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Ocelot (Leopardus pardalis) Food Habits in a Tropical Deciduous Forest of Jalisco, Mexico

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ABSTRACT.—Few studies have been conducted on the food habits of the ocelot (*Leopardus pardalis*), considered an endangered feline in Mexico. Past studies showed that rodents were the main component of ocelot diet. In our study ocelot prey consumption was measured as frequency of occurrence of prey in scats and then converted to biomass. The spiny-tailed iguana (*Ctenosaura pectinata*) was the most important prey of ocelots, followed by the spiny pocket mouse (*Liomys pictus*). Other rodents and some birds were also present in the scats, although representing only a minor proportion of the ocelot's diet. Evidence of subadult white-tailed deer (*Odocoileus virginianus*) was also found in scats indicating that ocelots can either capture prey bigger than themselves or are using deer as carrion.

INTRODUCTION

Members of the family Felidae are strict carnivores and as such they confront several difficulties when they feed. First, meat is a relatively limited food resource in nature, and second, felids generally feed on live prey, which makes acquisition of meat a highly energy-demanding activity (Gittleman and Harvey, 1982). Hence, the anatomical structure of a felid is related to the way its prey are detected and captured, resulting in a striking similarity in body shape among the 36 species of cats in the world regardless of the habitat in which they live (Kitchener, 1991). Furthermore, all Felidae have a common predator-prey size pattern (Rosenzweig, 1966). In this sense, the ocelot (*Leopardus pardalis*) is a medium size feline (~10 kg) that should consume small to medium size prey (Brown, 1990; Kitchener, 1991).

Studies of ocelot food habits are scarce and cover disjunct areas of its distribution. Ocelot diets are principally comprised of small mammals, but also include medium to large mammals, reptiles, amphibians, birds, fishes and insects (Bisbal, 1986; Emmons, 1987; Konecny, 1989; Sunquist *et al.*, 1989; Chinchilla, 1994; Crawshaw, 1995). Based on these results some authors have suggested that ocelots are opportunistic feeders (Bisbal, 1986; Emmons, 1987). Anecdotal data for Mexico, principally in the states of Sinaloa, Nayarit and Jalisco (mangrove, coastal dunes and tropical deciduous forest, respectively) indicated that ocelot's diet includes rabbits, small mammals, birds, iguanas, frogs, fishes, crabs and small turtles (Allen, 1906). This study presents data on ocelot food habits in a tropical deciduous forest of western Mexico.

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METHODS

The study was carried out in the Chamela-Cuixmala Biosphere Reserve (CCBR), which is located on the Pacific coast in the state of Jalisco and covers ca.13,600 ha. Elevation ranges from 0 to 500 m above sea level. Temperature fluctuates from 16 C to 32 C throughout the year and the average annual precipitation is 748 mm. Rainfall is seasonal, with a long dry period from October to June and a short wet period from July to October (Bullock, 1986). Seven types of vegetation are found in the Reserve (Rzedowski, 1983; Ceballos and Miranda, 1986; Lott, 1993), but tropical deciduous forest and tropical semideciduous forest are most common. Sample collection was mainly carried out at the Estación de Biología Chamela (EBCh). This field station, which is operated by the Universidad Nacional Autónoma de México (UNAM), has a road and trail system through both tropical deciduous forest and tropical semideciduous forest.

From March 1995 to December 1996 we spent approximately 15 d each month looking for scats along trails and creeks of the station, occasionally walking areas outside the reserve. We identified ocelot scats based on shape, color, odor and associated tracks (Aranda, 1981). Scats not associated with tracks were discarded. Ocelot tracks were distinguished from jaguar (*Panthera onca*), puma (*Puma concolor*), and jaguarundi (*Herpailurus jaguarondi*) by size and shape. Ocelot tracks (approximately 50 mm long $\times$ 55 mm wide) in the study area are 30% smaller than tracks of jaguars and pumas in this region (B. Miller, pers. comm.). Jaguarundi tracks are smaller than ocelots, toes are elongated and there is a wider distance between the central pad and the toe pads. Although margays (*Leopardus weidii*) have been recorded in the area (Ceballos and Miranda, 1986), no actual observations/captures occurred after 1990 (C. A. Lopez Gonzalez, pers. obs.). Margay tracks also are smaller than ocelots and not readily observed even when margays are common because the species is mostly arboreal (Reid, 1997).

