

POPULATION DENSITY ESTIMATE FOR THE WHITE-FACED CAPUCHIN MONKEY (*CEBUS IMITATOR*) IN THE MULTIPLE USE AREA MONTAÑA LA BOTIJA, CHOLUTECA, HONDURAS, AND A RANGE EXTENSION FOR THE SPECIES

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Abstract

Honduras is one of the Neotropical countries with the least amount of information available regarding the conservation status of its wild primate species. Understanding the real conservation status of these species is relevant, since they are of great importance for ecosystem dynamics due to the diverse ecological services they provide. However, there are many threats that endanger the conservation of these species in the country such as deforestation, illegal hunting, and illegal wildlife trafficking. The present research is the first official registration of the Central American white-faced capuchin monkey (*Cebus imitator*) for the Pacific slope in southern Honduras, increasing the range of its known distribution in the country. A preliminary population density estimate of the capuchin monkey was performed in the Multiple Use Area Montaña La Botija using the line transect method, resulting in a population density of 1.04 groups/km² and 4.96 ind/km² in the studied area. These results provide us with a first look at an isolated primate population that has never been described before and demonstrate the need to develop long-term studies to better understand the population dynamics, ecology, and behaviour, for this group in the zone.

Key Words: Distribution, population density, *Cebus imitator*, Capuchin monkeys, Honduras.

Resumen

Honduras es uno de los países del Neotrópico en donde menos información se tiene acerca del estado de conservación de sus especies de primates silvestres. El conocimiento del estado real de conservación de estas especies es relevante ya que son de gran importancia para las dinámicas de los ecosistemas debido a los diversos servicios ecológicos que ofrecen. Sin embargo, en el país se presentan amenazas que ponen en riesgo la conservación de estas especies como son: la deforestación del bosque, la cacería y el tráfico ilegal de especies silvestres. En esta investigación se hace el primer registro oficial de monos capuchinos cara blanca (*Cebus imitator*) para la vertiente del Pacífico en el sur del país, de esta forma se amplía su rango de distribución para Honduras. Se realizó una estimación preliminar de las densidades poblacionales de esta especie en el Área de Usos Múltiples Montaña La Botija, utilizando el método de transectos lineales, dando como resultado una densidad poblacional de monos capuchinos de 1.04 grupos/km² y 4.96 ind/km² en el área de estudio. Estos resultados nos dan un acercamiento a una población de primates aislada de la que no se tenía ningún registro previo y nos muestran la necesidad de realizar estudios a largo plazo con esta población para poder entender de mejor manera las dinámicas poblacionales, ecología y comportamiento de este grupo en la zona.

Palabras Clave: Distribución, densidad poblacional, *Cebus imitator*, monos capuchinos, Honduras.

Introduction

Neotropical primate species are of great importance in tropical ecosystem dynamics, since they act as seed dispersers, pollinators and are an important part of the food chain as prey and predators (de la Torre, 2000). They are primarily arboreal with a wide variety of diets (Chapman and Chapman, 1990) and complex social systems (Kinzey and Cunningham, 1994). They also encompass wide diversity in body size and color (Robinson and Redford, 1984). While the biodiversity of Neotropical primates is highest in tropical rainforests, some species prefer deciduous, gallery or montane forests at more than 2,000 m a.s.l. (Chivers, 1982).

Honduras has high overall biodiversity due to its topography and its location in a tropical zone, among other factors (SERNA, 2001). Currently three wild primate species are reported in the country: the spider monkey *Ateles geoffroyi* (Kuhl, 1820), the capuchin monkey *Cebus imitator* (Thomas, 1903), and the howler monkey *Alouatta palliata* (Gray, 1849). However, none of these species are officially registered in the southern region of Honduras. Reid (2009) indicates the presence of these species in most of the country in the distribution maps in the publication "A field guide to the Mammals of Central America And Southeast Mexico," however these are very general maps without mention of any specific locality where these species might be present in Honduras.

