CHAPTER TWENTY

Mapping Primate Populations in the Yucatan Peninsula, Mexico: A First Assessment

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INTRODUCTION

The Yucatan Peninsula: Pioneer Research

The Yucatan Peninsula occupies an important place in Mexican geography and was the indigenous homeland of the Maya, one of the most significant pre-Hispanic societies in the New World (Taube, 2003). Mayan groups inhabiting the Mexican portion of the Yucatan Peninsula (states of Campeche, Yucatan, and Quintana Roo) participated in a complex network of cultural, political, and economic activities, and developed land use patterns that contributed to the conservation of vast extensions of the natural landscape (Shaker, 1999).

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The Distribution of Primates on the Mexican Side of the Yucatan Peninsula

Three primate species are indigenous to Mexico: mantled howlers (*Alouatta palliata mexicana*), black howlers (*Alouatta pigra*), and Geoffroy's spider monkey (two subspecies *Ateles geoffroyi vellerosus* and *Ateles geoffroyi yucatanensis*). Only two of these taxa, *A. pigra* and *A. g. yucatanensis* are currently found in the Yucatan Peninsula (however, see below for confirmed sightings of *A. palliata* in the Yucatan). The black howler monkey exhibits a geographic distribution that includes Belize, Guatemala, and Mexico. *A. pigra* is the only *Alouatta* species present in the Yucatan Peninsula (Smith, 1970; Horwich and Johnson, 1986; Watts and Rico-Gray, 1987). Spider monkey populations (*A. g. yucatanensis*) coexist with *A. pigra* in several localities in this area (Watts and Rico-Gray, 1987); however, habitat destruction, hunting, and the pet trade put these populations at risk (Estrada *et al.*, 2004).

Major Land Use Patterns and Impact on Native Vegetation in the Yucatan Peninsula

Some 50 years ago, approximately 86,000 km^2 of the Yucatan Peninsula were covered with semievergreen forest. At present, however, very few sites currently exist with semievergreen forest fragments larger than 1000 km^2 and deforestation continues at a rate of 8000 km^2 per year (Challenger, 1998). It is clear that habitat destruction is the most significant threat to the survival of primates in the Yucatan Peninsula (Ramos Fernández and Ayala-Orozco, 2003). In some areas of each state, most of the natural vegetation has been modified or destroyed by slash-and-burn agriculture, cattle ranching, and accidental fires caused by slash and burn agriculture (Challenger, 1998). We are facing an important moment in which knowledge of the demography and distribution of primate species in the Yucatan Peninsula is critical to developing effective conservation and management policies.

Early Research on Primate Distribution in Yucatan Peninsula

Despite the need for conservation efforts in the Yucatan, little is known about the Peninsula's natural resources, including its wild primate populations. The first studies of population demography and distribution were conducted by

Watts *et al.* (1986) and Watts and Rico-Gray (1987). These researchers visited 18 forested Yucatan sites and confirmed the presence of *Ateles* and *Alouatta* at only eight of these sites. These authors concluded that habitat destruction, hunting and pet capture were the major factors affecting the presence of primates at these sites. At this same time, Horwich and Johnson (1986) published a report on the distribution and vegetation characteristics of forests inhabited by *A. pigra* in southeastern Mexico, including the Yucatan Peninsula. However, these authors acknowledged that much of their data came from indirect sources, rather than confirmed sightings, and thus should be viewed with great caution. Lara and Jorgenson (1998) also surveyed wild primates in the state of Quintana Roo. They conducted field observations aimed at understanding the relationship between the presence of particular vegetation types and the conservation status of howler and spider monkeys in this region.

Recent Research on Aspects of Ecology and Behavior

More recently, studies of Yucatan's primates have focused on questions of behavior and ecology. For example, Gonzalez-Kirchner (1998, 1999) examined group size, habitat use, and population density in *A. pigra* and *A. g. yucatanensis* in Muchukux, Quintana Roo. Navarro-Fernandez (2000) working in the state of Campeche developed a protocol for using local people to collect data on the location and density of *A. pigra* and *A. g. yucatanensis.* In an attempt to address questions concerning primate conservation and health, Bonilla-Moheno (2002) examined the effects of habitat disturbance and the presence of endoparasites on *A. pigra* and *A. g. yucatanensis* populations in the state of Quintana Roo. She found that the density and diversity of endoparasites in both primate species were greater in disturbed habitats. Similarly, Rangel-Negrín (2003) initiated a study of fecal cortisol levels in populations of *A. g. yucatanensis* inhabiting intact and altered habitats in Quintana Roo, México. Cortisol levels are an indicator of stress and may be a sensitive measure of the health of individuals in a natural population. The results of this study indicate that spider monkeys living in intact forest showed lower cortisol levels than individuals living in altered habitats or monkeys reared as pets or housed in zoos.

Primate population surveys also have been conducted in the protected forest of a reserve of the Mexican Forestry agency in El Tormento, Campeche. Barrueta *et al.* (2003) report the existence of a population of *A. pigra* coexisting with a smaller population of *A. geoffroyi.* In the same site, a 10-month-long

study of the foraging ecology of *A. pigra* yielded information on seasonal use of plant species, foraging patterns, and dietary preferences. An additional study examined foraging patterns and habitat preferences of groups of *A. pigra* existing in the continuous forest of the Calakmul Biospere Reserve and in adjacent fragmented landscapes in southern Campeche (see Rivera and Calme, this volume).

Ramos-Fernández and Ayala-Orozco (2003) examined the behavior of spider monkeys in Punta Laguna, Yucatan. This study addressed questions concerning patterns of habitat utilization in two groups of *A. g. yucatanensis* using GIS Technology. Finally, Estrada *et al.* (2004) initiated a series of population demography and group size studies of spider and howler monkeys inhabiting forests in proximity to Mayan archaeological sites, including regions of Campeche. These authors report that the protected forests surrounding Mayan sites contain sustainable populations of *A. pigra* and *A. geoffroyi*, and that studies of these populations should represent an important foci for conservation and management policies in Mesoamérica (see Estrada *et al.*, this volume).

