

Relative abundance and activity patterns of terrestrial mammalian species in Barra del Colorado Wildlife Refuge, Costa Rica

Stephanny Arroyo-Arce¹, Ian Thomson¹ & Roberto Salom-Pérez²

1. Coastal Jaguar Conservation, 126-3100 Santo Domingo, Heredia, Costa Rica, sturnina@gmail.com, ianithomson@hotmail.com
2. Panthera Costa Rica, 8-3870-1000 San José, Costa Rica, rsalom@panthera.org

Recibido 04-IV-2016 • Corregido 30-V-2016 • Aceptado 01-VII-2016

ABSTRACT: Relatively little information has been generated regarding the mammal diversity of Barra del Colorado Wildlife Refuge, Costa Rica. This study assessed relative abundance and activity patterns of some terrestrial mammalian species. We used ten camera traps distributed within the refuge, during 2014. After a total of 1 611 camera trap nights, we identified 15 mammalian species in seven orders and 11 families. The most abundant species were *Dasyprocta punctata*, *Leopardus pardalis*, *Tayassu pecari*, *Mazama temama*, *Pecari tajacu* and *Tapirus bairdii*, while *Tamandua mexicana* was characterized by its lower abundance. Activity patterns were estimated for eight species, all of which were similar with those previously described in the literature. Further monitoring is required in the refuge in order to increase our understanding of its diversity, information that will be essential for the proper management of the area.

Key words: terrestrial mammals, relative abundance, activity pattern, diversity, camera traps.

RESUMEN: Abundancia relativa y patrones de actividad de las especies de mamíferos terrestres en el Refugio Refugio Nacional de Vida Silvestre Barra del Colorado, Costa Rica. Poca información ha sido generada sobre la biodiversidad del Refugio Nacional de Vida Silvestre Barra del Colorado, Costa Rica. En el presente estudio determinamos la abundancia relativa y el patrón de actividad de ciertas especies de mamíferos terrestres. Durante el periodo 2014 se empleamos diez cámaras trampa, las cuales fueron distribuidas dentro del refugio. Después de un total de 1 611 noches de muestreo, se identificaron 15 especies de mamíferos distribuidos en siete órdenes y 11 familias. Las especies más abundantes fueron *Dasyprocta punctata*, *Leopardus pardalis*, *Tayassu pecari*, *Mazama temama*, *Pecari tajacu* y *Tapirus bairdii*, mientras que *Tamandua mexicana* reportó la menor abundancia. Se estimaron los patrones de actividad para ocho especies, los cuales fueron similares a lo previamente descrito en la literatura. Estudios adicionales son necesarios con el fin de incrementar nuestro conocimiento sobre la biodiversidad del refugio, información que será esencial para el adecuado manejo del área.

Palabras clave: mamíferos terrestres, abundancia relativa, patrón de actividad, diversidad, cámaras trampa.

In recent years, the use of camera traps has become a powerful tool in conservation. This method has been widely used to determine species diversity, daily activity patterns and relative abundance (Jiménez et al., 2010; Monroy-Vilchis, Zarco-González, Rodríguez-Soto, Soria-Díaz & Urios, 2011; Lira-Torres & Briones-Salas, 2012; Cortés-Marcial & Briones-Salas, 2014) as well as population density estimates (Weingarth et al., 2012; Tobler & Powell, 2013) and species behavior (Castañeda, Herrera & Pereira, 2013; Thomson, Arroyo-Arce & Spooner, 2014). It has also facilitated the study of elusive, cryptic and rare species of mammals (Beisiegel, 2009; Thapa, Kelly, Karki & Subedi, 2013).

Prior to our efforts, no camera trapping based studies had been conducted in Barra del Colorado Wildlife Refuge, in the northeastern Costa Rica. Further to this, wildlife monitoring in the area has been very limited. The few studies carried out in the refuge have focused mainly in studying the ichthyic resources (Chacón, 1996-1997; Alfaro-Montoya, Monge-Ortiz, Martínez-Fernández & Herrera-Quesada, 2015). While Grant and Lewis (2010) assessed crocodylian populations and their injuries related to boat traffic. Bonilla, Sandoval, Sánchez and López-Pozuelo (2014) described the first records of two species of gulls for the area. Regarding mammals, the few existing studies have focused on primates (Graham, Bulloch

& Lewis, 2013), bats (Vonhof, Whitenead & Fenton, 2004), and manatees (Jiménez, 1999). However, research on terrestrial mammalian species has not been conducted or has not been published.

