of forest of the natural reserves of Azuero (Méndez-Carvajal *et al.* 2004; Méndez-Carvajal 2005; Méndez-Carvajal and Ruiz-Bernard 2009). The Azuero spider monkey has been extirpated from the El Montuoso Forest Reserve (EMFR) and non-protected areas in Herrera province; it is now found only in the southern part of the peninsula, including the Mariato District (Veraguas province), Cerro Hoya National Park and La Tronosa

Table 6. Common trees species identified for the study areas surveyed and observed to be used by Azuero primates, Azuero Peninsula, Panama. A) Northern Region (l); B) Northern Region (h); C) Southern Region; D) Eastern Region; E) Western Region. Species of trees confirmed, according to Pérez and Deago (2001), Garibaldi *et al.* (2004), and Agustin Somoza in Méndez-Carvajal (2005).

Tree Species	Common name	A	B	C	D	E
<i>Amaioua corymbosa</i>	Madroño		×			
<i>Anacardium excelsum</i>	Espavé	×		×		×
<i>Apeiba tiborbou</i>	Cortezo		×			
<i>Astronium graveolens</i>	Zorro				×	
<i>Brosimum guianense</i>	Verbá		×			
<i>Bursera simaruba</i>	Carate	×	×	×	×	×
<i>Cassipourea elliptica</i>	Bocaculebra		×			
<i>Cedrela odorata</i>	Cedro amargo				×	
<i>Ceiba pentandra</i>	Ceiba			×		×
<i>Cordia alliodora</i>	Laurel				×	
<i>Dalbergia retusa</i>	Cocobolo				×	
<i>Diphysa robinoides</i>	Macano	×				
<i>Enterolobium cyclocarpum</i>	Corotú	×		×		×
<i>Ficus crocata</i>	Higuerón		×			
<i>Ficus yoponensis</i>	Higuerón	×		×		×
<i>Garcinia intermedia</i>	Madroño	×				
<i>Guazuma ulmifolia</i>	Guácimo	×		×		×
<i>Gustavia superba</i>	Membrillo	×				
<i>Inga vera</i>	Guaba	×		×		×
<i>Jacaranda copaia</i>	Jacaranda	×		×		×
<i>Miconia donaeana</i>	Palo de seno		×			
<i>Myrciaria floribunda</i>	Guayabillo		×			
<i>Ocotea dendrodefne</i>	Sigüa	×				
<i>Pachira quinata</i>	Cedro Espino			×	×	×
<i>Pachira spp.</i>	Yuco de monte			×		×
<i>Platymiscium pinnatum</i>	Quira				×	
<i>Quercus lancifolia</i>	Monterillo		×			
<i>Roupala montana</i>	Carne asada		×			
<i>Simarouba amara</i>	Aceituno		×			
<i>Spondias mombin</i>	Jobo	×		×		×
<i>Tabebuia guayacan</i>	Guayacán amarillo					
<i>Tabebuia rosea</i>	Roble				×	
<i>Ternstroemia tepezapote</i>	Manglillo		×			
<i>Viola sebifera</i>	Fruta dorada		×			
<i>Vochysia ferruginea</i>	Mayo		×			
<i>Xylopia spp.</i>	Malagueto	×				
<i>Zanthoxylum panamense</i>	Tachuelo		×			

Forest Reserve (Los Santos province) (Méndez-Carvajal and Ruiz-Bernard 2009). Deforestation and hunting has severely reduced and fragmented the ranges of *A. c. trabeata* and *A. g. azuerensis* in the region, mainly by eliminating suitable habitat, most particularly along the middle and northern parts of Azuero.

The extirpation of *A. g. azuerensis* from the El Montuoso Forest Reserve shows that its occurrence in a protected area is no guarantee of its survival. The Azuero spider monkey was hunted out by indigenous people and farmers. Hunting pressure seems to be less, however, for *A. c. trabeata*, and the howler monkey is evidently more adaptable than the spider monkeys.