Despite these important studies, information on the presence and conservation status of howler and spider monkey populations across a larger geographic region of the Yucatan Peninsula are lacking. Hence, in this paper we present the results of an area-wide survey that provides information on current locations of *A. pigra*, *A. palliata*, and *A. geoffroyi* populations in the Yucatan Peninsula. In addition, these surveys assessed the legal protection status of the habitats/sites that contained primate populations. We use this information to present a general assessment of the conservation status of primate populations and their habitat on the Yucatan Peninsula.

METHODS

Recognition of Wild Monkey Populations

Fieldwork was conducted during a period of 28 months (January 2000–April 2002). Surveys were conducted for approximately 12 days (13 ± 2 days) every 2 months. In order to census primate populations in areas within each state of the Peninsula (Campeche, Quintana Roo, and Yucatan), we conducted six surveys during the dry season (February–May) and eight surveys during the wet season (June–January). Sampling sites were selected based on data obtained from first published reports (see above), maps, letters, and unpublished documents (personal files of the late Dr. Elizabeth S. Watts). The initial objective was

to visit areas that had previously been censused, with the aim of corroborating and updating information on the presence/absence of monkey populations. In addition to these 20 localities, we selected a large number of new localities based on cartographic information of known distribution, location of suitable habitat types, and whether areas represented protected or unprotected sites. Overall, we visited 78 potential primate localities (10 localities were visited on more than one occasion either because they contained large forested areas [national reserves or in the southern border near Belize] or because of a particular interest in the habitat conditions in areas with primate populations). Site by site data on primate populations and habitat characteristics may be available from JCSS upon request.

Primate Surveys: Sampling and Identification of Habitat Characteristics

Three people generally worked together collecting data, including a field guide from a nearby town. Once the research team was formed, surveys were conducted following the transect method proposed by Struhsaker (1981). The maximum length of transects walked in this study was 5–10 km. Fieldwork began between 06:00 and 07:00 h and ended around 17:00–18:00 h, weather permitting; intense rain was an impediment, sometimes limiting visibility in deep forest. This varied along with observation conditions from site to site, as in severely altered areas, monkeys could be followed until the late afternoon, while in well-preserved parts, it became harder to find them after 17:00 h. In most of the sites visited, surveys of three to five transects were completed. At the largest sites, the number of transects walked was 8–10. Transects were traversed at a rate of 1–1.5 km/h, depending on the condition of the forest path; brief observation stops were made to listen for sounds and detect visual clues (feces, consumed fruit, broken branches, movement in the canopy, among others) that might indicate the presence of monkey troops. Special care was taken not to count the same group twice; this was avoided through radio communication between observers when an individual or group was detected. On this basis, the total number of troops (howler monkeys) or subgroups (spider monkeys) during the sampling period was recorded. We estimated the overall abundance of primate species as the number of troops/subgroups sighted per kilometer. During the entire study, we constructed 107 transects which covered a distance of 353.6 km in Campeche ($n = 36$ localities), 58 transects covering a distance of

293.4 km in Quintana Roo ($n = 25$ localities), and 5 transects covering 69 km in Yucatan ($n = 5$ localities). Finally, direct contact (visual or auditory cues) with a troop of primates was considered a "verified", sighting, while information provided by local inhabitants was scored as "reported".

Characteristics of the Troops and Subgroups Located

For each howler monkey troop or spider monkey subgroup located on a transect, a record was made of the place where it was observed and a consecutive letter of the alphabet was used to indicate the number of populations found for each species (Table 1). The following data also were recorded: species, group size, sex–age composition; time and date of sighting, length of observation, transect position, habitat type, conservation status of the forest (altered/preserved: see Serio-Silva and Rico-Gray, 2002), and legal protection status (CONANP, 2004); distance covered from transect tip, perpendicular distance from the transect to the geometric center of the group, and vertical position of the group in accordance with forest strata (National Research Council, 1992).

Geographic Characterization of Potential Available Habitat

On a map, the georeferenced points of each locality and state where the monkeys were sighted were marked and each vegetation type recorded (Flores and Espejel, 1994); their legal protection status also was noted. On the basis of geographic location, using a Global Positioning System (GPS; Garmin GPS 12, Kansas, USA) of areas where monkeys were found, calculations were made of the potential area available for use as natural habitat on the Peninsula. For this purpose, *landsat 5 TM Imagery* (SYPR, 2000) images were processed through Geographic Information Systems.

RESULTS

A total of 78 localities in the three states that comprise the Peninsula were visited, 66 of which contained (verified or reported) wild primates (Table 1, Figure 1). The number of localities visited per state was 36, 25, and 5 for Campeche, Quintana Roo, and Yucatan, respectively. In Campeche, the most common vegetation type surveyed (18 sites on these localities, 50.0%) was

Table 1. List of locations with the presence of wild primates on the Yucatan Peninsula, Mexico