In this study we present the first camera trap study of mammalian species in Barra del Colorado Wildlife Refuge. We gathered baseline data on species richness of mammals, as well as information on relative abundance and activity patterns of some terrestrial species. We also make special mention of wild felids as documented records in the area are scarce (Arroyo-Arce & Salom-Pérez, 2014), and peccaries which are one of the

most threatened Neotropical mammals (Emmons, 1984; Oliver, 1990).

MATERIALS AND METHODS

Study site: Barra del Colorado Wildlife Refuge is located in the Northeastern Caribbean coast of Costa Rica (10°46'18" N - 83°35'56" W; Fig. 1). Established in 1985, it covers an area of 81 177ha (La Gaceta, 2012). It is characterized by a low altitude mountain range, dominated by floodplains (Cerdas, 2013), where the predominant ecosystem is the Tropical Wet Forest and the Forest Transition

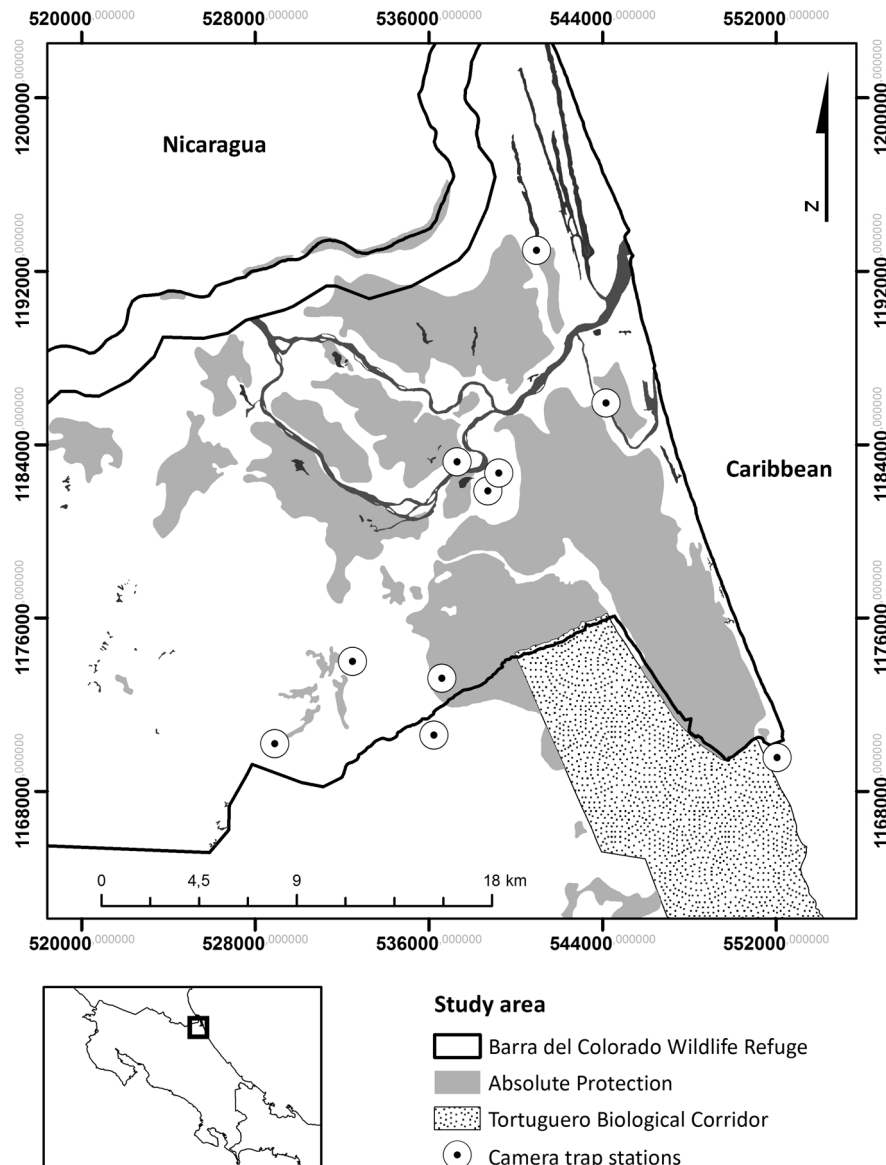


Fig. 1. Study area and camera trap distribution in Barra del Colorado Wildlife Refuge, Costa Rica.

to Basal Premontane (Holdridge, 1969). The average temperature of this area varies between 18°C and 33°C with a mean annual precipitation of 6 000mm (Cerdas, 2013).

