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Population Study of Coiba Howler Monkeys (*Alouatta coibensis coibensis*) and Coiba Capuchin Monkeys (*Cebus capucinus imitator*), Coiba Island National Park, Republic of Panama

Pedro Mendez-Carvajal*

Fundacion Pro-Conservacion de los Primates Panamenos (FCPP), Republica de Panama 0816-07905, Panama

Abstract

The Coiba howler monkey (*Alouatta coibensis coibensis*), and the capuchin monkey (*Cebus capucinus imitator*), are both living at Coiba Island, southwestern Panama, Central America. They are considered Vulnerable and Least Concern respectively by the International Union for Conservation of Nature (IUCN). I carried out population surveys of the two subspecies from May to July 2009 and revisited on May to September 2010. The study covered potential habitats for these primates in the four points of the island. Surveys determined their occurrence and densities in each area. In all, 850 hrs were spent in survey activities. I used two methods: 1) triangulations based on vocalizations; 2) strip-transect censuses. One hundred and nine Coiba howler monkey groups were detected and counted, totaling 472 individuals remaining in the wild with a mean of 4.3 individuals/group (range: 2–5). For the capuchin monkey, 626 individuals in 58 groups with a mean of 10.75 individuals/group (range: 5–16) were detected. Factors related to small group size for howler monkeys on Coiba Island are not known, but could be related to dietary resources throughout the year or seasonally, particularly ripe fruits. For capuchins monkeys, survivorship could be better than for *Alouatta* due to the wide range diet these monkeys could reach, this include arthropods, coconut and seeds of tea mangrove *Pelliciera rhizophora*.

The primates of Coiba are not exposed directly to hunting activities but their population needs to be monitored and studied in-depth to better understand their dynamics and behavioral adaptations to this island habitat.

Keywords: *Alouatta coibensis coibensis*; *Cebus capucinus imitator*; Coiba howler monkey; Coiba Island; Population; Conservation; Primates; Panama

Introduction

The Coiba howler monkey (*Alouatta coibensis coibensis*), is an endemic and little studied Neotropical monkey species with an isolated distribution consisting only of Coiba Island and Jicaron Island, both part of the Coiba Island National Park, Chiriqui Gulf, Panama [1-4]. Coiba is the second largest island in the Mesoamerican Pacific Ocean; it is located at 7° 10'04" to 7° 53'37"N and 8° 32'37" to 8° 56'15"W, with a size of 56 km² [1]. The island possesses an almost virgin forest in the category of insular tropical rain forest, with irregular topography and a richness of endemic fauna [2,3]. The Coiba howler monkey (*A. c. coibensis*) and Coiba capuchin monkey (*Cebus capucinus imitator*) are the only two non-human primates found on the island, a location which was used as a penal colony since 1919 to 2003. In addition to slight forestry activities, the penal colony cleared 20% of the forest for agricultural purposes (mainly providing food for the prison). Over the past century, in so far as is known, the only human-induced population pressures for either primate species were due to the occasional bushmeat hunting and deforestation activities practiced by the prisoners. There is no population estimates taken before and after the island's use as a penal colony, and these species are either *A. c. coibensis*, classified as Vulnerable and *C. c. imitator* as Least Concern by the International Union for Conservation of Nature (IUCN) [4].

In 1983, while the island was still in use as a penal colony, the Spanish Agency of International Cooperation (AECI) commenced the first scientific research on the island [5]. Between September 2001 and June 2002, the government of Panama in collaboration with the Environmental Authority of Panama (ANAM), Asociacion Nacional para la Conservacion de la Naturaleza (ANCON), the Smithsonian Tropical Research Institute (STRI), and the Instituto Panameno de