No.	Site name	Vegetation type	Primate species	Troop/ subgroups per site	State	Latitude N	Longitude W	Protection status
1	Dzibalchen	MSEF	A.p (V)	(a–b)	Campeche	19°29″	89°44″	Protected
2	Escarcega region	MSEF	A.p (V), A.g.y (V)	(a–n), (a–b)	Campeche	18°36″	90°40″	Not protected
3	Zaragoza CL	MSEF	A.p (V)	(a–f)	Campeche	18°28″	91°11″	Not protected
4	Pejelagarto CL	MSEF	A.p (V)	(a–d)	Campeche	18°11″	90°01″	Not protected
5	Cristalina CL	MSEF	A.p (V)	(a)	Campeche	18°46″	90°55″	Not protected
6	El Desengaño CL	TSEF	A.p (V)	(a–c)	Campeche	17°52″	90°29″	Not protected
7	El Naranjo CL	TEF	A.p (V)	(a–c)	Campeche	18°05″	91°06″	Not protected
8	El Ramonal CL	TSEF	A.p (V), A.g.y (V)	(a–c), (a–b)	Campeche	17°50″	90°38″	Not protected
9	El Zapote CL	TEF	A.p (V), A.g.y (V)	(a–e), (a–b)	Campeche	18°09″	91°37″	Not protected
10	Conhuas CL	MSEF	A.p (V), A.g.y (V)	(a–d), (a–c)	Campeche	18°42″	89°57″	Not protected
11	Calakmul	TEF	A.p (V), A.g.y (V)	(a–c), (a–b)	Campeche	18°08″	89°35″	Protected
12	Arroyo Negro	TEF	A.p (V), A.g.y (V)	(a–f), (a–c)	Campeche	17°50″	89°11″	Protected
13	Manuel Rejon/Unidad Militar	TEF	A.p (V), A.g.y (V)	(a–e), (a–c)	Campeche	17°56″	89°11″	Protected
14	Narciso Mendoza CL	MSEF	A.p (V)	(a–c)	Campeche	18°20″	89°23″	Protected
15	El Manantial CL	MSEF	A.p (V)	(a–b)	Campeche	18°25″	89°22″	Protected
16	La Victoria CL	MSEF	A.p (V)	(a)	Campeche	18°22″	89°22″	Protected
17	Kankabchen	MSEF	A.p (V)	(a)	Campeche	19°42″	88°56″	Not protected
18	Dos Lagunas	MSEF	A.p (V)	(a)	Campeche	18°48″	89°18″	Not protected
19	Near Hopelchen/ Dzibalchen	MSDF	A.p (V)	(a)	Campeche	19°36″	89°51″	Protected
20	Nunkini	MDF	A.g.y (V)	(a)	Campeche	20°24″	90°08″	Protected
21	El Remate	MANG	A.g.y (V)	(a)	Campeche	20°33″	90°23″	Protected
22	Nuevo Coahuila CL	TSEF	A.p (V)	(a–d)	Campeche	17°53″	90°44″	Not protected
23	El Sacrificio	TEF	A.p (V)	(a–e)	Campeche	18°05″	91°36″	Not protected
24	Nuevo Becal	MSEF	A.p (V)	(a–b)	Campeche	18°34″	89°30″	Protected

(*Continued*)

Table 1. *(Continued)*

No.	Site name	Vegetation type	Primate species	Troop/ subgroups per site	State	Latitude N	Longitude W	Protection status
25	Central Chiclera Villahermosa	TEF	A.p (V)	(a–c)	Campeche	17°55″	89°41″	Protected
26	La Esperanza CL	MSEF	A.p (V)	(a–b)	Campeche	18°19″	90°11″	Protected
27	10 km before Constitución	MSEF	A.p (V)	(a)	Campeche	18°34″	90°14″	Protected
28	Los Alacranes	TEF	A.p (V)	(a–c)	Campeche	17°58″	89°12″	Protected
29	Miguel Colorado	MSEF	A.p (V)	(a–b)	Campeche	18°46″	90°40″	Not protected
30	10 km near Chompoton	MSDF	A.p (V)	(a)	Campeche	19°25″	90°43″	Not protected
31	Calkini region	MANG	A.p (Re), A.g.y (V)	(a) (a)	Campeche	20°23″	90°03″	Protected
32	Petenes northern Campeche	MANG	A.p (Re), A.g.y (V)	(a) (a–b)	Campeche	20°23″	90°22″	Protected
33	Tenabo-Hanpolol	LDF	A.p (V), A.g.y (V)	(a) (a)	Campeche	20°00″	90°19″	Protected
34	Conquista Campesina	MSEF	A.p (V), A.p.m (V)	(a–b) (a–c)	Campeche	18°11″	91°17″	Not protected
35	El Alamo Ranch	MSEF	A.p (V), A.p.m (V)	(a–h) (a–b)	Campeche	18°48″	90°54″	Not protected
36	El Suspiro	MSEF	A.p (V), A.g.y (V)	(a–b) (a)	Campeche	18°27″	91°16″	Not protected
37	El Eden	MSDF	A.g.y (V)	(a)	Quintana Roo	21°10″	87°04″	Protected
38	Puerto Morelos	MSEF	A.g.y (V)	(a)	Quintana Roo	20° 50″	86° 54″	Protected
39	Pacchen	MSEF	A.p (V), A.g.y (V)	(a–b) (a–b)	Quintana Roo	20°44″	87°32″	Protected
40	Rancho Chacmuchuc	MSEF	A.p (V)	(a)	Quintana Roo	21°17″	86°52″	Protected
41	Playacar Tourist Complex	MSEF	A.p.m (V)	(a)	Quintana Roo	20°36″	87°05″	Protected
42	"Dos Ojos"/"Dos Aguas" area	MSEF	A.p (V), A.g.y (V)	(a) (a)	Quintana Roo	20°20″	87°24″	Protected
43	Carillo Puerto area	MSEF	A.p (V), A.g.y (V)	(a–h) (a)	Quintana Roo	19°34″	88°02″	Not protected
44	Petcacab area	MSEF	A.p (V), A.g.y (V)	(a–e) (a–f)	Quintana Roo	19°17″	88°13″	Protected