Data collection: Ten camera trap stations were set in the study area, between February and December of 2014. Each station consisted of one digital camera trap (Bushnell Trophy Cam or Bushnell Trophy Cam HD) placed 60cm above the ground; at locations where mammal detection probability was considered to be high (e.g. trails). Cameras were programmed to record photos (3 images) and videos (10s) at 3s interval. Each station had a scent lure (Chanel N°5) placed on a stick in front of the camera trap in an attempt to increase the time animals stood in front of the camera; increasing the sharpness of the image, and thus facilitating the identification of the species and individuals (e.g. coat pattern, wounds, scars, skin parasites). Stations were checked every month to collect memory cards, replace batteries if required, refresh the scent and ensure the equipment was still functioning.

Data analysis: Relative abundance index (RAI) for every mammalian species was determined using Equation 1.

Equation 1

$$RAI_{spa} = \text{events} * 100 \text{ camera trap nights} / \text{sampling effort.}$$

Where RAI_{spa} =relative abundance index for species 'a'; events=number of independent records per species; 100 camera trap nights=unit of standardization to compare

data with other studies; sampling effort=total amount of nights that the camera trap stations were working.

Following Springer et al. (2012) only one individual per species was counted at each camera trap station within a 24h period (independent record); with the exception of gregarious species and felids. For gregarious species, when instances of more than one individual were recorded at the same time and for the same station, the number of independent records was considered equal to the number of individuals observed in the same frame (Monroy-Vilchis et al., 2011). For felids (or other species where individuals could be identified) we considered consecutive records of the same individual, at the same station, as independent records when there was a 24h interval between detections (Monroy-Vilchis et al., 2011).

Activity patterns were estimated for those species with 11 or more independent records (Maffei, Noss, Cuéllar & Rumiz, 2005; Monroy-Vilchis et al., 2011). Records were grouped in two hours intervals, and the activity patterns were classified as diurnal (8:00-18:00h), nocturnal (20:00-6:00h) and crepuscular (6:00-8:00h and 18:00-20:00h). Species that showed sporadic and random intervals of activity were classified as cathemeral (Maffei et al., 2005; Monroy-Vilchis et al., 2011).

RESULTS

After a total of 1 611 camera trap nights, we were able to identify 15 mammalian species distributed between seven orders and 11 families (Table 1). The most common order were the carnivores, with six species, including

TABLE 1
Relative abundance index for mammalian species recorded by camera traps

Order	Family	Species	RAI ¹
Carnivora	Felidae	<i>Leopardus pardalis</i>	2,23
		<i>Panthera onca</i>	0,43
		<i>Puma concolor</i>	0,12
	Mustelidae Procyonidae	<i>Eira barbara</i>	0,37
		<i>Procyon lotor</i>	0,37
		<i>Nasua narica</i>	0,68
Cetartiodactyla	Cervidae	<i>Mazama temama</i>	1,37
		<i>Pecari tajacu</i>	1,24
	Tayassuidae	<i>Tayassu pecari</i>	1,68
Cingulata	Dasypodidae	<i>Dasypus novemcinctus</i>	0,99
Perissodactyla	Tapiridae	<i>Tapirus bairdii</i>	1,18
Rodentia	Cuniculidae	<i>Cuniculus paca</i>	0,56
	Dasyproctidae	<i>Dasyprocta punctata</i>	10,80
Didelphimorphia	Didelphidae	<i>Didelphis marsupialis</i>	0,31
Pilosa	Myrmecophagidae	<i>Tamandua mexicana</i>	0,06

1. RAI: relative abundance index.

three species of wild cats (*Leopardus pardalis*, *Panthera onca* and *Puma concolor*). It is important to highlight that one species of opossum (Didelphimorphia: Didelphidae) was not identified due to the poor quality of the photos, however it is suspected to be the gray four-eyed opossum (*Philander opossum*) or the brown four-eye opossum (*Metachirus nudicaudatus*); these records were not included in the data analysis. According to the 'relative abundance index', the most abundant mammalian species were Central American agouti (*Dasyprocta punctata*), ocelot (*L. pardalis*), white-lipped peccary (*Tayassu pecari*), red brocket deer (*Mazama temama*), collared peccary (*Pecari tajacu*) and Baird's tapir (*Tapirus bairdii*), respectively.

