SPATIAL DIFFERENCES AND LOCAL AVOIDANCE OF OCELOT (*Leopardus pardalis*) AND JAGUARUNDI (*Puma yagouaroundi*) IN NORTHEAST MEXICO

A Dissertation

By

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ABSTRACT

Spatial Differences and Local Avoidance of Ocelot (*Leopardus pardalis*) and Jaguarundi (*Puma yagouaroundi*) in Northeast Mexico

(August 2013)

Arturo Caso, B.S., Monterrey Tech; M.S., Texas A&M University-Kingsville
Chairman of Advisory Committee: Dr. Michael E. Tewes

Ecological patterns of the sympatric ocelot (*Leopardus pardalis*) and jaguarundi (*Puma yagouaroundi*) have not been documented, so little is known about the coexistence or avoidance of these endangered felines. I began a field project at Los Ebanos Ranch, Tamaulipas, northeast Mexico in 1991 to assess home range size, habitat use, and activity patterns of ocelots and jaguarundis. I captured 21 jaguarundis (13 M; 8 F) and 22 ocelots (9 M; 13 F). A VHF radio-collar was attached to each cat to assess their movements. Locate II and Locate III and ArcView 3.3 (Animal Extensions) computer programs were used to evaluate home range size (95% Fixed Kernel and 95% Minimum Convex Polygon), core areas size (50% Fixed Kernel and 50% Minimum Convex Polygon), and activity patterns. Habitat use relative to availability was assessed for both feline species using the Neu et al. (1974) test. Mean home range size (FK95) for male and female ocelots was 15.1 and 8.5 km², respectively. Mean home range size (FK95) of male and female jaguarundis was 16.2 and 12.1 km², respectively. Home ranges of both felids overlapped, however core areas had little overlap. Ocelots were predominantly nocturnal (75% nocturnal activity versus 25% diurnal), whereas jaguarundis were predominantly diurnal (15% nocturnal activity versus 85% diurnal). Ocelots used tropical sub-deciduous forest (82%) more intensively than open habitats (18%) available in their home ranges, while jaguarundis used tropical sub-deciduous forest (48%) and pasture-grassland (52%) with similar intensities. Tropical sub-deciduous forest was the preferred habitat for both species. Although home ranges of both felids overlapped, I found that core areas slightly overlapped and jaguarundis maintained a mean distance of >2 km from ocelots suggesting spatial avoidance of jaguarundis and ocelots in the study area.

DEDICATION

I would like to dedicate this dissertation to my daughters, Asali and Arusha, who really have a love for animals. I hope this manuscript will be a future example about “if you really want something, it will be possible with a lot of effort and patience.”

I would also like to dedicate this thesis to my wife, Sasha Carvajal-Villarreal, who has been supporting me during the good and bad moments and because she has been my field partner during the last 15 years. For sure new joys and challenges will come, but always together we will solve and enjoy them.

Also, I would like to dedicate this dissertation to my family. To my parents Andres Caso and Graciela Aguilar and to my brother Alfonso and my sisters Andrea and Graciela. I really regret that my father and my sister Graciela are not with us anymore, but I am pretty sure wherever they are, they are really happy knowing about this accomplishment.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

SPATIAL PATTERNS AND HABITAT USE OF JAGUARUNDI (*PUMA YAGOUAROUNDI*) IN TAMAULIPAS, NORTHEAST MEXICO

1. Introduction

The jaguarundi *(Puma yagouaroundi*) is a widely distributed small cat that ranges from northern Argentina to southern Texas, U.S. (Nowell and Jackson, 1996; Sunquist and Sunquist, 2002; Tewes and Schmidly, 1987). However, the last confirmed report of a jaguarundi in the U.S. was a road-killed individual found near Brownsville, Texas, in 1986 (Tewes and Schmidly, 1987). The jaguarundi is listed as a “least concern” species on the International Union for Conservation of Nature (IUCN) Red List (Caso et al., 2008). However, the Central and North American (including Mexican) populations of (*P. y. cacomitli*) are considered endangered (USFWS, 1982) and are listed as an Appendix I species by the Convention on the International Trade in Endangered Species (CITES) (Caso et al., 2008). The jaguarundi is considered a threatened species in Mexico by Ley General del Equilibrio Ecológico (SEMARNAT, 2001).

Jaguarundis are not commonly exploited for commercial trade; however they are occasionally killed because of their depredation on domestic poultry (Leopold, 1959; Nowell and Jackson, 1996). The diurnally active jaguarundi is the most common neotropical cat observed in the wild (Crawshaw, 1995; Leopold 1959). However, little is known about the species’ spatial movements and habitat use. Jaguarundi density is low throughout most of its range (Oliveira et al., 2010; Yu and Dobson, 2000). Jaguarundis are difficult to capture with box traps, leg-hold traps (Michalski et al., 2007), and with the use of trained dogs. Consequently, few radio-telemetry studies have examined spatial patterns and habitat use of this felid.

The style and format of this dissertation chapter follows the *Journal of Biological Conservation*.

Konecny (1989) captured 4 jaguarundis and radio-tracked 3 individuals (2 males; 1 female) after 2 years of field work in Belize. Konecny (1989) obtained a large mean home range size of 94.1 km² for males and 20.1 km² for the single female. These large areas may reflect space-use of transient males. The greatest effort to study jaguarundis using VHF radio-telemetry occurred in Brazil. Crawshaw (1995) captured 3 jaguarundis (2 sub-adult males and 1 sub-adult female) after 3,599 trap nights in southern Brazil (Iguaçu National Park) and radio-collared 1 male and 1 female. Crawshaw (1995) tracked the female jaguarundi for 18 days, obtaining a home range size of 19.6 km². The male jaguarundi was tracked for 35 days and exhibited a home range size of 7.2 km². Michalski et al. (2006, 2007) captured 3 different jaguarundis in Ipanema National Forest, Brazil, and obtained data on 2 individuals (1 male; 1 female) after 1 year of field effort. Michalski et al. (2006) obtained a home range size of 20.5 km² for a male and 1.9 km² for a female. Oliveira et al. (2010) radio-tracked 3 males in Taquari, Brazil, and obtained a mean home range of 23.4 km².

Jaguarundis occupied a broad range of open and closed habitats (Sunquist and Sunquist, 2002). However, jaguarundis seemed to use open areas much greater than sympatric ocelots (Caso, 1994; Nowell and Jackson, 1998; Sunquist and Sunquist, 2002).

Konecny (1989) found that 3 jaguarundis used mostly riparian and old field habitats, whereas Michalski et al. (2006) found that a female jaguarundi exclusively used secondary forest, and a male used grasslands, secondary, and eucalyptol forests. Additionally, jaguarundis avoided mature forest in the study area (Michalski et al., 2006).

Information on spatial patterns and habitat use of carnivores assists planning future conservation strategies. Habitat fragmentation is one of the major threats for many species and may cause future extinctions (Wilcox and Murphy, 1985). Because of small sample sizes obtained in previous studies, data from this study represents the first robust spatial and habitat use information using VHF radio-telemetry on free-ranging jaguarundis in their range, and it represents the first study of the endangered subspecies (*P. y. cacomitli*).

1.1 Objectives

1) Determine home range size, core area size, and amount of overlap among jaguarundi at Los Ebanos Ranch Complex (LERC).
2) Determine activity patterns of jaguarundi at LERC.
3) Determine habitat use patterns of jaguarundi at LERC.

2. Materials and methods

2.1 Study area

The LERC (23°28’7”N, 93°47’38”W) includes 3 private properties: Los Ebanos, Los Pericos, and Tepehuajes Ranches. The LEBC is located in the State of Tamaulipas in northeast Mexico, and is adjacent to the Gulf of Mexico (Fig. 1). Mean annual precipitation in this region is 72 cm with variation throughout the year (INEGI, 2011; Pennington and Sarukhan 1968). Temperatures range from 5ºC to 38ºC, with a mean of 24.6°C (INEGI, 2011). Topography is mostly flat with some hills in the western area and elevation ranges from 0-30 m (Caso, 1994; INEGI, 2011).

Land use practices implemented at LERC were dominated by cattle ranching and have resulted in native, lowland tropical sub-deciduous forest (Pennington and Sarukhan, 1968) occurring in strip patterns (Caso, 1994; Shindle, 1995; Shindle and Tewes, 1988).

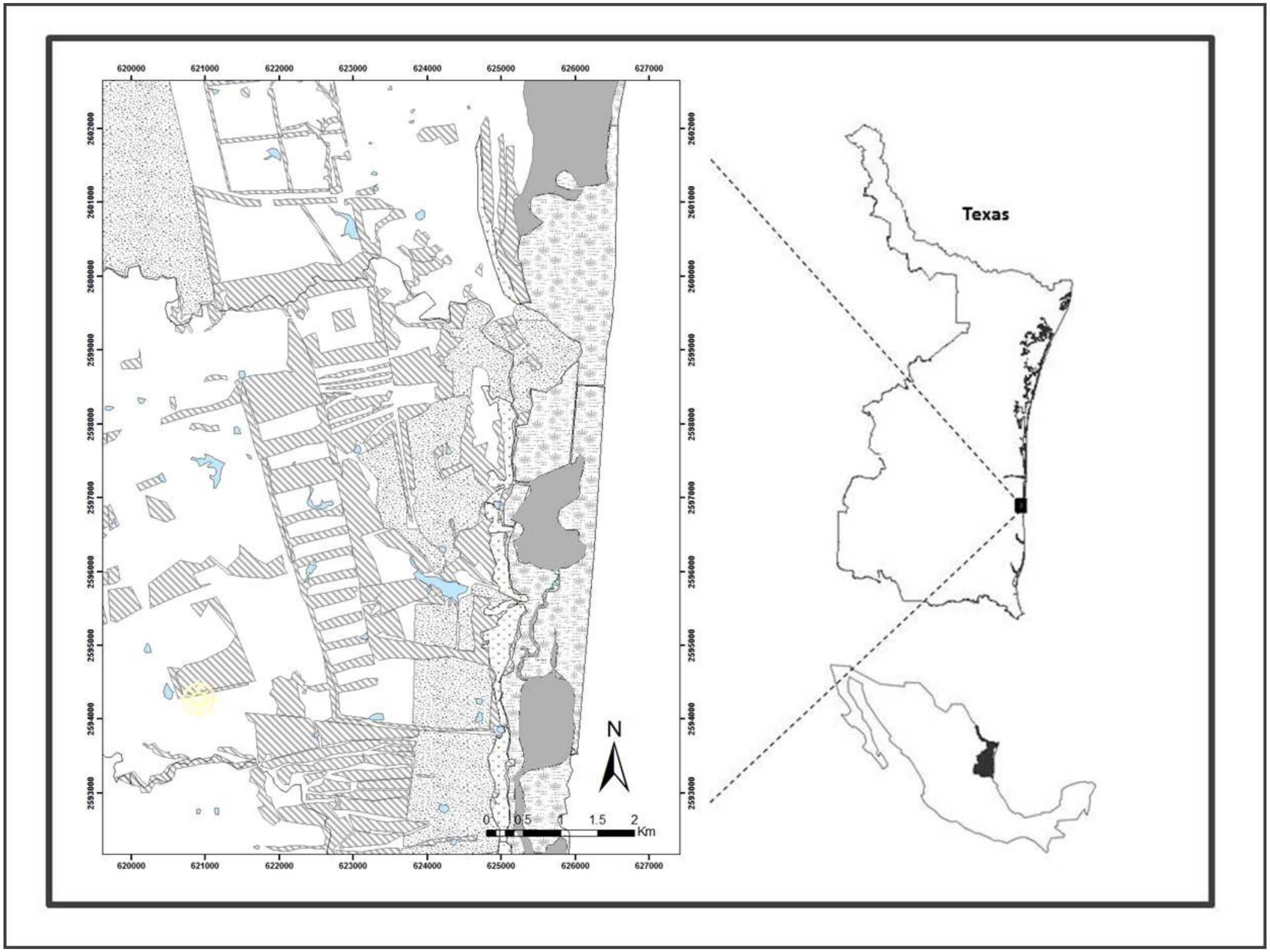

Figure 1. Location of jaguarundi study from June 1991-December 2003 on the Los Ebanos Ranch Complex in Tamaulipas, Mexico.

Natural habitat is considered tropical sub-deciduous forest and woody species encountered in the area are ebony (*Pithecellobium flexicaule*), gumbo limbo (chaca) tree (*Bursera semiaruba*), strangle fig (*Ficus tecolutensis*), tepehuaje (*Lysiloma acapulcensis*), guacima (*Guazuma ulmifolia*) and grangeno (*Celtis reticulata*) (Pennington and Sarukhan, 1968; Gonzalez-Medrano, 1972; Rzedowski, 1986, Shindle and Tewes, 1988). Five types of vegetation communities dominate the study area: undisturbed natural tropical sub-deciduous forest, African star (*Cynodon niemfluensis*) grassland, Guinea grass (*Panicum maximum*) grassland, Gulf cordgrass (*Spartina spartinae*) communities, and estuarine vegetation with mangrove (*Avicennia germinans*) (Gonzalez-Medrano, 1972; INEGI, 2011; Rzedowski, 1986; Shindle and Tewes, 1998).

2.2 Capture and handling

Individual jaguarundis were trapped from July 1991 to November 2007 with Tomahawk® wire box-traps (107 x 50 x 40 cm; Tomahawk Live Trap Company, Tomahawk, Wisconsin, USA) with an attachment for live bait such as chickens and coturnix quail (Caso, 1994; Caso et al., 2005; Tewes, 1986). Traps were set along game trails where suitable habitat was located, or where jaguarundis were observed. Traps were set continuously during trapping periods, and checked every morning before 1100 h. Traps were placed in areas with sufficient shade (e.g., under forest canopy) to prevent heat stress of captured cats.

Captured jaguarundis were immobilized with an intramuscular injection using either a mixture of ketamine hydrochloride (Ketaset®, Bristol Laboratories, Syracuse, NY) and xylazine (Rompun®, Bayer, Munich, Germany; Beltran and Tewes, 1995), or tiletamine hydrochloride-zolazepam (Zoletil® Virbac, Ltd., Carros, France) (Shindle and Tewes, 2000). The drug was administered to the captured jaguarundi with a pole syringe. Morphological measurements included total length (tail and body length), hind foot length (from pad to elbow), foot to shoulder (from pad to top of scapula), girth (rib cage) circumference, body temperature, and blood and hair samples were taken (Burt, 1989; Leopold 1959). Dental condition was evaluated to estimate age. A VHF 80-g radio-collar (148-151 MHz) with a mortality sensor (Wildlife Materials Inc., Murphysboro, Illinois; Telonics, Inc., Meza Arizona; and Advanced Telemetry Systems, Inc., Isanti, Minnesota) was attached to adult and sub-adult jaguarundis following handling procedures. The sedated felid was returned to the trap or a "pet carrier" box for protected recovery from the effects of immobilization. Jaguarundis were released at the capture site when effects of sedation ended and full coordination was achieved.

2.3 Spatial data collection

I attempted to locate every radio-collared jaguarundi 10 times each month from established ground-fixed stations to provide data on home range size and spatial patterns. Jaguarundis were located throughout the study area during diurnal and nocturnal periods. For each location, ≥2 bearings were taken from different fixed receiver stations with a Suunto hand-held compass (Sunnto Instruments, Finland; Kenward, 1987). Independence of locations was achieved by using 1 location each 24-h period.

Radio-telemetry information included identification number, date, and time for each location. Animal locations were determined using Locate II and III software (Tatamagouche, Nova Scotia, Canada). Some individuals (n = 9) were monitored hourly for activity patterns. For these individuals I measured the distance from the initial and final location, the average distance (m) traveled each hour, and the area occupied during the 24-h period as determined by minimum convex polygon 100% (MCP 100%). Linear distances were calculated on jaguarundis that were radio tracked on consecutive days (Rabinowitz and Nottingham 1986). Data were analyzed in

SAS 3.2 (SAS Institute, Cary, North Carolina).

2.4 Home range estimation

Home ranges were calculated using 2 estimators: the fixed kernel 95% (FK95) (Horne and Garton, 2006; White and Garrot, 1990; Worton, 1989) and minimum convex polygon 95% (MCP95) (MacDonald et al., 1980; Mohr 1947). The MCP95 home range estimator was used for comparison with previous studies and to measure home range overlap (Carvajal et al., 2012). Core areas were calculated using the fixed kernel 50% (FK50) and minimum convex polygon 50% (MCP50) estimates (Carvajal et al., 2012; Grassman, 2004; Hooge and Eichenlaub, 2000).

Radio telemetry error was assessed with a global position system (GPS) by identifying the location of 5 transmitters placed randomly in the same habitat where the cats roamed (Blankenship, 2000; Grassman, 2004), and the GPS locations compared with the corresponding telemetry location. Mean distance between triangulated radio locations and GPS locations indicated a mean triangulated error of 42±36 m.

The computer programs ArcView 3.2 and ArcGIS 9 and 10 with the Animal Movements extension were used to evaluate radio-telemetry data obtained during this project (Grassman, 2004; Hooge and Eichenlaub, 2000). Percentage overlap comparisons were calculated using the MCP95 and MCP50 estimators (Carvajal et al., 2012; Dillon and Kelly, 2008; Grassman et al., 2005). Home range values were from adult individuals and the minimum number of independent locations for each home range value using the asymptote test (Seaman et al., 1996) was 20 observations. Home range values, core area contour intervals and cat locations were converted with ArcMap 10 to polygon and point shape files. A 2-sample, 2-sided t-test (Dowdy and Wearden, 1991) were used to compare home range and core area size between males and females and to compare spatial patterns by gender (Fernandez, 2002).

2.5 Habitat use

Vegetation polygon shape files were created using ArcMap10 from digital orthophoto quadrangle imagery (DOQs) (INEGI, 2011) (Fig. 2). Five vegetation types were delineated within the study site: (1) undisturbed tropical sub-deciduous forest, (2) Guinea grass dominated grasslands, (3) African star grass dominated grasslands, (4) Gulf cordgrass dominated grasslands, and (5) salt marshes with mangrove (Caso, 1994; Shindle and Tewes, 1998) (Fig. 2).

The FK95 was used to delineate home ranges for calculating habitat availability for each individual jaguarundi (Austin et al., 2007; Horne, 1998), as this method was considered to provide the best home range estimate. To test availability of habitat within the study area, home range areas of individuals were grouped in one inclusive polygon that encompassed all home ranges (FK95; Michalski et al., 2006).

Vegetation use was determined by summing the number of locations within each habitat type for each jaguarundi and then converting to a percentage of all locations for that cat (Lawhead, 1984; Michalski et al., 2006). A Chi-square goodness-of-fit test (Zar, 1999) was used to determine if observed frequencies of habitat use differed significantly from expected frequencies based on the proportion of area contributed by each jaguarundi home range area (Broomhall et al., 2003; Byers et al., 1984; Crawshaw and Quigley, 1991; Lawhead, 1984; Michalski et al., 2006; Neu et al., 1974).