45	Centro Integral de Aprovechamiento de Vida Silvestre (Bacalar)	TSEF	A.p (V), A.g.y (V)	(a–b) (a)	Quintana Roo	18°48″	88°19″	Protected
46	Area de Bacalar—Xul-ha	TSEF	A.p (V), A.g.y (V)	(a) (a)	Quintana Roo	18°35″	88°27″	Not protected
47	Ejido Tres Garantias	TSEF	A.p (V), A.g.y (V)	(a–g) (a–h)	Quintana Roo	18°11″	89°05″	Protected
48	Area de "La Camiseta"	TSEF	A.p (V), A.g.y (V)	(a–d) (a–d)	Quintana Roo	18°07″	89°00″	Not protected
49	El Diez	TSEF	A.p (V), A.g.y (V)	(a) (a)	Quintana Roo	21°01″	87°17″	Not protected
50	Laguna Madera	MSEF	A.p (V), A.g.y (V)	(a–b) (a)	Quintana Roo	20°48″	87°38″	Not protected
51	Chunyaxche	MSEF	A.p (V), A.g.y (V)	(a–d) (a–c)	Quintana Roo	19°57″	87°37″	Protected
52	Sian Ka'an	MSDF	A.p (V), A.g.y (Re)	(a) (a)	Quintana Roo	19°33″	87°44″	Protected
53	Rancho "X" km. 92	MSEF	A.p (V)	(a)	Quintana Roo	19°28″	87°58″	Not protected
54	Bosque Andres Q. Roo	TSEF	A.p (V)	(a)	Quintana Roo	19°22″	88°02″	Not protected
55	Bosque cercano Bacalar	TSEF	A.p (V), A.g.y (Re)	(a) (a)	Quintana Roo	18°46″	88°33″	Not protected
56	Tomas Garrido	TSEF	A.p (V), A.g.y (V)	(a–c) (a–b)	Quintana Roo	18°01″	89°04″	Not protected
57	Estero Franco	TSEF	A.p (V)	(a–e)	Quintana Roo	17°56″	88°52″	Not protected
58	Dos Bocas	MSEF	A.p (V), A.g.y (Re)	(a) (a)	Quintana Roo	17°55″	88°52″	Not protected
59	U Yumil Ceh'	MSEF	A.g.y (V)	(a)	Quintana Roo	18°42″	87°45″	Protected
60	Cobá	MSEF	A.g.y (Re)	(a)	Quintana Roo	20°30″	87°41″	Protected
61	Chunhuhub	MSEF	A.g.y (Re)	(a)	Quintana Roo	19°35″	88°42″	Not protected
62	Tizimin-Panaba	MSDF	A.g.y (V)	(a)	Yucatan	21°14″	88°33″	Not protected
63	Las Coloradas	LDF	A.g.y (V)	(a)	Yucatan	21°35″	88°02″	Not protected
64	Colonia Yucatan	MSDF	A.g.y (V)	(a)	Yucatan	21°13″	87°49″	Not protected
65	Punta Laguna	MSEF	A.p (V), A.g.y (V)	(a) (a–b)	Yucatan	20°38″	87°37″	Protected
66	El Cuyo	LDF	A.g.y (V)	(a)	Yucatan	21°30″	87°43″	Not protected

Codes: CL = Commonland, A.p = *Alouatta pigra*, A.g.y. = *Ateles geoffroyi yucatanensis*, and A.p.m. = *Alouatta palliata mexicana*; (V) = verified and (Re) = reported people; Protected and not protected is related to Mexican legal status of each sampled areas; Letters a–g represent different howler troops and spider monkey subgroups located at each site. Vegetation type: LDF = low, deciduous forest; MSDF = medium, semideciduous forest; MSEF = medium, semievergreen forest, TEF = tall, evergreen forest, TSEF = tall, semievergreen forest, MDF = medium deciduous forest, and MANG = mangrove (Flores and Espejel-Carvajal, 1994).

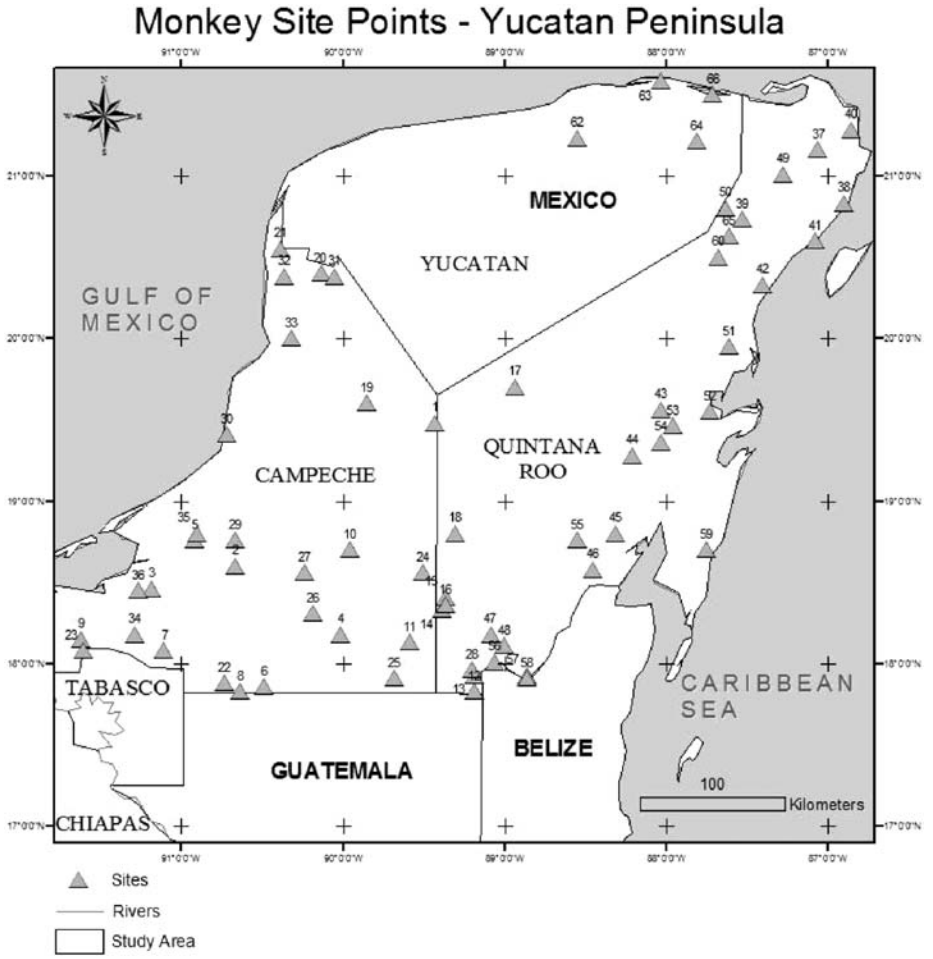

Figure 1. Localities for spider monkeys (*Ateles geoffroyi yucatanensis*), black howler monkeys (*Alouatta pigra*), and Mexican mantled howler monkeys (*Alouatta palliata mexicana*) in the Yucatan Peninsula, Mexico during the 2000–2002 surveys.