The puma (*P. concolor*) was recorded in the primary forest of the refuge, and a patch of forest located inside a private ranch. Unfortunately, individual pumas could not be identified from the photograph or video records as they did not have distinguishable marks (e.g. scars, tail-tip coloration, parasite marks). Determination of gender was not possible due to the angle and quality of the records; however, we could classify the age class of the animals (all were of adults).

The only photographic record of a jaguar (*P. onca*) occurred in the primary forest of a private biological station. All these records corresponded to the same individual, an adult male. The ocelot (*L. pardalis*) was recorded in the primary forest and a patch of forest located inside private ranches. It was estimated that a minimum of seven individuals were captured during our study period, including four males, two females and one cub whose gender was not possible to determine due to the quality of the photo.

White-lipped and collared peccary herds were recorded in the study area, but not at the same sites. However, all locations were located in the primary forest of the refuge, private biological stations or forest patches on private ranches. For both species we also recorded the presence of newborns throughout the study period.

Activity patterns were estimated for eight species of mammals (Fig. 2). Our results suggest that the ocelot and the nine-banded armadillo (*Dasyurus novemcinctus*) are mainly nocturnal, while white-nosed coati (*Nasua narica*) and collared peccary were diurnal. White-lipped peccary and Baird's tapir were classified as diurnal and nocturnal, respectively, however both species showed some activity during twilight hours. Both red brocket deer and Central American agouti were classified as cathemeral species.

In addition to mammals, we also recorded five species of birds distributed in four orders and families, respectively (Pelicaniformes/Ardeidae: *Tigrisoma mexicanum*, *Egretta thula*; Struthioniformes/Tinamidae: *Tinamus major*; Galliformes/Craccidae: *Crax rubra*; Gruiformes/Rallidae: *Aramides cajaneus*).

DISCUSSION

The mammal community composition and activity patterns reported in the refuge were as expected, and similar to those reported by other camera traps in adjacent protected areas (Arroyo-Arce, Guilder & Salom-Pérez, 2014; Coastal Jaguar Conservation, unpublished). Any discrepancies may be due to the intrinsic characteristics of the species (e.g. generalist or specialist species, sex, age, reproductive status) or of the study area (habitat suitability, availability of food, presence of shelter and dens, presence of predators or competitors), environmental variables and anthropogenic pressures (Monroy-Vilchis et al., 2011, Lira-Torres & Briones-Salas, 2012; Navarro & Gómez, 2015).

The few records of jaguars and pumas documented in this study could be related to the characteristics of these species, which are secretive, live at low densities, are territorial and require large home ranges (Cortés-Marcial & Briones-Salas, 2014). However, it could also be due to the habitat degradation that has occurred in the surrounding area of the refuge, as a result of human activity (Arroyo-Arce et al., 2014; Arroyo-Arce & Salom-Pérez, 2014). The low occurrences of these large felids could explain the higher abundance of the ocelot, as large predators can limit the abundance of medium and small predators (Mattey, 2012; Montalvo, Sáenz, Ramírez & Carrillo, 2015; Salom-Pérez et al., 2015).

Our findings also stress the importance of having documented the presence of the white-lipped and collared peccaries. Both species are highly threatened as they have suffered severe population declines, due to anthropogenic pressures (e.g. illegal poaching), throughout their geographic range (Emmons, 1984; Oliver, 1990). Their presence in the refuge is of great importance as they play an important ecological role (e.g. seed predators, modify plant diversity and composition), and are major prey items for large carnivores (Figueroa, 2013; Novack, Main, Sunquist & Labisky, 2005).

The nocturnal habits of the ocelot were similar to those reported previously in the literature (Di Bitetti, Paviolo & De Angelo, 2006; Moreno, Kays & Samudio, 2006; Jiménez et al., 2010, Lira-Torres & Briones-Salas, 2012). Some authors (Ludlow & Sunquist, 1987; Moreno et al., 2006) suggest this could be a strategy to overlap with the activity pattern of its main prey (small and medium-sized mammals). It could also be a mechanism to avoid competition or predation by larger species of cats such as jaguars and pumas (Gomez, Wallace, Ayala & Tejada, 2005; Maffei et al., 2005).

