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BRIEF REPORT

Density Estimates of Panamanian Owl Monkeys (*Aotus zonalis*) in Three Habitat Types

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The resolution of the ambiguity surrounding the taxonomy of *Aotus* means data on newly classified species are urgently needed for conservation efforts. We conducted a study on the Panamanian owl monkey (*Aotus zonalis*) between May and July 2008 at three localities in Chagres National Park, located east of the Panama Canal, using the line transect method to quantify abundance and distribution. Vegetation surveys were also conducted to provide a baseline quantification of the three habitat types. We observed 33 individuals within 16 groups in two out of the three sites. Population density was highest in Campo Chagres with 19.7 individuals/km^2 and intermediate densities of 14.3 individuals/km^2 were observed at Cerro Azul. In la Llana *A. zonalis* was not found to be present. The presence of *A. zonalis* in Chagres National Park, albeit at seemingly low abundance, is encouraging. A longer-term study will be necessary to validate the further abundance estimates gained in this pilot study in order to make conservation policy decisions. Am. J. Primatol. 72:187–192, 2010.

Key words: night monkey; dourocouli; Platyrhini; Chagres National Park; densities; line transects

INTRODUCTION

Since its first scientific description by the Spanish naturalist Félix de Azara in 1802 the taxonomy of *Aotus* has been debated, with various arrangements on the number of species and subspecies [Fernandez-Duque, 2007]. Although currently many favor a more speciose arrangement, the taxonomic status and distribution of many taxa are still ambiguous [Defler & Bueno, 2007]. This is particularly true for Mesoamerican owl monkeys, whose distribution is principally based on the reported locations of museum specimens [Rylands et al., 2006]. This uncertainty may hamper conservation efforts, as knowledge of both taxonomy and distribution are essential in assessing the conservation status of *Aotus*. The owl monkeys of Panama, currently identified as *A. zonalis* [Defler et al., 2001; Defler & Bueno, 2003; Goldman, 1914], are a case in point.

As is the case with most primates, owl monkeys are threatened by habitat loss [Strier, 2007]. Of 11 *Aotus* species included on the most recent IUCN Red List, the four possibly best-studied taxa (*A. brumbacki*, *A. griseimembra*, *A. lemurinus*, *and A. mic*onax) are listed as Vulnerable. Of the other seven, five are listed as Least Concern, and two as Data Deficient [IUCN, 2008]. This latter category is probably more appropriate for six of these taxa due to lack of research (*A. jorgehernandezi*, *A. nancymaae*, *A. nigriceps*, *A. trivirgatus*, *A. vociferan*, and *A. zonalis*). *A.azarae* belongs to the more well-studied species of *Aotus* [e.g. Morales-Jiménez et al., 2008]. *A. zonalis*, occurring in a small region of western Colombia, Panama, and possibly into Costa Rica, is one of the two listed as Data Deficient [Cuarón et al., 2008; Goldman, 1914; Hladik et al., 1971; Moynihan, 1964; Samudio, 1991].

Deforestation is becoming an increasing problem in the Neotropics, and in Panama is consistently linked with rural development [Robinson & Redford, 1991]. Slash and burn agriculture is a commonly occurring practice to cultivate crops such as yucca, rice, or corn [Robinson & Redford, 1991]. These processes have led to a 50% decrease of the virgin forest in Panama since the 1950s and today virgin forests cover 40.6% of the country [Robinson & Redford, 1991; Food and Agriculture Organization of the United Nations, 2006]. An exception is Chagres

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National Park (Chagres NP) in central Panama (Fig. 1), where deforestation appears to be a less significant threat, with 84% of forest remaining [National Environmental Authority, 2005]. In an attempt to encourage the government to maintain this level of protection, a local NGO SOMASPA has initiated rapid surveys of mammal species in the area. Here we present the results of a survey of *A. zonalis* in three areas of Chagres NP. We provide preliminary assessments of habitat availability in each area, as well as the first density estimates of this species.

METHODS

Vegetation Assessment

We selected three forest ecosystems within the National Park: lowland semi-deciduous forests (Campo Chagres), lowland moist-wet forest and higher-elevation cloud forest (la Llana), and secondary highland gallery forest (Cerro Azul) (Fig. 1, Table I). These areas were chosen to see whether differences in population densities of *A. zonalis* could be found between different habitats.