medium-height semievergreen forest (MSEF). This same vegetation type also was the most common surveyed in Quintana Roo (14 sites on these localities, 56%). In Yucatan, the most common vegetation was medium-height semideciduous forest (MSDF) and low-height deciduous forest (LDF) (two sites each).

We found the greatest density of *A. pigra* troops inhabiting MSEF forests in Campeche (mean = 5.6 ± 0.16 per km) and Quintana Roo (mean = 2.28 ± 0.18 per km). We found the greatest number of *A. g. yucatanensis* subgroups

in MSEF forests (mean = 0.49 ± 0.47 per km) and tall evergreen forest (TEF) forests (mean = 0.87 ± 0.11 per km) forests in Campeche. In Quintana Roo, the greatest number of spider monkey subgroups was found in MSEF vegetation (mean = 1.67 ± 0.10) (Table 2).

Campeche was the state with the greatest abundance of monkey populations ($n = 36$, 54.5%), followed by Quintana Roo ($n = 30$, 37.8%) and Yucatan ($n = 5$, 7.5%). Of all monkey sites, 24 (36.4%) included only *A. pigra*, 15 (22.7%) only *A. g. yucatanensis*, and 25 (37.9%) had both species. Sites with both howler and spider monkeys present were found in southeastern Campeche. We identified two sites (3.0%) that contained coexisting sympatric populations of *A. pigra* and *A. p. mexicana*.

A total of 158 *A. pigra* troops, 5 *A. p. mexicana* troops, and 70 subgroups of *A. g. yucatanensis* were recorded in our survey transects (170 transects, totaling 733.5 km). The probability of finding an *A. pigra* troop on the Yucatan Peninsula was 0.21 troops/km; for *A. g. yucatanensis* subgroups, it was 0.095 subgroups/km; and for *A. p. mexicana*, it was 0.0068 troops/km. The mean number of individuals per *A. pigra* troop and *A. g. yucatanensis* subgroups for our entire sample was 5.7 ± 1.8 and 11.4 ± 6.7, respectively; however, these data varied for each state by sex–age composition and particularly by vegetation type.

The state of Campeche had an average of 5.5 ± 1.8 *A. pigra* individuals per troop, with three solitary individuals also sighted. For *A. g. yucatanensis* the average was 8.9 ± 4.3 individuals per subgroup. In the state of Quintana Roo, the average was 6.4 ± 1.5 individuals per *A. pigra* troop, while it was 12.4 ± 7.1 individuals per *A. g. yucatanensis* subgroup. Finally, for Yucatan, the only *A. pigra* group located consisted of six individuals, while for *A. g. yucatanensis* the average number of individuals per subgroup was 14.7 ± 10.2. For *A. p. mexicana* troops located in various parts of the Peninsula (Campeche and Quintana Roo states), the average number of individuals per troop was 8.8 ± 1.9.

The adult sex-ratio of all *A. pigra* troops was 1:1.59 (male to females). For juveniles this ratio was 1:0.67. The ratio of adult females to immatures was 1:0.84. For *A. g. yucatanensis*, the male–female sex ratio was 1:1.50 for adults and 1:1.22 for juveniles. The ratio of adult females to immature was 1:0.87. The sex-ratios (male to females, juveniles and adult females to immatures) were relatively consistent for *A. pigra* and *A. geoffroyi* across the Peninsula. The adult sex ratio of all three primate species observed is presented in Table 3.

Table 2. Summary of primate troops/subgroups and sites surveyed including vegetation type for each state in the Yucatan Peninsula

State	Number of sites	Vegetation types	Transect length (km)	No. of *A. pigra* troops/km	No. of *A. g. yucatanensis* subgroups/km	No. of *A. palliata* troops/km	Protected status per site and length (km) surveyed in each condition
Campeche	18	MSEF	171	5.6	0.49	0.46	18 protected (159 km)
	8	TEF	83	3.25	0.87	–	18 not protected (195 km)
	3	TSEF	36	0.91	0.15	–	
	2	MANG	35	0.15	0.34	–	
	1	MSDF	13	0.32	–	–	
	1	MDF	4	–	0.23	–	
		LDF	12	0.86	0.09	–	
	Total 36		Total = 354 km				
Quintana Roo	14	MSEF	165	2.28	1.67	0.66	13 protected (188.8 km)
	8	TSEF	105	1.61	0.96	–	12 not protected (104.6 km)
	3	MSDF	23	0.48	0.66	–	
	Total 25		Total = 293 km				
Yucatan	2	MSDF	23.0	–	0.14	–	4 not protected (51 km)
	2	LDF	34.0	–	0.17	–	
	1	MSEF	12.0	0.05	0.11	–	
	Total 5		Total = 69 km				
Total	Total 66		716 km				

Codes: Vegetation type: LDF = low, deciduous forest; MSDF = medium, semideciduous forest; MSEF = medium, semievergreen forest; TEF = tall, evergreen forest; TSEF = tall, semievergreen forest; MDF = medium, deciduous forest; MANG = mangrove (Flores and Espejel, 1994).