The nocturnal behavior of the nine-banded armadillo also coincides with previous studies (Lira-Torres & Briones-Salas, 2012; Cortés-Marcial & Briones-Salas,

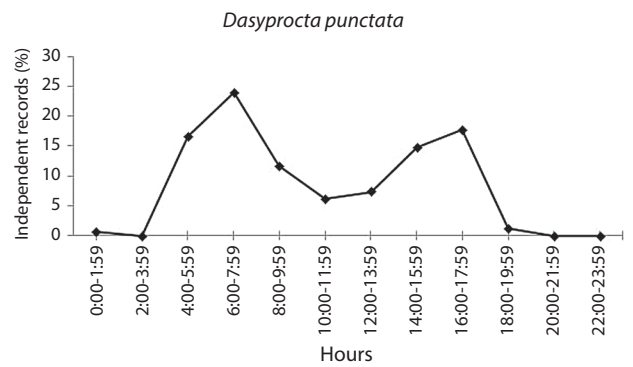
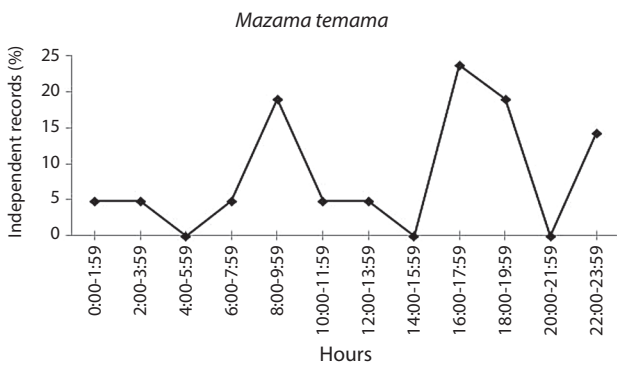
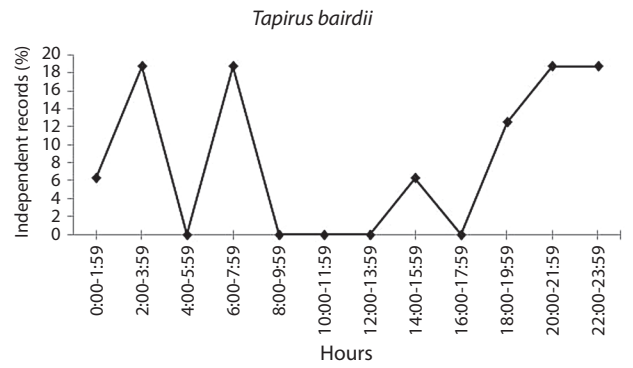
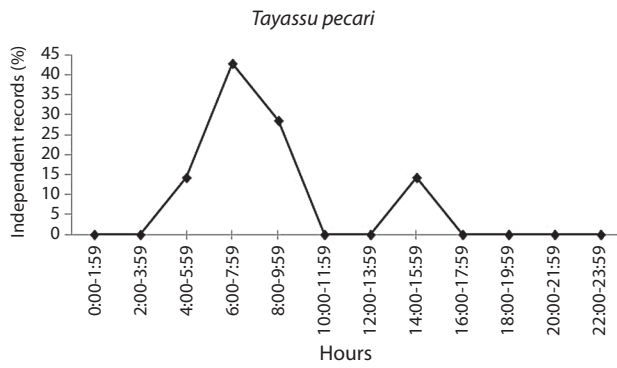
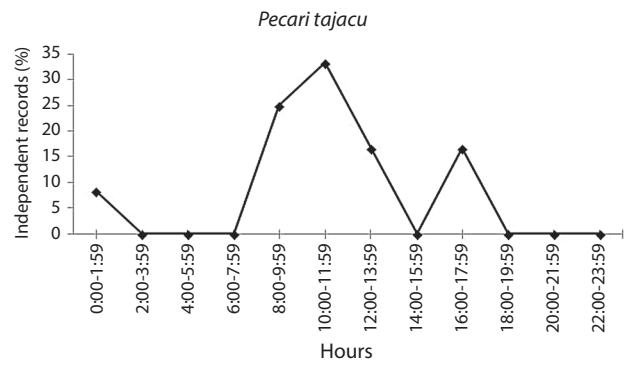
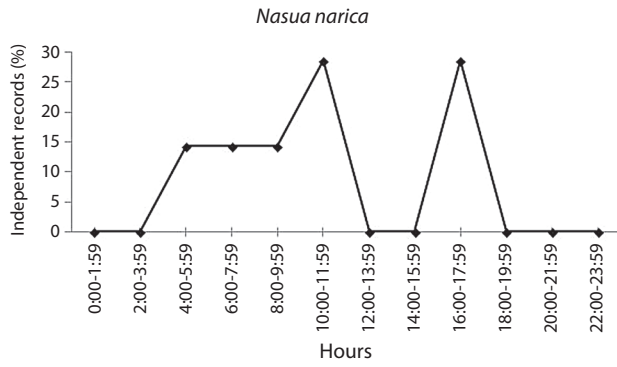
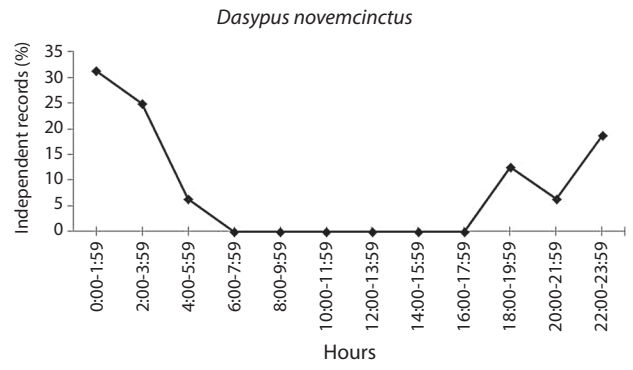
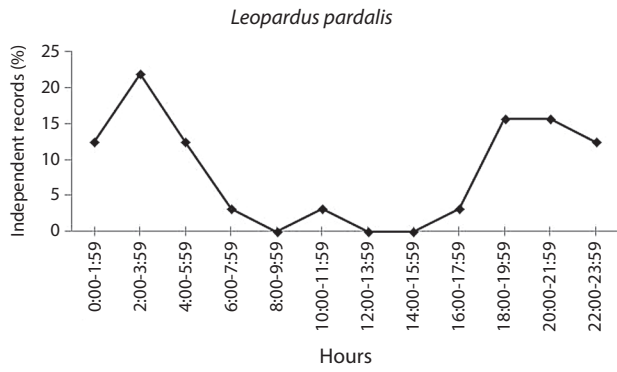


