BULLETIN

of the

FLORIDA
MUSEUM OF
NATURAL HISTORY

THE DIET OF THE FLORIDA PANTHER IN EVERGLADES NATIONAL PARK, FLORIDA

George H. Dalrymple and Oron L. Bass, Jr.

Volume 39, No. 5 pp. 173-193 1996

UNIVERSITY OF FLORIDA GAINESVILLE

Numbers of the **BULLETIN OF THE FLORIDA MUSEUM OF NATURAL HISTORY** are published at irregular intervals. Volumes contain about 300 pages and are not necessarily completed in any one calendar year.

Communications concerning purchase or exchange of the publications and all manuscripts should be addressed to: Managing Editor, Bulletin; Florida Museum of Natural History; University of Florida; P. O. Box 117800, Gainesville FL 32611-7800; U.S.A.

This journal is printed on recycled paper.

ISSN: 0071-6154 CODEN: BF 5BA5

Publication date: October 14, 1996 Price: $1.25

THE DIET OF THE FLORIDA PANTHER IN EVERGLADES NATIONAL PARK, FLORIDA

George H. Dalrymple[1] and Oron L. Bass, Jr.[2]

ABSTRACT

We examined the diet of Florida panthers (*Felis concolor coryi*) in Everglades National Park from 1984 to 1991 using data from 113 kill sites of 9 radio-collared panthers, and 272 scats found at kill sites and from free-ranging panthers. Nine species were identified at kill sites and 14 species from scats. White-tailed deer (*Odocoileus virginianus*) was the most important prey species according to kill and scat analyses. Most kills were of adult bucks and does. The mean time spent at kills was 3.86 days. Secondary prey species from scat analysis were marsh rabbits (*Sylvilagus palustris*) and raccoons (*Procyon lotor*). The diet of panthers in Everglades National Park (ENP) was compared to that of panthers from southwestern Florida, including Big Cypress National Preserve. The estimated consumed biomass of white-tailed deer in ENP was nearly identical to the combined consumed biomass of deer and feral hogs from southwestern Florida.

RESUMEN

Entre 1984 y 1991, se estudió la dieta de pumas de Florida (*Felis concolor coryi*) en el Parque Nacional Everglades, usando información obtenida de 113 sitios de matanza de 9 pumas con radio collares y de 272 muestras fecales obtenidas en sitios de matanzas y de pumas silvestres. Se identificaron 9 especies desde los sitios de matanza y 14 especies desde las muestras fecales. De acuerdo a los análisis fecales y de sitios de matanzas, el ciervo de cola blanca (*Odocoileus virginianus*) fue la especie presa más importante. La mayoría de las capturas fueron de machos y hembras adultos. El tiempo promedio en los sitios de matanza fue de 3.86 días. Especies secundarias obtenidas en muestras fecales

[1] George H. Dalrymple is Chief Scientist at Everglades Research Group, Inc. 35250 S.W. 212 Ave., Florida City FL 33034, U.S.A..

[2] Oron L. Bass, Jr., is a Wildlife Biologist at the South Florida Natural Resources Center, Everglades National Park, Homestead FL 33034, U.S.A.

DALRYMPLE, G. H., AND O. L. BASS, JR. 1996. The diet of the Florida panther in Everglades National Park, Florida. Bull. Florida Mus. Nat. Hist. 39(5):173-193.

fueron conejos de humedal (*Sylvilagus palustris*) y mapaches (*Procyon lotor*). Se comparó la dieta de pumas en el Parque Nacional Everglades (PNE) con la dieta de pumas del sudoeste de Florida, incluyendo la Reserva Nacional Big Cypress. La biomasa estimada consumida de ciervos de cola blanca en PNE fue casi idéntica a la biomasa consumida combinada de ciervos y cerdos silvestres del sudoeste de Florida.

INTRODUCTION

A complete analysis of the food habits of the Florida panther (*Felis concolor coryi*) in Everglades National Park (ENP) has not been reported previously. Because hunting is illegal in Everglades National Park, examination of kill sites and prey from scat analysis provided an opportunity to examine the impact of a large predator on an unhunted deer population. Maehr et al. (1990) determined that wild hog (*Sus scrofa*), and white-tailed deer (*Odocoileus virginianus*) were the most common species in the diets of the panthers in southwestern Florida. Although hogs were most important in the major part of the northern portion of their study area, white-tailed deer and raccoons were the dominant prey in most of the Big Cypress National Preserve (BCNP). Wild hogs are very rare in ENP, leading to increased dependency by panthers on deer (Smith and Bass 1994). The comparative data presented herein may be valuable in setting hunting regulations for both deer and hogs in southwestern Florida. Finally, an understanding of food habits is important in understanding patterns of mercury contamination, a problem that may be reducing the ability of ENP to support panthers (Jordan 1990; Roelke et al. 1991).