Table 3. Sex ratio for howler monkeys (*Alouatta pigra* and *Alouatta palliata*) and subgroups of spider monkeys (*Ateles geoffroyi yucatanensis*) during surveys in Yucatan Peninsula, Mexico

	Alouatta pigra	*Ateles geoffroyi yucatanensis*	*Alouatta palliata mexicana*
Adult sex ratio (male to female)	1:1.59	1:1.50	1:1.72
Juveniles	1:0.67	1:1.22	1:0.26
Adult female—immatures	1:0.84	1:0.87	1:0.84

Sites with Sympatry of *A. palliata* and *A. pigra*

Finally, it is of extreme importance to note that we observed sympatric population of *A. palliata* and *A. pigra* in the "El Alamo Ranch" (Locality # 35) and the "Conquista Campesina" commonland (Locality # 32). These appear to be the only areas whether these two species co-occur. It remains unclear if the range of both howler species traditionally overlapped (see Ford's chapter in this volume) or whether this represents a recent event due to habitat change and forest fragmentation.

Distribution of Vegetation Types in the Yucatan Peninsula

Based on the *landsat* satellite images and Mexican government cartography, we estimated that the potential forested habitat available for primate conservation in the Yucatan Peninsula is 93,942.39 km^2. This amounts to 63.9% of the Peninsula's total surface area and encompasses the entire region examined in our surveys (Figure 1). The distribution of vegetation types in this area is 1332.55 km^2(1.3%) of low semievergreen forest, 4712.01 km^2(5.0%) of MSDF, 8376.93 km^2(8.9%) of LDF, 14,071.23 km^2(15.0%) of TEF, and 65,449.67 km^2(69.7%) of MSEF. Although there continues to remain a substantial area of habitat suitable to primates in the Yucatan, of the total number of sites sampled, 34 (51.5%) were located in unprotected areas, with only 32 sites (48.5%) legally protected (CONANP, 2004). Clearly, primates in these unprotected areas remain vulnerable to human-induced habitat fragmentation associated with agriculture and cattle ranching. Some authors have suggested that the remaining forests of southern Mexico are being impacted by human

activity at a variable but high rate. For example, while the overall deforestation rate for the period 1990–2000 for southern Mexico, including the Yucatan Peninsula, has been estimated at −1.1%, in some areas of the Peninsula annual rates of deforestation are 7.7% (Estrada, 2004).

DISCUSSION

Our results indicate that although populations of *A. pigra* and *A. g. yucatanensis* are found throughout the Yucatan Peninsula, approximately half of the sites we censused have no legal or protected status. For example, we found more howler monkey populations in nonprotected areas ($N = 95$) than in protected areas ($N = 52$). In addition, we encountered populations of howler monkeys (*A. pigra*, 0.21 troops/km) more frequently than spider monkeys (0.095 subgroups/km). In the case of *A. pigra*, the mean troop size (5.7 ± 1.8) was similar to that reported by Estrada *et al.* (2004) for this species at other sites in the Peninsula (Calakmul, Campeche 7.5 ± 2.3 individuals) and in other southern sites—Yaxchilan, 6.6 ± 2.1 individuals (Estrada *et al.*, 2002b) and Palenque, Chiapas, 7.0 ± 2.8 individuals (Estrada *et al.*, 2002a). In the Yucatan Peninsula, *A. pigra* populations had an adult male–adult female sex ratio that was higher than that reported by Estrada *et al.* (2002a) for sites in Palenque but similar to those found in Belize (Ostro *et al.*, 1999) and Guatemala (Bolin, 1981). Factors such as forest patch size, forest patch productivity, landscape fragmentation, opportunities for migration, and the presence of corridors between forest patches are likely to play an important role in individual survivorship and the adult sex ratios of primate groups.

In the case of spider monkeys, we found more subgroups in protected areas ($N = 30$ areas than in nonprotected areas ($N = 23$). It is likely that protected areas contain a higher incidence of mature fruit trees and larger or more contiguous tracks of forest. Both of these the factors are critical to spider monkeys that are highly frugivorous and typically exploit home ranges of several hundred hectares. The spider monkey subgroups we observed were considerably larger (11.4–14.7 individuals/subgroup) than subgroups of this subspecies reported at other sites by Gonzalez-Kirchner (1999, 3.8–4.5 individuals/subgroup) and Estrada *et al.* (2002a, 7.7 ± 3.8). Whether this reflects a higher population density in response to a larger resource base or the temporary coalescing of individuals in response to forest fragmentation remains unclear.

Vegetation types have clear effects on the presence and persistence of wild primates in the Yucatan Peninsula. Groups of the three primate species were more likely to be found in MSEF (Table 4). Some vegetation types may be more adversely affected by human impact than others as a result of a particular land use patterns and of high human population densities in their vicinity. MSEF is the most extensive vegetation type in the Yucatan Peninsula and while it seems to be especially important for the persistence of primate populations, it is an ecosystem that produces millions of dollars in internationally traded goods annually, including timber, ornamental palms, latexes, spices, oils and botanical elements (Conservation International, 2000). As a result, this important habitat for primates may be endangered in the near future. However, concerned with the need to preserve this ecosystem, local governments and nongovernmental organizations (NGO) are working toward improved coordination to preserve and manage areas encompassed by MSEF in the Yucatan Peninsula (Conservation International, 2000).

We identified an important association between habitat type (MSEF, tall semievergreen forest (TESF), and TEF) and the mean number of primate troops and subgroups. In the case of black howler monkeys, troop size was the greatest in MSEF. In the case of spider monkeys, the largest subgroups were found in a variety of forest types including TEF, tall, TESF, and low-height deciduous forest (LDF) (Table 4).

