BIOLOGÍA 1

Tecnociencia 2006, Vol. 8, N° 1.

ECOLOGICAL DATA OBTAINED FROM LATRINE USE BY OCELOTS (*LEOPARDUS PARDALIS*) ON BARRO COLORADO ISLAND, PANAMA

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RESUMEN

Examinamos los patrones de actividad y la dieta de una sub-población de ocelotes (*Leopardus pardalis*) en la isla de Barro Colorado (BCI) Panamá, usando evidencia de las cámaras automáticas y depósitos de heces de cuatro individuos. Se obtuvo información de la letrina de ocelotes entre los meses de abril y octubre de 2001. Se confirmó por medio fotográfico que la letrina de los ocelotes fue utilizada por cuatro individuos. Tanto machos como hembras usaron las letrinas, lo cual sugiere que la letrina tiene una función social, aparte del marcaje de territorio. Los ocelotes presentaron mayor actividad durante las noches (X^2=5.06, P=0.05). Las letrinas de los ocelotes de BCI aparentemente parecen ser un buen sitio para facilitar el apareamiento. Setenta y cuatro heces fueron colectadas y analizadas, las cuales mostraron que los ocelotes de BCI depredan principalmente roedores (42.3%), edentados (31.5%), y reptiles (14.1%). Encontramos que los ocelotes de BCI depredan presas más grandes que los ocelotes de Cosha Cashu, Perú (Emmons 1987). El papel de ocelotes como depredadores en BCI parece solapar con el de los gatos grandes, pero se necesita mayor evidencia.

PALABRAS CLAVES

Isla de Barro Colorado, dieta, actividad circadiana, letrina, *Leopardus pardalis*, fotografias automáticas, análisis de heces, comportamiento social.

ABSTRACT

We examined activity patterns and diet of ocelots (*Leopardus pardalis*) on Barro Colorado Island (BCI), Panama, using evidence from remote photography and scat deposits of four individuals. Photographs from an ocelot latrine were taken from April to October 2001. Ocelot latrine use by different individuals was confirmed by photographic data. Both males and females used the latrine, which suggests that latrines have a social function other than just the marking of territory. This ocelots are mainly nocturnal (X^2=5.06, P=0.05). The ocelot latrines on BCI appear to be locations to facilitate mating. Seventy-four scats were collected and analyzed, showing that BCI ocelots feed primarily on rodents (42.3%), edentates (31.5%), and reptiles (14.1%). BCI ocelots prey on larger prey than at Cosa Cashu, Peru (Emmons 1987). The role of ocelots as predatots on BCI seems to overlap with that of larger cats, but more evidence is needed.

KEYWORDS
Barro Colorado island, diet, circadian activity, latrine, *Leopardus pardalis*, remote photography, scat analysis, social behavior.

INTRODUCTION
The study of the social behavior of neotropical cats is key to understanding their role in forest ecosystems. Ocelots (*Leopardus pardalis)*, like most other cats, are notoriously difficult to study by direct observation, and in most study areas it is not feasible to estimate cat populations from visual census methods because they are so rarely seen. Felids' secretive way of life allows for plenty of room for debate about their ecological importance (Terborgh 1992; Wright et al., 1994, 1999, 2000).

Ocelots, like many other carnivores, base their social system on the maintenance of a home range, which is usually advertised (Ewer 1973; Navarro 1985; Tewes 1986; Ludlow & Sunquist 1987; Crawshaw & Quigly 1989; Emmons 1989; Konecny 1989; Martinez-Meyer 1997). According to Konecny (1989), they advertise their home range by clawing in the ground or in trees, spraying urine and depositing feces. For example, some felids like African wild cats and bobcats, and ocelots can concentrate their feces in one site and make what is known as a "latrine". It is believed that one latrine can be used by more than one cat (Enders 1935; Ludlow & Sunquist 1987; Emmons 1988 in Kitchener, 1991). These latrines can be used for different purposes. They are used not only to delimit cats' home range, but to display intraspecific information about sex, age, reproductive status, and presumably the identity of individuals (Kitchener 1991).

Like other felines, ocelots habitually use human-made trails (Emmons et al., 1989; pers. obs.), and can therefore be monitored remotely there.

In addition, ocelots' tendency to use "latrines" allowed us to monitor their behavior specifically at one of these sites, providing a valuable source of data about diet (prey material) and social interactions. Data in this report are based on the study of latrine use by using remote photography through trip-cameras and scat analysis of a subpopulation of ocelots to better understand the role of their latrines and the ocelot ecology on Barro Colorado Island, Panama.