Some of the main factors that have a negative impact on global biodiversity are: habitat loss (Brooks *et al.*, 2002), competition with invasive species (Clavero and Garcia-Berthou, 2005), host-pathogen interactions (Roche *et al.*, 2012), climate change (Alan Pounds *et al.*, 2006) and illegal hunting (Grayson, 2001); with hunting the main cause attributed to the extinction of large mammals and birds (Peres, 2000; Barnosky *et al.*, 2004; Suarez *et al.*, 2009). All of these factors are currently present in most of the protected areas in Honduras (Secaria, 2013), one of the Neotropical countries with the least amount of information available regarding the conservation status of its wild primates and with little research published. Two doctoral theses provide some of the most relevant data available for wild primates in Honduras. The first one, by Buckley (1983) described feeding behavior, social behavior, and ecology of the white-faced capuchin monkey (*Cebus imitator*) near the city of Trujillo, in the north of Honduras. The second doctoral thesis, by Hines (2005), the first study on spider monkeys (*Ateles geoffroyi*) in Honduras, focused on the ecology and taxonomy of spider monkeys at the Pico Bonito National Park in the department of Atlántida. Additionally, there is a note about an albino spider monkey in captivity in the city of Catacamas at the department of Olancho, Honduras (Espinal *et al.*, 2016).

Given the current conservation concerns and lack of knowledge about Honduran primates, it is important to develop long term studies to know and learn more about the ecology, behavior, distribution, and conservation status of the existing primate species in the country. The main goal for this research was to verify the presence and estimate the population density of white-faced capuchin monkeys (*Cebus imitator*) in the Multiple Use Area “Montaña La Botija” (AUMLB), Honduras.

Materials and Methods

Study area

The AUMLB was declared a protected area in 2005. It is located in the department of Choluteca, in the southern region of the Pacific slope of Honduras (ANED, 2009). In order to select the study area, interviews were conducted with the local residents and satellite images of the area were studied to determine the place with the most likely conditions to encounter the species (less human intervention, greater amount of forests, and where the locals mentioned greater probability to find it). The chosen place was “La Montaña del Ojochal” located in the dry tropical forest life zone (Holdridge, 1967). The annual rainfall is between 1,000 and 2,000 mm and temperatures are above 24°C during the whole year (Holdridge, 1967). This area is located between 450 and 900 m a.s.l. (ANED, 2009).

A preliminary six-day trip was carried out, to prepare and establish the transects inside the study area: “El Ojochal” with a length of 2 km (13°17'47.6" N 86°44'35.3" W),

“El Tamarindo” with 2.2 km (13°17'39.5" N 86°48'42.3" W), “Los Mogotes” with 1.8 km (13°17'08" N 86°44'37" W) and the “Montaña Oscura” transect with 2.5 km (13°17'54.5" N 86°44'54.3" W) (Fig. 1). A total of 8.5 linear km of sampling transects were created, located between 500 to 1,200 m a.s.l.

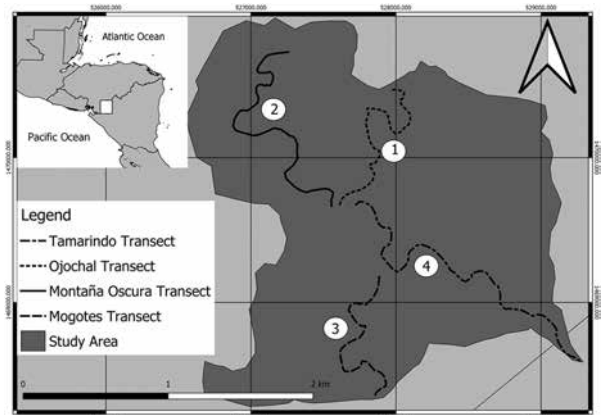


Figure 1. Study area and the 4 transects used: (1) transect El Ojochal, (2) transect Montaña Oscura, (3) transect Los Mogotes, (4) transect El Tamarindo.