We sampled vegetation using point-quarter sampling [Ganzhorn, 2003]. We sampled 39 plots (13 per ecosystem), randomly along transects. In these plotless samples we measured 156 trees and covered 0.25 ha of forest. Local researchers with extensive botanical knowledge identified tree species. A tree was defined as having a diameter at breast height (DBH) ≥ 10 cm; dead trees and trees having <10 cm DBH were not counted [Ganzhorn, 2003]. For each plot, we calculated average DBH, canopy cover, basal area ($CBH^2/4\pi$), tree density, and species composition [Nekaris et al., 2005]. These figures generated relative density, dominance, and frequency. Density refers to the number of individuals per unit area, dominance to the basal area, and frequency to the fraction of sample plots containing the species. For each species in our plots, we then calculated relative density, relative dominance, and relative frequency, which show the percentage of the individual species' value with respect to the total for all tree species. We then combined these values into a single importance value. The closer the value is to 100, the more important the species is in the community [Kent & Coker, 1996]. Canopy cover was measured in each of the four quadrates in all plots, yielding 52 measures, by using a vertically held viewing tube equipped with a grid at the far end, with percentage of coverage estimated by counting the percent of grid cells filled [Ganzhorn, 2003].

Owl Monkey Density Assessment

Svensson and one to two field assistants conducted the field study between May and July 2008

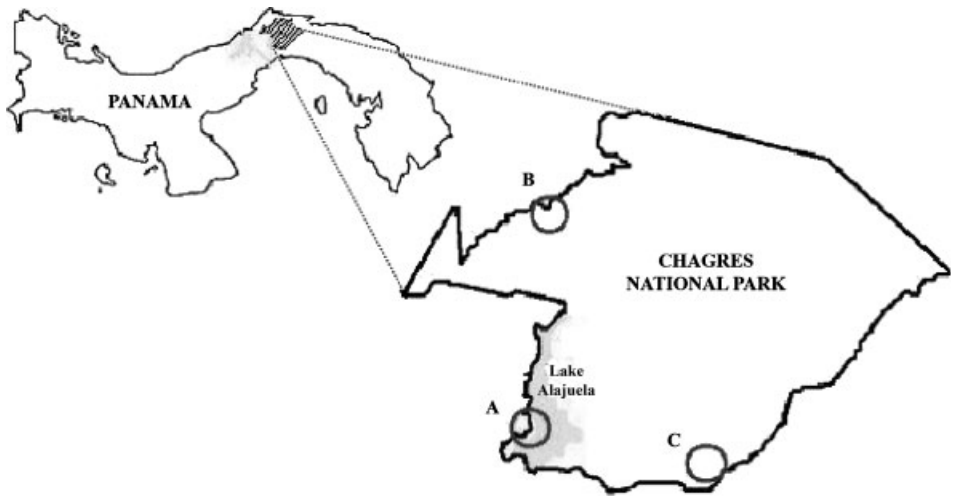

Fig. 1. Map of Chagres National Park's location within Panama and the three study sites inside the park (A, Campo Chagres; B, la Llana; C, Cerro Azul).

TABLE I. Overview of the Three Study Sites in Chagres National Park Surveyed During This Study

	Campo Chagres	La Llana	Cerro Azul
Coordinates	079°35′W, 09°12′N	079°35′W, 09°26′N	079°23′W, 09°11′N
Forest type	Semi-deciduous lowland	Lowland moist-wet forest/higher-elevation cloud forest	Secondary gallery highland
Protection status[a]	Intensive use zone	Special use zone and total protection zone	Active cultural zone
Altitude (m)	100–140	300–800	500–750

[a]Chagres NP is divided into six management zones.

using line transects [Aquino & Encarnación, 1994]. Because little is known about the activity pattern of *A. zonalis*, we maximized time in the forest by walking transects either between 18:00–00:00 hrs or between 03:00–06:00 hrs. We selected the transect to walk from a random number table [Struhsaker, 1981]. Each site was visited more than once, with several weeks separating the visits. We visited Campo Chagres twice, each time surveying five 2.5 km transects. We visited la Llana twice; eight 3 km transects were surveyed. Each visit, we walked three novel transects, while repeating one. We visited Cerro Azul three times; we walked four 2 km transects. Two of these we walked twice, and the other two we walked three times each. We walked each transect on a separate night.

Following established methods for nocturnal surveys, we constantly scanned vegetation along transects, walking at an average speed of 800 m/hr [Evans et al., 2000]. We paused for 5 min every 100–200 m to listen for calls, and to conduct more detailed searches using a headlamp and binoculars [Charles-Dominique, 1977]. Survey data included group size and structure, time of sighting, perpendicular distance of first animal to the transect and its height [Brockelman & Ali, 1987]. We precisely measured all distances and angles with a measuring tape, compass, clinometer, and GPS (Garmin MAP 60CSx). We measured strip width of transects based on how far the light of a headlamp would reach a reflective post in the different forest types [Charles-Dominique, 1977]. We calculated density using the formula: $D = n/2lw$ (D = density; n = number of *A. zonalis* sighted; l = transect length; w = effective strip half width) [Brockelman & Ali, 1987]. As previous studies suggested *Aotus* is more active during bright moon nights [Erkert & Gröber, 1986; Fernandez-Duque, 2003], we focused our transect efforts at this time, walking 27 out of 30 transects when the moon was present (risen).