ACKNOWLEDGMENTS

The cooperation and support of the Florida Game and Fresh Water Fish Commission, in particular, D. Maehr, C. Belden, M. Roelke, and T. Logan is greatly appreciated. We thank R. Brazie, D. Jansen, and T. Smith for field assistance. Computer assistance was provided by F. Draughn, D. Buker, and J. Ford, and V. Thue. Laurie Wilkins analyzed all of the scats, and her efforts, and knowledge are greatly appreciated. Gary Matson (Matson's Inc.) analyzed the dental material for aging white-tailed deer. We gratefully thank David Maehr, Melvin Sunquist, and William Robertson for careful readings of the manuscript, and their many helpful suggestions. Most of all, we thank Roy McBride for his long hours and dedication to the Florida panther in the Everglades National Park.

STUDY AREA

The overall study area, which was defined by the ranges of the panthers, included Everglades National Park and adjacent lands to the east, and the

portion of Big Cypress National Preserve along the western boundary of the park (Fig. 1). Everglades National Park (ENP) includes approximately 300,000 ha of southernmost Florida's mainland. The climate of the area is subtropical, with wet (June to November) and dry seasons (December to May), and a mean annual rainfall of 146 cm (Smith and Bass 1994). The lowest mean monthly temperatures (18.5°C) occur in December and January, and the highest means are in July and August (27°C).

Elevations range from 2 m (in the Long Pine Key upland pine forests) to sea level at Florida Bay. Soils, composed of marls and peats underlain with limestone, are poorly drained. About 90 percent of the park's land area has surface water present for 3-6 months between June and November. The remaining 10 percent of the park's mainland area is composed of pine and hardwood forests. Approximately 4,000 ha of the study area are dominated by rocky pineland with hardwood hammocks, known as Long Pine Key (LPK), bordered on the east by Taylor Slough, and on the west by Shark River Slough. Adjoining LPK on the south is an area of former farmland known as the Hole in the Donut (approximately 4,000 ha). It supports a nearly monotypic stand of the exotic tree Brazilian pepper (*Schinus terbinthefolius*). Further details of the study area and habitats are given by Smith and Bass (1994). The dominant plant communities of the area are shown in Figure 1.

METHODS

Radio-collaring Procedures

Panthers and deer were captured, radio-collared, and tracked following the procedures described in Smith and Bass (1994) and Smith et al. (1996). Radio-collared panthers were monitored daily from fixed-wing aircraft. Standard ground and aerial telemetry techniques were used for tracking and monitoring (Mech 1983). Locations of kills were determined by examining telemetry locations where a collared panther spent more than one day.

Scats and Kills

A ground search was made of the areas where it was considered likely that kills occurred. The remains of the kill were collected and identified, and all scats from the kill site were collected. Scats also were collected while tracking panthers or searching for sign. Scats were only included if they were from a known panther kill site, or, in the cases of isolated scats, it was known

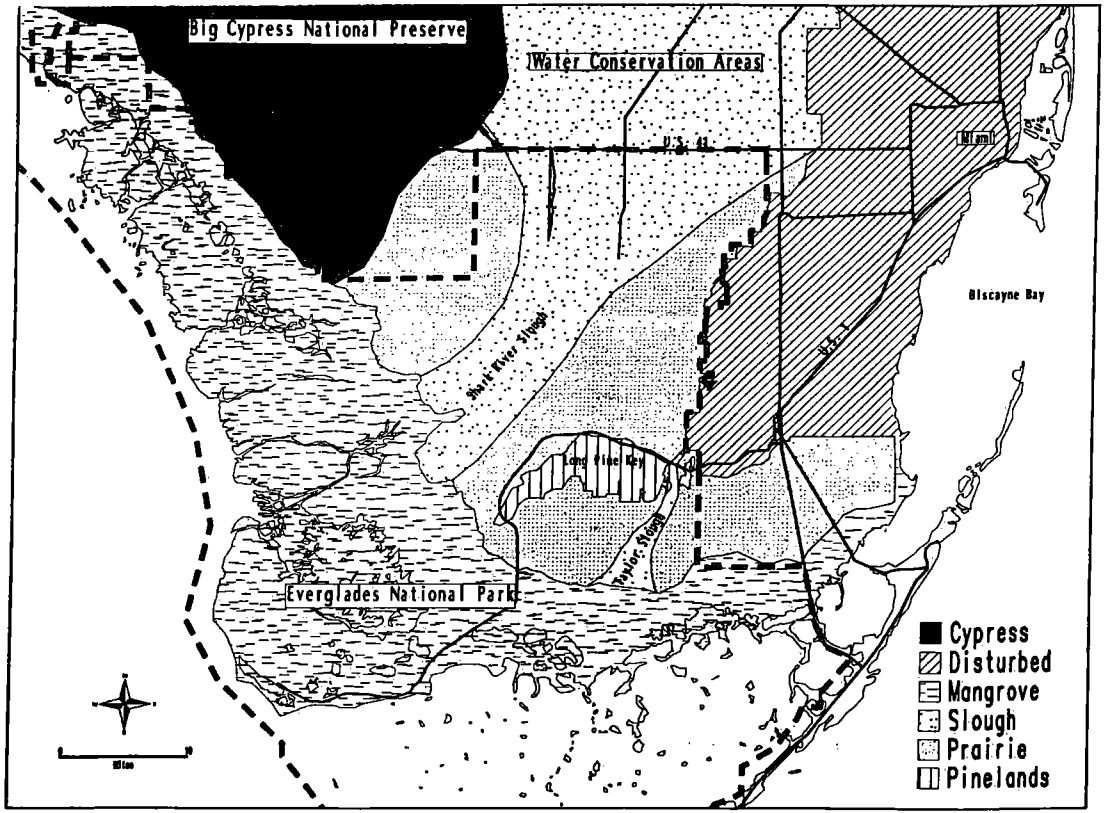

Figure 1. Map of study area showing the boundaries of Everglades National Park, with major geographic regions and plant communities listed.