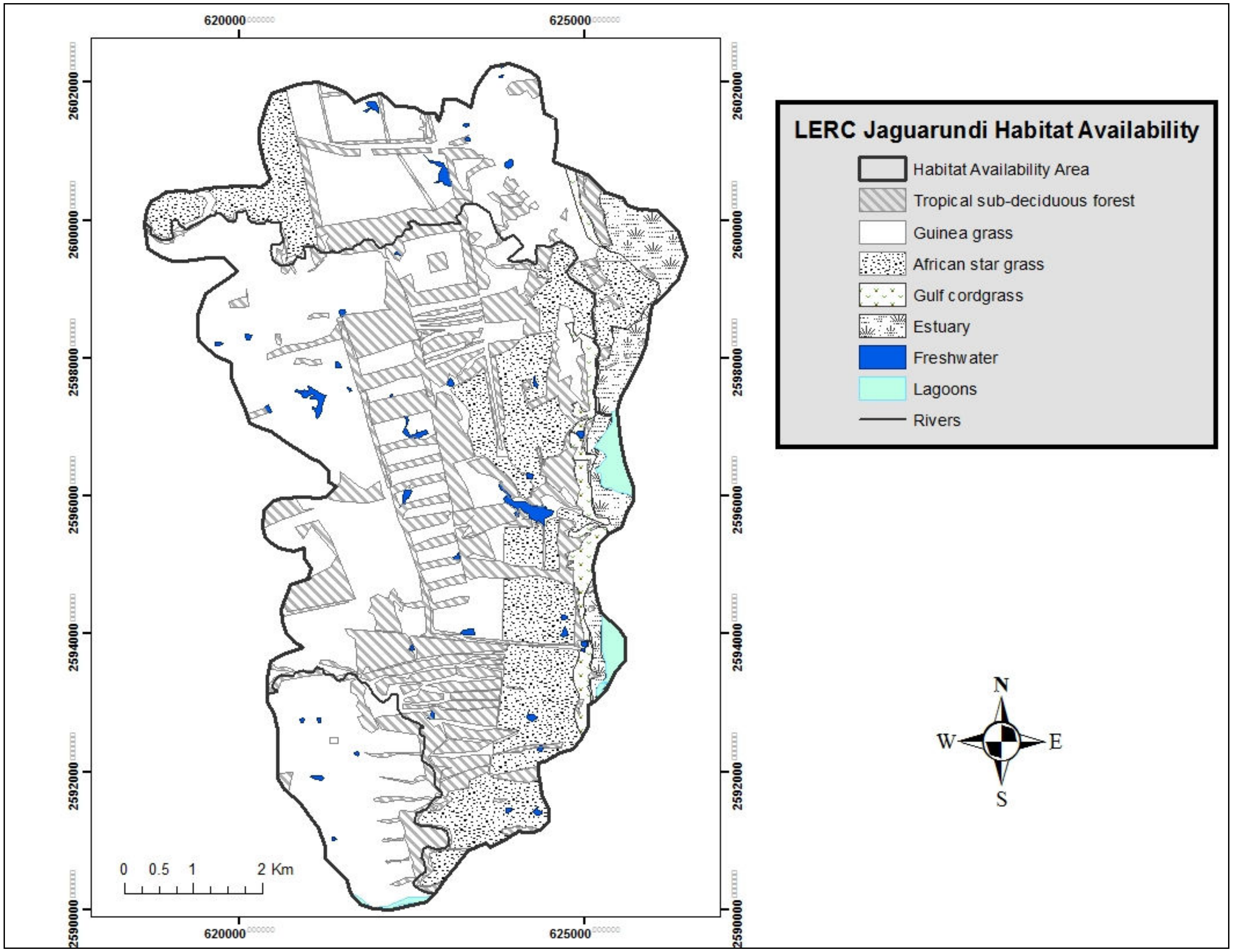

Figure 2. Habitat availability area created with cumulative ocelot home ranges (FK95) from June 1991-December 2003 at Los Ebanos Ranch Complex.

3. Results

3.1 Capture and handling

Twenty-one jaguarundis (13M, 8F) were captured during 21,742 trap nights. All captures were in traps set along the interface between tropical sub-deciduous forest and grassland areas or in locations adjacent to roads. Mean dosage administered to jaguarundis ($n = 18$) sedated with a mixture of Ketaset and Rompun was 16.9 mg/kg of ketamine hydrochloride and 1.2 mg/kg of xylazine (Table 1). Three jaguarundis were sedated with Zoletil 50 at a mean dosage of 5.3 mg/kg (Table 2). Mean induction time for jaguarundis with Ketaset was 6:30 min whereas using Zoletil 50 was 3:00 min (Table 1 and 2). Mean total length of captured adult jaguarundis was 114.2±4.3 cm for males and 102.5±4.7 cm (Table 3). Mean body mass was 5.8±0.6 kg for males and 4.0±0.5 kg for females (Table 3).

3.2 Home range size and overlap

I obtained 975 radio-locations from 18 jaguarundis; 10 males (2 sub-adults, 8 adults) and 8 adult females. Spatial data were not obtained on 3 jaguarundis, because 2 radio-collars failed and 1 kitten was not collared. Results of home range estimation were from adult individuals (8 males; 8 females) with >20 independent locations. Mean home range value for jaguarundi was 16.5±5.05 km² (FK95) and 10.73±4.74 km² (MCP95) for males and 12.09±5.16 km² (FK95) and 8.59±2.65 km² (MCP95) for females (Table 4). Core areas were 3.27±2.49 km² (FK50) and 2.74±1.28 (MCP50) for males, and 1.57±1.01 km² (FK 50) and 1.65±0.96 (MCP50) for females (Table 4). There were no significant differences between gender in home range values for different estimators and core areas (t-test, $P>0.05$; Table 4).

Table 1. Dosages of ketamine hydrochloride and xylazine per kg body weight to sedate jaguarundi from June 1991-December 2003 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

ID	Sex[1]/Age[2]	Weight (kg)	Ketamine mg/kg	Xylazine mg/kg	Mean body temp °C	Induction (min)	Release (h)
Jag01	F/A	3.7	32.43	1.08	40.7	5	10:15
Jag02	M/SA	3.4	20.58	1.4	40.3	5	4:15
Jag03	M/SA	4.8	18.75	1.2	39.4	4	4:10
Jag04	M/A	5.7	14.03	1.05	40.2	5	3:30
Jag05	F/A	4	12.5	0.5	39.3	8	5:15
Jag06	M/A	6.6	13.63	2.27	40.2	10	5:30
Jag07	F/A	3.9	21.8	0.35	40.7	8	5:10
Jag08	M/A	5.7	14.03	1.4	41.2	5	4:15
Jag09	M/A	6.2	12.9	0.96	40.3	6	3:05
Jag10	M/A	5.3	15.09	1.5	40.3	6	4:00
Jag11	F/A	4.3	16.27	1.4	40.4	4	4:20
Jag12	M/A	6.5	18.46	1.54	38.9	8	5:00

Table 1. Continued.

Jag13	F/M	4.4	13.63	1.14	38.6	4	4:15
Jag14	M/A	5.5	21.81	1.45	39.5	10	06:05
Jag15	M/A	6.5	15.38	1.54	39.0	10	04:30
Jag16	F/A	4.3	13.95	1.86	39.3	6	04:50
Jag17	M/SA	4	15	1	40.1	9	03:35
Jag18	F/SA	3	13.33	0.66	38.9	5	03:55
		Mean±SD	16.9±4.9	1.2±0.5	39.8±0.8	7±2	

[1] F=Female; M=Male;

[2] A= Adult; SA= Sub-adult.

Table 2. Dosages of Zoletil 50 per body kg weight to sedate jaguarundis from June 1991-December 2003 at Los Ebanos Ranch Complex,Tamaulipas, Mexico.

ID	Sex[1]/Age[2]	Weight (kg)	Zoletil mg/kg total	Mean temp °C	Induction (min)	Released (h)
Jag19	F/A	4	5	38.7	4	4:15
Jag20	M/A	5	6	33.3	4	5:35
Jag21	M/Cub	2	5	37.2	2	3:00
		Mean±SD	5.3±0.6	36.4±2.3	3.3±1.2	

[1] F=Female; M=Male;

[2] Age A=Adult; SA=Sub-adult.

Table 3. Body measurements (cm) and color phases of captured jaguarundis from June 1991-December 2003 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

ID	Sex[1]/Age[2]	Color phase	Total length	Hind foot	Foot to shoulder	Girth	Canine	Weight (kg)
Jag01	F/A	Gray	93	11	27	25	0.5	3.7
Jag02	M/SA	Red	104.4	13	23.5	26.5	0.7	3.4
Jag03	M/A	Red	113	14.5	30	28	0.8	4.8
Jag04	M/A	Red	113	14	28	28	0.8	5.7
Jag05	F/A	Gray	102.5	13	23.5	25	0.7	4
Jag06	M/A	Red	117.5	15	26	34	1	6.6
Jag07	F/A	Red	101.5	12.5	27.5	30.5	0.9	3.9
Jag08	M/A	Gray	111.5	13	28.5	28.5	1.1	5.7
Jag09	M/A	Red	115.5	14.3	28	28	0.9	6.2
Jag10	M/A	Gray	107	14	27	28	0.8	5.3
Jag11	F/A	Gray	99	13	23.5	26	0.8	4.3

Table 3. Continued.

Jag12	M/A	Gray	112	14.2	27.5	28	1	6.5
Jag13	F/A	Gray	105.5	13	25.5	24	0.7	4.4
Jag15	M/A	Gray	123	14	28	32.5	0.9	6.5
Jag16	F/A	Gray	106	12.5	27	26	1	4.3
Jag17	M/SA	Red	108.7	13.5	27	27.5	0.9	4
Jag18	F/A	Gray	106	12.5	24	29	1	3
Jag19	F/A	Red	106.8	12.5	24.75	29	1	4
Jag20	M/A	Gray	113	14	30	30	1	5
Jag21	Cub/male	Red	85.2	11	16.8	26	0.6	2
	Males	Mean	114.2 ± 4.3	14.1 ± 0.5	28.25 ± 1.3	29.25 ± 2.2	0.91 ± 0.1	5.78 ± 0.6
	Females	Mean	102.5 ± 4.7	12.5 ± 0.7	25.3 ± 1.7	26.8 ± 2.4	0.8 ± 0.2	4 ± 0.5

[1] F=Female; M=Male.

[2] Age A= Adult; SA=Sub-adult.

Overlapping home ranges among males and between males and females that were tracked during the same period (1994-1995; 1995-1996; n = 10) was extensive. However, little overlap was observed among females. Mean home range (MCP95) overlap percentage between male pairs (n = 4) was 30.4% (range: 6.4% – 61.2%; Table 5). Mean overlap percentage between male and female pairs (n = 4) was 38.3% (range: 21.6% – 56.9%). Two female pairs were tracked at the same time in the same area. One pair did not express home range overlap and the other pair had 9.3% home range overlap (Fig. 3 & Fig. 4). Overlap percentage for core areas (MCP 50%) between one male pair was 24.1% and 2.9% for a female pair. However, mean overlap percentage for core areas between male and female pairs (n = 4) was 24.5% (range: 1.7% – 38.9%; Table 5 & Fig. 3 & Fig. 4).

3.3 Activity patterns and daily movements

Mean daily movements of jaguarundis were 1.46±0.87 km for males and 0.88±0.66 km for females, with significant differences between gender (t-test, $P<0.001$). The area covered (MCP 100%) during a 24-h tracking period was 2.13±0.38 km² for males (n = 4) and 0.52±0.28 km² for females (n = 5) with significant differences between gender (t-test, $P<0.01$). Average distance covered each hour was 387±209.8 m for males and 180.67±140.5 m for females with significant differences between genders (t-test, $P< 0.001$). Activity levels indicated that jaguarundis were active through the diel peaking at mid-day (1100 – 1400 h; Fig. 5). During the study there were 21 sightings of jaguarundis at diurnal periods.

Table 4. Home range (fixed kernel [FK] 95% and 50%; minimum convex polygon [MCP] 95% and 50%) of adult jaguarundis from June 1991-December 2003 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

ID	Gender[1]	Period of tracking	Months	N[2]	FK95 (km²)	FK50 (km²)	MCP95 (km²)	MCP50 (km²)
Jag01	F	20 Jul, 1991 - 25 Apr, 1992	8	165	6.22	0.64	8.87	1.68
Jag03	M	14 Mar, 1993 - 13 Jun, 1993	3	45	13.37	2.88	7.12	1.58
Jag04	M	15 Jul, 1994 - 30 Jan, 1995	6	76	15.53	2.01	11.3	2.67
Jag05	F	16 Jul, 1994 - 29 Jan, 1995	6	96	16.36	2.24	13.59	3.39
Jag06	M	19 Jul, 1994 - 19 Oct, 1994	3	39	13.39	2.21	8.09	2.64
Jag07	F	1 Aug, 1994 - 25 Aug, 1994	1	22	11.99	1.35	6.72	0.98
Jag08	M	17 Aug, 1994 - 13 Jan, 1995	5	43	18.53	4.61	10.85	4.28
Jag09	M	13 Oct,1995 - 01 May, 1996	7	36	11.98	1.2	7.76	1.56
Jag10	M	31 Oct,1995 - 21 Aug, 1996	10	35	22.12	8.67	13.17	4.55
Jag11	F	2 Nov, 1995 - 24 Nov, 1995	1	22	10.28	1.23	6.49	0.66
Jag12	M	4 Nov,1995 - 12 Dec, 1996	13	88	10.01	0.98	8.98	1.16

Table 4. Continued.

Jag13	F	5 Nov, 1995 - 1 Jan, 1996	2	22	20.7	3.51	11.12	2.23
Jag14	M	19 Oct, 1996 - 28 May, 1997	7	48	24.3	3.56	18.55	3.48
Jag16	F	10 Mar, 1999 - 18 Sep, 1999	6	36	10.44	0.56	7.28	1.63
Jag18	F	11 Oct, 2000 - 15 Aug, 2001	10	69	5.5	0.84	5.77	0.51
Jag19	F	20 Mar, 2003 - 12 Dec, 2003	7	27	15.23	2.15	8.87	2.14
		Males	Mean ± SD		16.15±5.05	3.27±2.49	11.73±4.74	2.74±1.28
		Females	Mean ± SD		12.09±5.16	1.57±1.01	8.59±2.65	1.65±0.95
			t -test; P-value[3]		t= 1.59; P=0.13	t= 1.8; P= 0.11	t= 1.31; P=0.21	t= 1.9; P=0.07

[1] F=female; M=male.

[2] Number of independent locations.

[3] t-test and P-values for home range and core areas comparison.

Table 5. Home range (minimum convex polygon [MCP] 95%) and core area (minimum convex polygon [MCP] 50%) overlap of jaguarundis from June 1991-December 2003 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

	No. of Pairs		% of Overlapping		SD		Range	
	MCP 95%	MCP 50%	MCP 95%	MCP 50%	MCP 95%	MCP 50%	MCP 95%	MCP 50%
Male vs Male	4	1	29.8	24.11	23.41	n/a	6.36 – 61.21	n/a
Female vs Female	1	1	9.3	2.9	n/a	n/a	n/a	n/a
Male vs Female	4	4	37.7	24.5	19.12	13.71	20.91 – 56.9	1.65 – 38.93

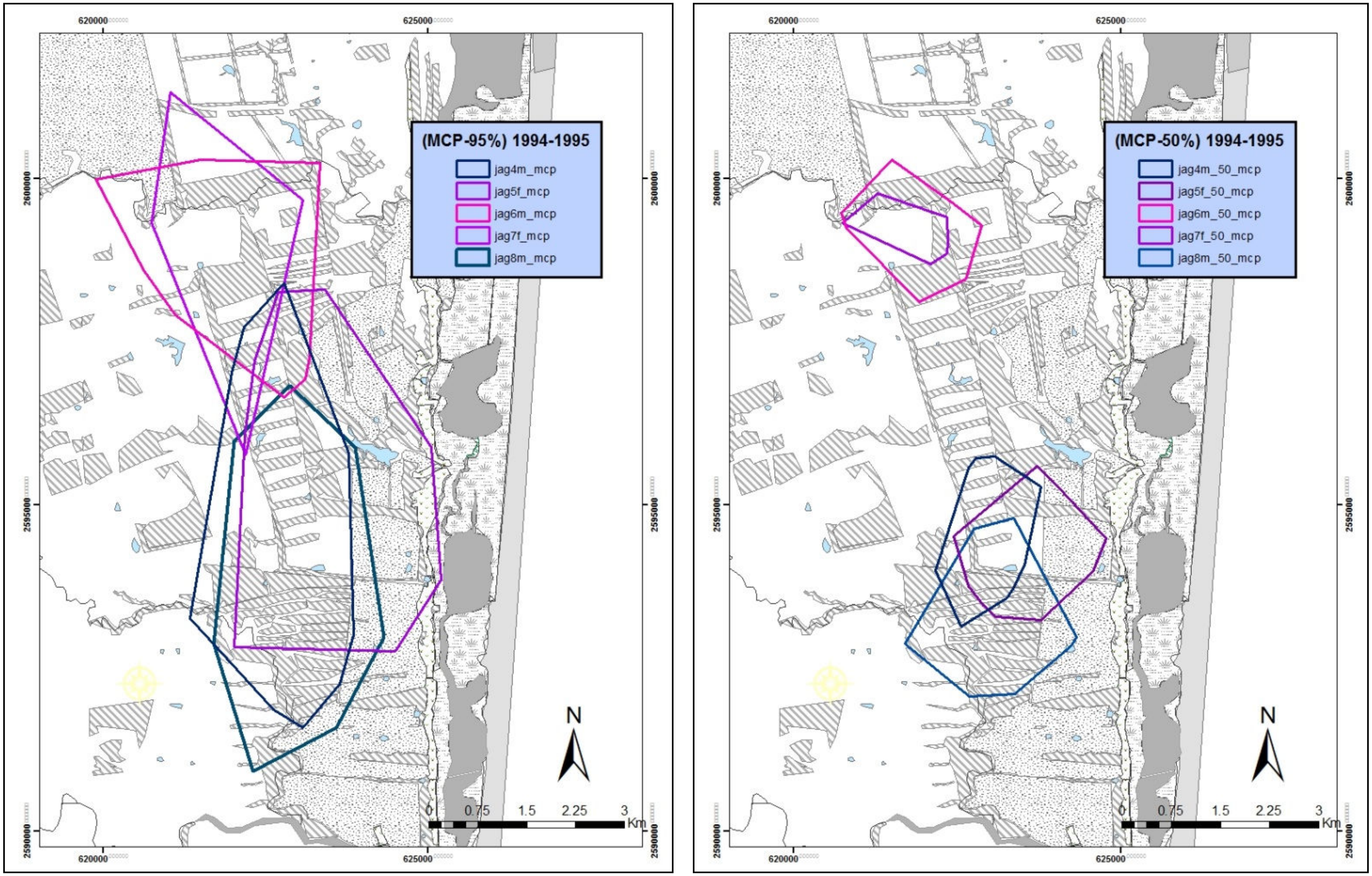

Figure 3. Selected jaguarundi male and female home ranges and core areas (Jag4M, Jag5F, Jag6M, Jag7F, and Jag8M) using minimum convex polygon at Los Ebanos Ranch, Tamaulipas, Mexico, January 1994-May1995.

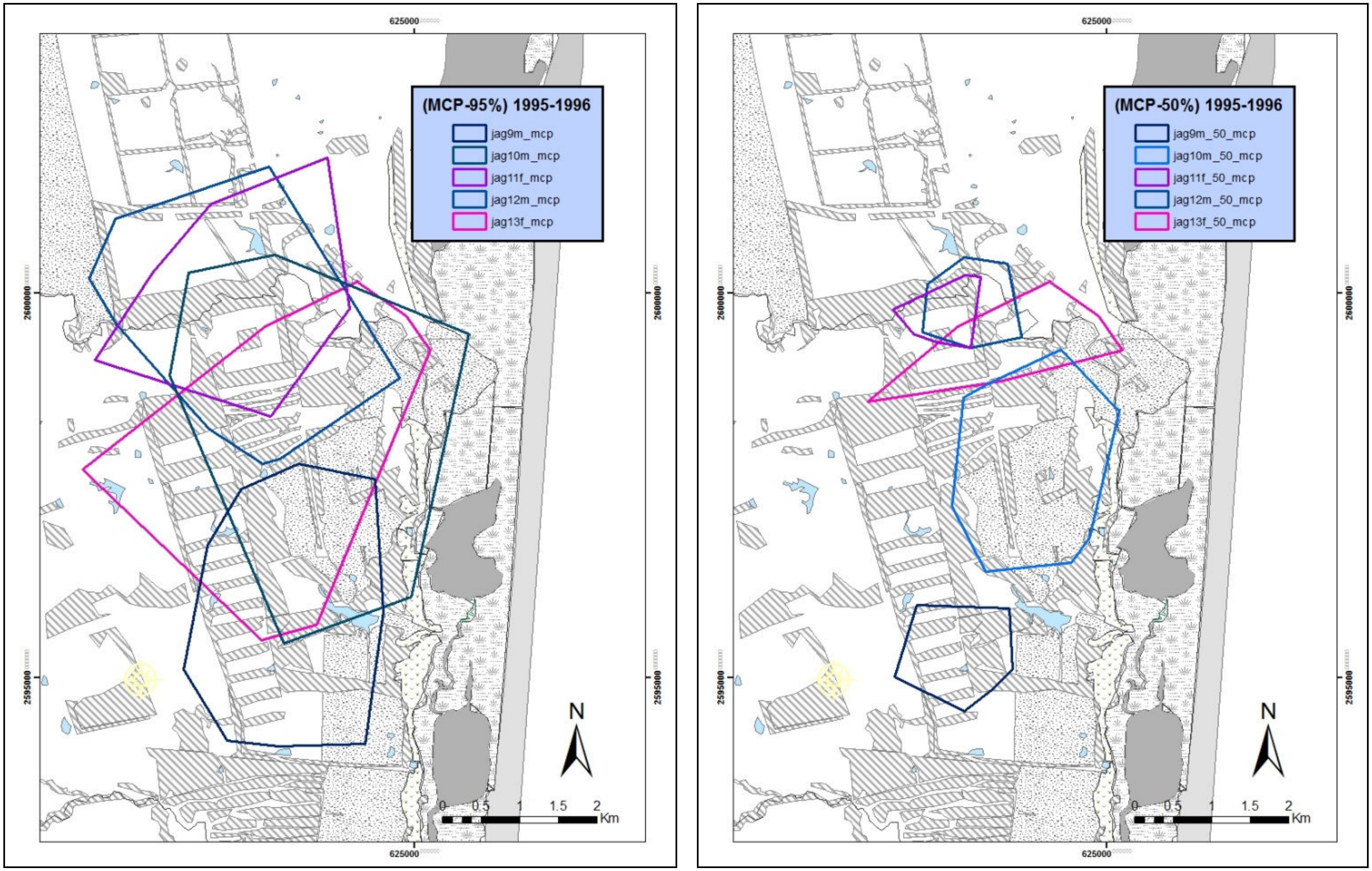

Figure 4. Selected jaguarundi male and female home ranges and core areas (Jag9M, Jag10M, Jag11F, Jag12M, and Jag13F) using minimum convex polygon at Los Ebanos Ranch, Tamaulipas, Mexico, August 1995–September1996.