Fig. 2. Activity patterns of eight mammalian species recorded by camera traps.

2014). The diurnal activity of the white-nosed coati was also reported for other areas (Lira-Torres & Briones-Salas, 2012, Cortés-Marcial & Briones-Salas, 2014) but differs from Monroy-Vilchis et al., (2011) who mentioned that the species remains active 24 hours a day. Activity periods of the collared peccary were similar to those reported in the literature (Tobler, Carrillo-Percestequi & Powell, 2009; Cortés-Marcial & Briones-Salas, 2014), who also categorized it as diurnal. However, differs from Lira-Torres & Briones-Salas (2012) who described it as a cathemeral species.

Tobler et al. (2009) describe the white-lipped peccary as a diurnal species; however, our data categorized it as both diurnal and crepuscular, similar to the research by Lira-Torres & Briones-Salas (2012). Our study shows that the Baird's tapir should be considered a nocturnal and crepuscular species, as previously described in the literature (Tobler et al., 2009; Lira-Torres & Briones-Salas, 2012).

Our data for the red brocket deer and the Central American agouti indicates that both species are more active from 8:00h to 18:00h. However, they also had occasional bouts of activity during the rest of the day, which was similar to what was described previously (Lambert, Kays, Jansen, Aliaga-Rossel & Wikelski, 2009; Tobler et al., 2009).

This study should be considered as a preliminary evaluation of the mammalian diversity found in Barra del Colorado Wildlife Refuge, which represents an important contribution towards increasing our knowledge of the wildlife in the area. However, our methodology and sampling effort were biased towards certain species and sectors of the refuge. Therefore, further research should focus on species and sectors not targeted in our study in order to have a better understanding of the faunal composition of the refuge. This information will help generate a more effective management of the refuge.

ACKNOWLEDGEMENTS

Funding was provided by Liz Claiborne Art Ortenberg Jaguar Research Grant Program at Panthera, The Rufford Small Grants Foundation and Idea Wild. We gratefully acknowledge Área de Conservación Tortuguero/SINAC, Estación Biológica El Zota, Reserva Biológica Cerro Coronel and local farmers of Barra del Colorado Wildlife Refuge for their support throughout the execution of this investigation.

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