During our investigation we confirmed the existence of an area in the state of Campeche where populations of *A. pigra* and *A. p. mexicana* are sympatric. On "El Alamo Ranch" (Locality # 35) and the "Conquista Campesina" commonland (Locality # 32), we documented two and three *A. p. mexicana* troops, respectively, interacting at mean distances of 100–300 m from *A. pigra* troops. The *A. p. mexicana* troops exhibited characteristics that are typical of the species in other regions (e.g., Los Tuxtlas, Veracruz, Mexico), such as dark brown fur color and a yellow-reddish mantle. However, adult males howls seem to be more variable than in our previous observations of this species. The adult sex ratio of these mantled howler troops (total of 46 individuals) was 1:1.72 males to females. These values are similar to those reported by Estrada (1982) at Los Tuxtlas, Veracruz. The only other report of sympatric howler species was by Smith (1970) in Macuspana, Tabasco. The coexistence of *A. pigra* and *A. p. mexicana* at these sites in Campeche is extremely precarious. The groups we observed were living on private property and ranches that have been reducing their forest cover each year in order to increase cattle production.

Table 4. Sex–age composition and mean composition of troops of howler monkeys (*Alouatta pigra* and *Alouatta palliata*) and subgroups of spider monkeys (*Ateles geoffroyi yucatanensis*) sighted during surveys in Yucatan Peninsula, Mexico

Species and sex–age category	State	MDF	LDF	MANG	MSDF	MSEF	TEF	TSEF
Alouatta pigra								
Ad. male (mean ± SD)								
	Campeche	–	1	1	1.5 ± 0.7	1.6 ± 0.7	1.3 ± 0.5	1.4 ± 0.5
	Quintana Roo	–	–	–	1.2 ± 0.5	1.3 ± 0.5	–	1.6 ± 0.8
	Yucatan	–	–	–	–	1	–	–
Ad. female (mean ± SD)								
	Campeche	–	1	2	3	2.5 ± 0.9	2.1 ± 0.9	2.1 ± 0.9
	Quintana Roo	–	–	–	2.5 ± 1.3	2.2 ± 0.8	–	2.7 ± 0.7
	Yucatan	–	–	–	–	2	–	–
Juv. male (mean ± SD)								
	Campeche	–	2	–	0.5 ± 0.7	0.7 ± 0.7	0.6 ± 0.6	0.4 ± 0.5
	Quintana Roo	–	–	–	0.7 ± 0.5	0.8 ± 0.7	–	0.7 ± 0.4
	Yucatan	–	–	–	–	–	–	–
Juv. female (mean ± SD)								
	Campeche	–	–	0.5 ± 0.7	–	0.5 ± 0.6	0.3 ± 0.4	0.4 ± 0.5
	Quintana Roo	–	–	–	0.2 ± 0.5	0.6 ± 0.7	–	0.4 ± 0.5
	Yucatan	–	–	–	–	1	–	–
Infant (mean ± SD)								
	Campeche	–	–	1.5 ± 0.7	0.5 ± 0.7	0.7 ± 0.6	0.4 ± 0.6	0.4 ± 0.5
	Quintana Roo	–	–	–	1.2 ± 0.8	1.2 ± 0.8	–	1.1 ± 0.6
	Yucatan	–	–	–	–	2	–	–
Total (mean ± SD)								
	Campeche	–	4	5	5.5 ± 0.7	6.2 ± 1.7	4.7 ± 1.9	4.7 ± 1.4
	Quintana Roo	–	–	–	6.0 ± 1.8	6.3 ± 1.3	–	6.6 ± 1.7
	Yucatan	–	–	–	–	6	–	–

Ateles geoffroyi yucatanensis								
Ad. male (mean ± SD)								
	Campeche	1	4	2.2 ± 0.9	–	2.2 ± 2.1	3.0 ± 1.6	1.5 ± 0.7
	Quintana Roo	–	–	–	2.0 ± 1.4	3.7 ± 2.3	–	2.8 ± 1.5
	Yucatan	–	2.5 ± 0.7	–	2.5 ± 2.1	4.0 ± 2.8	–	–
Ad. female (mean ± SD)								
	Campeche	1	6	3.2 ± 1.2	–	3.3 ± 2.5	3.8 ± 1.2	2
	Quintana Roo	–	–	–	4.5 ± 2.1	5.6 ± 3.0	–	4.2 ± 1.8
	Yucatan	–	3.5 ± 0.7	–	4.5 ± 2.1	9.0 ± 5.6	–	–
Juv. male (mean ± SD)								
	Campeche	–	1	–	0.5 ± 0.7	1.0 ± 1.1	0.8 ± 0.6	0.5 ± 0.7
	Quintana Roo	–	–	–	–	1.2 ± 1.5	–	0.9 ± 0.9
	Yucatan	–	1	–	–	5.0 ± 2.8	–	–
Juv. female (mean ± SD)								
	Campeche	–	1	0.5 ± 0.5	–	1.0 ± 1.2	1.3 ± 0.6	0.5 ± 0.7
	Quintana Roo	–	–	–	–	1.3 ± 1.5	–	1.1 ± 0.9
	Yucatan	–	1	–	0.5 ± 0.7	7.0 ± 1.4	–	–
Infant (mean ± SD)								
	Campeche	1	–	0.7 ± 0.5	–	1.6 ± 1.0	1.6 ± 0.7	1.0 ± 1.4
	Quintana Roo	–	–	–	2.5 ± 0.7	2.1 ± 1.8	–	1.7 ± 1.3
	Yucatan	–	2.0 ± 1.4	–	1.5 ± 0.7	–	–	–
Total (mean ± SD)								
	Campeche	3	12	6.7 ± 2.5	–	9.1 ± 6.6	10.5 ± 3	5.5 ± 0.7
	Quintana Roo	–	–	–	9.5 ± 3.5	14.0 ± 9	–	11 ± 4.4
	Yucatan	–	10.0 ± 2.8	–	9.0 ± 5.6	25 ± 12.7	–	–
Alouatta palliata mexicana								
Ad. male (mean ± SD)								
	Campeche (*)	–	–	–	–	2.2 ± 0.8	–	–
	Quintana Roo (**)	–	–	–	–	3	–	–

(*Continued*)