Data Collection

Data collection occurred during June to December 2011. It consisted of monthly field trips with an average duration of 10 days, for a total of 65 days of field work. The duration of each trip varied based mainly on the weather conditions of the study area.

To estimate the population density of *Cebus imitator*, the line transect method was used, following the proposed guidelines by NRC (1981) and Peres (1999b). This method has been widely applied during the last three decades to quantify primates' population abundance in tropical forests (Peres, 1999b). The four transects were randomly walked, one each day and not repeating the same transect on two consecutive days, an average of three times each transect per field trip. For round trip walks on the transect, the travel in each direction was considered as independent. The outward walks were done from 06:00 to 10:00 hours, and the return walks were done from 14:00 to 18:00 hours, waiting approximately 3 hours at the end of the transect, usually at midday when the primates are less active, time enough for the animals to redistribute on the space (Wallace *et al.*, 1998; Peres, 1999b; Quinten, 2016). It is also important to mention that there was never more than one encounter in a given transect on the same day.

When a group of the studied species was detected, observations were made during a standardized amount of time (ten to fifteen minutes). Guidelines in the methodology included that the observer should remain on the census transect path and not follow the animals outside the transect line (Peres, 1999b). When possible, the following information was registered for the studied species during the

census walks: time and location in the transect, location of the sighted population (angle calculated using a field compass and the perpendicular distance from the transect to the first sighted individual), group composition by age and sex, and opportunistic observations (species of feeding trees utilized).

Thanks to these censuses it was possible to determine the number of individuals per transect area and subsequently for the study area. It was also possible to estimate the number of groups of existing primates, as well as the composition and quantity of individuals in each of them. Additionally, maturity stage was categorized as follows: adult (large individuals with fully developed sexual characteristics), sub-adult (same size as the adult but with a slimmer body structure), juvenile (medium individual with less developed sexual characteristics), infant (small individual who spent most of its time being carried by an adult).

In addition to data collected to estimate capuchin population density, samples were collected from all the trees for approximately 5 m from each side of the transect with a circumference larger than 15 cm at breast height; samples with flower or fruit could be classified more precisely, however due to factors such as crown height or because a tree was not flowering or fruiting at the time, this was not always possible. Collected samples were identified by professionals at the Herbarium of the Biology Department at the Universidad Nacional Autónoma de Honduras.

Study species

Cebus imitator (Thomas 1903)

The IUCN places this species in the Least Concern category (LC) (Rylands *et al.*, 2013). CITES places it in the II appendix for Honduras (many populations are threatened by deforestation and illegal trafficking). This species belongs to Cebidae and is distributed in Central America from northwest Honduras to Panama, and from sea level to 1,500m (Boubli *et al.*, 2012; Rylands *et al.*, 2013). Its fur is black, except the face and ears, the sides of the neck, the shoulders, the chest, and the upper part of the arms, which are white-yellowish. It has a black prehensile tail (Emmons and Feer, 1997). White-faced capuchins live in large multi-female, multi-male troops of up to 40 individuals, with female philopatry and male dispersal to other groups as juveniles (Oppenheimer, 1968; Freese, 1978; Fedigan, 1993). Within the groups' dominance levels, both sexes present a linear hierarchy (Perry, 1995; Jack and Fedigan, 2006). In females, this hierarchy, is due to matrilineal kinship and coalitions, while in males is mainly, due to intrasexual competition (Perry, 1995; Perry, 1998; Jack, 2003). Capuchins are territorial animals with a consistent home range that sometimes can overlap with other groups. They are omnivorous and have one of the most varied diet among the Neotropical primates, feeding on vegetable matter (fruits, flowers, shoots, nuts), insects and small vertebrates (Chapman and Fedigan, 1990; Eisenberg and Redford, 1999). They

are highly opportunistic foragers, capable of manipulating a wide range of materials and substrates whether to feed, move or defend themselves since they have great skills with their hands (Rose, 1994). Their varied diet allows them to make changes in their feeding resources in different parts of the year when, for example, some fruits are scarce or are not in season (Chapman and Fedigan 1990). This flexibility reduces competition with other arboreal mammals like spider monkeys, squirrel monkeys, coatis, anteaters, and even some birds. The capuchin monkey uses all the forest levels and travels on the ground to cross open areas, drink water and forage. Their active hours start early in the day and they are more active during the morning and afternoon (Reid, 2009).