We strictly adhered to ethical guidelines approved before research, laid out by Oxford Brookes University Ethics Committee (www.brookes.ac.uk/res/ethics). The National Environmental Authority of Panama issued the research permit.

Analysis

Descriptive parametric statistics, including the mean and standard deviation, were used to describe habitat characteristics. Owing to small sample sizes, for comparison of vegetation data and encounter rates between sites, we employed the nonparametric Kruskal–Wallis one-way analysis of variance by rank [Zar, 1999]. We used Microsoft Excel to calculate importance value indices.

RESULTS

The total number of tree species identified was 41 but in all three sites there were an abundance of trees where identification was not possible (Table II). The site with the highest species richness was Campo Chagres with 20 tree species enumerated and identified. La Llana and Cerro Azul had a species richness of 17 and 13, respectively. Out of the trees identified at Campo Chagres 31% were hardwood species, 55% at la Llana, and at Cero Azul 23%.

We found a significant difference in tree density per hectare and mean canopy cover between the three sites (Table II). The tree density was highest in Cerro Azul with an average of 1236.0 trees/ha. Average tree density at la Llana was 995.4 trees/ha and in Campo Chagres 394.7 trees/ha. La Llana had the highest mean canopy cover of 87.3%, followed by Campo Chagres with 70.4% and Cerro Azul with 52.7%.

We found no significant difference in mean basal area of trees between the sites (K–W: $\chi^2 = 5.565$, df = 2, $P > 0.05$). There was also no significant difference on mean DBH of trees between the three sites (K–W: $\chi^2 = 5.344$, df = 2, $P > 0.05$).

We spent 92 hr surveying 75.4 km of transects in Chagres NP (Table III).

TABLE II. Habitat Parameters for Each Site

Parameter	Campo Chagres	La Llana	Cerro Azul
Species richness (unidentified sp)	20 (3)	17 (9)	13 (7)
Density (per ha)	395***,a	995***,a	1236***,a
Canopy cover (%)	70 ± 23***,b	87 ± 7***,b	52 ± 10***,b
DBH (m)	0.35 ± 0.16	0.30 ± 0.14	0.22 ± 0.08
Basal area (m^2 per site)	0.18 ± 0.22	0.11 ± 0.13	0.05 ± 0.03
Species with the highest Importance value index	*Bursera simarouba*: 64.9 *Astronium graveolens*: 49.4 *Spondias mombin*: 41.3	*Anacardium excelsum:* 53.5 *Inga* sp: 40.9 *Manilkara sapota*: 39.6	*Zuelania guidonia*: 75.1 *Calycophyllum candidissimum*: 39.1 *Inga* sp.: 30.5

Those with significant differences based on Kruskal–Wallis tests are marked with ***($P \leq 0.001$). All average values include standard deviation (±). Values are based on 13 plots for each site, yielding 52 trees and measures of canopy cover each.
[a]K–W: $\chi^2 = 19.90$, df = 2, $P \leq 0.001$.
[b]K–W: $\chi^2 = 17.16$, df = 2, $P \leq 0.001$.

TABLE III. Encounter Rates and Transect Information

	Campo Chagres	La Llana	Cerro Azul	Total across the three sites
Total distance (km)[a]	25.4 ($n = 10$)	30 ($n = 10$)	20 ($n = 10$)	75.4
Number of *Aotus*	25	0	8	33
Presence/absence	Present	Absent	Present	–
Strip width (m)	50	24	28	34
Individuals/km^2	19.7^{***,b}	0^{***,b}	14.3^{***,b}	13.2
Groups/km^2	9.5	0	7.1	6.3
Average group size	2.1	0	2.0	2.1

We found a significant difference between the encounter rates in the three different forest habitats. Those with significant differences based on Kruskal–Wallis tests are marked with $^{***}(P \leq 0.001)$.
[a]n = number of transects walked at the site.
[b]K–W: $\chi^2 = 15.3$, df = 2, $P \leq 0.001$.

No *A. zonalis* were detected at la Llana. *Aotus* were observed at Campo Chagres with 25 individuals in 12 groups, at altitudes of 100–140 m above sea level (a.s.l.). In Cerro Azul we observed eight individuals in four groups at 630–690 m a.s.l. Mean group size was 2.1 ± 0.1 animals (range: 1–4), almost always adult pairs. We observed an infant within the groups four times, and a juvenile once.

The average height of *A. zonalis* in Campo Chagres was 9 m (range: 3–20 m) and 13 m (range: 4–21 m) in Cerro Azul. Of 11 nights when the 16 encounters of *A. zonalis* occurred, the moon was absent on two nights.