3.4 Habitat use

Jaguarundis used tropical sub-deciduous forest (47.9%) and Guinea grass (44.6%) communities similarly. However, comparing habitat type availability and preference for the entire study area using the Neu et al. (1974) test, jaguarundis were shown to prefer tropical sub-deciduous forest habitat ($X^2 = 242.9$, d.f. = 4, $P < 0.001$) while the other habitat types were avoided (Table 6). Percent use was lower (6.6%) for African star grasslands and even less on Gulf cordgrass (0.7%) and estuary (0.2%) areas (Table 6). These habitats were avoided by jaguarundis ($X^2 = 242.9$, d.f. = 4, $P < 0.001$; Table 6). Habitat use compared within jaguarundi home ranges (FK95) using Neu et al. (1974) test showed that jaguarundis preferred tropical sub-deciduous forest and used Gulf cordgrass in proportion to availability ($X^2 = 314.5$, d.f. = 4, $P < 0.0001$) while the other habitat types were avoided (Table 7).

Male jaguarundis used tropical sub-deciduous forest (52.7%), Guinea grass (39.9%), African star grass (15.2%), Gulf cordgrass (0.4%), and estuary (0.2%); whereas female jaguarundis used tropical sub-deciduous forest (42.9%), Guinea grass (49.6%), African star grass (6.4%), Gulf cordgrass (0.9%), and estuary (0.2%) habitats. The Neu et. al. (1974) test showed that tropical sub-deciduous forest areas were preferred and Gulf cordgrass areas were used in proportion to availability by both male and female jaguarundis ($X^2 = 314.5$, d.f. = 4, $P < 0.001$), while Guinea grass areas were avoided by male jaguarundis but used in proportion to availability by female jaguarundis (Table 8).

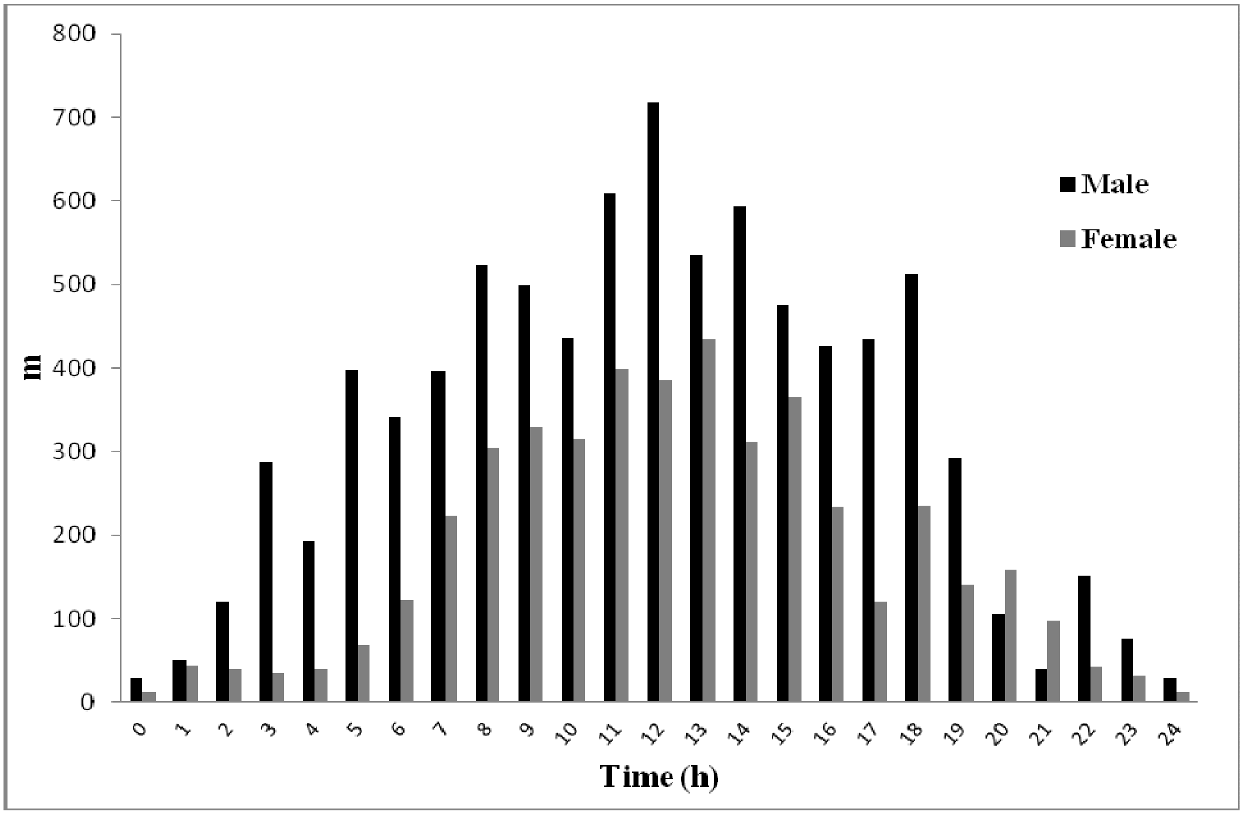

Figure 5. Hourly distance (m) traveled by female and male jaguarundis during 24-h periods from June 1991- December 2003 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

Table 6. Summary of habitat availability and use by jaguarundis within study area from June 1991-December 2003 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

Habitat use	Proportion of availability %	95% C.I. of use	Preferred/Avoided
Tropical sub-deciduous forest	25.3	44.7 - 51.1	Preferred
Guinea grass	48.8	41.4 - 47.8	Avoided
Gulf cordgrass	2.1	0.13 - 1.17	Avoided
African star grass	18.1	5.01 - 8.21	Avoided
Estuary	5.6	0.0 - 0.52	Avoided

Table 7. Summary of habitat availability and use by jaguarundis within the home ranges (fixed fernel [FK] 95%) from June 1991-December 2003 at Los Ebanos Ranch Complex,Tamaulipas, Mexico.

Habitat Use	Habitat availability within home range %	95% C.I. of use	Preferred/Avoided
Tropical sub-deciduous forest	35.2	44.7 - 51.1	Preferred
Guinea grass	49.4	41.4 - 47.8	Avoided
Gulf cordgrass	0.8	0.13 - 1.17	Used in proportion
African star grass	13.3	5.01 - 8.21	Avoided
Estuary	1.3	0 - 0.52	Avoided

Red phase jaguarundis (n = 7) used tropical sub-deciduous forest (53.9%) and Guinea grass (40.4%), whereas African star grass (5.7%), Gulf cordgrass, and estuary habitat were not used. Gray phase jaguarundis (n = 9) used tropical sub-deciduous forest (44.7%), Guinea grass (46.9%), African star grass (7.1%), Gulf cordgrass (0.9%), and estuary (0.3%). The Neu et al. (1974) test showed that tropical sub-deciduous forest was preferred by red phase jaguarundis with other areas avoided; whereas gray phase jaguarundis preferred tropical sub-deciduous forest and Guinea grass habitats, with Gulf cordgrass used in proportion to availability ($X^2 = 183.2$, d.f. = 4, $P < 0.001$) (Table 9).

4. Discussion

4.1 Capture and handling

Capturing carnivores is often necessary to collect information on ecological parameters such as home range size and activity patterns (Michalski et al., 2007). However, jaguarundis were extremely difficult to capture, with a capture success rate of 1 jaguarundi over 1,320 trap-nights. Konecny (1989) trapped 4 individuals in 21 months of trapping; however, details of trapping effort were not reported. Crawshaw (1995) captured 3 jaguarundis after 3,599 trap nights, or 1,119 trap nights for 1 jaguarundi.

Michalski et al. (2007) used a combination of wire box-traps and soft-catch leg-holds for 736 trap nights, and captured 3 different jaguarundis with 2 recaptures (1 jaguarundi capture over 147 trap nights). All jaguarundi captures by Michalski et al. (2007) were in box-traps baited with live bait. The success rate by Michalski et al. (2007) may be attributed to a high density of jaguarundis because of the reduction of other larger predators (e.g., ocelots) that were not captured in the study.

Table 8. Comparison of habitat availability and use by gender of jaguarundis from January 1991-December 2003 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

Habitat type	Proportion of availability within Home range (%)		95% confidence Interval		Preferred/Avoided	
	Males	Females	Males	Females	Males	Females
Tropical sub-deciduous forest	35.4	34.8	48.1 - 57.2	38.4 - 47.5	A	A
Guinea grass	40.2	53.3	35.5 - 44.3	45 - 54.2	B	C
Gulf cordgrass	0.8	0.9	0 - 1	0.02 - 1.8	C	C
African star grass	15.2	10	4.5 - 9.1	4.2 - 8.7	B	B
Estuary	1.4	1.2	0 - 0.6	0 - 0.7	B	B

A= Preferred; B=Avoided; C=Used in proportion to availability.

Table 9. Comparison of habitat availability and use by color phase of jaguarundis from January 1991-December 2003 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

	Proportion of availability within					
Habitat type	Home range (FK)		95% Confidence interval		Preferred/Avoided	
	Red phase	Gray phase	Red phase	Gray phase	Red phase	Gray phase
African star grass	12.99	13.51	3.13 - 82.3	7.79-12.74	B	B
Tropical sub-deciduous forest	35.14	35.26	48.46 - 59.43	69.40-76.47	A	A
Guinea grass	51.34	47.85	34.98 - 45.78	64.11-71.70	B	A
Gulf cordgrass	0.45	1.18	0 - 0.01	0.20 - 1.78	B	C
Estuary	0.09	2.53	0 - 0.01	0 - 0.79	B	B

A= Preferred; B=Avoided; C=Used in proportion to availability.

Trapping success for jaguarundis at LEBC with box-traps seemed related to the large trapping effort of 21,742 trap-nights. Other trapping techniques such as soft-catch leg-hold or use of trained dogs were avoided because of safety concerns for jaguarundis. Michalski et al. (2007) state that use of leg-hold traps could increase trapping success; however, caution should be used because some injuries may happen to the captured animals (Michalski et al. 2007).

4.2 Home range size and overlap

A home range can be defined as the smallest convex polygon that encloses the locational observations (Burt, 1943; Gittleman and Harvey, 1982). Many factors can affect the results of a radio-telemetry study, including home range estimators (e.g., minimum convex polygon, harmonic mean, and fixed kernel), sample size, outliers, triangulation error, and number of animals with radio collars (Harris et al., 1990; Kenward, 1987). Home range results in this study are similar to values obtained by Crawshaw (1995), Michalski et al. (2006), and Oliveira et al. (2010). However, the home range (MCP95) mean values (males = 11.7±4.7 km^2; females = 8.6±2.7 km^2) from this study are much smaller compared to Konecny (1989) (males = 94.2 km^2, female = 12.9 km^2). Jaguarundis captured by Konecny (1989) had a mean weight of 5.5 kg (n = 2) for males and 4.4 kg for one female, similar to the weights obtained for adult jaguarundis (6.0 kg for males, 4.1 kg for females) in this study. Dispersers or transients may be one possible explanation for the large home ranges that Konecny (1989) reported. Another possible explanation may be the radio-telemetry system (fixed station antennas) that Konecny (1989) used had signal bounce in the mountainous terrain. This method may have produced large telemetry errors.

Because of the difficulty in capturing jaguarundis, it is unlikely that every individual was captured within the study area. However, the results indicate substantial home range overlap between male jaguarundis, suggesting this species is not territorial. Male home ranges of many cat species do not overlap extensively (Sunquist and Sunquist, 2002). However, other studies of margays (*Leopardus wiedii*), leopard cats (*Prionailurus bengalensis*), and bobcats (*Lynx rufus*) indicate that male home ranges can overlap extensively (Carvajal et al., 2012; Grassman et al., 2005; Nielsen and Woolf, 2001). Male jaguarundis in this study appeared to overlap with multiple female home ranges (Figs. 3 & 4 and Table 5). One possible reason sympatric female jaguarundis did not express substantial overlap is that adequate food resources unlikely occurred in the area. If these resources were limited, then females may form territories within their home ranges (Sunquist and Sunquist, 2002). Another possible explanation is there were other females without collars overlapping the collared females but they were not detected.

Of 3 published studies on jaguarundis (Crawshaw, 1995; Konecny, 1989; and Michalski et al., 2006), jaguarundis were reported to use one restricted area for periods of time and then switch to another area. These movements are often typical of transient animals (Sunquist and Sunquist, 2002). However, at LEBC this pattern was not observed for any of the radio-collared jaguarundis, thus suggesting that the adult jaguarundis tracked on this study were resident cats.

4.3 Activity patterns and daily movements

In this study jaguarundis were essentially diurnal predators. Males covered a greater area than females in a 24-h period with a peak of activity at mid-day (1100-1400 h). These results are similar to the patterns Konecny (1989) found for 3 jaguarundis in Belize with peak of activity around 1100 h.

Daily movements were also similar to patterns in Belize (Konecny, 1989). Konecny (1989) found that female and male jaguarundis had similar daily movements with mean hourly movement of 253 m. However, the distance covered during a 24-h period averaged 6.6 km in

Belize. Jaguarundis had a mean hourly movement of 284 m in Mexico, with significant differences (two-tailed, t-test $P<0.001$) between male and female jaguarundi movements (387 m/h for males; 181 m/h for females). Mean distance (from start location to end location) during a 24-h period covered by jaguarundis was 3.9 km.

Jaguarundis tended to cover a large area during a diel period, and this pattern is probably related to their hunting strategy. Jaguarundis were observed hunting on 3 occasions. One jaguarundi attempted to surprise American coots (*Fulica americana*) on the shore of a small pond. The jaguarundi was rapidly jumping through grass attempting to capture the coots. On a second occasion, a jaguarundi trotted along a trail and suddenly attacked a small eastern cottontail (*Sylvilagus floridanus*) but I could not determine if the capture was successful. A third observation recorded a jaguarundi attempting to capture wild turkey (*Meleagris gallopavo*) chicks but the turkey hen protected the chicks with its wings. Although the jaguarundi made quick attacks a few times, the hen was able to keep the jaguarundi away from the chicks.

Tófoli et al. (2009) reported that jaguarundi diet in southeastern Brazil included small mammals (42%), birds (21%), reptiles (14%), and medium-sized mammals (3%). Even though small mammals represented the highest percentage of the jaguarundi diet, birds and reptiles were an important part of the diet and are probably captured by surprise during the rapid foraging movements of the jaguarundi.

4.4 Habitat use

Jaguarundis used disturbed areas near pristine tropical forests and showed considerable flexibility in habitat use (Konecny, 1989; Michalski and Peres, 2005; Oliveira, 1998; Sunquist and Sunquist, 2002). Konecny (1989) captured jaguarundis in secondary growth habitat; however, individuals moved toward mature forests following release. Also, Konecny (1989) noted that all jaguarundis were captured near streams and seemed to prefer riparian habitats. Konecny (1989) believed use of old field habitats by jaguarundis was related to their main prey of hispid cotton rats (*Sigmodon hispidus*) that were found in the scats of jaguarundis. Hispid cotton rats preferred the herbaceous cover of this habitat type.

Michalski et al. (2006) recorded a female jaguarundi that used secondary forest exclusively, and a male jaguarundi used other habitat types including secondary forests, grasslands, and eucalyptus forests accordingly to availability. However, Michalski et al. (2006) reported that both individuals avoided mature forest. In my study, all captures were in traps set on the edge of tropical sub-deciduous forests or in forest corridors. Jaguarundis used tropical sub-deciduous forest as well as disturbed areas such as grasslands in similar percentages. Percent use was similar among jaguarundis for tropical sub-deciduous forest (44.6%) and grasslands (Guinea grass and African star grass) (51.2%); however, tropical sub-deciduous forests were preferred over the other habitat types accordingly with availability. Female jaguarundis used Guinea grass pastures in proportion with availability while males avoided this habitat.

Gloger's Rule suggests that mammals with dark pelages are associated with dark environments, and most melanistic cat species are found in rain forest habitats with low light penetration (Montagna et al., 1993; Sunquist and Sunquist, 2002). Gray phase (dark) jaguarundis are considered genetically a mutant form (Eizirik et al., 2003) and Seidensticker and Lumpkin (2004) stated that the dark phase jaguarundis are more common in rain forest habitat, whereas the reddish jaguarundis occur more often in dry forests. Although there was a limited sample size, I found that gray phase jaguarundis preferred tropical sub-deciduous forest areas and Guinea grass pastures, whereas red phase jaguarundis preferred only tropical sub-deciduous forests and avoided grasslands.

Even though cubs in the same litter could exhibit gray or reddish phases, the gray phase jaguarundis are generally more common than the reddish phase through the jaguarundi range. This patterns may be related to a hypothesis that genes for dark pelages may provide resistance to viral infections (Seidensticker and Lumpkin, 2004). However, number of jaguarundis captured in this study were similar between the two color phases (gray, n =11; red, n=10).

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CHAPTER II

SPATIAL PATTERNS AND HABITAT USE OF OCELOT (*LEOPARDUS PARDALIS*) IN TAMAULIPAS, NORTHEAST MEXICO

INTRODUCTION

The ocelot *(Leopardus pardalis*) is a small cat that occurs from northern Argentina to southern Texas, U.S. (Goldman 1943, Tewes and Everett 1986, Nowell and Jackson 1996, Sunquist and Sunquist 2002, Hunter 2012). The ocelot is listed by the IUCN Red List as a threatened species; however, the northeastern sub-species (*L. p. albecens*), including the northeastern Mexican populations are listed as an Appendix I species by the Convention on the International Trade in Endangered Species (CITES) (Caso et al. 2008, Hunter 2012). In Mexico the ocelot is considered federally endangered by the Ley General del Equilibrio Ecológico (SEMARNAT 2001).

Ocelots were formerly widely exploited for commercial trade (Martinez-Meyer 1997); however, after inclusion as an endangered species in 1986 by Mexican laws and participation of Mexico in CITES, ocelot trade was greatly reduced and the cats are now only occasionally poached in Mexico (Nowell and Jackson 1996). Ocelots are affected by habitat destruction and their range has been reduced during the last 30 years (Leopold 1959, Tewes 1986, Sunquist and Sunquist 2002, Oliveira et al. 2010).

Recently, remote-sensing camera trapping has become a common method to determine activity patterns, population sizes, and densities of wild cats (Maffei et al. 2005, Dillon 2005, Dillon and Kelly 2008). However, radio telemetry is the primary method to determine the home range size and spatial organization of many felids (Tewes 1986,

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The style and format of this dissertation chapter follows the *Journal of Zoology, London.*

Emmons 1988, Konecny 1989). Ocelot home range size has been studied in several regions outside Mexico (Table 10).

Little is known about the spatial organization and habitat use of ocelot in Mexico. Martinez-Meyer and Lopez-Gonzalez (1999) captured 18 ocelots in Chamela Biosphere Reserve, Jalisco, Mexico, but because of deaths and radio-collar failures, they obtained adequate data on 8 individuals (5 males; 3 females; Table 10). Martinez-Meyer and Lopez-Gonzalez (1999) obtained an ocelot mean home range size of 5.2 km^2 for males and 5.7 km^2 for females. Conversely, Fernandez (2002) in the same study area found larger home range sizes for males (24.5 km^2; n = 3) than for females (7.3 km^2; n = 2). Fernandez (2002) could not explain the differences between home range sizes for ocelots within the Chamela Biosphere Reserve.

Fernandez (2002) found that ocelots mostly used tropical deciduous forests and occasionally grasslands. Fernandez (2002) also found that ocelots were more active during nocturnal hours with two peaks of activity, one between 0500-0700 h and another at 2100-2300 h. These findings coincide with Dillon (2005) that found ocelots were active after sunset and before sunrise in Belize. Konencny (1989) reported peak ocelot activity in the early morning and late evening, with a mean 6.35 km travel distance over 24 h.

Additional radiotelemetry data are needed on the ocelot in Mexico. The endangered subspecies (*L. p. albecens*) has not been previously studied in the country; therefore, this research is important by providing the first ecological information on the conservation of the ocelot in Mexico.