Turismo (IPAT) took steps toward creating a biological field research station, whose initial work included biodiversity surveys. In addition, these efforts were supported by Secretaria Nacional de Ciencia y Tecnologia (SENACYT) and The Nature Conservancy (TNC). As the area was restricted by authorities until 2003, scientific documentation of Coiba's biodiversity was inconsistent. Today, Coiba Island is considered as a biodiversity hotspot due to its high endemism, including the presence of the endemic howler monkey, agouti, *Dasyprocta coibae*, a subspecies of white-tailed deer, *Odocoileus virginianus rothschildi*, and many others including marine fauna, birds and plants [6-8]. To date, few studies have focused on the mammals of Coiba [2,6,9,10]. The future of Coiba Island is now projected to be an important one which will include extensive tourist activities (e.g., coral diving, cruise visits and jungle exploration trips). At present, effort is focused on procedures to guard and protect the land and marine resources from illegal activities such as commercial fishing and logging [1].

Population surveys of the Coiba Island monkeys have not been conducted since 1977, a study that concluded small group size and a low infant rate among the Coiba howler monkeys compared to their mainland conspecifics in Panama. This could indicate a difference

*Corresponding author: Pedro Mendez-Carvajal, Fundacion Pro-Conservacion de los Primates Panamenos (FCPP), Republica de Panama 0816-07905, Panama, E-mail: fcprimatespanama@gmail.com

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of group size related to the species itself, or could have been due to potential hunting pressure or a circumstance of seasonality. Based on this previous research, it was important to obtain data pertaining to their actual population status to determine if these primate populations are declining, set baselines for future research, and monitor their conservation and ecology. Population studies of primates and other mammal species are important to document their current status, and obtain information about their densities, group structure and population dynamics [11]. Such information is helpful in assessing the suggested conservation plans for Isla Coiba National Park and documenting the population trends of the island's primate species [12]. As a part of an ecological study, to better understand the population dynamics of the Coiba primates, I carried out an island-wide survey of both species.

Methods

Study area

Research was carried out in the humid tropical forest of Coiba Island, Panama. This island lies some 55 km off the southwest coast of Veraguas Province, Panama. Eighty-five percent of the forest cover on the island is regarded as primary forest; in the lowland, trees can attain a height of 30 m high with some emergent trees reaching up to 50 m in height. The island also has some pre-montane forest with a maximum elevation of 200 m.a.s.l. [13]. Vegetation is composed largely of members of the following families: *Leguminosae*, *Rubiaceae*, and *Melastomataceae*. Common lowland tree species include *Calophyllum longifolium*, *Eschweilera pittieri*, *Cassipourea elliptica*, and *Ternstroemia tepezapote*, while highland species include *Calophyllum longifolium*, *Tetragastris panamensis* and *Carapa guianensis*. The island also has mangrove stands (*Rhizophora mangle* and *Conocarpus erectus*) along some parts of the coasts, interconnected with wetland stands of *Prioria copaeifera* [5]. Annual precipitation averages is 3500 mm, with a rainy season between May and December and dry months between January and April. Temperature can exceed 30°C, but the average is a fairly constant 26°C. Coiba Island has ca. 20% of the original vegetation altered due to past logging activities around the major camps of the penal colony and there are a large number of feral animals including horses, pigs, dogs, buffalo and over 2,000 cattle estimated to be on the island [14].