that a panther had been in the general vicinity, and the scat exceeded the maximum known size of bobcat scat. Scats were analyzed at the Florida Museum of Natural History following methods described in Maehr et al. (1990), and quantified following Ackerman et al. (1984), and the estimates of prey mass of Chapman and Feldhammer (1982) were used.

In order to test the null hypothesis that prey remains were distributed similarly between scat categories, we separated the scats into two categories: (1) scats from kill sites, and (2) other scats (not attributable to a particular kill). The two rodent species and two bird species found in scats were lumped into the categories "rodents" and "birds" for analysis.

The ages of deer from a sample of 64 skulls were determined from dentitions (Harlow and Jones 1965; Severinghaus 1949; G. Matson, pers. comm.). Of the deer skulls collected, 35 were from panther kill sites and the other 29 were picked up randomly on Long Pine Key.

We follow Ackerman et al. (1984) in presenting the results for scat analysis as frequency of occurrence (the percent of total scats with a prey type) and as percent occurrence (number of times a prey type was found as a percent of all prey items). They developed a method for estimating the relative biomass and numbers of prey based on occurrence in scats. Maehr et al. (1990) used the mass estimates of prey from Chapman and Feldhammer (1982) and the procedures of Ackerman et al. (1984) to evaluate scats data from southwest Florida. They restricted the analysis to the more common prey species found in scats. We followed the above procedures to allow for comparison of our data to the previous studies.

In comparisons of central tendencies among data sets, both parametric (independent *t*) and nonparametric (Mann Whitney U) tests were performed, and there were no differences in interpretations of the results. Mean values with sample sizes, degrees of freedom, and standard errors (se) are reported. In comparisons of distribution patterns between groups, the chi square statistic ("Pearson statistic," Sokal and Rohlf 1995:696), and the Kolmogrov-Smirnov test were used.

Individual Variation Versus Sample Statistics

Generalizations about diet of large predators are often misleading in that they give the impression that the sample is homogeneous, whereas most biologists who work with such data are only too aware of the degree of individual variation. While sample size of kills or scats may be relatively large, they still come from a small sample of animals, and they are not

equally distributed among the subjects. In order to make it clear that many variables, including age, sex, reproductive condition, season, and habitat use all play a role in the diet of the panthers studied, we briefly list the history of each cat separately in the results section. This should make it clear how careful we must be in generalizing about large predator habits, when we work with small numbers of individuals. If we have learned anything about large predators, it is that they are dynamic, flexible, and sometimes unpredictable.

RESULTS

Kills

We searched 113 kill sites of 8 panthers (no kill sites were located for panther #42, see below), and found prey at 99 of them. Of the 108 prey items found at the 99 kill sites (4 sites had two prey, and 3 sites had 3 prey), 9 species of prey were identified. White-tailed deer were found most frequently (57 %), followed by raccoons, alligators, opossums, hogs, marsh rabbits, otters, armadillos, and bobcats (Table 1).

Age estimates of deer at kill sites ranged from 1 to 15 years (Fig. 2). The average age, based on premolar data, was 5.09 years (n = 35, se = 0.74). The average age of a random sample (Eisenberg and Sunquist 1994; Smith et al. 1996) of 29 deer skulls was 4.4 years (n = 29, se = 0.57). There was no significant difference between the average age of randomly sampled deer and those from panther kills (t = -0.77, df = 62, p = 0.44), and the cumulative frequency distributions by age were not different (Kolmogrov-Smirnov test, n's = 29, 35, d = -0.119, $p > 0.05$; Fig. 2).

Adult male deer were killed more frequently than other sex and age classes of deer (47.5 %, Table 2), and the sex ratio of adult bucks to does killed by panthers was 2.1:1. The sex ratio of adult deer in ENP (based on aerial surveys during the peak rut months of July through October) was estimated as 1:2.4 (Eisenberg and Sunquist 1994). Comparison of the sex ratios indicates that panthers selected adult bucks over does (χ^2 = 73.88, df = 1, $p < 0.0001$).

Panthers spent an average of 3.86 (se = 0.19) days at kills, but this was biased by the large proportion of deer in the diet. Panthers spent the most time at adult buck kills (4.74 days, se = 0.411), and the least time at opossum kills (1.6 days, se = 0.245, Table 3). Panthers spent significantly more days at deer kills than alligator (t = 3.86), raccoon (t = 5.16), and opossum (t = 4.07) kills (all p's < 0.05), but there was no difference in duration of stay at

Table 1. Summary of kills by nine Florida panthers in Everglades National Park from 99 sites for 108 prey items by species.