Table 10. Comparative ocelot adult home range sizes from different studies and regions.

Site	Male $\bar{x}$ km² (n)	Female $\bar{x}$ km² (n)	Home range estimator[1]	Source
Texas, USA	12.3 (5)	7.0 (3)	MCP	Tewes 1986
Texas, USA	6.2 (3)	2.97 (3)	MCP	Laack 1991
Jalisco, Mexico	5.2 (6)	5.7 (3)	MCP	Martinez Meyer and Lopez-Gonzalez 1999
Jalisco, Mexico	24.30/13.31 (4)	7.34/5.85 (6)	MCP/FK	Fernandez 2002
Cockscomb, Belize	N/A	14.7 (1)	MCP	Konecny 1989
Ciquibul, Belize	30.8 (2)	30 (3)	FK	Dillon 2005
Venezuela	10.6 (2)	3.4 (6)	MCP	Ludlow & Sunquist 1987
Amazon, Peru	7.0 (2)	1.8 (3)	MCP	Emmons 1998
Pantanal, Brazil	N/A	1.3 (3)	MCP	Crawshaw and Quigley 1989
Pantanal, Brazil	5.4 (1)	2.6 (2)	MCP	Rocha 2006
Iguaçu, Brazil/Argentina	38.8 (6)	17.4 (5)	MCP	Crawshaw 1995

[1] Home range estimator: MCP=minimum convex polygon; FK=fixed kernel

OBJECTIVES

The objectives of this study were to:

1) Determine the home range and core area size, and amount of spatial overlap among ocelots at Los Ebanos Ranch Complex (LERC).
2) Determine the activity patterns of ocelots at LERC.
3) Determine the habitat use patterns of ocelots at LERC.

STUDY SITE

The Los Ebanos Ranch Complex (LERC; 23°28'7"N, 93°47'38"W) includes three private properties: the Los Ebanos, Los Pericos, and Tepehuajes Ranches. The LERC is located in the State of Tamaulipas in northeast Mexico, and is adjacent to the Gulf of Mexico (Fig. 6). Mean annual precipitation in this region is 72 cm with variation throughout the year and no well-defined dry and wet seasons (Pennington and Sarukhan 1968; Rzedowski 1986). Temperatures range from 5ºC to 38ºC, with a mean of 24.6°C (Rzedowski 1986). Topography is flat with some hills to the west and elevation ranges from 0 to 30 m (Rzedowski 1986, Caso 1994).

Land use practices (primarily cattle ranching) implemented at LERC have resulted in native, tropical sub-deciduous forest (Pennington and Sarukhan 1968) occurring in patches and strip patterns (Caso 1994, Shindle 1995). Woody species encountered in the area include ebony (*Pithecellobium flexicaule*), gumbo limbo (chaca) tree (*Bursera semiaruba*), strangle fig (*Ficus tecolutensis*), tepehuaje (*Lysiloma acapulcensis*), guacima (*Guazuma ulmifolia*), and grangeno (*Celtis reticulata*; Pennington and Sarukhan 1968, Gonzalez-Medrano 1972, Rzedowski 1986). In the study area, there are primarily five types of vegetation communities: undisturbed tropical sub-deciduous forest, African star (*Cynodon niemfluensis*) grassland, Guinea grass (*Panicum maximum*) grassland, Gulf cordgrass (*Spartina spartinae*) grasslands, and estuarine vegetation

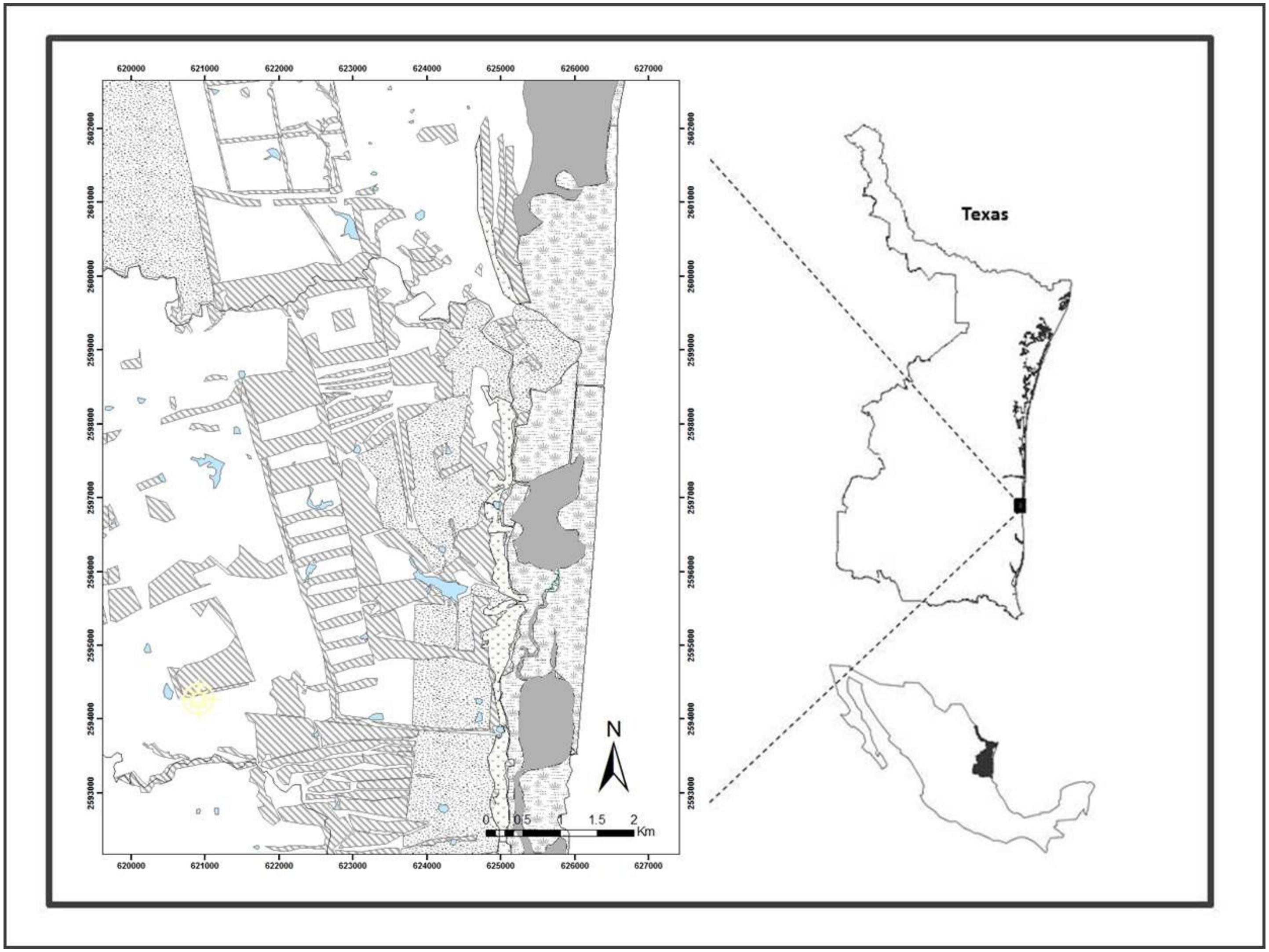

Figure 6. Location of ocelot study from June 1991-December 2007 on the Los Ebanos Ranch Complex in Tamaulipas, Mexico.

mixed with mangrove (*Avicennia germinans*; Gonzalez-Medrano 1972, Rzedowski 1986, Shindle 1995, Shindle and Tewes 1998).

MATERIALS AND METHODS

Capture and handling

Ocelots were captured intermittently from July 1991 through November 2007 with Tomahawk® wire box-traps (107 x 50 x 40 cm; Tomahawk Live Trap Company, Tomahawk, Wisconsin) with a separate rear compartment for live bait such as chickens and coturnix quail (Tewes 1986, Caso 1994, Caso et al. 2005). Box-traps were placed along game trails where suitable habitat (i.e., mature forest) was located. Traps were open continuously during trapping periods, and checked every morning before 1100 h. Traps were placed in locations with sufficient shade to prevent heat stress of captured cats. Captured ocelots were immobilized with an intramuscular injection using either a mixture of ketamine hydrochloride (Ketaset®, Bristol Laboratories, Syracuse, NY) and xylazine (Rompun®, Bayer, Munich, Germany) (Beltran and Tewes 1995), or tiletamine hydrochloride-zolazepam (Zoletil® Virbac, Ltd., Carros, France) (Caso 1994, Shindle and Tewes 2000). Drugs were administered to captured ocelot with a pole syringe. Morphological measurements included total length (tail and body length), hind foot length (from pad to elbow), foot to shoulder (from pad to top of scapula), girth (rib cage) circumference, body temperature, and blood and hair samples were taken (Burt 1989, Leopold 1959). Dental condition was evaluated to estimate age. A VHF 120-g radio-collar (148.00-149.99 MHz) with a mortality sensor (Wildlife Materials, Inc.®, Murphysboro, Illinois; Telonics, Inc., Meza Arizona; and Advanced Telemetry Systems. Inc.®, Isanti Minnesota) was attached to adult and sub-adult ocelots following handling procedures. Sedated ocelots were placed inside the trap or in a “pet carrier” box for protected recovery from the effects of the immobilization. Ocelots were released at the capture site when the effects of sedation ended and full coordination was achieved.

Spatial data and activity patterns

I attempted to locate every radio-collared ocelot 10 times each month from established fixed ground stations to provide data on home range size and spatial patterns. I used portable VHF radio-telemetry equipment (Telonics® and Advanced Telemetry Systems®) for radio-tracking. Ocelots were located throughout the study area during diurnal and nocturnal periods. For each location, ≥2 bearings were taken from different fixed receiver stations with a Suunto® (Sunnto Instruments, Finland) hand-held compass (Kenward 1987). Independence of locations was established by using one location each 24-h period.

Telemetry information included the identification number, date, time, and activity (pulse gain change) for each location. Ocelot locations were determined using Locate II ® and III computer programs (Tatamagouche, NS, Canada). Some individuals (n = 10) were monitored hourly during a 24-h period to obtain data for activity patterns. For these individuals the distance from the start location to end location, the average distance (m) covered each hour, and the area (MCP100) occupied during the 24-h diel were measured. Daily distances were also recorded for ocelots that were radio tracked on consecutive days, measuring the linear distance between locations (Rabinowitz 1989, Bailey 1993). Significance of probability was determined by SAS 3.2® (SAS Institute, Cary, North Carolina).

Home range estimation

The computer programs ArcView 3.3® and ArcGIS 9® and 10 (Animal Movements Extensions) were used to evaluate radio-telemetry data obtained during this project (Hooge and Eichenlaub 2000, Grassman et al. 2005). Ocelot home ranges were calculated using two estimators: the fixed kernel 95% (FK95; White and Garrot 1990, Horne and Garton 2006) and minimum convex polygon 95% (MCP95; Mohr 1947, MacDonald et al. 1980, Oliveira et al. 2010). The MCP home range estimator was used for comparison with previous studies and to measure home range overlap (Oliveira et al. 2010, Carvajal et al. 2012). Core areas were calculated using the fixed kernel 50% (FK50) and minimum convex polygon 50% (MCP50) (Hooge and Eichenlaub 2000, Grassman et al. 2005, Carvajal et al. 2012) estimators.

Radio telemetry error was assessed with a global positioning system (GPS) by identifying the location of 5 transmitters placed randomly in the same habitat where the ocelots roamed (Blankenship 2000, Grassman 2004), and the GPS positions were compared with the corresponding telemetry location. Mean distance between radio locations and GPS locations indicated a mean triangulated error of 42±36 m.

Percentage overlap comparisons were calculated using the MCP95 estimator and the MCP50 for core areas (Grassman et al. 2005, Dillon and Kelly 2008, Carvajal et al. 2012). Home range values were from adult individuals with a minimum of 25 independent locations for each home range value based upon an asymptote test (Fernandez 2002, Grassman et al. 2005). Home range boundaries, core area contour intervals, and ocelot locations were converted with ArcMap 10 to polygon and point shape files. A 2-sample, 2-sided t-tests (Dowdy and Wearden, 1991) was used to compare home range values and core areas between males and females and to compare spatial patterns (Fernandez, 2002).

Habitat use

Vegetation polygon shape files were created using ArcMap10 from digital orthophoto quadrangle imagery (DOQs; INEGI, 2011; Fig. 7). Five vegetation types were delineated within the study site: (1) undisturbed tropical sub-deciduous forest, (2) Guinea grass dominated grasslands, (3) African star grass dominated grasslands, (4) Gulf cordgrass dominated grasslands, and (5) salt marshes with mangrove (Caso 1994, Shindle 1995; Fig. 7). Availability of habitat within the study area was assessed using a polygon contour that included the home ranges (95% FK) of each ocelot (Oliveira et al. 2010).

The FK95 was used to delineate home ranges for calculating habitat availability for individual ocelots (Austin et al. 2007, Horne et al. 2009, Oliveira et al. 2010), as this method was considered to provide the best home range estimate. Vegetation use was determined by summing the number of radio-locations within each habitat type for each ocelot and then converting to a percentage (Lawhead 1984, Michalski et al. 2006). A Chi-square goodness-of-fit test (Zar 1999) was used to determine if the observed frequencies of habitat use differed significantly from the expected frequencies based on the proportion of area contributed to each ocelot home range area (Neu et al. 1974, Michalski et al. 2006).

To test the availability of habitat within the study area, home range areas of all individuals were grouped into 1 polygon that encompassed all of the home range areas (Michalski et al. 2006; Fig. 7). Neu et al. (1974) test was used to measure ocelot habitat preference or avoidance of habitat types within home ranges and study area.

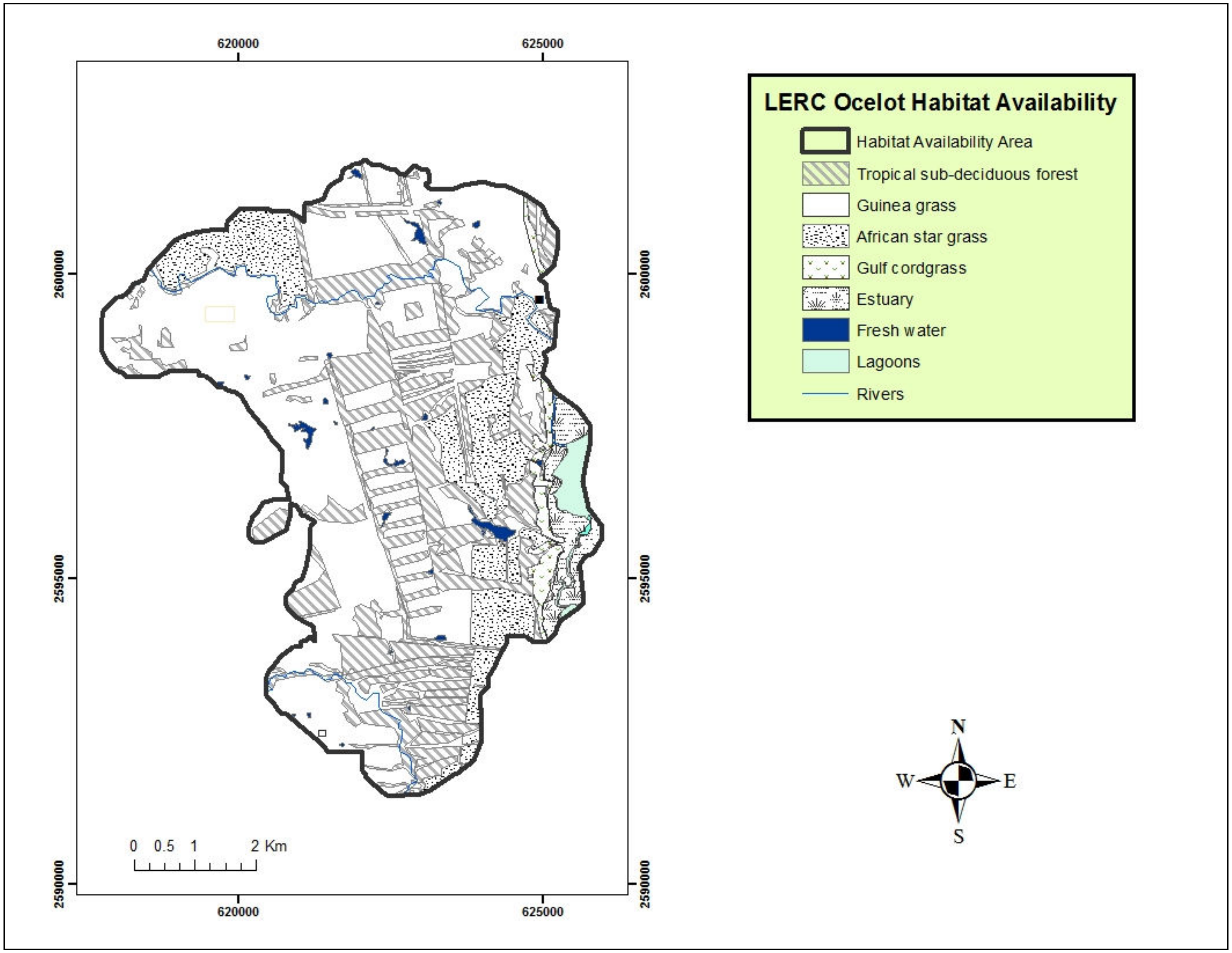

Figure 7. Habitat availability area created with cumulative ocelot home ranges using the 95% fixed kernel estimator from June 1991-December 2007 at Los Ebanos Ranch Complex.

RESULTS

Capture and handling

Twenty-nine ocelots (14M, 15F) were captured during 21,742 trap nights from June 1991 to December 2007. All captures occurred in traps set along the edge between tropical sub-deciduous forest and grassland areas. Ocelots (n = 23) were sedated with Ketaset® and Rompun® at a mean dosage of 18±4 mg/kg of ketamine hydrochloride and 0.6±0.2 mg/kg of xylazine (Table 11). Six ocelots were sedated with tiletamine-zolazepam (Zoletil 50®) at a mean dosage of 4.8±1.0 mg/kg (Table 12). Mean induction time for ketamine-xylazine was 9 min and Zoletil 50 was 8:30 min. (Table 11 and 12). Mean body weight was 10.8±0.8 kg for adult males and 7.4±0.7 kg for females (Table 13).

Home range size and overlap

I obtained 1,344 radio-locations from 22 ocelots; 9 males (1 sub-adult, 8 adults) and 13 females (4 sub-adults, 9 adults). Home range estimation was evaluated for adult individuals with ≥25 independent locations (8 males; 9 females). Mean home range size for ocelots was 15.09±8.10 km^2 (FK95) and 11.56±4.51 km^2 (MCP95) for males and 8.47±3.57 km^2 (FK95) and 9.47±5.21 km^2 (MCP95) for females (Table 14). Core areas were 1.59±1.11 km^2 (FK50) and 1.60±0.79 (MCP50) for males, and 1.0±0.66 km^2 (FK50) and 2.01±1.81 (MCP50) for females (Table 14). Although female core areas (MCP50) were larger than for males, there were no significant difference between sexes for the home range values for both home range estimators, and core areas (t-test, $P>0.05$; Table 14).

Table 11. Dosages of ketamine hydrochloride and xylazine per kg of body weight to sedate ocelots from June 1991-December 2007 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

ID	Gender[1]/Age[2]	Weight (kg)	Ketamine mg/kg	Xylazine mg/kg	Mean Body Temp °C	Induction (min)
Oce01	M/SA	8.7	17.24	0.45	41.0	10
Oce02	F/A	7.2	20.83	0.42	41.2	8
Oce03	F/A	7.8	15.38	0.26	39.5	15
Oce04	M/A	10.6	21.69	0.50	39.2	10
Oce05	M/A	10	23.00	0.40	36.1	15
Oce06	M/SA	8.4	17.86	0.48	42.1	15
Oce07	F/SA	5.5	18.18	0.36	41.8	3
Oce08	F/SA	6	25.00	0.67	40.3	15
Oce09	M/SA	8	17.50	0.25	39.7	9
Oce10	F/A	8	11.25	0.50	39.8	9
Oce11	F/SA	4.9	24.49	0.41	40.4	3
Oce12	F/SA	5.4	20.00	0.52	38.9	7

Table 11. Continued.

Oce13	M/A	11	14.78	0.61	40.2	6
Oce14	M/A	9.7	22.68	0.82	40.7	12
Oce15	F/A	7.5	18.67	0.80	40.2	9
Oce16	F/A	8	17.50	0.50	37.8	12
Oce17	M/A	11.5	14.78	0.52	38.8	11
Oce18	F/A	7.5	16.00	0.80	39.3	10
Oce19	M/A	11.5	14.78	0.70	40.0	7
Oce20	F/Cub	3	16.67	0.67	40.7	7
Oce21	F/SA	5.2	15.38	0.77	38.7	3
Oce22	M/SA	6	13.33	0.67	41.1	6
Oce23	F/SA	5	16.00	0.80	40.0	6
	Mean± SD	7.67±2.33	17.96±3.61	0.56±0.17	39.9±1.3	9.04±3.80

[1] Gender F= Female; M=Male.