Results

The presence of the capuchin monkey (*Cebus imitator*) was registered in the Pacific slope of Honduras through several encounters in three of the four transects used within the study area (El Ojochal, El Tamarindo and Los Mogotes). During these encounters, pictures and videos of different individuals were taken for identification purposes, as well as to provide evidence for the presence of the species in the zone (Fig. 2).

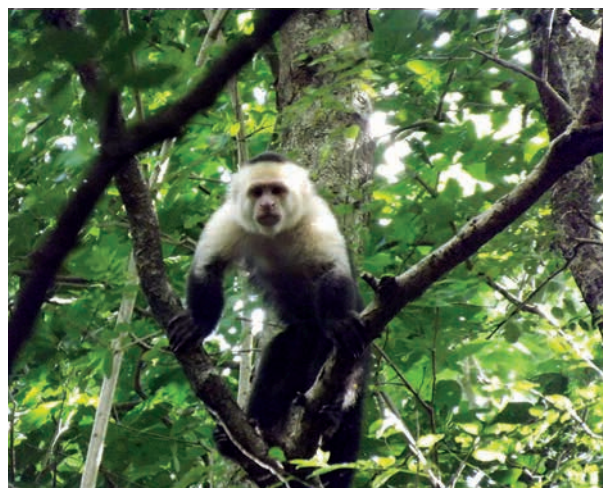


Figure 2. Photograph of an adult male (AM) in the transect El Ojochal.

Each transect was walked 34 times during the study, for a total of 28 km and more than 800 hours of work, resulting in 142 minutes of visual contact with the species and more than 20 minutes of video recorded for different individuals. From these walks there were a total of nine encounters with capuchin monkeys and a total of 43 individuals registered, with an average group size of 4.7 ind/group (3-9 range). Due to the low number of encounters it was not possible to use the software Distance to run the population density analysis. However, it was possible to estimate the individual and group density per transect and for the whole study area using the formulas established by the National Research Council (NRC, 1981; Table 1).

Table 1. Population density of *Cebus imitator* on each of the transects used during the research.

Transect	Group density (groups/km ²)	Individual Density (individuals/km ²)	Variance	Confidence limits by 95 %	Accuracy %
El Ojochal	3.06	14.38	1.8663	0.6535	14.00
El Tamarindo	1.12	5.27	1.2916	0.4523	9.046
Los Mogotes	0.46	2.16	0.3429	0.1200	12
Montaña Oscura	0	0	_____	_____	_____
Total area	1.04	4.96	1.4987	0.2951	6.1787

It was not always possible to identify sex due to the animals' fast movement, low visibility because of the forest cover, and the field's irregular topography. However, it was possible to differentiate stage of maturity, based on size (30 adults, 10 sub-adults and 3 juveniles).

Plants identified in the forest included 689 individual trees, which were distributed in 62 different species pertaining to 32 families, with *Lysiloma auritum* the most abundant species (133 individuals or 19.3%), followed by *Bursera simaruba* and *Neomillspaughia paniculata* (52 individuals or 7% each), *Quercus* sp. (53 individuals or 7%) and *Brosimum alicastrum* (41 individuals or 5%). Some of the registered plants were used as food by the capuchin monkeys during the study, including the fruit, the flower or less commonly, the leaf (Table 2).

Table 2. Plant species used as food by *Cebus imitator* inside the study area.