METHODS

***Study Site*.-** Barro Colorado Island (BCI) is located at 9°9' N and 79°51' W, and was formed during the construction of the Panama Canal. BCI has been used as a biological research site since the 1920's and is now administered by the Smithsonian Tropical Research Institute. The island is approximately 15 km^2 in area and is covered by a mix of old growth and secondary growth moist tropical forest (Leigh 1999). This paper focuses on one group of the BCI ocelot population (perhaps 10% of the total island population) that frequents Harvard Trail (map Fig. 1.). This trail is approximately 2100m long. The last 1000m traverse a peninsula and end at the shore of Lake Gatun. The nearby forest is densely tangled, and has a lower canopy with respect to more interior parts of the island.

Harvard latrine.- The latrine is found in an observation shelter for game wardens, a small 2 x 2m hut, with a cement floor and zinc roof, open on all sides. The hut is not located within the forest, but rather in tall Vietnam grass (*Saccharum spontaneum*), approximately 5 m from the lakeshore. Periodic visits have revealed ocelot scats scattered across the cement floor of the hut. At least eight different latrines have been found on BCI in the last few years; the Harvard latrine is only one of three actively used in 2001.

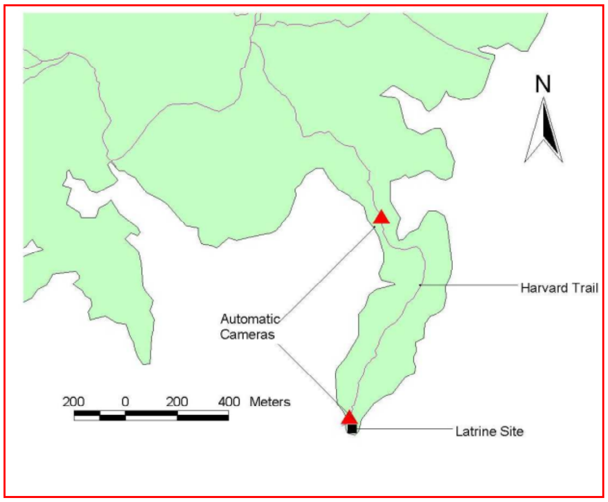

Fig. 1. Map of study area on Barro Colorado Island. Scale 200m.

Data from scats collected at the latrine enable us to identify prey items taken by the same ocelots which were also recorded in the photographs. Monthly collections turned up 15-20 scats; later bi-monthly collections resulted in about 8 scats per visit. Scats were collected every 15 days so as not to interfere with the animals' activities. Scats were identified as ocelot scats by their associated tracks, photos, and measured dimensions (Emmons 1987; Ludlow & Sunquist; 1987). Each sample (one complete scat) was disintegrated manually. In accord with standard fecal analysis procedures (Aranda 1994), the components were washed with detergent and a disinfectant solution to inhibit the growth of fungi on the samples. A sieve was used to eliminate excess water, and the components were dried at room temperature, in an oven, or in a dry-room. The prey parts were identified to species in most cases with the use of a stereoscope and by comparison with a reference collection at the Museum of the University of Panama (Moreno 2002).

Remote Photography and Animal Identification.- Cameras in the pass with the ability to automatically photograph passing wildlife have been in use on BCI since the 1920's (Chapman 1929). However, only recently has there been a systematic study using these cameras on the island. These cameras have been monitored since 1994 enabling us to gather temporal and spatial information on the mammal/ocelot population (Giacalone & Moreno. unpub data).

Photographs from up to 16 cameras on other parts of the island were used to identify locations away from the latrine that were visited by the sub-population of "Harvard cats" (Giacalone & Moreno, unpub. data). An automatic infrared-sensing camera (©CamTrakker, Camtrack South Inc.) was first installed at the Harvard latrine on April 4, 2001. A second camera was paired with the first on July 11, 2001. We used standard ISO-200 speed, 36-exposure film. Ocelots like many other cats have unique markings that can be used to identify individuals (Casariego-Madorell 1998; Karanth 1995). We established paired cameras to correlate right and left sides of the cats' bodies. By analyzing spot or marking patterns, we were able to identify individual ocelots (Trolle & Kery 2003). Time-stamps on the photographs showed the times when ocelots visited the latrine area. Examining these photographs and identifying unique features of individual spotting patterns enabled us to identify individual ocelots, even when only small portions of the body were visible. In adition, we analyze the hour of those pictures to show the activity patterns of this subpopulation of ocelots.