[2] Age A= Adult; SA= Sub-adult.

Table 12. Dosages of Zoletil 50 per kg of body weight to sedate ocelots at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

ID	Gender[1]/Age[2]	Weight (kg)	Zoletil mg/kg	Mean Temp ºC	Induction (min)
Oce24	M/A	12	5.83	38.4	4
Oce25	M/A	10	4.00	37.5	5
Oce26	F/A	6	4.17	39.1	4
Oce27	M/SA	6	4.25	37.5	8
Oce28	M/SA	8	5.63	39.0	4
Oce29	F/A	7	5.00	40.4	7
	Mean± SD	8.17±2.40	4.81±1.01	38.7±1.1	5.33±1.75

[1] Gender F= Female; M=Male.

[2] Age A= Adult; SA= Sub-adult.

Table 13. Body measurements (cm) of captured ocelots from June 1991-December 2007 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

ID	Sex[1]/Age[2]	Total length	Hind foot	Foot to shoulder	Girth	Canine	Weight (kg)
Oce01	M/SA	110	12.5	30.5	36	1.3	8.7
Oce02	F/A	93	13	28.5	35	1.3	7.2
Oce03	F/A	93.5	13	32.5	36	1.2	7.8
Oce04	M/A	113	15.1	33.2	39	1.5	10.6
Oce05	M/A	116	15.5	34.5	41	1.4	10
Oce06	M/SA	104	14	29	39	1.3	8.4
Oce07	F/SA	100.5	12.5	29	28.5	1.3	5.5
Oce08	F/SA	100	13.5	34	34	1.3	6
Oce09	M/SA	99	14.5	31	33	1.5	8
Oce10	F/A	96.5	13	32	38	1.3	8
Oce11	F/SA	96	12.5	26.5	30	1.4	4.9

Table 13. Continued.

Oce12	F/SA	91	13.5	13.5	31.5	1.1	5.4
Oce13	M/A	118.5	15	34	40.5	1.8	11
Oce14	M/A	105.5	15	35.5	40	1.6	9.7
Oce15	F/A	103	14	34	32	1.3	7.5
Oce16	F/A	103.1	14.3	33.5	36.2	1.4	8
Oce17	M/A	111.7	15.2	38.6	44.1	1.7	11.5
Oce18	F/A	102	14	30	37.5	1.4	7.5
Oce19	M/A	108.4	15.2	37.5	42.7	1.6	11.5
Oce20	F/Cub	85.5	12	23	26	0.6	3
Oce21	F/SA	92	13.4	32	32.5	1.2	5.2
Oce22	M/SA	101.7	15.2	28	34	1.5	6
Oce23	F/SA	70.5	12.5	32.5	33	1.2	5
Oce24	M/A	112	15.5	29	39	1.8	12
Oce25	M/A	114	14	28	44	1.6	11.5

Table 13. Continued.

Oce26	F/A	105	13	31.5	36	1.5	6
Oce27	M/SA	82.5	13.5	27	34.4	0.8	6
Oce28	M/SA	107.4	15	35.5	35.5	1.3	8
Oce29	F/A	94.5	15	30	34	1.4	7
	Mean± SD	100.91±10.64	14.08±1.14	30.89±4.80	35.97±4.41	1.37±0.26	7.82±2.37

[1] Gender F= Female; M=Male.

[2] Age A= Adult; SA= Sub-adult.

Overlapping home ranges (MCP95) among males, females, and between male and female ocelots occurred (Fig. 8 and 9). Mean overlap percentage between male pairs (n = 4) was 40.5% (range: 12.3% – 83.8%), and 15.5% (range: 1.9% – 39.3%) between female pairs (n = 4). Mean overlap percentage between male and female pairs (n = 8) was 38.7% (range: 16.4% – 70.2%; Figs. 3 and 4). Core areas (MCP50) overlapped between females, and males and females, but there was almost no overlap between males (Fig. 8 and 9). Core area overlap between female pairs (n = 2) was 40.1% (range: 19.5% – 60.6%), whereas one male pair core area overlapped 1.1 %. Mean overlap percentage for core areas between male and female pairs (n = 6) was 25% (range: 4.7% – 49%; Figs. 3 and 4).

Activity patterns and daily movements

Mean daily movement of ocelots was 1.25±0.85 km for males and 1.1±0.82 km for females, with no statistical differences between sexes (t-test, $P>0.05$). The area covered (MCP 100%) during a 24-h tracking period was 2.48±0.27 km^2 for males (n = 5) and 0.66±0.28 km^2 for females (n = 5), with significant differences between sexes (t-test, $P<0.0001$). The average distance covered per hour was 345.8±37 m for males and 216.6±29.6 m for females with statistical differences between sexes (t-test, $P<0.001$). Activity levels indicated that ocelots were active through the diel, with two peaks of activity, one between 400-600 h and another between 2000-2200 h (Fig. 10). Ocelots were significantly more active at night than during the day (t-test, $P<0.001$).

Table 14. Home range (fixed kernel [FK] 95% and 50%; minimum convex polygon [MCP] 95% and 50%) of adult ocelots from June 1991-December 2007 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

ID	Gender[1]	Period of tracking	Months	N[2]	FK95 (km^2)	FK50 (km^2)	MCP95 (km^2)	MCP50 (km^2)
Oce02	F	15 Jun, 1991 - 30 May, 1992	11	77	9.62	0.88	14.09	1.41
Oce03	F	16 Jun, 1991 - 5 July, 1992	13	123	9.71	0.79	9.23	2.08
Oce04	M	30 Jun, 1991 - 05 July, 1992	11	88	3.64	0.39	6.97	0.29
Oce05	M	25 Jan, 1992 - 12 Sep, 1992	8	55	11.72	0.96	9.07	1.51
Oce10	F	9 Oct, 1995 - 8 Apr, 2001	63	321	14.4	1.17	18.02	2.78
Oce13	M	27 Oct, 1997 - 14 May, 1998	7	33	27.94	3.29	19.59	2
Oce14	M	11 Mar, 1998 - 30 Apr, 1998	1.5	28	16.44	1.64	8.47	2.58
Oce15	F	10 Sep, 1998 - 19 Dec, 1998	3	30	5.52	0.37	3.74	0.67
Oce16	F	13 Oct, 1998 - 11 Dec, 2001	38	115	9.35	1.63	13.29	1.47
Oce17	M	03 Nov, 1999 - 26 Feb, 2001	15	44	15.84	1.44	11.49	1.49
Oce18	F	18 Dec, 1999 - 22 Nov, 2002	34	139	6.97	1.06	9.01	1
Oce19	M	2 Jan, 2000 - 2 Feb, 2001	13	42	18.19	1.32	14.14	2.15

Table 14. Continued.

Oce21	F	10 Oct, 2000 - 08 May, 2001	7	55	7.5	0.63	10	0.84
Oce24	M	3 Dec, 2001 - 7 Dec, 2002	12	49	21.66	3.18	15.52	2.15
Oce25	M	9 May, 2002 - 26 Mar, 2003	10	65	5.25	0.48	7.24	0.66
Oce26	F	21 Mar, 2003 - 25 Oct, 2003	6	37	1.87	0.16	1.35	0.2
Oce29	F	11 Nov, 2005 - 3 Dec, 2007	23	43	11.26	2.33	6.52	2.02
		Males	Mean ± SD		15.09±8.10	1.59±1.11	11.56±4.51	1.60±0.79
		Females	Mean ± SD		8.47±3.57	1±0.66	9.47±5.21	2.01±1.81
			t -test[3]		t=-2.1	t=-1.3	t=-0.88	t=-0.25
			P-value[3]		p=0.06	P=0.22	P=0.39	P=0.80

[1] F=female; M=male.

[2] Number of independent locations.

[3] t-test and P-values for home range and core area comparison.

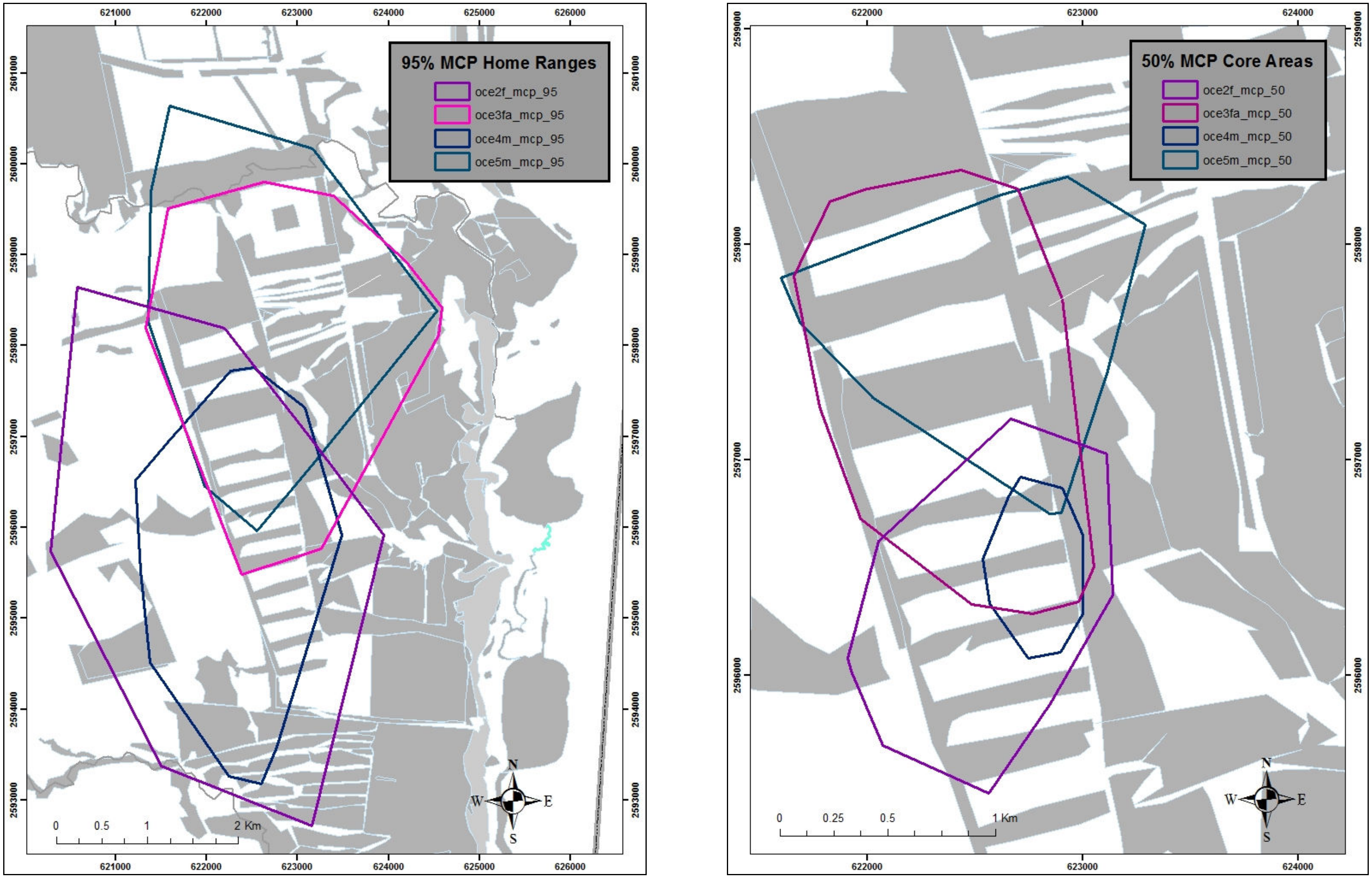

Figure 8. Selected ocelot male and female home ranges (Oce02F, Oce03F, Oce04M and, Oce05M) using minimum convex polygon at Los Ebanos Ranch, Tamaulipas, Mexico, June 1991-December 1992.

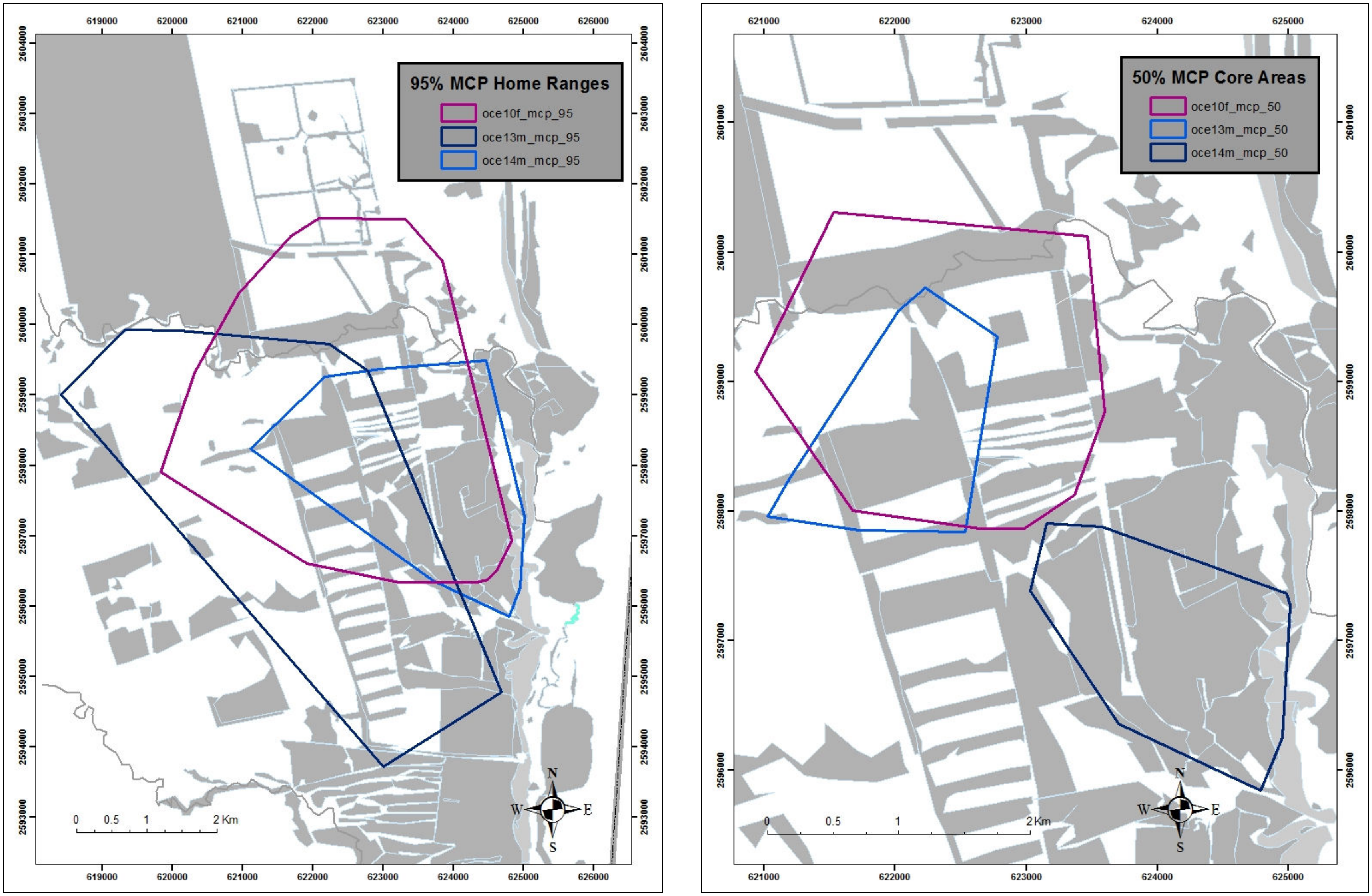

Figure 9. Selected ocelot male and female home ranges and core areas (Oce10F, Oce13M, and Oce14M) using minimum convex polygon at Los Ebanos Ranch, Tamaulipas, Mexico, February 1997-March 1998.

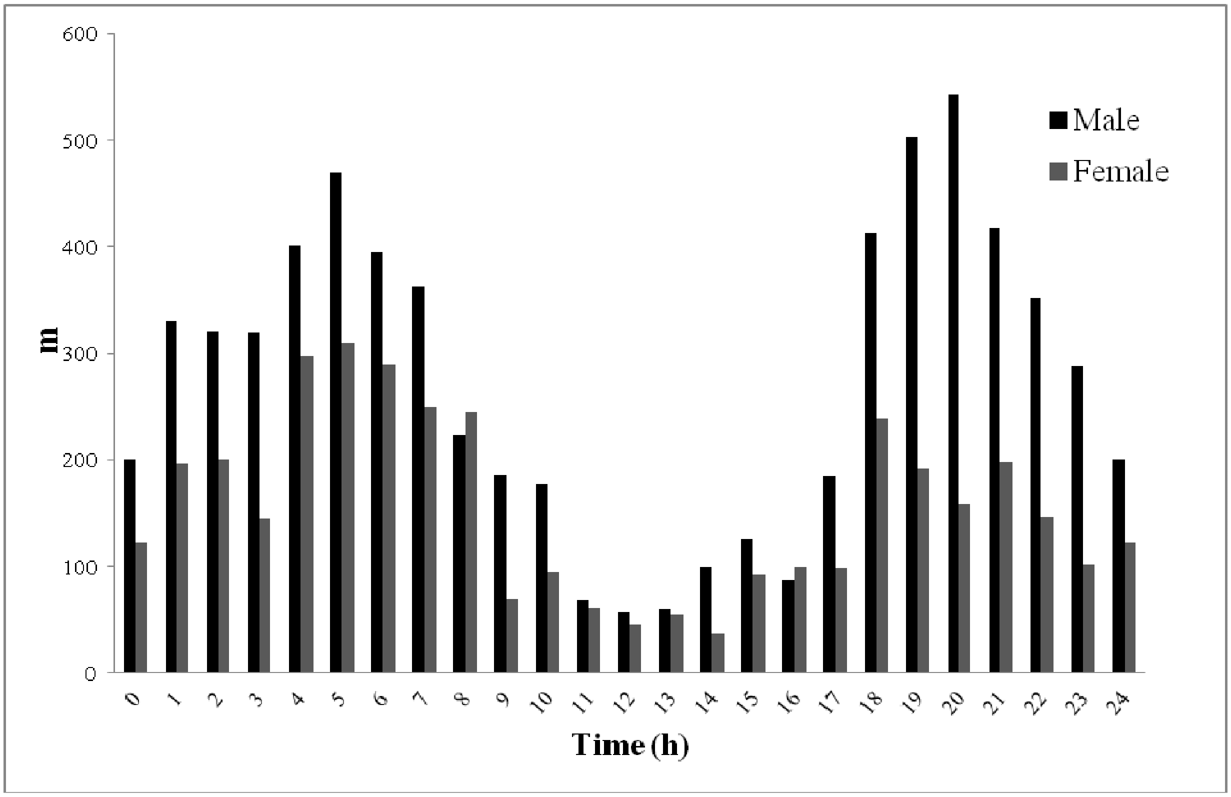

Figure 10. Hourly distance (m) traveled by female and male ocelots during 24-h periods from June 1991-December 2007 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

Habitat use

Habitat utilization and availability were compared for the entire ocelot population. Within the home range (FK95) areas, ocelots used tropical sub-deciduous forest (82.3%), Guinea grass (15.9%), African star grass (1.2%), Gulf cordgrass (0.3%), and estuary (0.4%) areas. Ocelots preferred tropical sub-deciduous forest while the other habitat types were avoided (X^2 = 907.4, d.f.=4, P<0.0001). Habitat use results were similar when tested for the entire study area; ocelots preferred tropical sub-deciduous forest habitat whereas the other habitat types were avoided (X^2 = 1680.2, d.f.=4, P<0.0001) (Table 15 and 16).

Habitat use between males and females was similar. Both sexes preferred tropical sub-deciduous forest habitat while other habitat types were avoided (males; X^2 = 330.8, d.f.=4, P<0.0001; females; X^2 = 510.4, d.f.=4, P<0.0001; Table 17).

DISCUSSION

Capture and handling

Use of wire box-traps with live bait seems to be the safest and most effective method to capture medium-size carnivores (Caso 1994). The 23 ocelots were captured 42 times during 21,742 trap nights with 1 ocelot capture per 518 trap nights. Ocelots are not difficult to capture with box-traps. Other studies have had success with a similar trapping effort (Tewes 1986, Laack 1991, Ludlow and Sunquist 1987, Fernandez 2002).