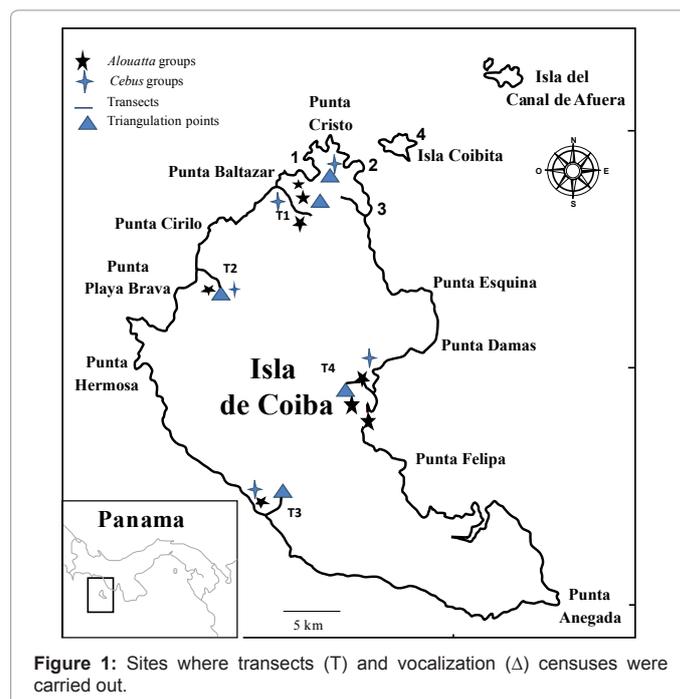
Surveys

Two methods were used to carry out this survey, the Triangulation method and the Strip Transect method. Triangulation utilizes the establishment of three different listening points forming an approximately equidistant triangle [15,16] with each researcher recording a compass bearing on any howling that occurs, noting down the time. Compass readings are then plotted along with time of howling, whereby intersecting lines would denote a group of howler monkeys [17,18]. In our study, detections of howling were carried out between: 5:30-7:00, 12:00-14:00, and 17:00-19:00 hrs. Even though we recognize that many groups may not vocalize at noon as they typically do, it increased our probabilities for recognizing any new group or confirming those detected earlier. Each triangulation point was mapped and analyzed to eliminate points where the compass bearing coincided with previous groups recorded. We camped at five different sites around Coiba Island for a minimum of five days (see Figure 1). We utilized 12 listening points in total for different triangulation areas, each point with a 1 km distance from each other point into the forest (Figure 1). Triangulation methods have been used in the past to detect howler monkeys at other locales, including Barro Colorado

Island [17], Azuero Peninsula [19], and in Colombia [16]. Densities by Triangulation were calculated using $D = fn/A$, where D = is the relative density, n = is the number of groups detected vocalizing in a sampling period, f = is the conversion factor considering that not all the groups can be perceived, and A = listening area.

We also utilized the Strip Transect method for censuses, using six transects, each 1 km long and 40 meters wide. Pre-established straight transects were walked each at morning between 06:30 to 12:30 hrs, and 14:00-18:00 hrs, and all sightings of primates and any vocalization activities at any time during these periods were recorded [20]. Coiba Island was visited once per month for a three-month period between May and July 2009 with a total effort of 850 survey hrs per 30 day survey. Walking speed was 0.5 km/h with an approximate 10 min stop each 100 m. The island was revisited in May and September 2010, and new transects were established within four new areas according to the topography and trails previously demarcated. These transects were used to enter into the forest to set our triangulation base 1 km from the coast, so they were not overlapped with the triangulation area, both species of monkeys are sympatric in the total range of the island, so probabilities of finding these species are even. New transects were laid out at the following localities: Cerro Equis (Transect 1, NW), Playa Rosario (Transect 2, NW), La Falla (Transect 3, SE), Los Pozos (Transect 4, E) (Figure 1). These areas were chosen to complete a semi-random evaluation in the four cardinal points of the island, all with the same vegetation and potential for primate observations. Further reasons these points were selected were due to accessibility and the previously used trails utilized by prior scientists.

Identification of individuals used the following criteria: For howler monkeys, adult males were recognized for their long beard and presence of testicles, adult females were identified as same body size of male and presence of vulva, while juveniles and infants were identify by their size and independency from the mother. For infants and juveniles of this species it is not possible to visually detect sex until adult age, so minimal data were collected on this. For capuchin monkeys, adult



males were recognized by their body size and presence of testicles, while adult females were also recognized by body size, presence of vulva, or if holding an infant. Juveniles and infants were not sexed due to fast movement, dense canopy and distances of the groups; however, this was not of relevance to our primary objectives. The densities for Strip Transect detections were calculated using the following equation: $D = \Sigma n / 2LW$, where: D = density; Σn = the sum of the total individuals observed, and $2LW$ = the longitude multiplied by two times the width of the transect [18].