The forests harboring *A. c. trabeata* and the Panamanian white-throated capuchin, *Cebus capucinus imitator*, in the southwestern part of the peninsula are classified as evergreen subtropical lowland and montane forest, but in the southeast semideciduous and largely secondary forest prevail (Garibaldi *et al.* 2004; Pérez and Deago, 2001). Important for these species and for *A. g. azuerensis* in the south is the Cerro Hoya National Park, and the riparian vegetation along the Ventana town border as far as Cambutal, then following the mangroves of the southeastern coast of Azuero mixing with the gallery forest and patches of forest near the coast in the vicinity of Tonosi, Venao, Cañas as far as Pedasi (Fig. 1.).

Population estimates for the Azuero howler and Azuero spider monkey

The population estimates for the howler and spider monkeys from Azuero have changed from previous calculations made in 2008 (Méndez-Carvajal and Ruiz-Bernard 2009). The estimate for the spider monkey has increased slightly, from 117 to 145 individuals still surviving in Azuero. That for the howlers, on the other hand has dropped with an increase in the area covered by the surveys, from 4,214 in 2008 to around 3,092 (Méndez-Carvajal 2008). Not all the locations surveyed had both species; howler monkeys demonstrated better plasticity in deforested zones, as found by Clarke *et al.* (2002) and Baumgarten and Williamson (2007). *Alouatta* does better than *Ateles* in fragmented habitats.

Population densities

Densities of *A. c. trabeata* of 0.52 individuals/km² for the northern highlands and 2.2 individuals/km² for the lowlands are evidently low when compared to estimates in other areas; for example, *A. palliata* in Los Tuxtlas, Mexico, with 23 individuals/km² (Estrada and Coates-Estrada 1996); La Selva, Costa Rica, with 12.2 individuals/km² (Fishkind and Sussman 1987), and Barro Colorado Island, Panama, with 91.7 individuals/km² (Milton 1992). One possible factor in this is that *A. coibensis* has a tendency to live in smaller uni-male-multifemale, groups than *A. palliata* elsewhere in Mesoamerica (Méndez-Carvajal and Serio-Silva 2011). The difference in population densities between highland and lowland areas may be related to lower nutrient availability at higher altitudes (600–1,559 m above sea level) where temperatures

are lower (Chapman and Balcom 1998). Morales-Jiménez (2002) found differences in group sizes for *Alouatta seniculus* in the Andes, with 3.1 individuals/group in high elevations, and 6.9 individuals/group in the lowlands, similar to our groups. Our survey found no effect of elevation on population density (Spearman rank correlation coefficient 0.045, $n=31$, $p=0.811$). For highlands in Azuero (600 m), lower densities of howlers could be caused by hunting; for food in the Sonadora area behind the EMFR (northern region, highland), and also in the Cerro Hoya National Park for traditional medicinal potions, influenced directly by the Ngäbe Buglé indigenous people (Torres de Araúz 1980).

In the eastern region, the densities of *A. c. trabeata* were 42.6 individuals/km², but much lower on the western side of Azuero at 17.2 individuals/km². This could be explained by the connectivity of living fences, widespread on the western side; allowing the monkeys to move more easily through the landscape. Even if howler monkeys adapt well to surviving in disturbed forests (Ferrari 2002), overcrowding with the lack of migration is a problem. The local people on the east side of the Azuero Peninsula are more tolerant and protective of howler monkeys and exploit the forest fragments less for such as charcoal and medicinal products.