Family	Species	Item
Anacardiaceae	<i>Spondias purpurea</i>	Fruit
Apocynaceae	<i>Tabernaemontana donnell-smithii</i>	Fruit
Burseraceae	<i>Bursera simaruba</i>	Fruit
Fabaceae	<i>Acacia deamii</i>	Young leaves
Fabaceae	<i>Inga vera</i>	Fruit
Malpighiaceae	<i>Byrsonima crassifolia</i>	Fruit
Malvaceae	<i>Guazuma ulmifolia</i>	Flower
Moraceae	<i>Brosimum alicastrum</i>	Fruit
Moraceae	<i>Ficus cotinifolia</i>	Fruit
Muntingiaceae	<i>Muntingia calabura</i>	Fruit
Rubiaceae	<i>Chiococca alba</i>	Flower

Discussion

The presence of *Cebus imitator* inside AUMLB was confirmed, the first official registration of this or any non-human primate species in the Honduran Pacific slope in the southern part of the country. The capuchin monkey, one of the three primate species reported in Honduras, is the only one present in the study area. It is distributed in El Cañon del Ojochal, a remnant of tropical dry forest located

by the Tinto riverbank. This is one of the best-preserved forest patches in the area, although it has been recently affected by human activity.

This research had a total of nine focal encounters with *Cebus imitator* in the whole research area, which is a low number of encounters in comparison with some other studies of the species (Chapman *et al.*, 1988; Estrada and Coates-Estrada, 1996; Timock and Vaughan, 2002; Tinsley Johnson *et al.*, 2020), but similar to the ones reported in the wildlife refuge centre "Rio Escalante-Chococente", in the south of Nicaragua (Williams-Guillén *et al.*, 2013), although these authors mention their study was possibly an under-registration of encounters for the species in this area. Estimations obtained from a low number of encounters must be cautiously interpreted (Plumtre, 2000; Gonzales-Solis *et al.*, 2001), but the data are especially relevant when there is no other information available for the species in the study area.

Encounters with capuchin monkeys occurred in three out of the four established transects for the study. The transect "Montaña Oscura" was the only one without any encounters with the species, despite being the most extensive transect in length (Fig. 1) with the same number of walks performed as in the other ones. This may be attributed to many factors, including its elevation from 800 to 1,040 m.a.s.l., which in the study area corresponds to a shift in the dominant plant species to *Quercus* sp. and *Pinus oocarpa*. This transect was also the one closest to a main road, with three communities and an active mine (during data collection) where cars and the mine's engines produced loud noises that could have affected the monkeys' presence or the possibility to detect them.

A population density of 1.04 groups/km² and 4.96 ind/km² was estimated for AUMLB. From 142 minutes of visual contact and more than 20 minutes of video recorded, it was possible to differentiate 6 individuals (2 adult males, 1 adult female, 2 subadult males and 1 subadult female), using scars and physical characteristics as a reference. The six differentiated individuals were from the same group, subjects of several encounters along the Ojochal transect. During the encounters in the Tamarindo and Mogotes transects, it wasn't possible to differentiate the individuals, so it could not be determined if this was the

same group from the Ojochal transect or a different one. However, based on the field conditions and the distances between transects, I believe it is possible there are at least two different groups in the study area. No capuchin infants were observed during the walks, but this could be explained by the timid and evasive behavior of the species in the presence of the researcher, making direct observations difficult for all individuals in the group. Another factor could be the limited experience of the researcher at the time of the development of the study, as well as the possibility of birth seasonality patterns of the species in the study area (Di Bitetti and Janson, 2000), or long interbirth intervals like the ones reported for this species in Costa Rica (Fedigan and Rose, 1995). This situation could also serve as a wake-up call, since the absence of infants could be a symptom of the population's poor health, bringing up serious doubts about the likelihood of continuity of the species in the zone.

For a better understanding of the current situation of the species in the study area, the results here were compared with population densities obtained for *Cebus imitator* in Panama, Costa Rica, and Nicaragua (Table 3).

Table 3. Capuchin monkey population density comparison across studies.