Scats were dried at room temperature, placed in nylon stockings and washed in flowing water until undigested remains were obtained (hair, bones, teeth, feathers, scales; Emmons, 1987). Remains were identified by comparing them to reference material from the EBCh and Instituto de Biología, UNAM scientific collections. Hair was analyzed by comparing medulla patterns with a reference collection from specimens collected in the same area (Arita and Aranda, 1987). Age of white-tailed deer (*Odocoileus virginiana*) was determined by analyzing differences in color, length and thickness of hair from different parts of the body among fawns, subadults and adults (A. De Villa, pers. obs.). Age and sex of spiny-tailed iguanas (*Ctenosaura pectinata*) were determined by size of scales of the dorsal crest, which are very prominent in adult males. However, we could not distinguish between females and juveniles so they were pooled in a single category. Bird remains were insufficient for identification as; and because there are no keys for feather-bone remains, we were not able to determine species, genus or even order; therefore, they were grouped as "birds." The scats included some insects, plant matter (seeds and grass) and garbage, but these items were discarded from the analysis because they are often swallowed while eating a target prey.

We calculated the Shannon-Wiener diversity index (Krebs, 1985) of prey for 1995 and 1996 and used a *t* test to determine if there were significant differences between years in prey diversity (Zar, 1984: 146–148). It was not possible to conduct a DNA analysis on the scats to individually identify animals and avoid pseudo-replication in the samples. The area surveyed had an average density of 1.8 ocelots/km^2 (Casariego Madorell, 1998). Given the spatial and temporal separation between samples, we considered every scat as an individual foraging event (Emmons, 1987).

TABLE 1.—Frequency of occurrence, prey weight, correction factor and relative biomass of prey consumed by ocelots based on 51 scats collected

Species	(A) Frequency of occurrence	(B) Prey weight (g)	(C) Correction factor	(D) Relative biomass
Marmosa canescens	17.6	30	16.8	7.2
Liomys pictus	62.7	50	16.8	25.6
Sigmodon mascotensis	5.9	180	17.4	2.5
Reithrodontomys fulvescens	3.9	12	16.7	1.6
Peromyscus perfulvus	3.9	30	16.8	1.6
Oryzomys. melanotis	3.9	30	16.8	1.6
Baiomys musculus	2.0	8	16.7	0.8
Xenomys nelsoni	2.0	80	17.0	0.8
Nyctomys sumichrasti	2.0	42	16.8	0.8
Odocoileus virginiana	9.8	15,000	78.0	18.6
Ctenosaura pectinata	70.6	800	19.9	34.1
Teiidae	11.8	60	16.9	4.8

The results are reported in several ways. Frequency of occurrence (Ackerman *et al.*, 1984; Baker *et al.*, 1993) was estimated by the formula FO = (fi/N) 100, where fi is the number of scats in which item i appears and N is the total number of scats. Relative frequency of food items RF = (fi/Σfi)100 was estimated as the number of times item i was found as a percentage of all food items found. Although frequency of occurrence indicates how common an item is on the diet, the relative frequency provides a better indication with which each item is consumed because it accounts for more than one of a given item being found in a scat (Ackerman *et al.*, 1984).