Azuero spider monkeys with 1.4 individuals/km² for fragmented habitat suffer more from hunting pressure and the use of the forest patches by people (Méndez-Carvajal and Ruiz-Bernard 2009). Densities in this study were similar to those in other areas where they are hunted; for example, Boca de Cupe, Darien, Panama, with 3.6 individuals/km²; (Moreno-Ruiz 2006), and lower than those recorded from Tikal, Guatemala (*A. g. yucatanensis*) with 24 individuals/km² (Cant 1990). Densities of *A. g. frontatus* have been estimated at 9 individuals/km² in the Santa Rosa Natural Park, in Costa Rica (Freese 1976). Except for the Río Oria and La Miel area, the Azuero spider monkey has been found only as family groups (male, female, juvenile and infants), contrasting with a typical spider monkey sub-grouping system (Carpenter 1935; Aureli and Schaffner 2008).

Group composition: Azuero howler monkey

The Azuero howlers in the lowlands tended to have larger groups. The howlers from the Northern (lowland) community had an average of 23.8 individuals/group (15–39) (Méndez-Carvajal 2005), which is high when compared with the average of the Azuero howler populations elsewhere with 6.1–10.0 individuals/group (3–12) (Méndez-Carvajal *et al.* 2004). Due to the abundance of trees reported as potential resources for howlers in the Azuero area, we could expect them to be more abundant with larger groups in the Northern region (lowland), as was found on Barro Colorado Island (BCI) Panama. Statistical analysis of Azuero howler group structure vs. habitat size was applied in this study using Spearman's test, showing a positive correlation (-4.50 , $n=31$, $p=0.011$), confirming the hypothesis that groups in the eastern region are a slightly more connected through small patches (linear

shape home-ranges), while the Northern region groups are more isolated (Fig. 1).

Group structure presented differences in the male/female ratio, and was found to be more uni-male than multi-male, contrary to the first report of the Azuero howler monkeys in the Northern region (lowland) (Méndez-Carvajal 2005). The group composition was similar to that found for *A. c. coibensis* on Coiba Island, with 1.8 for males and 2.8 for females (Milton and Mittermeier 1977; Méndez-Carvajal *et al.* 2010b).

Group composition: Azuero spider monkey

The subgroup size average of the Azuero spider monkey, 3.8 individuals/subgroup, is comparable with that found for *A. fusciceps rufiventris* at 4 individuals/subgroup (Méndez-Carvajal *et al.* (2010a), and 3.5 individuals/subgroup for Venezuelan *A. hybridus* (see Cordero-Rodríguez and Bjord 2001). *Ateles g. azuerensis* was found in smaller groups (12 individuals/group) in forest patches in the southern area; La Miel, Flores, Oria and Cañas. Total size of groups of Azuero spider monkeys could be considered low in devastated areas if we compare them with averages found in protected areas such as Calakmul Reserve or Quintana Roo, Mexico (28.5 individuals/group) (Ramos-Fernández *et al.* 2003; Estrada *et al.* 2004), Barro Colorado, Panama (24 individuals/group) (Di Fiore and Campbell 2007) and *Ateles fusciceps rufiventris* from Chucanti-Darien, Panama, with average of 30 individuals/group (Méndez-Carvajal *et al.* 2010a).

Conservation Status

Deforestation has been the principal threat to these subspecies. Land use in Azuero is agricultural. If the region is well supported economically, based on small, medium or large businesses, subsistence hunting could be minimal. Previous questionnaires given out before the start of this project in 2001 found that monkeys are not a vital resource for Azuero locals (Ruiz-Bernard *et al.* 2010). Environmental education and awareness programs informing the communities of the value of their forests and living fences, and of the ecological role of the primates, could be highly positive for the conservation of the region's primates. It will be important to set up a permanent monitoring program for the two primates and their habitats.

Our informal interviews with the people from the communities revealed two issues of relevance: (1) the lack of any informative material that values the region's fauna and flora, and (2) the lack of interest in protecting wildlife, especially these monkeys which are considered to be little more than crop pests. The Fundación Pro-Conservación de los Primates Panameños (FCPP) has been offering educational talks to elementary schools and colleges to create a basic conservation understanding for the future generations of the Azuero people (Ruiz-Bernard *et al.* 2010). FCPP is still monitoring the groups found in the natural reserves of Azuero.

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