Results

Alouatta coibensis coibensis

Triangulation results: Seven Coiba howler groups were encountered and counted directly with a mean of 4 ind/group (range 2-5 individuals per group). In total, 33 individuals were seen and counted including 15 adult males (this total includes 4 satellite or solitary males), 10 adult females, 3 juveniles, 2 infants and 3 unidentified individuals. Male/female sex ratio was estimated at 1:0.9, mean group proportions were estimated at 0.36 males, 0.34 females, 0.1 juveniles, and 0.06 infants (0.1 of the sample was not seen well enough to determine age or sex) (Table 1). Locations of the seven groups are shown in Figure 1. We estimated 7.2 groups for T1, 1.8 for T2, 5.4 for T3, and 1.8 groups for T4, average density for the entire island is calculated as 4.1 groups/km² (Tables 2, 3).

Strip transect: Densities were calculated as 0.10 ind/km² for

Transect 1	Group	Age and sex composition					Total
		♂	♀	J	I	NI	
Cerro Equis	A1	1	1	1	-	1	4
	A2	1	2	2	-	-	5
	A3	2	1	-	-	1	4
	Satellite	3	-	-	-	-	3
Total		7	4	3	-	2	16
Transect 2	Group	♂	♀	J	I	NI	Total
Playa Rosario	B1	2	1	-	-	-	3
	Satellite	1	-	-	-	-	1
Total		3	2	-	1	-	6
Transect 3	Group	♂	♀	J	I	NI	Total
La Falla	C1	2	2	-	1	-	5
	Satellite	1	-	-	-	-	1
Total		3	2	-	1	-	6
Transect 4	Group	♂	♀	J	I	NI	Total
Los Pozos	D1	1	1	-	-	-	2
	D2	2	2	-	1	1	6
Total		3	3	-	1	1	8
Complete Total*	7	11	10	3	2	3	*29/ 33
Averages	-	1.6	1.4	0.4	0.2	0.4	4.3
Proportions	-	0.3793	0.3448	0.1	0.0689	0.1	1
SD	-	0.71	0.53	0.71	-	-	

*Total males per group, averages and proportions do not include satellite males detected. SD=Standard deviation. ♂=Adult male. ♀=Adult female, J=juvenile, I=infant, NI=not identified.

Table 1: Group composition of *A. c. coibensis* observed between June 2009 and Sept. 2010 on Coiba Island, Panama.

Transects	Effort (hrs)	Area (km ²) 2LW	Groups sighted by Strip Transect	Relative Abundance (ind/km ²)
T1	220	25	3	0.10
T2	200	40	2	0.05
T3	190	25	2	0.08
T4	240	25	2	0.08
Total	850	115	9	0.08

Table 2: Effort invested and relative abundance of *A. c. coibensis*, Coiba Island at Coiba Island National Park, Panama, using Strip Transect.

Triangulations	Effort (hrs)	Area (km ²)	Groups detected by Triangulation	Relative Abundance (groups/km ²)
T1	220	0.2	2	7.2
T2	200	0.4	1	1.8
T3	190	0.4	3	5.4
T4	240	0.4	1	1.8
Total	850	1.4	7	4.1

Table 3: Effort invested and relative abundance of *A. c. coibensis*, Coiba Island at Coiba Island National Park, Panama, using Triangulation.

transect T1, 0.05 ind/km² for T2, and 0.08 ind/km² for T3 and for T4. A total average density calculated as 0.08 ind/km² for the entire island, I obtained an estimate of nine groups with three satellite adult males.