While these methods allow a comparison to other studies, both overestimate small prey items and underestimate large prey in the diet (Ackerman *et al.*, 1984; Karanth and Sunquist, 1995). Consumption of large prey results in a lower probability that indigestible material will be present in the scat (Mech, 1970; Baker *et al.*, 1993). Also, each prey species varies in its degree of digestibility. To overcome these limitations, Floyd *et al.* (1978) and Ackerman *et al.* (1984) experimentally derived correction factors that converted frequency of occurrence values for each taxon to an estimate of relative biomass consumed. Floyd *et al.* (1978) worked with wolves (*Canis lupus*) and Ackerman *et al.* (1984) worked with pumas (*Puma concolor*), but their technique has also been used for leopards (*Panthera pardus*), tigers (*Panthera tigris*), and dhole (*Cuon alpinus*) (Karanth and Sunquist, 1995); jaguars (*Panthera onca*) (Nuñez *et al.*, 2000); and bobcats (*Lynx rufus*) (Baker *et al.*, 1993, 2001). For bobcats, the total dry weight of remains for each species was converted to an estimate of biomass consumed using the equation $y = 16.63 + 4.09x$, where y is the fresh weight of prey consumed (g) per g of scat produced (dry weight) and x is the estimated live body weight (kg) of prey items (Baker *et al.*, 1993; Baker *et al.*, 2001). We consider that this correction factor is directly applicable for ocelots due to size similarity of the two species. We performed two experimental feeding trials with black iguanas (*Ctenosaura pectinata*) to derive x in the previous equation by feeding two captive ocelots (1 male and 1 female) adult male and female iguanas. In each case, iguanas were weighed before being provided to the ocelots and uneaten remains were removed from enclosures and weighed to estimate the amount each ocelot consumed (Baker *et al.*, 1993). Scats produced by these feeding events were collected and analyzed to see how much material was recovered. We present our data in Table 1, using exactly the same format as Ackerman *et al.* (1984). Average prey

TABLE 2.—Categories of food found in the scats (N = 51 containing 131 food items); FO = frequency of occurrence (fi/N) 100; RF = relative frequency (fi/Σfi) 100

Food	No. of occurrences	FO	RF
Mammals	51	100.0	45.0
Marsupials	9	17.6	6.9
Marmosa canescens	9	17.6	6.9
Rodents	45	88.2	34.3
Liomys pictus	32	62.7	24.4
Sigmodon mascotensis	3	5.9	2.3
Reithrodontomys fulvescens	2	3.9	1.5
Peromyscus perfulvus	2	3.9	1.5
Oryzomys melanotis	2	3.9	1.5
Baiomys musculus	1	2.0	0.8
Xenomys nelsoni	1	2.0	0.8
Nyctomys sumichrasti	1	2.0	0.8
Unidentified rodent	1	2.0	0.8
Ungulates	5	9.8	3.8
Odocoileus virginianus	5	9.8	3.8
Reptiles	42	82.3	32.1
Ctenosaura pectinata	36	70.6	27.5
Teiidae	6	11.8	4.6
Birds	4	7.8	3.0
Insects	4	7.8	3.0
Plant matter	21	41.2	16.0
Seeds	17	33.3	13.0
Grass	4	7.8	3.0
Plastic	1	2.0	0.8

weight in that table was obtained from literature and museum specimens. Relative biomass is calculated according to Ackerman *et al.* (1984) by the formula (Frequency of Occurrence × Correction Factor)/Sum of (Frequency of Occurence × Correction Factor).

RESULTS

We walked a total of 2544 km and found 51 ocelot scats (14 in 1995 and 37 in 1996) during the dry season. We were unable to find any scats during the wet season because of fast decay and disintegration by dung beetles and ants. There was no statistical difference ($P > 0.05$) in the diversity index of 1995 ($H' = 1.62$) and 1996 ($H' = 1.83$) so results were combined for the rest of the analysis.

Food items.—Mammals were the highest percentage of ocelot's diet, followed by reptiles and birds (Table 1). Rodents, especially the spiny pocket mouse (*Liomys pictus*, 25%), were the most commonly consumed mammal prey. All white-tailed deer (*Odocoileus virginianus*) consumed were subadults. Adult spiny-tailed iguanas (*Ctenosaura pectinata*) were preyed upon almost as frequently as rodents (Tables 1, 2). Adult male iguanas were recorded twice as often as female/juveniles iguanas.