Number of individuals (ind/km ²)	Location	Source
12.3 +/- 7	Punta Leona Private Wildlife Refuge, Costa Rica	Timock and Vaughan, 2002
17.73 – 32.57	Santa Rosa National Park, Costa Rica	Chapman et al., 1988
1.08	Coiba Island National Park, Republic of Panama	Mendez-Carvajal, 2012
31 +/- 26	Manuel Antonio National Park, Costa Rica	Estrada et al., 2006
34.47	Santa Rosa, Costa Rica	DeGama-Blanchet and Fedigan, 2006
11	Southwestern Nicaragua	Williams-Guillén et al., 2013
36.24	Taboga Forest, Costa Rica	Tinsley Johnson et al., 2020
4.96	Multiple Use Area "Montaña La Botija", Honduras	Present study

Factors affecting the population density of capuchin monkeys in the study area include: selective logging, and the transformation of forest into grassland for extensive cattle

ranching or agriculture for annual crops of corn or beans. The existence of these crops has created a conflict between monkeys and humans, as local people express they are experiencing economic losses because of the damage the monkeys cause to their crops, mainly in corn fields. Another factor is forest cover loss because of fires during dry seasons. In addition, local people are not aware of the importance of this species on the ecosystem, and finally, there is no protection from the government towards this or other species living within the limits of the country's protected areas (Secaria, 2013).

Food resource availability is a determining factor for primate abundance; deforestation is the most significant problem capuchins face in AUMLA (Terborgh, 1983; Balcomb et al., 2000; Stevenson, 2001; 2016). Capuchin monkeys are susceptible to habitat loss and tend to recover more slowly compared with other primate species like the howler monkey (Roncancio and Gomez-Pozada, 2009; Amato *et al.*, 2014). This is related to their diet, since capuchin monkeys need a greater area of forest to fulfill feeding needs, and in periods of fruit scarcity, are forced to travel greater distances to find food, different from howler monkeys that can survive on a folivorous diet (Milton and Fedigan, 2004).

It is probable that the presence of the *Cebus imitator* in the area is a result of the existence of an old biological corridor that connected the Honduran and the Nicaraguan "Mosquitia" with the south of Honduras and went all the way around the Coco o Segovia River. This biological corridor was also used by other species that local people have mentioned seeing in the area a long time ago, such as the jaguar (*Panthera onca*), the howler monkey (*Alouatta palliata*), and the spider monkey (*Ateles geoffroyi*), among other species (Marineros and Martinez, 1998) that are no longer present in the area.

The continuous forest that once allowed for the movement of capuchin monkeys and other species between the north and south of Honduras has been logged and fragmented to build up cities, roads, agriculture fields and cattle ranching, leaving scattered patches of forests in the whole region, and limiting the flow of species between the two slopes (Fig. 3). This impact is so strong that the closest registered population of capuchin monkeys according to Marineros and Martinez (1998) can be found approximately 89 km away in the Valle de Jamastran in the department of El Paraiso (Figure 3); these two populations are completely isolated from each other, with cities and towns between them. Figure 3 includes other registered locations of known populations of *Cebus imitator* at the moment in Honduras. Table 4 shows the corresponding localities and coordinates, as well as sources including books, management plans for protected areas, a doctoral thesis, and the author's personal observations.