Table 4. *(Continued)*

Species and sex–age category	State	MDF	LDF	MANG	MSDF	MSEF	TEF	TSEF
Ad. female (mean ± SD)								
	Campeche (*)	–	–	–	–	3.8 ± 0.8	–	–
	Quintana Roo (**)	–	–	–	–	2	–	–
Juvenile (mean ± SD)								
	Campeche (*)	–	–	–	–	1.0 ± 0.7	–	–
	Quintana Roo (**)	–	–	–	–	1	–	–
Infant (mean ± SD)								
	Campeche (*)	–	–	–	–	2.2 ± 0.4	–	–
	Quintana Roo (**)	–	–	–	–	1	–	–
Total (mean ± SD)								
	Campeche (*)	–	–	–	–	9.2 ± 1.9	–	–
	Quintana Roo (**)	–	–	–	–	7	–	–

Codes: Vegetation type: LDF = low, deciduous forest; MSDF = medium, semideciduous forest; MSEF = medium, semievergreen forest; TEF = tall, evergreen forest; TSEF = tall, semievergreen forest; MDF = medium, deciduous forest; and MANG = mangrove (Flores y Espejel, 1994). (*) Troops located in sympatric area; (**) Troops located in a five stars hotels out of their natural geographic distribution.

General Conservation Considerations Regarding the Yucatan Peninsula as a Priority Area for Primate Conservation in Mexico

Data presented in this chapter indicate that at present, the conservation status of Yucatan Peninsula's primate populations can be described as follows. There remain large tracks of forest as well as fragmented landscapes where primate populations continue to survive. However, there are areas that are being negatively impacted by the effects of habitat disturbance. For example, clearing areas for cattle ranching in Campeche, agriculture in Yucatan, and most damaging, the establishment of tourist areas in northern Quintana Roo have diminished forest cover and isolated several primate populations. This is the case for Puerto Morelos Botanical Garden (Location # 38), which is located near the extensive tourist infrastructure of Playa del Carmen and Cancun. Furthermore, the desire of hotels to attract more tourists and a lack of understanding by hotel administrators have led to errors of judgment that could have severe negative effects on the native primate populations. One example is the introduction of an *A. p. mexicana* troop (Location # 41) into the "Playacar" tourist complex, located in northern Quintana Roo. This is an area exclusively endemic to *A. pigra*. It is certainly possible that mantled howlers from this captive group could escape and contact and possibly join a nearby *A. pigra* group.

It is likely that expanding agriculture, timber harvesting, and cattle ranching in the near future will result in increased forest fragmentation, forest degradation, and habitat loss. This may result in the fragmentation of primate populations, population isolation, and may lead to demographic, social, and reproductive disruption. One example of this is our observation in southern Campeche that howler monkeys living in very small (<1 ha) forest fragments commonly walk, feed, and drink on the ground (Pozo-Montuy, 2003). Under such conditions, the howlers are extremely vulnerable to predation by carnivores such as coyotes (*Canis latrans*) (Pozo-Montuy, pers. obs.). A similar situation, and increased in time spent on the ground, was reported for *A. p. mexicana* in southeastern Veracruz (Serio-Silva and Rico-Gray, 2000a).

The future of the Yucatan Peninsula's primate populations remains uncertain. However, with informed conservation efforts howler and spider monkey populations can continue to persist. Because the Yucatan Peninsula still contains large tracks of forested habitats, this region must be considered among the highest priority conservation regions in Mesoamerica (Serio-Silva and Rico-Gray, 2000b). What is needed, are larger scale and long-term research

programs staffed by biologists, primatologists, ecologists, and anthropologists. In this way, critical knowledge of the behavioral ecology and demography of Yucatan Peninsula's primate populations can be obtained, and this knowledge can serve as the basis for developing and evaluating effective conservation and management policies. Given the current status of Yucatan Peninsula's primate populations we recommend the following conservation guidelines for the region.

(1) Increase and support efforts to promote the habitat and population conservation status of three states on the Yucatan Peninsula.
(2) Develop and prioritize research projects focused on the basic ecology, behavior, management, and conservation of primate populations in their natural habitat, evaluate effects of habitat fragmentation, and promote student training in primatology in local universities.
(3) Establish links with the local governments to increase the number of protected forested areas and set up community-based conservation initiatives in specific localities.

SUMMARY

In this paper, we present the results of an area-wide survey (January 2000–April 2002) that provides information on current locations of *A. pigra*, *A. p. mexicana* and *A. g. yucatanensis* populations in the Yucatan Peninsula. Primates were encountered in 66 of 78 sites surveyed. Of these, 24 sites harbored *A. pigra*, 15 harbored *A. g. yucatanensis*, and both species were encountered in 24 sites. In total, we found 70 subgroups of *A. g. yucatanensis* of which 6 in Yucatan, 40 in Quintana Roo, and 24 in Campeche. A total of 149 *A. pigra* troops were encountered of which 1 in Yucatan, 39 in Quintana Roo, and 109 in Campeche. All four *A. p. mexicana* troops were found in Campeche. An important corollary is the new report of two sites in Campeche where *A. pigra* and *A. p. mexicana* coexist sympatrically.

In addition, surveys assessed the legal protection status of the habitats/sites in which primate populations were present. Using GIS, we identified 93,942.39 km^2 (63.9% of total) as potential habitat for the three primate species occurring in Mexico. In this sense, although there continues to remain a substantial area of habitat suitable to primates in the Yucatan Peninsula, of the total number of sites sampled, 34 (51.5%) were located in unprotected areas, with only 32 sites (48.5%) legally protected. We evaluated how vegetation

types could be having clear effects on the possibility to find wild primates in the Yucatan Peninsula. We found that populations of the three primate species were more likely to be found in MSEF. Finally, even though the Yucatan Peninsula is considered one of the most important Mexican forested areas to promote effective conservation management (for primates), we found early evidences of negative impact on habitat disturbance as a consequence of tourism in some sites in the north of the Yucatan Peninsula.

We use this information to present a general assessment of the conservation status of primate populations and their habitat on the Yucatan Peninsula.

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