Biomass consumed.—Most of the prey (84.6%) consumed by the ocelot were small (<1 kg); 69.2% weighed less than 0.1 kg and 15.4% weighed between 0.1 to −1 kg. Male iguanas (≈1.1 kg) were the only medium sized prey (7.7%) and large animals (>10 kg) comprised

7.7% of the diet. *Ctenosaura pectinata* and *Liomys pictus* were the most important prey items and, combined with white-tailed deer, comprised 78% of the total biomass consumed.

DISCUSSION

During this study, mammals were consumed more frequently than other prey categories (Table 2). Biomasses of mammalian and reptilian prey were approximately equal (Table 1). A summary of the literature on ocelot food habits suggests that ocelot in other areas are more dependent on mammals as a food source (Table 3). Although the reasons for this difference are unclear, the CCBR is composed mainly of tropical deciduous forest, a habitat that extends in a continuous 1500 km band along the Pacific coast of Mexico. Our results may reflect food habits of ocelots throughout this habitat type.

Spiny-tailed iguanas were the most important prey species of the ocelot, both in terms of frequency of occurrence and biomass (Tables 1, 2). This differs from previous studies (*e.g.*, Konecny, 1989). Consumption of reptiles by bobcats is inversely related to latitude, possibly because numbers of reptiles increase as their body size decreases with decreasing latitude (Delibes *et al.*, 1997). Unlike bobcats, consumption of reptiles by ocelots appears to increase with latitude, given that Mexico is in the northern portion of ocelot range.

We do not have population densities for spiny-tailed iguanas in the region and the available information is contradictory. García and Ceballos (1994) suggest these iguanas are not abundant and may even be endangered, whereas Ramírez-Bautista (1994) relied on anecdotal evidence to designate them as one of the most common species. We agree with Ramírez-Bautista (1994) because ocelots are opportunistic predators and prey abundance strongly influences their diet (Bisbal, 1986; Emmons, 1987). Furthermore, the spiny-tailed iguana is also a very important prey for other species in the region, like gray fox (*Urocyon cinereoargenteus*; Hidalgo Mihart *et al.*, 1998), coyotes (*Canis latrans*, Hidalgo *et al.*, 2001) and puma (*Puma concolor*; Nuñez *et al.*, 1999). Spiny-tailed iguanas are found at the edge of forested areas, xerophytic scrub, mangrove and even in agricultural areas; and are diurnal and terrestrial (García and Ceballos, 1994; Ramírez-Bautista, 1994). These characteristics of the iguana can be used to infer habits of ocelots. For example, ocelots may use edge habitats, even though they primarily inhabit forests (Emmons, 1987). Although described as predominantly crepuscular and nocturnal (Emmons, 1987; Sunquist *et al.*, 1989), they may show diurnal tendencies (Carrillo Percastegui, 2001).

The spiny pocket mouse was the most frequently consumed mammal species and it is also the most abundant rodent in the forest (up to 85/ha, Ceballos, 1990; Briones, 1996). This rodent is nocturnal and terrestrial and inhabits the tropical deciduous forest and the tropical semidecidous forest, but also agricultural areas to a lesser extent (Ceballos, 1990). All of these characteristics coincide with ocelot habits (Konecny, 1989; Sunquist *et al.*, 1989)

The ocelot feeds on other mammals in smaller proportion, possibly due to their low relative abundance (Mendoza, 1997) or to behavioral patterns that reduce their availability. In this respect, the mouse possum is relatively abundant but almost totally arboreal (Ceballos and Miranda, 1986; Konecny, 1989; Sunquist *et al.*, 1989; Briones, 1996), so is eaten by ocelots infrequently (Tables 1, 2).