RESULTS

Photographic data.- Ocelot photographs were first obtained from the Harvard Trail location at marker H-21 on April 4, 2001 and the last photograph of an ocelot was taken October 10, 2001. During the entire period of this study, the cameras took 10 rolls of film. Each roll lasted from 10 - 32 days. Each roll produced from two to nineteen ocelot photographs. In total, 64 photographs of four individual ocelots were taken: one adult female, one immature female, and two adult males (Fig. 2.). All four of the ocelots that were photographed as they visited the latrine are described below.

Left to right: R-34, I-23

Left to right: V-19, G-22

Fig. 2. Four ocelots photographed near Harvard Trail latrine.

Ocelot R-34, a mature male, appeared at the latrine on 4 April and frequented the site for the next few days, while female I-23 was visiting the latrine. He usually frequented the site in the morning, afternoon, and early evening, on days when the other male was not present. An injury to this ocelot's left ear was visible in all April photographs. This wound was still unhealed when the animal was captured and radio-collared on 25 July. He appeared in photographs from other locations up to two kilometers from the latrine.

Ocelot I-23, a breeding female, was photographed several times in April. On April 5 she appeared to be in estrus when photos showed her with pink vulva. She often appeared at this site by mid-day between 11:00 and 15:00, showing a daytime activity. She was also photographed carrying a dead spiny rat (*Proechimys*) on 27 October

2000 and later with a young kitten following her on 17 December 2000 a kilometer from the latrine location.

Ocelot V-19, a mature male, first appeared at marker H-21 on April 8, 2001, and visited the latrine frequently in April and May, usually in the middle of the night. The photographs show a rash that appears to be mange on his foreleg at the elbow joint. This ocelot was also photographed on another trail at least 2 km from the Harvard latrine in January through April 2000.

Ocelot G-22, an immature female, was the kitten of I-23, that appeared at the latrine on 2, 22, and 24 June 2001, twice around midnight and once just before dawn. She was previously photographed one kilometer from this site as a young kitten with her mother, on 17 December 2000.

Latrine use.- The greatest latrine visitation or use was between April 4 and 10, when 19 ocelot photographs were taken of three individuals, the adult female and two adult males. The next most active period was from August 3 to 19, when 8 photos were taken of the same 3 individuals. From August 29 to September 3, there were 7 photos of the adult female and one male. The greatest ocelot activity during the April - October study period at the latrine was in April. A total of 26 visits to the latrine area were recorded by photography, and 9 scats were collected, compared to a monthly mean of 8 scats for the rest of the study period.

Circadian Activity.- Circadian activity patterns of BCI ocelots are shown in Fig. 3. According to the time stamps on a sample of (N= 64) photographs, BCI ocelots are mainly nocturnal (N= 62.5% and D=37.5%) (X^2= 5.06, P= 0.05).

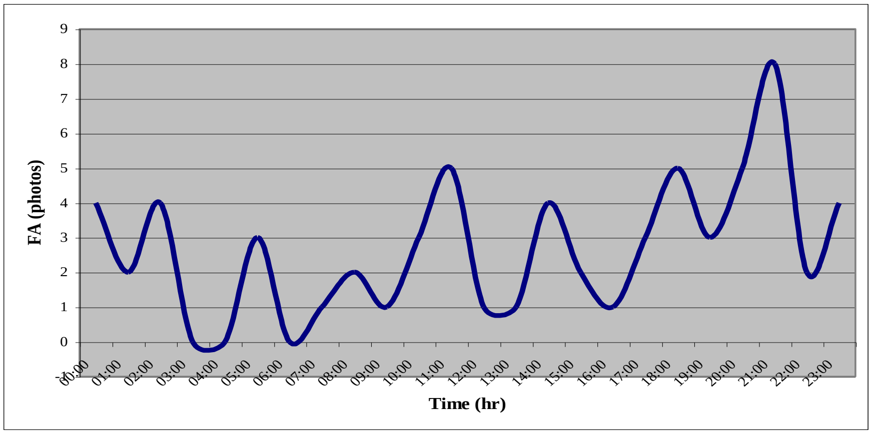

Fig. 3. Circadian activity of BCI ocelots on Harvard Trail.