Table 15. Summary of habitat availability and use by ocelots within study area from June 1991-December 2007 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

Habitat use	Proportion availability %	95% C.I.	Preferred/Avoided
Tropical sub-deciduous forest	39.1	80.6 - 84.9	Preferred
Guinea grass	47.1	13.8 - 18.1	Avoided
African star grass	10.8	0.6 - 1.8	Avoided
Gulf cordgrass	1.1	0.0 - 0.6	Avoided
Estuary	1.9	0.01- 0.7	Avoided

Table 16. Summary of habitat availability and use by ocelots within home range from June 1991- December 2007 at Los Ebanos Ranch Complex (fixed kernel 95%).

Habitat use	Proportion of availability %	95% C.I.	Preferred/Avoided
Tropical sub-deciduous forest	28.2	80.6 - 84.9	Preferred
Guinea grass	51.4	13.8 - 18.1	Avoided
African star grass	14.2	0.6 - 1.8	Avoided
Gulf cordgrass	2.0	0.0 - 0.6	Avoided
Estuary	4.2	0.01 - 0.7	Avoided

Table 17. Comparison of habitat availability and use by ocelot gender from June 1991-December 2007 at Los Ebanos Ranch Complex, Tamaulipas, Mexico.

Habitat type	Proportion of availability within Home range (%)		95% confidence Interval		Preferred/Avoided	
	Males	Females	Males	Females	Males	Females
Tropical sub-deciduous forest	42.6	28.2	80.7, 86	80.1, 84.5	A	A
Guinea grass	43.8	51.4	12.3, 17.3	13.8, 18.1	B	B
African star grass	9.1	14.2	0.4, 2	0.6, 1.8	B	B
Gulf cordgrass	1.5	2	-0.1, 0.6	-0.03, 0.6	B	B
Estuary	3.1	4.2	0.01, 1.1	0.01, 0.7	B	B

A= Preferred; B=Avoided; C=Used in proportion to availability.

The mixture of ketamine hydrochloride and xylazine (ketamine 18±4 mg/kg; xylazine 0.6±0.2 mg/kg) used in this study differed from that used by Beltran and Tewes (1995; ketamine 14.7±1.6 mg/kg; xylazine 1.1±0.1 mg/kg) for ocelots in Texas. However, mean induction time (12 min) was longer in their study compared to the mean induction time (9 min) for this study. I used a dosage (4.8±1.0 mg/kg) of Zoletil50 ® similar to the dosage Shindle and Tewes (2000) used (5.1±0.8 mg/kg), and obtained a similar mean induction time (5 min) to that found by Shindle and Tewes (2000) of 4 min.

Home range and overlap

Home range sizes and percent overlap differ throughout the ocelot range. Different factors can affect the results of a radio-telemetry study, including home range estimators (i.e., minimum convex polygon and fixed kernel), quantity of data, outliers, amount of triangulation error, and number of animals with radio collars (Kenward 2001). Additionally, home range sizes of the same species in various areas of their ranges can differ because of habitat fragmentation, prey density, and human disturbances (Emmons 1988, Crawshaw 1995). Differences in home range size also are expected to reflect differences in resource availability (i.e., prey) among areas (Gompper and Gittleman 1991).

Oliveira et al. (2010) compared ocelot studies in different areas to assess if there was a positive correlation between ocelot home range size and body weight. They found that ocelots were larger (11.1±2.2 kg) in the rainforest of Brazil compared with ocelots from the thornshrub areas of Texas (8.7±1.4 kg; Tewes 1986, Laack 1991). Oliveira et al. (2010) stated that these differences in size were probably related to prey size. Ocelots in the rainforest need to exploit larger prey such as pacas (*Agouti paca*) and agoutis (*Dasyprocta* spp.), whereas in Texas the diet is mainly rodents and lagomorphs (Tewes 1986). Although not significant, Oliveira et al. (2010)

found a positive tendency of correlation between home range size and body weight but there were no differences in mean adult ocelot home range sizes when comparing habitat types across its range.

Habitat structure at the LERC is similar to that found in Texas (Shindle and Tewes 2000). I found similar results in ocelot body weight and home range size (MCP95) compared to the results found by Laack (1991) and Tewes (1986) for Texas (mean body weight = 8.5±1.4 kg, home range size range = 6.2 – 12.3 km²). Mean body weight of adult ocelots at the LERC was 9.0±1.9 kg and mean home range size (MCP95) for males and females was 10.5±4.9 km². Compared with the Chamela study in western Mexico (Fernandez 2002), I found that the home range sizes on the LERC were larger for males (LERC: 15.1±8.1; Chamela: 11.7±4.7 km²) and females (LERC: 8.5±3.6; Chamela: 5.8±2.0 km²). This difference is likely related to habitat differences and prey availability.

Kitchner (1991) reported that males of cat species are territorial and that home ranges do not usually overlap. However, some New World felids such as margays (*Leopardus wiedii*) and bobcats (*Lynx rufus*) do not always show strong territoriality, and home ranges of males may overlap extensively (Nielsen and Woolf 2001, Carvajal et al. 2012).

Dillon (2005) found male ocelots in Belize overlapped home ranges more than females (24.7% vs. 16.2%). Female home ranges were overlapped by more than one male. Similar spatial patterns have been recorded in other ocelot studies (Emmons 1988, Ludlow and Sunquist 1987, Fernandez 2002). In this study, Similar patterns for home range (MCP95) overlap occurred between male pairs (40.5%) and between female pairs (15.5%). However, comparison of core areas (MCP50) revealed there was overlap between females and males (25%) and female pairs (40.1%), with overlap almost non-existent (1.1%) between males suggesting that male ocelots maintained some level of territoriality at the LERC.

Other studies have shown that male ocelots have larger home ranges than females (Tewes 1986, Emmons 1988, Ludlow and Sunquist 1989). However, I did not find any significant home range size differences between males and females in this study. Martinez-Meyer and Lopez (1999) did not find significant differences between male and female ocelot home ranges at Chamela, Mexico. The LERC habitat is fragmented and the arrangement of habitat patches and corridors may have caused both sexes to use their ranges in a similar way.

Activity patterns

Ocelots are considered strongly nocturnal predators (Emmons 1988), but they exhibit some diurnal and crepuscular activity particularly during overcast days (Ludlow and Sunquist 1987, Crawshaw 1995, Dillon 2005). Dillon (2005) found that ocelots had two activity peaks, one after sunset and another before sunrise. Ludlow and Sunquist (1987) and Emmons (1988) stated that ocelots were active 12-14 hours a day and rested between dawn and late afternoon. The LERC ocelots were active through the diel with two activity peaks, one between 0400-0600 h and another between 2000-2200 h (Fig. 10).

Mean travel distances recorded in different studies ranged 1.8 – 7.6 km, with males travelling twice the distances recorded for females (Ludlow and Sunquist 1987, Emmons 1988, Konecny 1989). Dillon and Kelly (2008) reported the distance covered by ocelots as 2.1 km for males and 1.7 for females. Male ocelots at the LERC covered 1.3±0.9 km whereas females covered 1.1±0.8 km, with no significant differences between gender (t-test, $p>0.05$).

Emmons (1988) found that male ocelots often patrolled the perimeter of their home range travelling at a speed of 0.8 to 1.4 km/hr while seldom pausing. Sunquist and Sunquist (2002) reported that ocelots have two basic foraging strategies (waiting and moving fast). Ocelots travelled at 0.3 km/hr while searching for prey, but when moving to other locations orhunting at a faster pace, Sunquist and Sunquist (2002) reported that ocelots may travel at 0.8 to 1.4 km/h, similar to rates reported by Emmons (1988).

I found that the mean travel speed for ocelots at the LERC during a 24-h period was 0.2 km/h. Male ocelots travelled at 0.3 km/h whereas females travelled at 0.1 km/h with differences (t-test, P>0.001) between gender.

Habitat use

Ocelots occupy a broad range of closed habitats (Sunquist and Sunquist 2002) and while flexible in habitat use (Oliveira et al. 2010), they generally prefer to use primary forests (Caso 1994, Nowell and Jackson 1996, Sunquist and Sunquist 2002). The range of habitat types that ocelots use varies from the thornshrub of Texas (Tewes 1986, Shindle and Tewes 2000, Haines et al. 2005), to rainforest of Peru, Brazil, and Argentina (Emmons 1988, Crawshaw and Quigley 1989, Crawshaw 2005). Ocelots have also been found in other habitat types such as savannahs in Venezuela (Mondolfi 1986, Ludlow and Sunquist 1987), tropical forests in Belize (Konecny 1989, Dillon and Kelly 2008), and deciduous forests in Jalisco, Mexico (Martinez-Meyer and Lopez 1999, Fernandez 2002).

Even though ocelots occur in a broad range of habitat types, they need sufficient amounts of dense vegetative cover (Tewes 1986, Ludlow and Sunquist 1987, Harveson et al. 2005, Haines et al. 2006). Horne et al. (2009) estimated that ocelots needed at least 75% canopy cover in their home ranges. Shindle and Tewes (2000) compared species composition and habitat structure between Laguna Atascosa National Wildlife Refuge (LANWR) and the LERC and found 12.9% of shared woody species; however, the habitat structure was similar (Shindle and Tewes 2000).

Konecny (1989) found that ocelots used mostly secondary forest in Belize but in the Emas National Park (ENP), Brazil, ocelots used areas of dense forest, savannah, pastures, and agricultural areas (Oliveira et al. 2010). In the ENP, undisturbed forest was positively selected whereas vegetation communities such as forest-woodland-savannah and pasture-agriculture were used in proportion to availability, while grassland-savannah and flooded grassland were avoided (Oliveira et al. 2010).

I found similar results to Fernandez (2002) where ocelots used tropical sub-deciduous forest 82.3% of the time, Guinea grass pastures 15.9%, and the other areas 1.9%. However, Neu et al. (1974) habitat use test showed that tropical sub-deciduous forest was preferred over the other habitat types by both gender.

It appears that habitat preference by ocelots at the LERC may have been related to prey availability. An ongoing ocelot scat study indicated that ocelot prey at the LERC was mostly comprised of small rodents such as Mexican spiny pocket mouse (*Liomys irroratus*), deer mouse (*Peromyscus* spp.), and northern pygmy mouse (*Baiomys taylori*), and these species also were related to tropical sub-deciduous forest or edge between forests and pastures (E. Rendón *pers. com.*). In Chamela, Mexico, the Mexican spiny pocket mouse was the most important mammal within the ocelot diet (Fernandez 2002).

Because the field data for ocelots in Mexico are limited, results of this study provide valuable information on home range size, habitat use, and spatial organization of the ocelot in Mexico. These results should assist in the implementation of future conservation measures and strategies for the species in Mexico and other areas of its range.

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CHAPTER III

COEXISTANCE OR AVOIDANCE OF OCELOT (*LEOPARDUS PARDALIS*) AND JAGUARUNDI (*PUMA YAGOUAROUNDI*) IN TAMAULIPAS, NORTHEAST MEXICO

INTRODUCTION

In tropical regions the distribution of species is predominantly limited by biotic factors such as competition, commensalism, and parasitism (Lomolino et al. 2006). Coexistence between sympatric carnivores may be possible because of differences in habitat use, activity patterns, and prey selection (Rosenzweig 1966, Maehr 1996, Thornton et al. 2004). Although availability of cover, prey, and water affect carnivore movements, intraspecific and interspecific spatial relationships of felines are important for understanding coexistence (Sunquist and Sunquist 2002). Large carnivores may kill smaller sympatric carnivores, particularly their young, causing up to 68% of known mortality in some carnivore species (Palomares and Caro 1999). Furthermore, spatial relationships of males and females of different species also may affect habitat use or presence of species in certain areas (Sunquist and Sunquist 2002, Oliveira et al. 2010).

As an example, ocelots (*Leopardus pardalis*) and bobcats (*Lynx rufus*) co-occur at Laguna Atascosa National Wildlife Refuge (LANWR), located in southern Texas about 40 km north of the U.S.-Mexico border. Both cat species have been captured frequently over 30 years by biologists at this refuge (Tewes 1986, Laack 1991, Horne et al. 2009), whereas jaguarundis (*Puma yagouaroundi*) are rare with the last confirmed report in Texas in 1986 (Tewes and Everett 1986). Absence of jaguarundi may be attributed to the presence of the larger ocelot and bobcat and other medium-size predators such as the coyote (*Canis latrans*). Trophic competition and direct interactions may create the absence of jaguarundis in Texas.

The style and format of this dissertation chapter follows the *Journal of Zoology, London.*

The Los Ebanos Ranch Complex (LERC) in Tamaulipas, Mexico, was the study area for this project. Three felid species (i.e., ocelot, jaguarundi, and bobcat) were captured; however, bobcats were rare and primarily occupied coastal areas, and jaguarundis were rarely captured in the study area (Caso 1994).

Caso (1994) found that habitat use and activity patterns were different for sympatric ocelots and jaguarundis, possibly allowing these carnivores to co-exist. Sanchez-Cordero et al. (2008) found a geographical distribution overlap between ocelot and jaguarundi (83.5%) and bobcat and jaguarundi (71.4%) in Mexico; however fine scale analyses with radio-telemetry data may be warranted to determine the amount of interactions. Oliveira et al. (2010) proposed the "ocelot effect" in Brazil where areas with high ocelot abundance suppressed other small sympatric cats, including jaguarundi.

Furthermore, Carvajal et al. (2012) and Caso et al. (2005) recorded margay (*Leopardus wiedii*) in areas where ocelots were absent within the "El Cielo" Biosphere Reserve. Other ocelot researchers have reported low jaguarundi populations in their study areas, and they were not able to capture a jaguarundi in areas where ocelot captures were relatively common (A. Dillon and M. Sunquist, *pers. com*.). An ongoing remote-sensing camera study in Jalisco, Mexico, has indicated that the ratio of ocelot to jaguarundi photograph events is 150:1, suggesting that jaguarundis are uncommon compared to ocelots in that area (R. Nuñes, *pers. com*.). Michalski et al. (2006) captured 3 jaguarundis and had a capture success rate of 1 jaguarundi capture over 147 trap nights. However, Michalski et al. (2006) were not able to capture an ocelot likely because they were absent in their study area which contained a small amount of natural habitat and poor habitat quality (eucalyptol forests and grasslands). Because my study had a robust sample size for ocelot and jaguarundi, the results effectively reveal if there is coexistence or avoidance between jaguarundis and ocelots, or if larger felids (e.g., ocelot) may suppress the presence of the smaller felids (e.g., jaguarundi).

OBJECTIVES

The objectives of this study were to:

1) Determine home range and core area overlap among jaguarundis and ocelots at the LERC.
2) Determine differences in activity and habitat use patterns of jaguarundis and ocelots at the LERC.
3) Determine if there was local temporal segregation of jaguarundis and ocelots at the LERC.

STUDY AREA

The LERC (23°28’7”N, 93°47’38”W) includes 3 private properties: Los Ebanos, Los Pericos, and Tepehuajes Ranches. The LERC is located in the State of Tamaulipas in northeast Mexico, and is adjacent to the Gulf of Mexico (Fig. 11). Mean annual precipitation in this region is 72 cm with variation throughout the year (Pennington and Sarukhan 1968, Rzedowski 1986). Temperatures ranged from 5ºC to 38ºC, with a mean of 24.6°C (Rzedowski 1986). Topography was mostly flat with some hills in the western area and elevation ranges from 0-30 m (Rzedowski 1986, Caso 1994). Land use practices implemented at LERC were dominated by cattle ranching and have resulted in native, tropical sub-deciduous forest (Pennington and Sarukhan 1968) occurring in human-created strip patterns (Caso 1994, Shindle 1995). Natural habitat is considered tropical sub-deciduous forest.

Woody species encountered in the area included ebony (*Pithecellobium flexicaule*), gumbo limbo (chaca) tree (*Bursera semiaruba*), strangle fig (*Ficus tecolutensis*), tepehuaje (*Lysiloma acapulcensis*), guacima (*Guazuma ulmifolia*), and grangeno (*Celtis reticulate*;

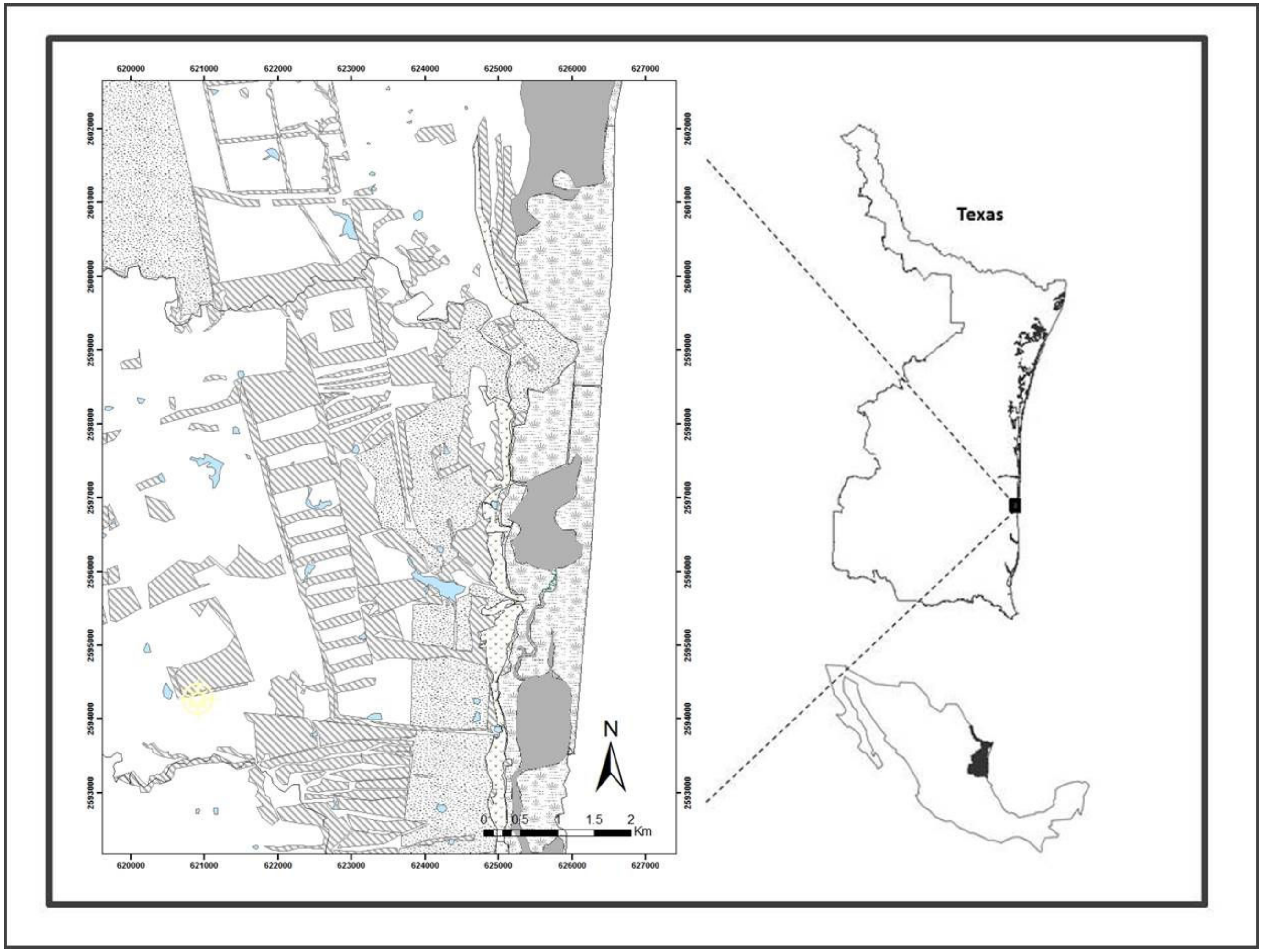

Figure 11. Location of ocelot and jaguarundi study from July 1991-December 2007 on the Los Ebanos Ranch Complex in Tamaulipas, Mexico.

Pennington and Sarukhan 1968, Gonzalez-Medrano 1972, Rzedowski 1986). Five types of vegetation communities dominate the study area: undisturbed natural tropical sub-deciduous forest, African star (*Cynodon niemfluensis*) grassland, Guinea grass (*Panicum maximum*) grassland, Gulf cordgrass (*Spartina spartinae*) grassland, and estuarine vegetation with mangrove (*Avicennia germinans*) (Gonzalez-Medrano 1972, Rzedowski 1986, Shindle and Tewes 1998).

MATERIALS AND METHODS

Capture and handling

Individual jaguarundis and ocelots were trapped intermittently from July 1991 to November 2007 with Tomahawk wire box-traps (107 x 50 x 40 cm; Tomahawk Live Trap Company, Tomahawk, Wisconsin, USA) with a separate protected attachment for live bait such as chickens and coturnix quail (Tewes 1986, Caso 1994, Caso et al. 2005). Traps were placed along game trails where suitable habitat was located. Traps were open continuously during trapping periods, and checked every morning before 1100 h. Traps were placed in locations with sufficient shade (e.g., under forest canopy) to prevent heat stress of captured cats.