Prey Type	Number Kill Sites	Frequency Occurrence	Number Items	Percent Occurrence
Deer	54	59.6	61	56.5
Rabbit	3	2.8	3	2.8
Raccoon	16	16.2	18	16.7
Armadillo	1	1.0	1	0.9
Otter	2	2.0	2	1.9
Hog	5	5.1	5	4.6
Alligator	11	11.1	12	11.1
Opossum	5	5.1	5	4.6
Bobcat	1	1.0	1	0.9

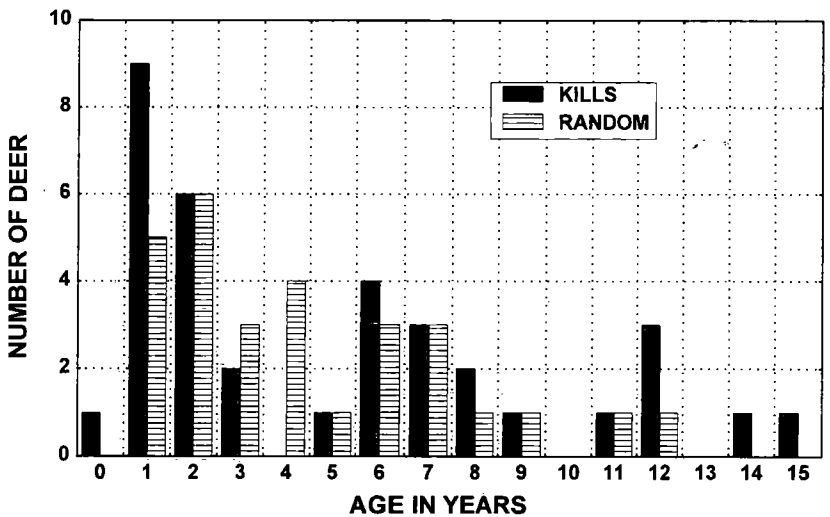

Figure 2. Distribution by age of white-tailed deer found at kill-sites of Florida panthers, and of deer in a random sample of skulls from the study area (from Eisenberg and Sunquist 1994; age of deer of one year or greater based on PM2 dental evaluation).

Table 2. Frequency and percent of 54 white-tailed deer of the total prey from kill sites of radio-collared Florida panthers. Numbers in parentheses are the percent of deer in known sex/size categories, excluding Unspecifiable

Deer Category	Frequency	Percent Total	
Adult buck	19	36.2	(47.5)
Adult doe	9	16.7	(22.5)
Yearling	6	11.1	(15.0)
Fawn	6	11.1	(15.0)
Unspecifiable	14	24.9	

Table 3. Days spent at kill for prey types with at least five occurrences, for radio-collared panthers in Everglades National Park. The category All Deer includes deer whose sex or age were not specified. M = mean; Med = median; Max = maximum; Min = minimum; SE = standard error; N = sample size of prey type.

Prey	M	Med	Max	Min	SE	N
All deer	4.50	5	11	1	0.214	54
Adult buck	4.74	5	11	2	0.411	19
Adult doe	3.67	4	6	1	0.500	9
Yearlings	4.50	4	6	3	0.563	6
Fawn	3.50	3	7	1	0.806	6
Raccoon	2.12	2	6	0.66*	0.368	14
Alligator	2.50	2	4	1	0.307	10
Opossum	1.60	2	2	1	0.245	5
Hog	4.60	4	9	3	1.123	5

* The minimum number of days at raccoon kills is less than one day because more than one raccoon was found at several individual kill sites.

kill sites between deer and hog ($t = 0.13$, $p = 0.29$). Panthers spent similar amounts of time at deer kills regardless of the age of the deer (Table 3).

Kills found per month varied from 10 in February to 1 in September. We found fewer kills during the wet season. The month with the highest proportion of deer kills was March. The months with the highest proportion of small prey were March and October. However, there was no statistical evidence of a seasonal shift in food habits between deer and other prey (Fig. 3).

Kills of Individual Panthers

Panther #14, an adult female, approximately 5-6 years old, was captured in December 1986. At the time of initial capture, she had two yearling kittens: one male (#16) and one female (#21). Between December 1986 and July 1991, panther #14 was radio-tracked in the Long Pine Key and Hole-in-the-Donut area and southern Taylor Slough. She primarily ate white-tailed deer (88% of kill sites) and killed 29 radio-collared deer. She also ate one each of the following prey: marsh rabbit, raccoon, alligator, and opossum. On 21 June 1991, panther #14 was found dead on the east side of the Hole-in-the-Donut. Her death may have been caused by a combination of chronic renal diseases, mercury contamination, and stress of a recent pregnancy.

Panther #15, an adult female, was captured December 1986. At the time of capture she had two kittens. Both kittens (#22 and #23) were captured in March 1987. Between December 1986 and June 1988 she was located 505 times. She frequently was located in the western portion of Long Pine Key and the eastern edge of Shark Slough. Based on kill remains she ate 14 deer (including bucks, does, yearlings, and fawns), a marsh rabbit, and an opossum. She also was located in the eastern portion of Long Pine Key. She was found dead in 1988. The necropsy report listed the cause as natural, due to bacterial infection from a puncture wound.