Prey determined from scats.- A total of 74 scats, which included 92 prey items, were collected from the Harvard latrine between August 1999 and December 2001. The percentages of prey items found in these 74 scats are presented in Tables 1 and 2. BCI ocelots have preference for rodents, both small and large, (42.3%) and edentates (31.5%), followed by reptiles (14.1%) (Table 1). Ocelots from both BCI and Cocha Cachu in Peru preferred mammals as prey, but differed in the ranking preference of their prey (Table 2). For example, Peruvian ocelots feed mostly on small rodents (58.7%).

Table 1.- Ocelot scat analysis of material collected at Harvard latrine on Barro Colorado Island, Panama. Prey grouping is by taxonomic category (N=74, prey item = 92).

Group	**Frequency of Appearance**	**Percent Occurrence (%)**
Marsupials (opossums)	3	3.26
Edentates (sloth, anteater, armadillo)	29	31.52
Rodents (agouti, spiny rat, squirrel)	39	42.39
Primates (capuchin)	4	4.34
Carnivores (coatimundi)	3	3.26
Reptilia	13	14.13
Unidentified mammals	1	1.09
Total	**92**	**100**

Table 2. Ocelot diet compared across study sites: Percentages of prey species taken by ocelots at Harvard latrine (this paper) (92 prey items in 74 scats) compared with data from Peru (Cocha Cashu: 177 prey items in 62 scats; Emmons 1987).

Category	Emmons (1987) (%) N= 177	This paper (%) N= 92
Marsupials	5.64	3.26
Bats	1.69	-
Small rodents	58.75	22.81
Rabbits	1.13	-
Large mammals (> 1kg) - Large rodents	5.64	19.56
- Other large terrestrial (armadillo, tamandua, coati)	-	7.60
Arboreal mammals (2 species of sloth and 1 primate)	2.26	31.50
Birds	10.73	-
Reptiles	12.00	14.13
Fish	2.25	-

DISCUSSION

Latrine use and marking behavior.- In this study, the combined use of photographs and scat collections provided several insights into ocelot behavior. This is the first time also that the use of an ocelot latrine by many different individuals has been confirmed by photographic data. Harvard latrine was used by both males and females, which suggests that latrines have a social function other than just marking territory. The time of the greatest activity at the latrine may have ocurred during the mating period, since one of the males (R-34) visited the latrine intensively when the adult female (I-23) was apparently in estrus. His visits were followed by visits from another mature male (V-19).

Visual evidence of estrus condition in a visiting female ocelot, and coincidental and frequent visits by two adult male ocelots, indicate a social purpose for the latrine. From our results, we inferred three social behaviors related to latrine use by ocelots. The ocelot latrines on BCI appear to be locations to communicate the time for mating (Moreno &.Giacalone in prep.) Males may assess the reproductive status of local female inhabitants; females can communicate their reproductive state; and males can leave advertising of their own presence for other males or females, and identify males who use the same area. Frequent visits to a latrine by males when a female is in estrus may help the males locate a receptive female as well as inform females of the presence and identities of males (Kitchener 1991; Smith et al. 1988).

In Panama, Moreno reported four latrines in abandoned game warden stations in Soberania National Park on the mainland opposite to Barro Colorado Island (unpub. data). Along the two kilometer length of Harvard trail on BCI, scats were found generally at the latrine at the end of the trail and in two or three other sites along the length of the trail, though they were not locations that were used repeatedly, as are true latrines. Ocelots on BCI deposit many scats in latrines located in cement structures such as game warden look-out posts, on the tops of wire cages, against trees with wide buttressed bases and large roots, up on fallen trees and sometimes along trails. Generally, these sites provide a visually distinctive, somewhat sheltered location where scent may be preserved (Chinchilla 1997; Ludlow & Sunquist 1987; Moreno, pers. obs.).

Throughout their range, ocelots have variable marking behavior. In Venezuela, Ludlow and Sunquist (1987), reported latrines at the intersection of roads, and observed dozens of feces at single sites. Emmons (1988) did not find great accumulations of scats in Cocha Cashu, but she reported that there was a tendency for males (identified by tracks) to use some sites repeatedly to deposit feces. Chinchilla (1997) in Costa Rica's Corcovado National Park reported two ocelot latrines, one of which was in an abandoned game warden station.