Captured ocelots and jaguarundis were immobilized with an intramuscular injection using either a mixture of ketamine hydrochloride (Ketaset, Bristol Laboratories, Syracuse, NY) and Rompun® (xylazine; Beltran and Tewes 1995), or Zoletil® (Virbac, Ltd., Carros, France; tiletamine hydrochloride-zolazepam; Shindle and Tewes 2000). These drugs were administered intramuscularly to the captured feline with a pole syringe. Morphological measurements, body temperature, and blood and hair samples were taken. Dental condition was evaluated to estimate age. A VHF 80-g radio-collar (148-151 MHz) with a mortality sensor (Wildlife Materials Inc., Murphysboro, Illinois; Telonics, Inc., Meza, Arizona; Advanced Telemetry Systems. Inc., Isanti, Minnesota) was attached to adult and sub-adult ocelots and jaguarundis following handling procedures. The sedated felid was returned to the box trap or a “pet carrier” box for protected recovery from the effects of the immobilization. Cats were released at the capture site when the effects of sedation ended and full coordination was achieved.

Spatial data collection and activity patterns

I attempted to locate every radio-collared cat 10 times each month from established ground-fixed stations to provide data on home range overlap, habitat use, and other spatial patterns. Jaguarundis and ocelots were located throughout the study area during diurnal and nocturnal periods. For each location, ≥2 bearings were taken from different fixed receiver stations with a Suunto hand-held compass (Sunnto Instruments, Finland; Kenward 1987). Independence of locations was assumed by using 1 location each 24-h period.

Telemetry information included identification number, date, time, and activity (pulse gain change) for each location. Cat locations were determined using Locate II and III software (Tatamagouche, Nova Scotia, Canada). Selected jaguarundis (n = 9) and ocelots (n =10) were monitored hourly for activity patterns. For these individuals I measured the distance between the initial and final locations, the average distance (m) traveled each hour, and the area (MCP 100%) occupied during the 24-h period. Linear distance was calculated for ocelots and jaguarundis that were radio tracked on consecutive days (Rabinowitz and Nottinham 1986). Significance of probability was determined using SAS 3.2® (SAS Institute, Cary, North Carolina) software program.

Home range overlap

Home range overlap of felines that were tracked during the same period was calculated using the minimum convex polygon 95% (MCP95) estimator (Carvajal et al. 2012, MacDonald et al. 1980, Mohr 1947). Core areas were calculated using the minimum convex polygon 50% (MCP50; Carvajal et al. 2012 Grassman 2004, Grassman et al. 2005, Hooge and Eichenlaub 2000). Radio telemetry error was assessed with a global position system (GPS) by identifying the location of 5 transmitters placed randomly in the same habitat where the cats occurred (Blankenship 2000, Grassman 2004), and the GPS locations compared with the corresponding telemetry location. Mean distance between radio locations and GPS locations indicated a mean triangulated error of 42±36 m. The computer programs ArcView 3.2 and ArcGIS 9 and 10 (Animal Movements Extensions) were used to evaluate radio-telemetry data obtained during this study (Hooge and Eichenlaub 2000, Grassman et al. 2005). Home range areas were recorded from adult individuals. Minimum number of independent locations for each home range value using the asymptote test (Seaman and Powell 1996) was determined to be 20 observations for jaguarundi and 25 observations for ocelot. Home range sizes, core area contour intervals, and cat locations were converted with ArcMap 10 to a polygon and point shape files.

Habitat use

Vegetation polygon shape files were created using ArcMap10 from digital orthophoto quadrangle imagery (DOQs; INEGI, 2011; Fig. 2 and Fig. 7). Five vegetation types were delineated within the study site: (1) undisturbed mature tropical sub-deciduous forests, (2) Guinea grass dominated grasslands, (3) African star grass dominated grasslands, (4) Gulf cordgrass dominated grasslands, and (5) salt marshes with mangrove (Caso, 1994; Shindle, 1995; Fig. 2 and Fig. 7). Availability of habitat within the study area was assessed using a polygon contour that included all the home ranges determined by fixed kernel 96% (FK95) of the individuals for each species.

The FK95 was used to delineate home ranges for calculating habitat availability for individual jaguarundis (Austin et al. 2007, Horne et al. 2009), as this method was considered to provide the best home range estimate. Vegetation use was determined by summing the number of locations within each habitat type for each animal and then converting to a percentage (Michalski et al. 2006, Lawhead 1984). A Chi-square goodness-of-fit test (Zar 1999) was used to determine if observed frequencies of habitat use differed significantly from expected frequencies based on the proportion of area contributed within each jaguarundi home range area (FK95; Byers and Steinhorst 1984, Crawshaw and Quigley1991, Lawhead 1984, Michalski et al. 2006, Neu et al. 1974). To test availability of habitat within the study area, home ranges of all individuals were grouped in 1 polygon that encompassed all home ranges (Michalski et al. 2006).

Interspecific and intraspecific relationships

Two methods were used to estimate the interaction between jaguarundis and ocelots. The first method entailed creating buffer areas around each ocelot and jaguarundi location where the home ranges overlapped (Mattison et al. 2011), and that were tracked during the same day and approximately at the same time (Fig. 12). The size of these buffer areas were determined using the mean area that an ocelot (male = 2.48 km²; female = 0.66 km²) and jaguarundi (male = 2.11 km²; female = 0.62 km²) covered during a 24-h period (Chapter I and II). The radius of these circular buffer areas was calculated and the distance between locations was measured to identify if there was any overlap between the buffer areas, and to test if each animal had a probability of an encounter in a 24-h period (Fig. 12). Percentage of overlap of buffer areas was calculated by species and gender.

The second method consisted of measuring the mean distance between locations of individuals that were tracked on the same date, with only locations within pair overlap areas evaluated (Mattison et al. 2011). Comparisons were made by species and gender. For comparison, distances between individuals of the same species were measured and then compared to means of distances found between species. A two-sample z-test determined the statistical differences between means of groups of the same or different species and by gender.

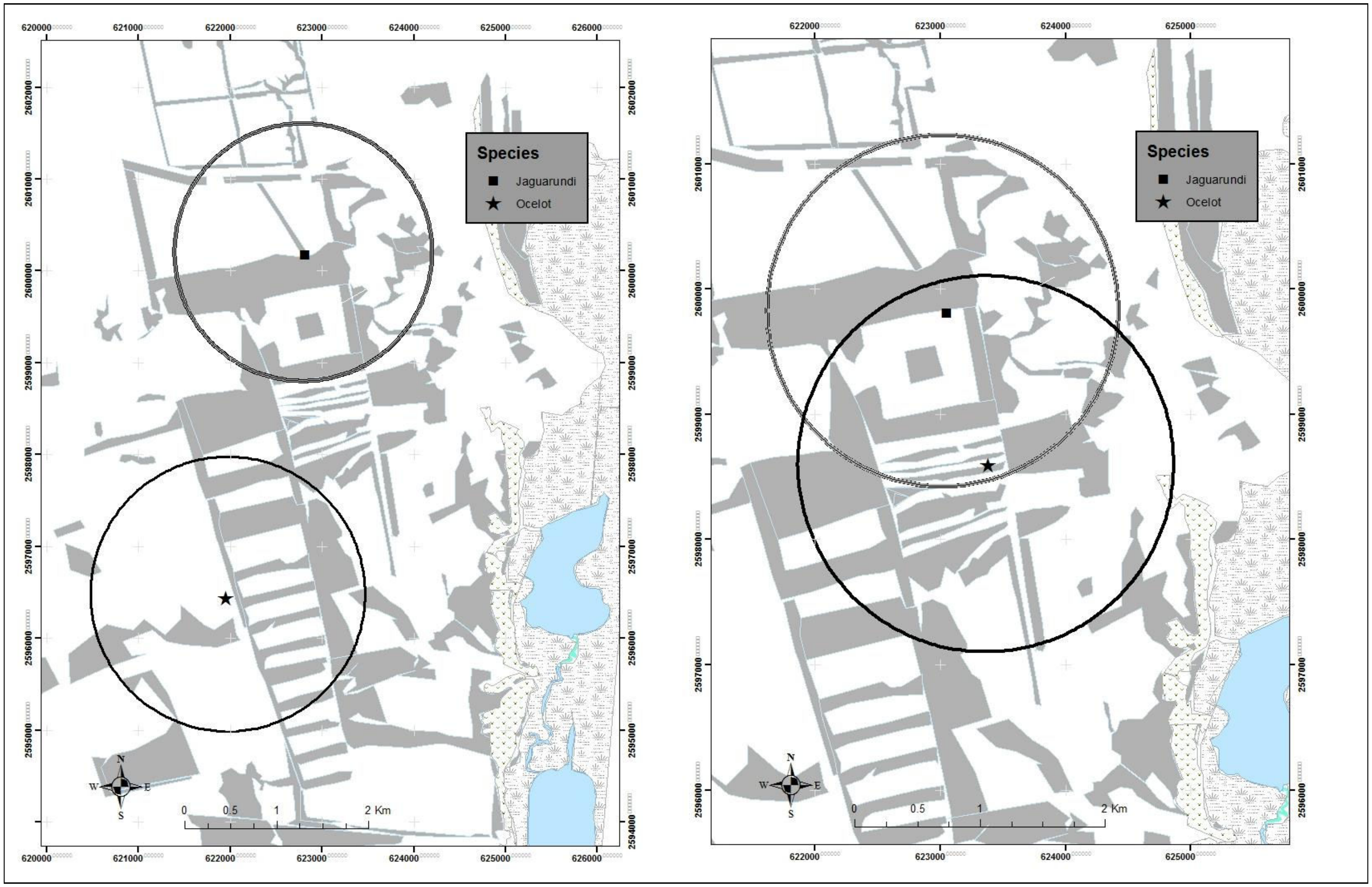

Figure 12. Buffer areas created with 24-h activity area values of ocelot and jaguarundi, showing avoidance and overlap of both species on Los Ebanos Ranch Complex in Tamaulipas, Mexico.

RESULTS

Capture and handling

Twenty-one jaguarundis (13M, 8F) and 29 ocelots (14M, 15F) were captured during 21,742 trap nights from July 1991 to December 2007. All captures occurred in traps set along the interface between tropical sub-deciduous forest and grassland pastures or in locations adjacent to roads. Jaguarundis (n = 18) were sedated with Ketaset® and Rompun® at a mean dosage of 16.9 mg/kg of ketamine hydrocloride and 1.2 mg/kg of xylazine (Table 1). Three jaguarundis were sedated with tiletamine-zolazepam (Zoletil 50) at a mean dosage of 5.3 mg/kg (Table 2). Mean induction time for jaguarundis with Ketaset was 6:30 min, and 3:00 min with Zoletil 50 (Table 1 and 2).

Ocelots (n = 23) were sedated with Ketaset® and Rompun® at a mean dosage of 18 mg/kg of ketamine hydrochloride 0.6 mg/kg of xylazine (Table 11). Six ocelots were sedated with Zoletil 50® at a mean dosage of 4.8 mg/kg (Table 12). Mean induction time for ketamine-xylazine was 9 min, and 8:30 min with Zoletil 50 (Table 11 and 12).

Activity patterns

Mean daily movement of jaguarundis (n = 8) was 1.90±0.80 km and 2.04±0.77 km for ocelots (n = 10), without significant differences between species (t-test, $P>0.05$). The area covered (MCP 100%) by jaguarundis (n = 8) during a 24-h tracking period was 1.37±0.82 km^2 and 1.69±0.99 km^2 for ocelots (n = 10) without significant differences between species (t-test, $P>0.05$). Activity levels indicated that jaguarundis were active through the diel peaking at mid-day (1100–1400 h; Fig.13). However, jaguarundis were significantly more active during the day than at night (t-test, $P<0.001$; Chapter I). Activity levels indicated that ocelots also were active throughout the diel, but with two peaks of activity, one between 400-600 h and another between 2000-2200 h (Fig. 13). Ocelots were significantly more active at night than during the day (t-test, $P<0.001$; Chapter II).

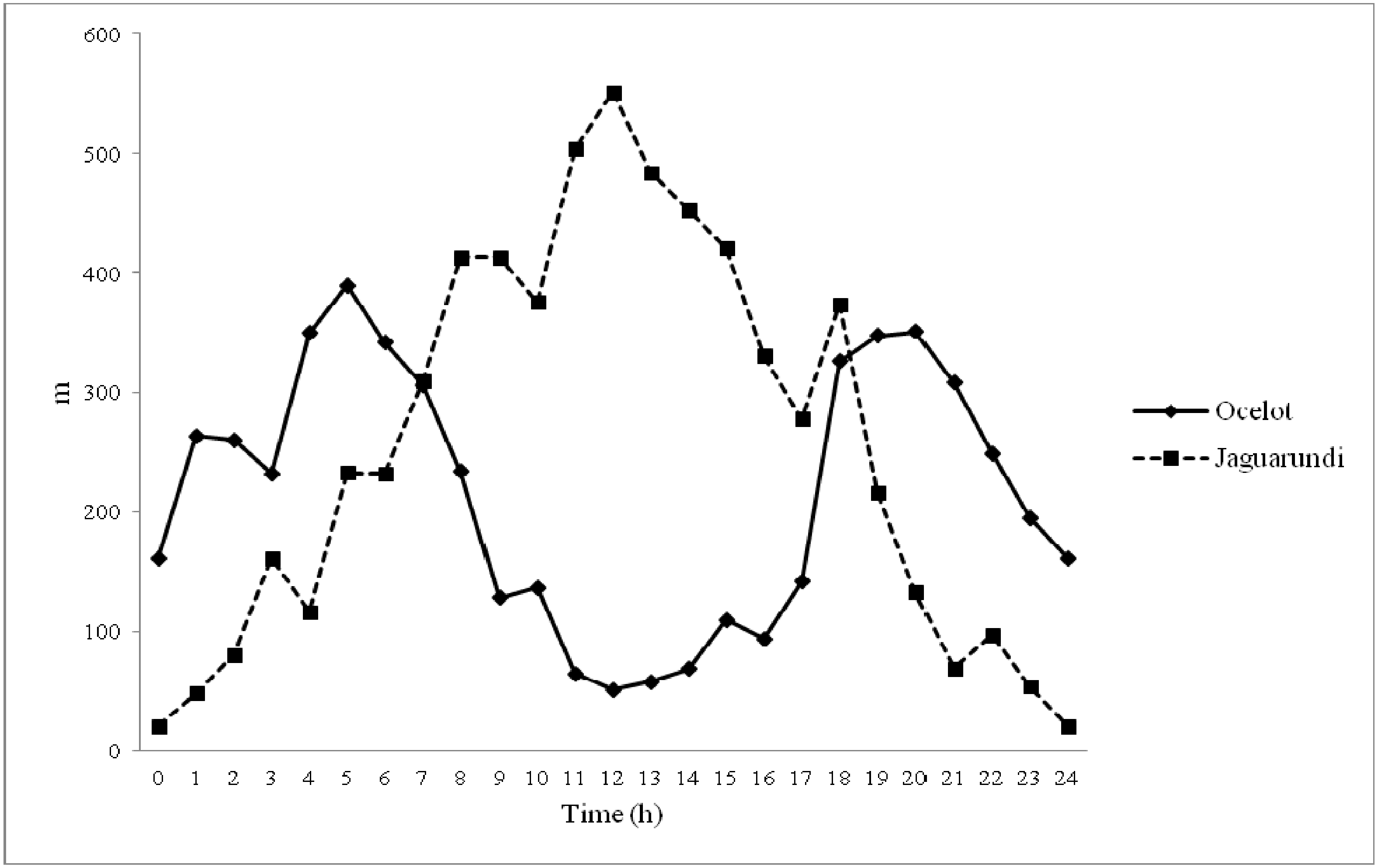

Figure 13. Hourly distance (m) travelled by ocelot and jaguarundi at Los Ebanos Ranch Compex in Tamaulipas, Mexico, June 1991- December 2007.

Home range overlap

There were overlapping home ranges (MCP95) among jaguarundis and ocelots (Fig. 14). Mean overlap percentage between male jaguarundi and female ocelot pairs (n = 5; Table 18) was 54.8% (range: 39.6.3% – 80.8%), and 30.9% (range: 11.1% – 42.9%) between female jaguarundi and female ocelot pairs (n = 4; Table 18). Mean overlap percentage between male ocelot and female jaguarundi pairs (n = 4; Table 18) was 36.8% (range: 5.4% – 66.9%) and 24.6% between male ocelot and male jaguarundi pairs (n = 2; Table 18).

There was core area (MCP50) overlap between females and males of both cat species (Fig. 14), but these areas were more exclusive than home range areas (MCP95). Core area overlap between male jaguarundi and female ocelot pairs (n = 5; Table 18) was 19.2% (range: 2.9% – 44.9%), and 7.5% (range: 0.0 % – 17.4%) between female jaguarundi and female ocelot pairs (n = 4; Table 18). There was no overlap of core areas between male ocelot and male jaguarundi and only the core area of one pair of male ocelot and female jaguarundi overlapped 17.7 %, whereas another 3 pair did not overlap (Table 18).

Habitat use

Habitat use and availability were compared for the entire ocelot and jaguarundi population. Within home ranges (FK95), ocelots used tropical sub-deciduous forest (82.3%), Guinea grass (15.9%), African star grass (1.2%), Gulf cordgrass (0.3%), and estuary (0.4%) areas (Chapter II). However, Neu et al. (1974) test indicated the preferred habitat for ocelots was tropical sub-deciduous forest, whereas the other habitat types were avoided ($X^2 = 907.4$, d.f.=4, P<0.0001; Chapter II). Habitat use results were similar when tested for the entire study area; ocelots preferred tropical sub-deciduous forest habitat whereas the other habitat types were avoided ($X^2 = 1680.2$, d.f.= 4, P<0.0001; Table 15 and 16).

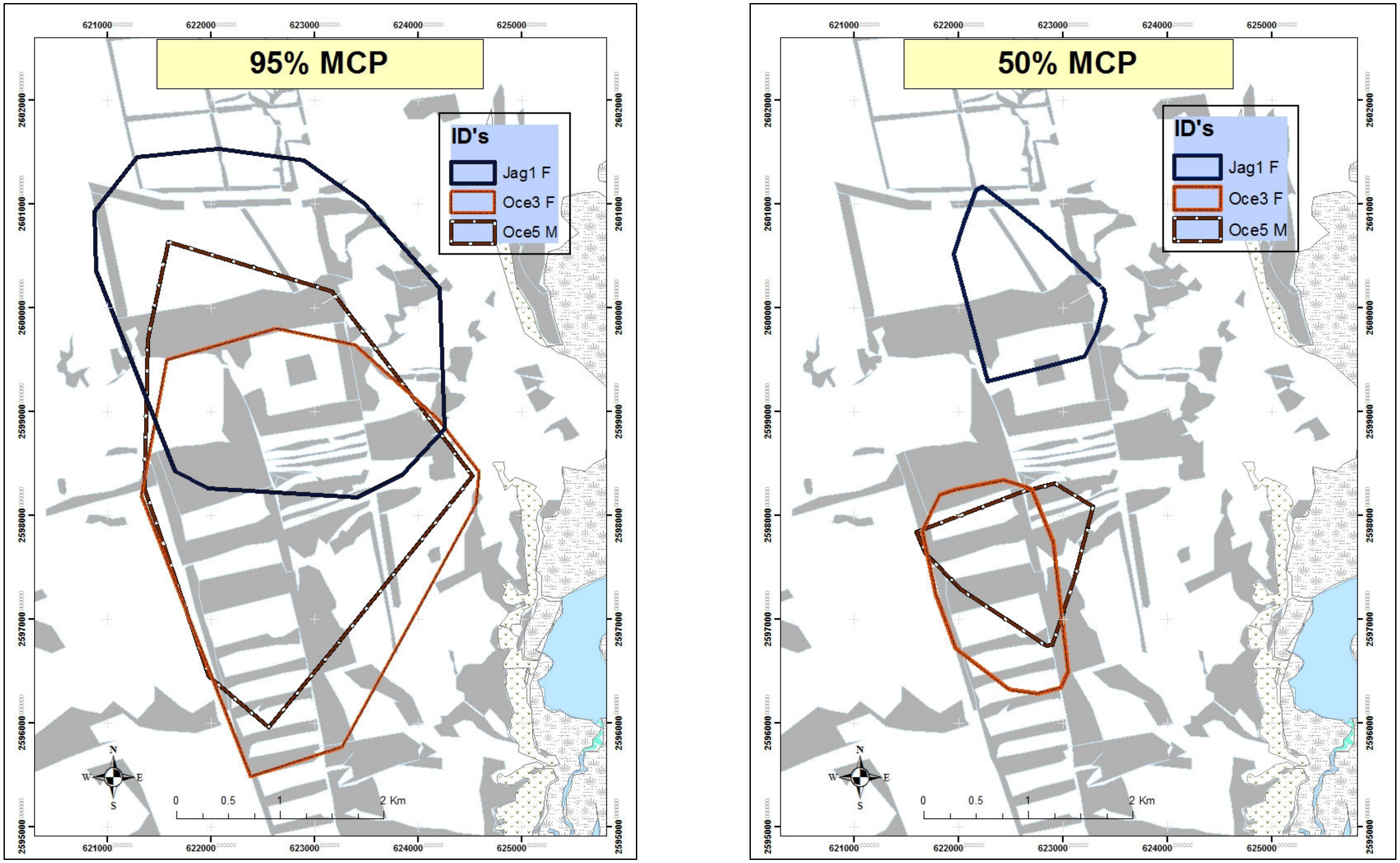

Figure 14. Home range and core area overlap of a jaguarundi (Jag01F) and two ocelots (Oce3F; Oce5M) on Los Ebanos Ranch Complex in Tamaulipas, Mexico, August 1991-May 1992.