Panther #16 was captured in January 1987, as an 18-month-old yearling male still with his mother, #14. In March 1987, he separated from his mother and moved north into the East Everglades. Between March 1987 and March 1989, his home range included eastern portions of ENP as far north as Tamiami Trail and south to the Long Pine Key area. During March 1989, he crossed Shark Slough and moved into southern BCNP. In late October 1989, he returned to the eastern side of Shark Slough (ENP). He occupied the

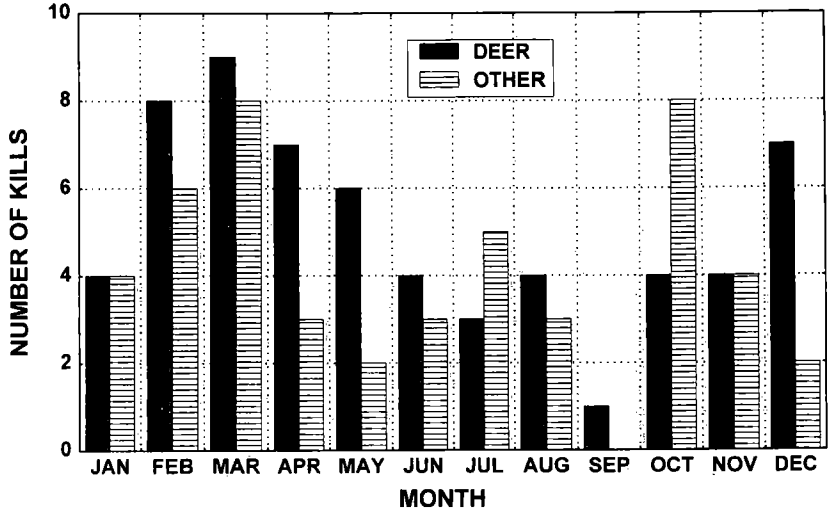

Figure 3. Kills per month for all nine Florida panthers, separated into the categories deer and other prey.

largest home range of all the study animals (estimated at about 900-sq-mi), including most of ENP and southern BCNP, and had the most diverse diet, including: 7 deer, 5 hogs, 11 alligators, 8 raccoons, a marsh rabbit, an otter, and a bobcat.

Panther #21 was captured in March 1987, as an 18-month-old yearling female still with her mother, #14. She separated from her mother in late March 1987 and traveled eastward. Between April 1987 and July 1988, panther #21 was radio-located 469 times. She moved out of ENP and crossed major roads a total of 45 times. She was struck by a vehicle on 21 July 1988. The areas she used were primarily abandoned farm lands, and sawgrass marshes with buttonwood hammocks. Prey at three kill sites were two deer and an armadillo.

Panther #22, an adult female, was captured along with her litter mate (#23) in March 1987. At five kill sites no prey was found, but at six other

kills sites there were three deer and three opossum. She separated from her mother (#15) in December 1987 at 16 months of age. Between December 1987 and March 1989, panther #22 was located 504 times in Long Pine Key/Hole-in-the-Donut area and southern Taylor Slough. On 19 March 1989, radio transmission was lost. She was not located during subsequent searches of her home range during the 1989 and 1990 capture seasons. In February 1991, panther #22 was recaptured and the malfunctioning collar replaced. Between February and July 1991, she was radio-tracked three times a week. During this period she used the same general area (western portion of Long Pine Key/Hole-in-the-Donut). On 22 July 1991, panther #22 was found dead at the bottom of a solution hole in western Long Pine Key. Preliminary cause of death was by a subcutaneous bacterial infection. At the time of her death, she had lost 50 percent of her body weight. This suggests that the infection was progressive over a relatively long period.

Panther #23 was captured as a 6-month-old kitten, along with her sister, #22, in March 1987. She was a 4-year-old female at the end of the study period. As a result of capture-related activity, she was abandoned by her mother and spent the majority of the first 3 years (June 1987-January 1989) in captivity. In late February 1989, she was returned to ENP and released on Long Pine Key. Between February 1989 and February 1990, she had an extensive home-range, covering the eastern portion of ENP, extending from the mangrove forests to agricultural lands in the East Everglades. In early March 1990, she crossed Shark Slough and moved into southern BCNP, using much of the same area as male panther #16. In late June 1990, she crossed U.S. 41, entering eastern BCNP. By mid-July 1990, she showed signs of denning, and remained at the same location for the next month. On 13 August 1990, panther #23 moved north from the den site location and did not return. This movement pattern indicated that she had lost the kitten(s) at about a month old. A subsequent search of the den site area was unable to locate any sign of the kitten(s). At the end of the study, panther #23 occupied the eastern portion of BCNP north of Tamiami Trail. Prey at four kill sites were four raccoons.