An estimate of total population size for Coiba Island howler monkeys was obtained using the average density of 4.1 groups/km² (found in the compilation of our four triangulation areas) and multiplying this average density with the total area of the island suitable for howler monkeys (27.8 km²). Because not all the vegetation on Coiba is suitable for howler monkeys, I eliminated the 20% of deforested zone previously dedicated to cattle and farming activities (11.2 km²), in addition to the mangrove forest (18 km²). Thus, a high estimate provides us with a total of approximately 109.88 howling monkey groups on Coiba Island. Multiplying the total number of groups by average group size (4.3 ind/group), provided a rough population estimate of 472 howler monkeys for the entire island.

Cebus capucinus imitator

In 850 hours of data collection, four groups of capuchin monkeys were detected, with average of 10.75 individuals (range 5-16) per group. Identification of individuals was difficult due to the forest height, rapid leaping movements, and canopy cover. In total, 43 individuals were counted, including 5 adult males, 4 adult females and 5 juveniles; we also counted 29 unrecognizable individuals (Table 4). No infants were recorded most likely due to observation difficulties. An estimate of total population size for *C. c. imitator* was obtained using the average groups detected (1.3 ind/km²) and multiplying this by the average density of 10.75 individuals/group, then multiplying this amount for the total area of viable habitat: mature and secondary forest plus mangroves (44.8 km²) (Table 5). I estimate the total population of capuchins monkey on Coiba Island is approximately 626 individuals. Densities for *C. c. imitator* were calculated by using Strip Transects, with 0.4 for T1, 0.25 for T2, 0.25 and 0.43 individuals/km² for T4. A total density of 0.33 individuals/km² was estimated for the entire island. Calculation of Densities used for *C. capucinus* utilized the formula: $D = \Sigma n / 2LM$; $D = 43 / 120 = 0.36$ individuals/km² (Tables 4 and 5).

Discussion

Alouatta coibensis coibensis

Based on Strip Transect data, our survey indicates a density of

Transect	Groups	Age and sex composition					Total
		♂	♀	J	I	NI	
T1	1	-	-	1	-	15	16
T2	2	-	-	-	-	10	10
T4	3	1	-	-	-	4	5
T4	4	4	4	4	-	-	12
Total	-	5	4	5	-	29	43
Average*							10.75

*Averages were not possible to calculate for group structure. ♂=Adult male, ♀=Adult female, J=juvenile, I=infant, NI=not identified.

Table 4: Group composition of *C. c. imitator* observed at Coiba Island, Coiba Island National Park, Panama.

Transects	Effort (hrs)	Area (km ²) 2LW	Individuals	Groups	Relative Abundance (ind/km ²)	Relative Abundance (groups/km ²)
T1	220	40	16	1	0.4	0.03
T2	200	40	10	1	0.25	0.03
T3	190	25	-	-	-	-
T4	240	40	17	2	0.43	0.05
Total	850	145	43	4	1.08	0.11
Averages			10.75	1.3	0.36	0.03

Table 5: Effort invested and relative abundance of *C. c. imitator*, Coiba Island at Coiba Island National Park, Panama.

0.08 individuals/km² of *A. c. coibensis*. This estimate falls below the mean reported for this species in El Montuoso Forest Reserve for *A. c. trabeata* in the northern Azuero Peninsula with 6.1 individuals/km², and 2.2 individuals/km² for the conspecifics at Cerro Hoya National Park in the southern Azuero Peninsula in Panama [21]. The density of groups per area was 4.1 individuals per km², with a group size of 4.3 individuals, an estimate that was slightly lower than the group average estimated previously in 1977 [9]. This small group size is similar to the average group size reported for *A. caraya*, *A. seniculus*, *A. guariba*, and *A. pigra*, as well those reported for *A. c. trabeata* [9,22-25], and far smaller than average group size generally reported for *A. palliata* [17]. Factors related to small group size for howler monkeys on Coiba Island are not known, but could be related to their biology as a different species, seasonally available dietary resources, and in particular ripe fruits. Studies of Coiba's flora indicate that this island is poor in tree species diversity per km², as compared with Barro Colorado Island and various other study sites throughout Mesoamerica [26]. Most of the fruits are hard-covered with woody capsules from predominant larger trees in species such as: *Sterculia apetala*, *Carapa guianensis*, *Pachira quinata*, *Prioria copaeifera*, *Couratari panamensis*, *Eschweilera pittieri* [9,13,26]. Studies related to group size of *Alouatta* spp. demonstrate that group size may be affected if animals must travel extended distances to obtain essential resources [27]. As larger groups of primates typically show larger day ranges, small group size would travel less distance and help to conserve energy [28]. It is known that the population size of a species will be directly related with the availability of alimentary resources in the habitat [29].