Lizards of the family Teiidae were a lower rank food source for the ocelot, even though they inhabit tropical deciduous and semideciduous forest, have terrestrial habits, and are abundant in the region (Ramírez-Bautista, 1994; García and Ceballos, 1994). They are alternative prey for these felines when the food supply is scarce in the dry season, but possibly costly to capture. The benefit of capturing a whiptail lizard (either *Ameiva* sp. or *Cnemidophorus* sp.) is reduced because this species is rather fast and the energy expenditure for

Table 3.—Summary of food habits of ocelots from various localities throughout its geographic range

Region, Latitude	Sample size	Habitat type	Human impact	Relative frequency of Mammals
Texas (26°N)[a]	77	Tropical thorn scrub	High, protected area	77
Jalisco (19°N)[b]	51	Tropical dry forest	Low, protected area	45
Belize (17°N)[c]	49	Tropical rainforest	High, non protected area	75
Costa Rica (8°N)[d]	23	Tropical rainforest	Low, protected area	60
Peru-Cocha Cashu (8°S)[e]	62	Tropical rainforest	Low, protected area	67
Venezuela (8°S)[f]	10	Tropical habitats	Low-High, non protected area	75
Venezuela (8°S)[g]	42	Tropical flooded forest	High, non protected area	52
Brazil-Iguazu (25°S)[h]	56	Tropical rainforest	High, protected area, fragmented	100

[a] Tewes *et al.*, 1999; [b] This study; [c] Konecny, 1989; [d] Chinchilla, 1994; [e] Emmons, 1987; [f] Bisbal, 1986; [g] Sunquist *et al.*, 1989; [h] Crawshaw, 1995.

this capture by the ocelot during the day would be higher than capturing either iguanas or nocturnal mammals.

Ocelots can capture prey larger than themselves (Konecny, 1989; Tewes *et al.*, 1998). Three of five scats with deer remains are from 1995 when the dry season was especially harsh. Either ocelots searched for larger prey that could give them a better energetic trade-off, or they fed on carcasses due to an extreme dry season (Crawshaw, 1995). Carrion use by wild cats has been detected mostly in African lions (*Panthera leo*), leopards (*P. pardus*) and pumas (Schaller, 1972; Bailey, 1993; Holt, 1994). Ocelot males are 20 to 25% larger than females, perhaps making them more capable of capturing larger prey.

The low frequency of birds in the scats is possibly related to the ocelot's terrestrial habits (Konecny, 1989; Sunquist *et al.*, 1989; Martinez Meyer, 1997), which reduces the opportunity to consume arboreal species. However, birds were frequently preyed upon by ocelots in Texas (Tewes *et al.*, 1999). This is probably a reflection of habitat structure differences, because the Texas thornscrub is relatively short and makes perching bird species more available (L. Laack, pers. comm.). There was no consumption of amphibians, but this may be an artifact of samples collected during the dry season.

The principal prey item of the ocelot in Peru is the rodent (*Proechimys* sp.) that weighs between 150–550 g. (Emmons, 1987). The weight of that rodent approximately corresponds to a medium sized *Ctenosaura pectinata* in CCBR. Both items represent considerable biomass per capture effort for the ocelot in those areas. The situation is similar in Venezuela where principal prey are *Proechimys* sp. and *Dasyprocta aguti* (Bisbal, 1986), in Belize (*Didelphis marsupialis* and *Philander opossum*, Konecny, 1989) and Costa Rica (*Proechimys* sp., Chinchilla, 1994). Rabbits, also similar in size to iguanas, are a major prey item in Texas (Tewes *et al.*, 1999). The remainder of the prey items were mainly rodents, which were not an important contribution to the biomass eaten by ocelots. Small mammal research in the CCBR (Ceballos, 1990; Mendoza, 1997) has shown that most species of rodents are relatively uncommon and are captured by ocelots according to their overall availability.

There is a potential for humans to compete with ocelots for food resources. Subsistence hunting by humans in this portion of the ocelot distribution relies heavily on white-tailed deer and iguanas (this last one considered a delicacy in the Mexican states of Guerrero and Oaxaca). Consumption of these prey items by humans may indirectly affect the survival of ocelots, since these two species comprise 50% of the biomass consumed. Female with litters increase their activity patterns during lactation to provide enough nourishment for their kittens (Emmons, 1988; Martinez Meyer, 1997). Reduction in the number of available iguanas would force ocelots to spend more time capturing smaller prey items (*i.e.*, spiny pocket mice), which may not provide a large enough food supply to assure the survival of the litters.

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