Panther #27, a 3-4 year old female, was captured and radio-collared in April 1988. Prey at three kill sites were two raccoons and an otter. She was located 451 times between April 1988 and July 1989. During these 15 months of radio-tracking she occupied portions of northern Long Pine Key, the East Everglades, and northern Shark Slough. On 26 July 1989, panther #27 was found dead in a tree island in northeast Shark Slough. A necropsy, performed by the Florida Game and Fish Commission veterinarian on this

animal, found no obvious cause of death. As a result of recent findings of high levels of mercury in freshwater fish and alligators in ENP (Roelke et al. 1991), the animal was screened for pesticides and heavy metals, and high levels of mercury (98 ppm) and selenium (22 ppm) were found in the animal's liver. Mercury toxicosis was the most likely cause of death of panther #27 (M. Roelke, pers. comm.).

Panther #39, an adult male, approximately 3-4 years old, was captured on a tree island in lower Shark Slough on 19 February 1990. At the time of capture, he weighed 102 lbs. From February to May 1990, he was radio-tracked only 81 times, representing the shortest period of data collection for any of the study animals. During this period, panther #39 ranged from Long Pine Key and East Everglades area, to the west side of Shark Slough. He crossed Shark Slough frequently. Between 4 May and 18 May 1991, he confined himself to a hardwood hammock and willow stand on the west side of Shark Slough. On 16 May 1990, a ground check of the area was made to determine the condition of the animal. The cat was approached on the ground and exhibited only limited movement, remaining out of sight. The decision was made to recapture the panther for examination. On the day of capture, 18 May 1990, the panther was found dead. The necropsy report listed cause of death as severe pyothorax from a puncture wound to the chest cavity (M. Roelke, pers. comm). Two deer were found at two kill sites.

Panther #42 was a subadult male, and 2 years old at the end of this study. Captured in March 1990, as a 10-month-old yearling still with his mother, he was the offspring of a backcross between Panther #14 (mother) and #16 (#14's son). In May 1990, he separated from his mother and moved north into the East Everglades. During the next 12 months, May 1990-May 1991, he confined himself to the northeast Shark Slough in the East Everglades. In early May 1991, he moved his center of activity into northern Shark Slough and west of Shark Valley Tower. He was occupying the area between Shark Valley Tower Road west to the ENP-BCNP boundary at the end of this study. No kill sites were found for this panther.

All Scats

In a total of 272 scats, 14 species and 291 prey items were represented (Table 4). White-tailed deer (*Odocoileus virginianus*) was the most important based on frequency of occurrence (69.1 % of scats) and percent occurrence (64.6 % of the prey items), followed by marsh rabbits (*Sylvilagus palustris*) and raccoons (*Procyon lotor*) (Table 4). A fox squirrel (*Sciurus*

niger) was found in one scat, and cotton rats (*Sigmodon hispidus*) in four scats. A large wading bird and an unidentified smaller bird were found in one scat each.

Deer composed 78.4 percent of estimated consumed biomass, followed by marsh rabbits (10.4 %). Marsh rabbits were also the most common prey consumed based on this analysis, comprising 57.6 percent of the prey by numbers (Table 5).

Kill-site Scats Versus Other Scats

There was a significant difference in the frequency of occurrence of prey found in the scats from kills vs. other locations ($\chi^2 = 83.2$, $p < 0.001$, df = 7). Deer made up over 80 percent of the prey and occurred in over 80 percent of the scats from kill sites, while they made up only about half that amount from scats from other locations. Marsh rabbits were more important in scats from other locations (39.6 % of the scats, and 35.9 % of prey; Table 4).

Deer were consistently identified as the most important prey item from kills and scats. Alligators and raccoons were the second and third most common prey identified in scats from kill sites, while marsh rabbits were the second most common prey in scats from non-kill sites (57.6 % of prey items, based on estimates of biomass consumed).

DISCUSSION

Anderson (1983) suggested a sample of 90-100 scats or stomach contents was necessary to characterize the food habits of mountain lions within 10 percent of actual use ($p = 0.05$). Our sample sizes for total scats, kill-site scats, and other scats all exceed the minimum suggested for our study period.

When the scats were subdivided between kill sites and other locations, the disparity in the kill and scat data was clearer. Scats found away from kill-sites contained many more marsh rabbits and other small prey. Remains of alligators were found in few scats (0.74 % of prey items) and were only found in scats from kill sites. Of the ten alligator kills, 5 were made by male panther #16.

The most obvious inconsistency between kill and scat data was the complete absence of opossum from the scats, even though opossum made up 6.6 percent of the prey from kills (see Tables 4 and 6). There were fewer rabbits at kills than from scats, and there were more raccoons and alligators

Table 4. Summary of kill and scat data of Florida panthers in Everglades National Park. Percent occurrence and frequency of occurrence are given for total scats, and for scats separated into scats from kill sites and other sites. PERC = percent occurrence (the percent of all the prey items in scats), FREQ = frequency of occurrence (the percent of the scats with prey type). The two rodents and two bird species are lumped together as "rodents" and "birds." (Opossum was not found in scats, although it was recorded at kill sites.)