Table 18. Home range and core area overlap between ocelots and jaguarundis on Los Ebanos Ranch Complex in Tamaulipas, Mexico, June 1991-December 2007.

Species	Pairs	95% MCP	50% MCP
Ocelot female - Jaguarundi male	5	54.8%	19.2%
Ocelot female - Jaguarundi female	4	30.9%	7.5%
Ocelot male - Jaguarundi female	4	36.8%	4.4%
Ocelot male - Jaguarundi female	2	24.6%	0%

Jaguarundis used tropical sub-deciduous forest (47.9%) and Guinea grass (44.6%) areas similarly (Chapter I). However, comparing habitat type availability and preference for the entire study area using the Neu et al. (1974) test, jaguarundis preferred tropical sub-deciduous forest habitat ($X^2 = 242.9$, d.f. = 4, $P < 0.001$; Chapter I), whereas the other habitat types were avoided (Table 6). Percentage of use was lower (6.6%) for African star grasslands and much reduced for Gulf cordgrass (0.7%) and estuary (0.2%) areas (Table 6). These habitats were avoided by jaguarundis ($X^2 = 242.9$, d.f. = 4, $P < 0.001$; Table 6). Habitat use compared within jaguarundi home ranges (FK95) using Neu et al. (1974) test showed that jaguarundis preferred tropical sub-deciduous forest habitat and used Gulf cordgrass in proportion to availability ($X^2 = 314.5$, d.f. = 4, $P < 0.0001$; Chapter I), whereas the other habitat types were avoided (Table 7).

Interspecific and intraspecific relationships

I obtained information on 627 locations of jaguarundis and ocelots that were tracked during the same date and that shared home range overlap (Table 19). Mean distance between jaguarundis (either gender) and ocelots was greater for male ocelots (2.7±1.4 km), than female ocelots (1.9±1.2 km; 2-sample z-test, $P=0.001$; Table 19; Fig. 15). Mean distance between male jaguarundi and female ocelot was 2.1±1.2 km and 2.3±1.8 km with male ocelot. There was no statistical difference (2-tailed t-test, $P>0.05$; Table 19) between ocelot gender. However, mean distance between female jaguarundi and female ocelot was 1.6±1.1 km and 2.8±1.2 km with male ocelot, with statistical significance (2-tailed t-test, $P<0.0001$; Table 19; Fig. 15) between ocelot gender. Distances between locations of animals of the same species are summarized in (Table 19). I found globally that the mean distance between ocelots and jaguarundis was 2.1±1.3 km and the mean distance between ocelots was 1.4±0.8 km, whereas mean distance

Table 19. Mean distances and buffer overlap between ocelots and jaguarundis on Los Ebanos Ranch Complex in Tamaulipas, Mexico, June 1991-December 2007.

Species	No. of paired locations	Distance	% of Buffer Overlap
Ocelot – Jaguarundi Comparisons			
Female Ocelot - Male Jaguarundi	86	2.08±1.20	29.1%
Female Ocelot - Female Jaguarundi	54	1.64±1.09	31.5%
Male Ocelot - Female Jaguarundi	29	2.83±1.24	10.3%
Male Ocelot - Male Jaguarundi	10	2.31±1.83	50.0%
Ocelot Comparisons			
Female Ocelot - Female Ocelot	172	1.53±0.71	17.4%
Female Ocelot – Male Ocelot	152	1.03±0.70	71.1%
Male Ocelot - Male Ocelot	25	1.75±0.74	68.0%
Jaguarundi Comparisons			
Female Jaguarundi – Female Jaguarundi	18	2.39±1.08	29.1%
Female Jaguarundi – Male Jaguarundi	55	1.41±0.84	49.1%
Male Jaguarundi - Male Jaguarundi	26	1.45±1.03	68.1%

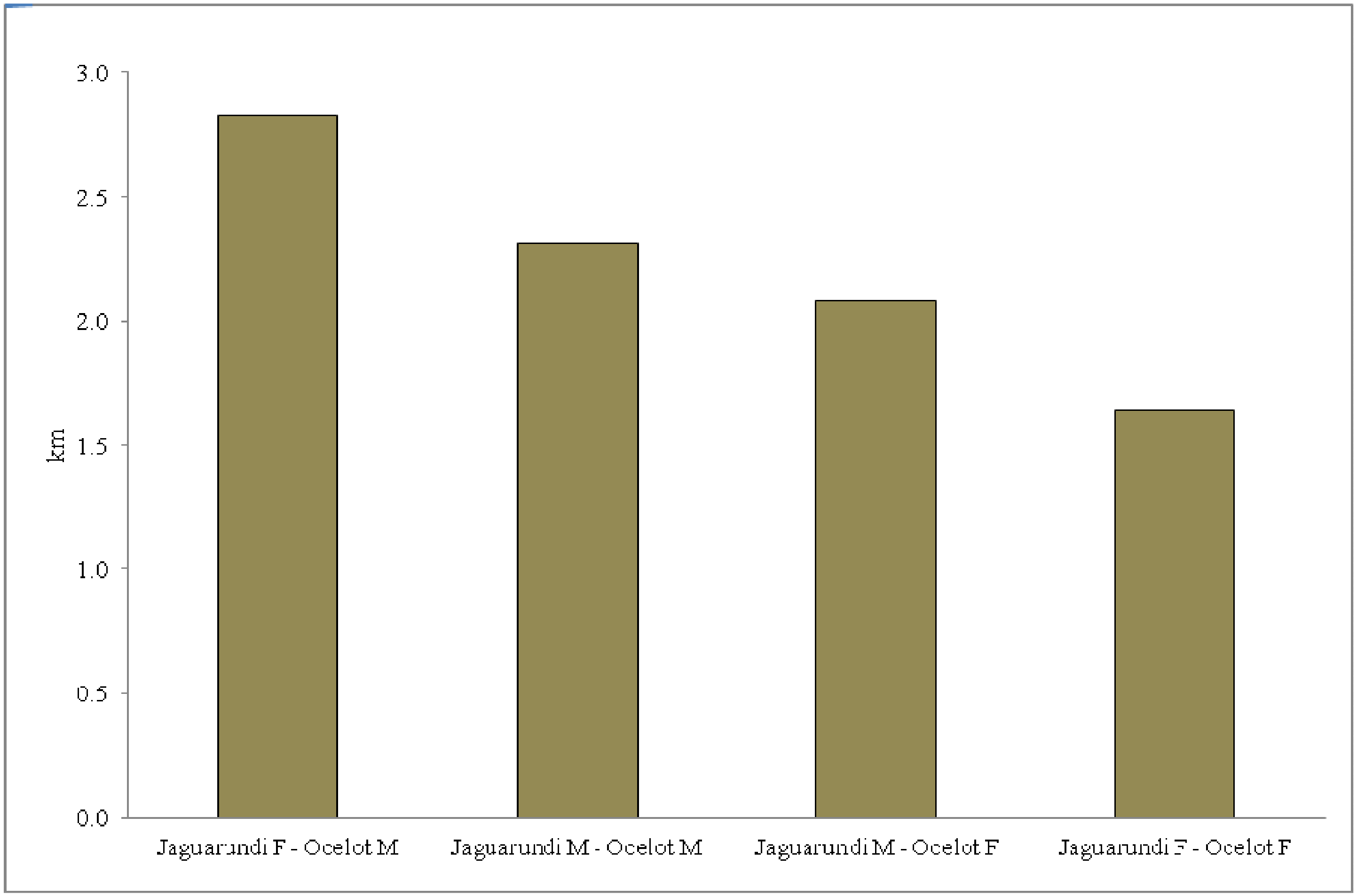

Figure 15. Mean distances of daily locations between ocelots and jaguarundis by gender on Los Ebanos Ranch Complex, Tamaulipas, Mexico, June 1991-December 2007. (M=Male; F= Female)

between jaguarundis was 1.5±0.9 km, with significant differences (2-sampled z-test, $P<0.001$) between distances of jaguarundis with ocelots and no significant differences (2-sampled z-test, $P>0.05$) with individuals of the same species (Table 19; Fig. 16).

Percentage of overlap using the buffer method indicated that male and female jaguarundis had less buffer overlap with male ocelots, and that this occurred on 5 occasions (12.8%) with 1 male jaguarundi, and on 3 occasions (7.7%) with female jaguarundis ($n = 39$ locations). For female ocelots, male jaguarundis overlapped on 25 occasions (29.1%; $n = 86$ locations) and with female jaguarundis overlap occurred on 17 occasions (31.5%; $n = 54$ locations; Table 19).

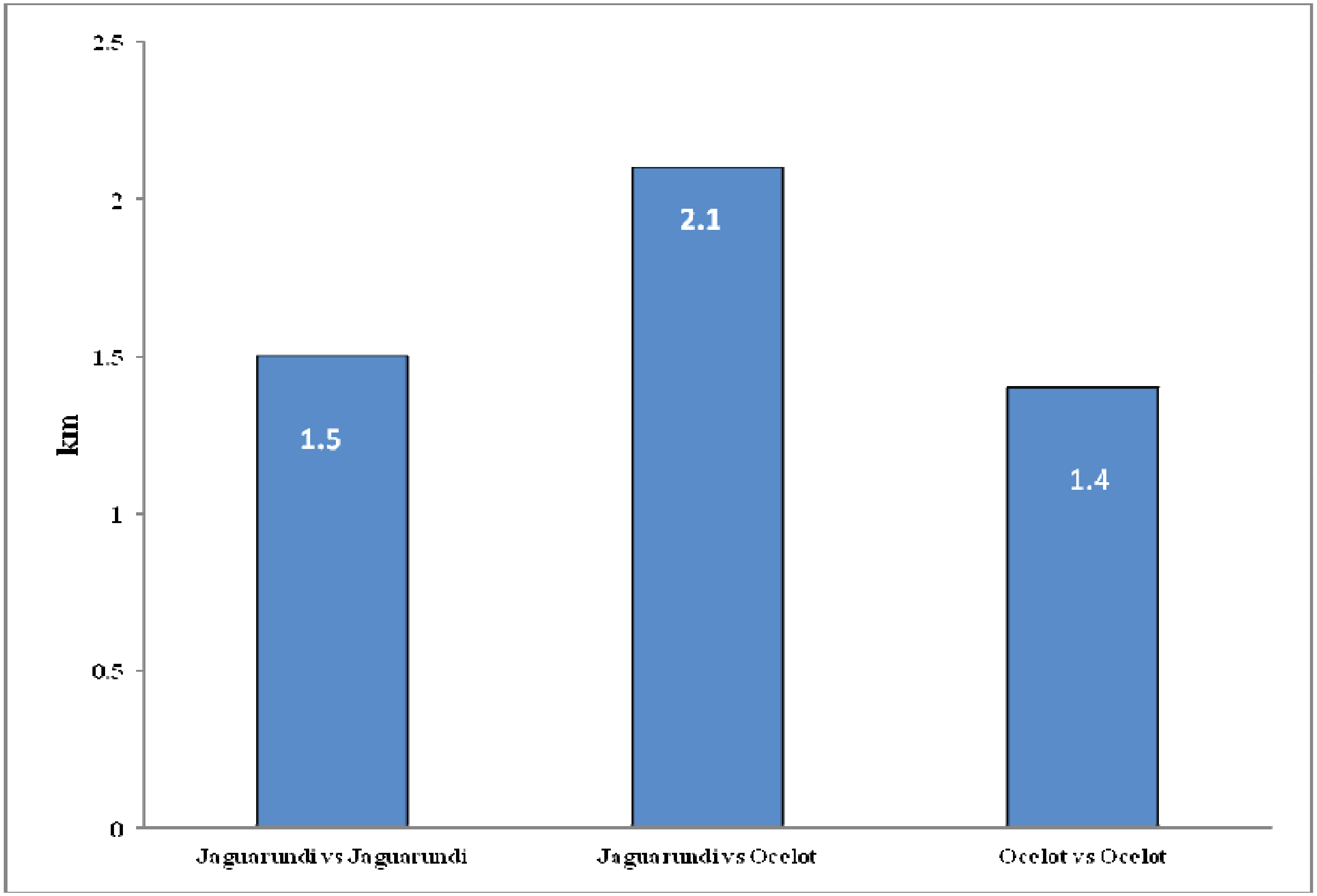

Figure 16. Mean distances between daily paired locations for ocelots and jaguarundis on Los Ebanos Ranch Complex, Tamaulipas, Mexico, June 1991-December 2007.

DISCUSSION

Ocelot and jaguarundi overlap distribution ranges in Mexico (Leopold 1959, Villa and Cervantes 2002, Sanchez-Cordero et al. 2008), however, local abundance of a species may be influenced by proximate factors such as prey density, habitat, presence of potential competitors, and predators, and to a less extent environmental factors (Oliveira et al. 2010). Much emphasis has been placed on the trophic competition among carnivores, suggesting that this competition may limit or suppress the presence of one species in an area (Lomolino et al. 2005, Sanchez-Cordero et al. 2008). However, high overlap in one niche dimension may be compensated by low overlap in another axis (Oliveira et al. 2010), therefore coexistence between sympatric carnivores may be possible because of differences in habitat use and activity patterns (Rosenzweig 1966, Kitchener 1991, Thornton et al. 2004). I found differences in activity patterns between ocelots (nocturnal) and jaguarundis (diurnal) at the LERC. Other studies found that jaguarundis are diurnal whereas ocelots are predominantly nocturnal (Tewes 1986, Konecny 1989, Laack 1991, Oliveira et al. 2010).

Konecny (1989) reported that ocelots and jaguarundis overlapped their home ranges considerably in Belize, although the 3 jaguarundis had larger home ranges. Home range sizes at the LERC were similar between ocelots (males = 15.1 km^2; females = 9.5 km^2) and jaguarundis (males = 16.5 km^2; females = 12.1 km^2), with 85.7% home range (MCP95) overlap between jaguarundis and ocelots. However, overlapping core areas (MCP50) was lower (14.8%) with ocelots and jaguarundis of different gender, and absent between male ocelots and male jaguarundis, suggesting that ocelots and jaguarundis maintain some level of spatial avoidance.

Previous studies found that ocelots used undisturbed tropical forest or dense thornshrub and only occasionally moved from cover (Tewes 1986, Tewes and Everett 1986, Ludlow and Sunquist 1987, Emmons 1988, Laack 1991, Caso 1994, Grigione et al. 2001, Sunquist and Sunquist 2002). I found that ocelots used tropical sub-deciduous forest (82.3%), Guinea grass (15.9%), African star grass (1.2%), Gulf cordgrass (0.3%), and estuary (0.4%) areas, whereas the tropical sub-deciduous forest was the preferred habitat by ocelots (Chapter II). Jaguarundis used tropical sub-deciduous forest (47.9%) and areas mostly void of woody cover including Guinea grass pastures (44.6%), African star pastures (6.6%), Gulf cordgrass (0.7%) and estuary (0.2%) areas. These more open areas were used much less by ocelots. The tropical sub-deciduous forest also was the preferred habitat by jaguarundis (Chapter I).

Konecny (1989) found that jaguarundis primarily used riparian and old forests. Sunquist and Sunquist (2002) also reported that jaguarundis may use more open areas than ocelots, and that jaguarundis occur more in areas that have dense cover with openings and edges. Although there were habitat use differences between ocelots and jaguarundis, the tropical sub-deciduous forests were preferred habitat for both felids. If a larger predator (e.g., ocelot) occupies a high quality habitat, it may cause a smaller species (e.g., jaguarundi) to use the same area at lower densities (Bisbal 1989, Linnell and Strand 2000). Jaguarundis densities are low in other areas where jaguarundis and ocelots occur sympatrically.

In Chamela Biosphere Reserve in Jalisco, Mexico, the ratio of ocelot to jaguarundi photographic events is 150:1, suggesting that jaguarundis were uncommon compared to ocelots in the same area (R. Nuñes *pers. com.*). No jaguarundi captures occurred in other ocelot studies in different parts of Central and South America where jaguarundi also ranged and where box traps were used to capture both felids (Emmons 1988, Sunquist and Sunquist 2002, Dillon and Kelly 2008). Exceptions include Konency (1989) and Crawshaw (1995) where both felids were captured, although jaguarundi captures were uncommon. In Brazil, Crawshaw (1995) captured 21 ocelots and 3 jaguarundis after 3,559 trap nights.

An ongoing ocelot scat analysis study indicated that ocelot prey at the LERC was mostly comprised of small rodents such as Mexican spiny pocket mouse (*Liomys irroratus*), deer mouse (*Peromyscus* spp.), and northern pygmy mouse (*Baiomys taylori*); these species were associated with the tropical sub-deciduous forest (E. Rendon, *pers. com.*). The same study found that the hispid cotton rat (*Sigmodon hispidus*) was captured exclusively in pasture areas. Although there is no food habit analysis for jaguarundis at the LERC, Konecny (1989) in Belize and Mondolfi (1986) in Venezuela reported that the main prey of jaguarundis was the hispid cotton rat. Thus, I assume that because of different habitat use, potential competition between ocelots and jaguarundis at the trophic level may have been reduced at the LERC.

In general, differences in activity, habitat use, and to some extent segregated space use may allow the ocelot and jaguarundi to coexist in the same area. However, there still can be direct effects of one species with the other. Changes in the density of one carnivore species may affect the density of another species (Henke and Bryant 1999). Studies have found that interspecific interferences are widespread within carnivore guilds (Palomares and Caro 1999); however, this importance is seldom quantified by biologists (Linnell and Strand 2000).

Many studies have identified incidences of intraguild predation between carnivores (Linnell et al, 1998, Oliveira et al. 2010). Linnell and Strand (2000) reported intraguild predation among 97 pairs of carnivore species. The “ocelot effect” that Oliveira et al. (2010) identified in Brazil is probably an influential ecological factor because areas with high ocelot density tend to have lower densities of smaller sympatric cats. Jaguarundis and other small cats may avoid ocelots. Carvajal et al. (2012) found a high margay density at El Cielo Biosphere Reserve in Tamaulipas, Mexico, but ocelots were absent in the area.

Although I did not observe antagonistic interactions between the secretive ocelot and jaguarundi at the LERC, the mean distances between ocelots and jaguarundis tracked at the same time were significantly longer (>2 km) compared with the distances between ocelot individuals (1.4 km) and between jaguarundi individuals (1.5 km) (Fig. 16). Also, the low percentage of core area overlap between the species suggest that jaguarundis avoided encounters with ocelots, particularly with male ocelots (Fig. 15). Oliveira et al. (2010) found that in areas where ocelots and jaguarundis occur sympatrically, ocelots always occurred in higher densities. Lower densities of jaguarundis may reflect intraguild predation by ocelots or the threat of antagonistic encounters (Oliveira et al. 2010).

Future research should explore the interaction of carnivores and not assume that coexistence and avoidance occurs only through exploitative competition. Coexistence of different members of a guild produce increased biodiversity (Linnell and Strand 2000).

CONCLUSIONS

Because exploitative competition may not be an important biotic factor between ocelots and jaguarundis, differences in habitat use and activity patterns may allow ocelots and jaguarundis to occur in the same area. This study found that jaguarundis avoided ocelots spatially, particularly with male ocelots (Table 19; Fig. 15). If ocelot density is high in an area the jaguarundi population may be lower. Jaguarundis may be rare or absent in Texas because of the presence of ocelots in high densities in woody areas, and the high density of bobcats and coyotes in the open areas. Predation on domestic cats by coyotes and bobcats has been documented (Seidensticker and Lumpkin 2004, Grubbs and Krausman 2009). Jaguarundis are similar in size and body mass to domestic cats, thus it is likely that predation on jaguarundis by these larger carnivores may restrict the distribution of the jaguarundi in Texas.

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