Our 16 sightings of *A. zonalis* occurred in seven tree species (on three sitings the tree was unidentifiable). Nearly half of sightings occurred in two species: *Gustavia superba* (Lecythidaceae) ($n = 4$) and *Spondias mombin* (Anacardiaceae) ($n = 3$). Of the nine species with the highest IVI across the three sites, *A. zonalis* was only sighted in *S. mombin*.

We heard *A. zonalis* call nine times, but did not see the calling individual. Because of ambiguity of additional calls that may or may not have been *Aotus*, we only included sightings in our density estimates. Three additional groups of *A. zonalis* were observed opportunistically within 20 m of the ranger stations in Cerro Azul and Campo Chagres.

DISCUSSION

We confirmed the presence and assessed the density of *A. zonalis* in three areas of Chagres NP. Previously only anecdotal evidence of *Aotus* in the area existed [Samudio, personal communication]. We found the species to be absent from la Llana and most abundant in Campo Chagres.

Aotus have been found to inhabit areas with relatively dense canopy and high plant species diversity [Aquino & Encarnación, 1994; Kinzey, 1997]. Although our vegetation survey was preliminary, our study does not follow this trend as no *A. zonalis* were observed in la Llana, which had the highest mean canopy coverage and high average tree density (Table II). The absence of *Aotus* in la Llana might be due to the predominance of hardwood trees (55%), particularly *Anacardium excelsum* (Anacardiaceae) and *Manilkara zapota* (Sapotaceae). The northern grey-necked *Aotus* group (*A. brumbacki*, *A. lemurinus*, *A. griseimembra*, *A. trivirgatus*, *A. vociferans*, and *A. zonalis*) is known to display strong selectivity of habitat and almost exclusively utilize tree holes as sleeping sites. The abundance of hardwood tree species therefore may present fewer suitable nesting sites for *A. zonalis* in terms of tree hollows [Aquino & Encarnación, 1988; Hershkovitz, 1983]. Another possible explanation for the lack of *Aotus* sightings in la Llana could be the comparatively denser and less disturbed forest at the site, causing reduced visibility. The presence of *A. zonalis* in Campo Chagres and Cerro Azul may be related to the presence of important food trees. Indeed, genera with high importance values, including *Spondias*, *Inga*, and *Calycophyllum* are known to be important food sources to other species of the genus [Aquino & Encarnación, 1986; Garcia & Braza, 1993; Puertas et al., 1995; Dogiramá, personal communication].

Our findings yield interesting comparisons with other studies that can help to plan further surveys for *A. zonalis*. The use of height at Chagres NP was similar to findings from Barro Colorado Island in Panama [Moynihan, 1964]; it is key to scan all levels of the forest when searching for this genus [c.f. Evans et al., 2000]. Censuses on other *Aotus* species suggested that they are best conducted from 18:00 to 21:00 hr and/or 3:00 and 6:00 hr, as the species were most active at those times [Aquino & Encarnación, 1994; Wright, 1994]. In our study, however, we encountered *Aotus* until 23:30. We did not conduct censuses between 00:00–02:59. It is possible that *A. zonalis* was active during that time and therefore, our census schedule may have influenced our results. Indeed, for other nocturnal species such as lorises (*Nycticebus* sp), covering all hours of the night has proven to be vital for accurately estimating abundance [Nekaris et al., 2008]. The majority of transects in this study were walked on nights where the moon was present. We did however observe *A. zonalis* on moonless night as well on two

occasions. In future studies it might be beneficial to include surveys on nights when the moon is absent as well as nights with the moon present.

Although groups of two individuals were most common, a group of four was seen on one occasion in Cerro Azul. Groups of three individuals were observed on three occasions at Campo Chagres. The groups consisted of two adults with one infant, and in the larger group also a juvenile. Based on our census, 25% of the *A. zonalis* groups at both sites had reproduced.

During all encounters of family groups ($n = 4$), infants were carried by an adult. Although the sex of the carrier could not be determined, we were able to identify that in one of these cases, a lactating females was *not* carrying the infant. If the behavior of *A. zonalis* is similar to other *Aotus* species [Fernandez-Duque et al., 2008; Rotundo et al., 2005; Wright, 1990], it is possible that the adult carrying the infant was a male. Our average group numbers were smaller than found in previous studies, but this could be due to the short-term nature of our survey with unhabituated groups.

Distribution of *A. zonalis* in the more disturbed areas of Panama is still unknown, and efforts to understand its conservation status are long overdue. The densities in our study fall in the mid to upper range of previous work on this genus [Fernandez-Duque, 2007], meaning that Chagres NP may provide an important haven for this species in Panama. Chagres NP recently updated their management plan aiming to improve research, protection, and management of biodiversity over the next 5 years, including the areas of Campo Chagres and Cerro Azul [National Environmental Authority, 2005]. We hope that the data presented here will provide the baseline information for a longer-term study on this primate species.

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