Prey Species	Total Scats	Kill Sites	Other Sites	Total Scats		Kill Sites		Other Sites	
				Perc	Freq	Perc	Freq	Perc	Freq
Deer	188	143	45	64.6	69.1	82.2	86.1	38.5	42.5
Rabbit	54	12	42	18.6	19.9	6.9	7.2	35.9	39.6
Raccoon	19	9	10	6.5	7.0	5.2	5.4	8.6	9.4
Armadillo	9	2	7	3.1	3.3	1.2	1.2	5.9	6.6
Rodents	5	0	5	1.7	1.8	0.0	0.0	4.3	4.7
Otter	6	4	2	2.1	2.2	2.3	2.4	1.7	1.9
Birds	3	1	2	1.0	1.1	0.6	0.6	1.7	1.9
Hog	2	1	1	0.7	0.7	0.6	0.6	0.9	0.9
Alligator	2	2	0	0.7	0.7	1.2	1.2	0.0	0.0
Grey fox	1	0	1	0.3	0.4	0.0	0.0	0.9	0.9
Skunk	1	0	1	0.3	0.4	0.0	0.0	0.9	0.9
Snake	1	0	1	0.3	0.4	0.0	0.0	0.9	0.9
Total scats	272	166	106						
Total prey	291	174	117						

Table 5. Estimated biomass (kg) and number of prey consumed by Florida panthers based on scats from panthers in Everglades National Park. (No correction factor for prey was used when the estimated mass of a prey type was less than 2 kg, as suggested by Ackerman et al. [1984].)

Prey Type	Estimated		Correction Factor	Total Biomass	Percent Biomass	Number Consumed	Percent Consumed
	Freq	Mass					
Deer	188	36.0	3.2	609.12	78.36	16.9	18.1
Rabbit	54	1.5	–	81.00	10.42	54.0	57.6
Raccoon	19	5.0	2.2	40.94	5.27	8.2	8.7
Armadillo	9	6.0	2.2	19.71	2.54	3.3	3.5
Otter	6	8.0	2.3	13.56	1.74	1.7	1.8
Hog	2	23.0	2.8	5.57	0.72	0.2	0.3
Alligator	2	8.0	2.3	4.52	0.58	0.6	0.6
Skunk	1	2.5	2.1	2.07	0.27	0.8	0.9
Rodents	5	0.1	–	0.50	0.06	5.0	5.3
Birds	3	0.1	–	0.30	0.04	3.0	3.2

at kills than from scats (Table 6). The difference in prey species from kills and from scats suggests that there are differences in the amount of time needed by panthers to consume prey of different species. Small prey are consumed quickly, and produce fewer scats compared to large prey (Karanth and Sunquist 1995).

Maehr et al. (1990) identified 14 species in 270 scats and 7 species of prey at 38 kills in southwestern Florida. In ENP we found 14 species in 272 scats and nine species at 99 kills where the prey was found. We did not find livestock or panther remains in our samples, and bobcats, otters, foxes, and skunks were not represented in the BCNP data (Fig. 4; Table 7). The number of species recorded in kills and scats from ENP and southwestern Florida are very similar; however, the two areas shared only six actual prey species. Hogs, which were especially important in the diet of some southwestern Florida panthers, were insignificant in the ENP panthers, which may be due to the generally wetter conditions in ENP. Based on the analysis of consumed biomass, the amount of deer and hogs taken by panthers in southwestern Florida was about equal to the deer biomass taken in ENP.

Regular use of alligators as prey appears to be a distinctive, perhaps idiosyncratic, characteristic of panthers in the ENP ecosystem. However, a three-year drought during the study may have increased the availability of alligators to panthers, since panthers prefer upland habitats (Smith and Bass 1994).

Iriarte et al. (1990) analyzed puma diets across the species' range. They noted a general tendency for pumas to consume a wider variety of prey in the tropics. They suggested that prey availability and vulnerability, habitat characteristics, and potential competition from jaguars (*Panthera onca*) explained the differences they found between North America and the tropics. They noted that the panther data of Maehr et al. (1990) in southwestern Florida did not follow the typical North American pattern of reliance on large ungulate prey, and they emphasized the fact that the southwestern Florida data revealed a low rate of deer consumption. The data for the panthers in the Everglades National Park show characteristics of both the North American pattern of reliance on white-tailed deer, and the wider food niche breadth described for tropical pumas. The wide food niche breadth of Florida panthers in the Big Cypress area is not explained merely by a lack of deer in that part of the panther's range, because the panthers in ENP also show this tendency while relying heavily on an unhunted deer population.

Table 6. Comparison of percent of total scats and total kill sites that contained prey species in Everglades National Park.