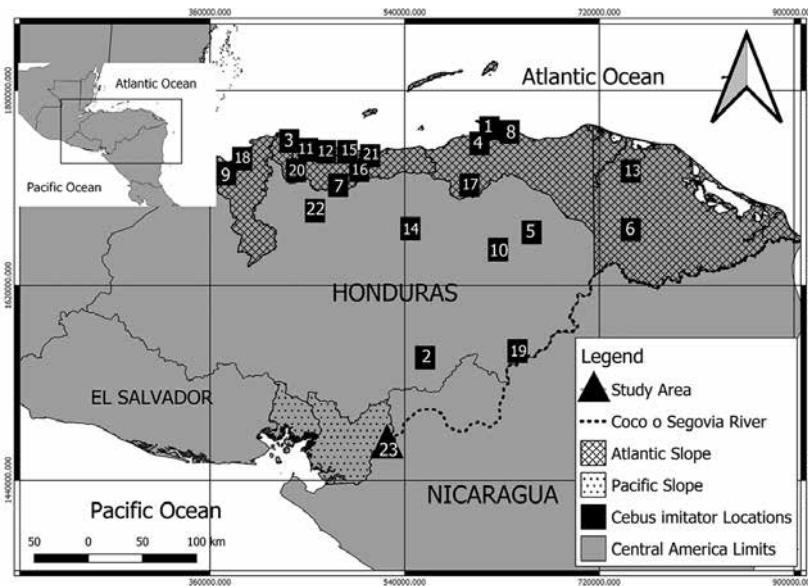


Figure 3. Map of the Atlantic and Pacific slopes and their connection through the Coco o Segovia River.

Table 4. Localities and coordinates of other populations of *Cebus imitator* in Honduras.

Number	Locations	Coordinates	Source
1	Trujillo Mangroves	15°55'56.34"N 85°55'0.24"W	Buckley, 1983
2	Jamastran Valley	13°59'22.26"N 86°27'39.50"W	Marineros and Martinez, 1998
3	Laguna de los Micos	15°48'15.40"N 87°36'20.12"W	Marineros and Martinez, 1998
4	Capiro y Calentura National Park	15°52'19.51"N 85°56'27.94"W	Marineros and Martinez, 1998
5	Pisijire village, Olancho	15°10'17.93"N 85°26'49.37"W	Marineros and Martinez, 1998
6	Krausirpi village, Gracias a Dios	15° 2'39.05"N 84°52'26.76"W	Marineros and Martinez, 1998
7	Texiguat Wildlife Refuge	15°27'44.29"N 87°16'53.72"W	Marineros and Martinez, 1998
8	Laguna de Guaymoreto	15°57'58.60"N 85°51'35.92"W	Marineros and Martinez, 1998
9	Cusuco National Park	15°33'46.39"N 88°18'12.44"W	Marineros and Martinez, 1998
10	Sierra de Agalta National Park	14°58'1.92"N 85°51'47.66"W	Marineros and Martinez, 1998
11	Jeannette Kawas National Park	15°49'6.54"N 87°22'12.32"W	PROLANSATE, 2004
12	Punta Izopo National Park	15°49'27.38"N 87°21'4.75"W	PROLANSATE, 2004
13	Biosfera del Río Plátano	15°27'4.89"N 84°48'50.08"W	Zambrano, 2008
14	La Muralla Wildlife Refuge	15° 4'58.16"N 86°45'22.03"W	CEAH, 2010
15	Cuero y Salado Wildlife Refuge	15°46'45.11"N 87° 8'27.37"W	Portillo and Carrasco, 2012
16	Pico Bonito National Park	15°36'59.03"N 86°51'42.77"W	Carrasco <i>et al.</i> , 2013

Number	Locations	Coordinates	Source
17	Botaderos National Park	15°26'3.02"N 86° 4'50.36"W	Guillen and Guillen, 2013
18	San Antonio village, Cortés	15°45'18.54"N 88° 2'47.38"W	Personal observation
19	Patuca National Park	14°17'54.14"N 85°13'53.01"W	Personal observation
20	Santiago village, Atlantida	15°39'4.09"N 87°37'51.94"W	Personal observation
21	Nombre de Dios National Park	15°47'49.16"N 86°32'40.32"W	Personal observation
22	Pico Pijol National Park	15°10'26.09"N 87°34'25.26"W	Mioñes et al., 2018
23	Montaña La Botija Multiple Use Area	13°17'38.03"N 86°44'41.81"W	Current study

These preliminary results point to a clear need to continue the study of this capuchin monkey population (*Cebus imitator*) in southern Honduras in order to determine with greater certainty its current conservation status. It is also necessary to search for closer populations to this study area to better understand migration dynamics as this capuchin monkey population, the only one reported up to this point in this region of the country, is in real danger of disappearing from the area.

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