Cebus capucinus imitator

Capuchins presented low group densities and similar individual densities with 0.03 groups/km² and 1.3 ind/km², compared with previous data obtained [9]: 0.92 ind/km² in southern Coiba, 0.09 ind/km² from Barro Colorado Island [30], and also 0.52 ind/km² for Las Pavas, Panama Canal [Pers. Obs.]. Due to their diurnal activity, speed of travel, and variety of food that these monkeys demand, densities could be inaccurate in some way depending on time of day

and preferences for specific foraging areas. In Coiba, capuchin groups would spend multiple days foraging in an area close to the mangrove forest, eating *P. rhizophora* [Pers. Obs.]. Average capuchin group size is 10.75 individuals/group, which fall in the range (i.e. 12-20 ind/groups) previously denoted by Milton and Mittermeier in 1977 [9], and into the typical range compared with other *Cebus* species like *C. olivaceus* with 12-32 individuals/group and *C. apella* with 14 individuals/group [31]. Survivorship of these monkeys could be better than for *Alouatta* spp. due to the wide range diet these monkeys could reach [32], this include arthropods, coconut [9,32], and seeds of tea mangroves *P. rhizophora* [Pers. Obs.].

Advantages and Disadvantages of the Methods Used

I recommend using the combination of these two methods: strip transects and triangulation for howler and capuchin monkeys, as both primates could be easily detected. Overall, the triangulation method followed by the direct observation of the groups, appears to be the most precise for detecting howler groups rather than transects which we used to calculate howler monkey group density and total population. Similar conclusions were reached using both methods while estimating populations of Costa Rican primates [33]. In terms of practicality, both methods are recommended in primate studies to conduct rapid population surveys [34]. Calculations from these methods are convenient to obtain total population of primates, overall for isolated habitats, the probability of use of the same forest, and knowledge of the exact amount of forest coverture. However, transect lines in particular could fall in recounting bias and the observer should take into account the patterns of activity and behavior of the target animal [18,25]. As a tendency for our studies in Panama, we recommend the use of more than one technique while doing surveys, allowing for the highest accuracy in results.

Conservation

Coiban primates are not exposed directly to hunting activities as the penal colony has been removed to another locale on the mainland; however, climatic instability, often long rainy periods and consistent high humidity in combination with the generally poor, quality of dietary resources the island offers could be influencing the reproductive success of the island's primate species. The capuchin population actually could be in a more favorable position than the howler population in terms of wild food resources. As a part of the conservation effort of the Fundación Pro-Conservación de los Primates Panameños (FCPP), in 2010, a brief mammal survey on Coiba detected high densities of hematophagous bats *Desmodus rotundus* on the southeastern side of the island, likely related to the presence of feral cattle in the national park. The presence of feral cattle, if they proliferate, could pose a threat to the many of the endemic mammals of Coiba. Cows heavily impact the understory and could diminish the regeneration of disturbed areas. I consider Coiba howler and capuchins as vulnerable species that need to be monitored and studied in depth to better understand their population dynamics and behavioral adaptations to this island habitat. The continued monitoring of the populations of mammals, specially these primates, will assist in understanding the conservation needs of the island, and potentially curb any possible perils induced by the growing tourism.

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