Circadian activity. - According to photographic data for this study (Fig. 3), BCI ocelots are mainly nocturnal (62.5%), showing activity patterns fundamentally similar to those observed in Peru (Emmons 1988), and Venezuela (Ludlow & Sunquist 1987). Although BCI ocelots are mainly nocturnal, significant diurnal activity (37.5%) occurs within this population (Moreno pers. obs.). This finding is consistent with Enders (1935) who reported that on BCI Goldman and Chapman found ocelots active at almost any hour of the day, depending on the principal prey species' activity pattern. Similarly, Crawshaw and Quigley (1985) reported highly diurnal activity in Brazilian pantanal ocelots.

Proportions of prey species in diet. - As seen in Table 2, BCI ocelots take different proportions of prey types compared with ocelots in Cocha Cashu, Peru (Emmons 1987). BCI scats contain fewer prey items per scat (1.2) compared with those from Peru (2.8). This difference might be explained by the observation that BCI ocelots feed on higher proportions of larger prey than Peruvian ocelots. The scats from Peru were predominantly filled with rats and smaller rodents (58%), whereas BCI scats contained only 22% rats, squirrels, and smaller rodents.

BCI ocelots prey upon a mammalian carnivore, coatimundi (*Nasua narica*), but Peruvian ocelots have not been reported to do so. On the other hand, BCI ocelots' scats contain no fish or birds, also unusual when compared with other studies (Emmons 1987). Ocelot tracks have been observed twice (Moreno, unpub.data) near bird remains, but the scats showed no evidence of bird prey. Sloths, both two-toed and three-toed sloth species, make up more than a quarter of the BCI ocelot prey items, as opposed to barely 2% in Peru. However, one must keep in mind that sloths are rare in Manu, Peru (Leigh 1999). These sloths are both larger (4 - 8 kg) and more arboreal than the usual prey recorded in other ocelot studies (Konecny 1989; Emmons 1987; Ludlow & Sunquist 1987; Devilla-Mesa 1998; Chinchilla 1997). One possible explanation is that sloths' main predator, the harpy eagle, has not been present on the island for many decades (except for a brief failed re-introduction attempt in 2000), allowing for a robust sloth population. On the other hand, capuchin monkeys are the only one of four species of monkey on BCI found in BCI ocelot scats, and the only species that spends a great deal of time foraging on the ground.

Prey size and predator niche.- Our results show that BCI ocelots are preying on larger prey than at Cosa Cashu, Peru (Emmons 1987). This may be related to the fact that many of the scats collected were from the large males that frequented the latrine. Some authors consider the taking of large prey a trait of well-developed adult males (Mondolfi 1982). Nevertheless, the role of ocelots on BCI seems to overlap with that of larger cats, unlike the role of ocelots where larger predators are abundant. While there is a relatively low abundance of larger cats on the island, they are not completely absent at this time. There have been sightings, tracks, scats, and photographs of perhaps three pumas (*Puma concolor*) since 1999.

This study indicates how much more remains to be understood about this endangered species. Comparative data between habitat types will afford a more complete understanding of the roles a predator may play in those habitats, and the impact of its predation on prey populations. Furthermore, in species with wide geographic ranges, the plasticity of mammalian behaviors among various habitats is an important adaptation for success under variable selective pressures. We believe that it is important to keep these factors in mind in order to better understand the role of these threatened species and establish successful conservation and management plans.

ACKNOWLEDGEMENTS
The authors would like to thank the following organizations and persons: the Smithsonian Tropical Research Institute (STRI) for support of the project; Gregory E. Willis for his boundless energy in the field and insights into mammalian ecology; Giselle Muschett for her constructive comments on the manuscript and help with the translation; Bonifacio de Leon for his knowledge of animal behavior; Montclair State University for permitting J. Giacalone time in the field; Dr. Ira Rubinoff for his love of cats and support to the project; Dr. Egbert G. Leigh, Jr. for lively and enlightening discussion of ocelots and their prey, and for improvements to the manuscript; Dr. Joseph Wright for his encouragement and collaboration; Pedro Mendez and Ivan Dominguez for collecting the first ocelot scats that Moreno analyzed; the CamTrakSouth staff, especially Dan Stoneburner, for their technical support, donations, and encouragement; and a special thanks to BCI's game wardens for informing Moreno of the Harvard latrine and for all their continued support and deep interest in the wildlife of BCI. Dr. Rafael Samudio Jr., Dr. Roland Kays, Patrick Kelley, Enzo Aliaga-Rossel and Paula Capece for comments on the manuscript. And most of all, thanks to all the gorgeous ocelots of BCI, whose curiosity and tolerance of camera flashes gave us many photographs to start this project.

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Recibido mayo de 2004, aceptado agosto de 2005.