Prey Species	Percent Occurrence	
	Scats	Kills
Deer	64.6	56.5
Rabbit	18.6	2.8
Raccoon	6.5	16.7
Armadillo	3.1	0.9
Rodents	1.7	–
Otter	2.1	1.9
Birds	1.0	–
Hog	0.7	4.6
Alligator	0.7	11.1
Grey fox	0.3	–
Skunk	0.3	–
Snake	0.3	–
Opossum	0.0	4.6
Bobcat	0.0	0.9

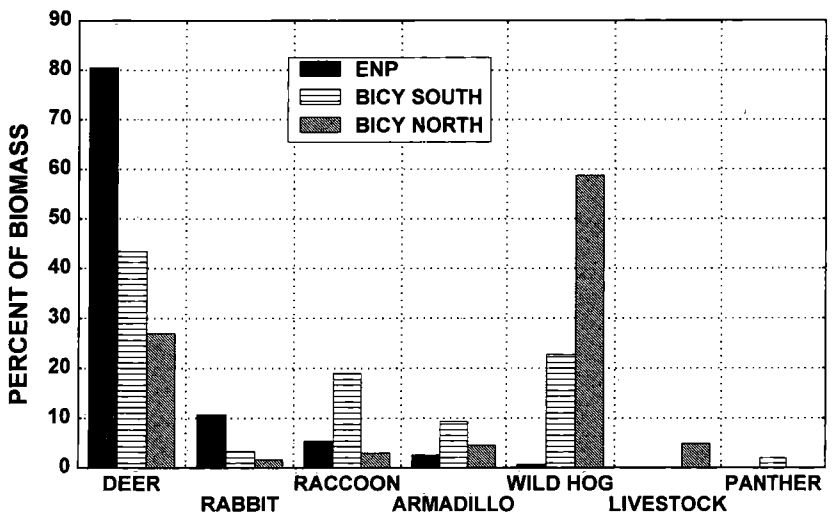

Figure 4. Estimated percent of biomass consumed from scat data for Florida panthers in Everglades National Park compared to data from the Big Cypress region of southwestern Florida from Maehr et al. (1990).

Table 7. Comparison of estimates of percent of total biomass consumed by Florida panthers, based on formula of Ackerman et al. (1984), for Everglades National Park and the Big Cypress region (Maehr et al. 1990). * = one alligator found in scat from study by Maehr et al. (1990), but not listed by location.

	Everglades National Park	Big Cypress	
		North	South
Deer	78.36	27.00	43.00
Rabbit	10.42	1.70	3.40
Raccoon	5.27	3.00	19.00
Armadillo	2.54	4.60	9.30
Otter	1.74	0.00	0.00
Hog	0.72	58.70	22.70
Alligator	0.58	0.00*	0.00*
Skunk	0.27	0.00	0.00
Rodent	0.06	0.05	0.10
Birds	0.04	0.00	0.00
Livestock	0.00	4.90	0.00
Panther	0.00	0.00	2.00

Bobcats are a frequent predator on white-tailed deer in parts of southern Florida (Land 1991, Boulay 1992). However, the degree to which bobcats compete with panthers is still unclear. Potential competition from recreational hunting of white-tailed deer is an issue in the Big Cypress region, where panthers show a higher use of wild hogs, and livestock. Where hunting does not occur, as within the confines of Everglades National Park, there was a clear reliance by panthers on deer. The seasonal variation in standing water levels, the lower densities of prey populations in southern Florida, and the seasonal variation in the use of tree island habitat may all contribute to a more opportunistic feeding strategy by panthers. However, white-tailed deer remain the principal prey species, especially in Everglades National Park. The data from scats found away from kill sites in this study suggest that a wide range of small prey species are taken opportunistically.

Since the data presented above indicate that panthers selected older deer, and bucks over does, it is reasonable to hypothesize that Florida panthers in the Everglades are stalking isolated individuals in and along tree island edges.

Selective predation on older deer by pumas has also been noted by Hornocker (1970), Spalding and Lesowski (1971), and Ackerman et al. (1984), and Robinette et al. (1977) noted increased vulnerability of bucks in Utah and Nevada. In the southern Everglades, Miller (1993) and Eisenberg and Sunquist (1994) stated that adult bucks spent more time alone, and prefer to spend time on tree islands. Isolated bucks in the dense cover of tree islands may be easier to stalk by panthers. They also noted that females tend to stay in groups in more open prairie habitat. Such groups may be more difficult to approach and stalk by panthers.

Moreover, the reduced rate of deer kills in the wet months of July through September in the current study correspond to the months when bucks are more commonly associated with groups of does in open prairie habitat (Eisenberg and Sunquist 1994; Smith et al. 1996), and again this may make close approach by stealth more difficult for panthers to successfully kill deer.

In the Big Cypress National Preserve, Miller (1993) found adult male deer to be twice as likely to use hardwood tree islands as females. Miller also suggested groups of female deer may use open habitat more often as part of a predator avoidance behavior.

In evaluating bobcat predation on fawns in the Big Cypress, Boulay (1992) pointed out that peak rates of bobcat predation on fawns were June and July, and that rates of fawn kill were much lower from August to December. Boulay also suggested that the higher rate of predation on male fawn vs. females may be due to tendency for male fawns to wander farther and use tree island habitat more commonly, which may make them more susceptible to the stalking behavior of bobcats. In summary, the data available for both ENP panther and BCNP bobcats, indicate that deer that are isolated and use tree islands are more susceptible to panther predation.

Iriarte et al. (1990:188) related diet to body size in pumas, suggesting that smaller pumas forage selectively on smaller prey. They relied on the data from scat analysis by Maehr et al. (1990) to argue that: "Low deer densities in much of the puma's range in Florida may explain, in part, the low MWVP [mean weight of vertebrate prey] value of Florida pumas when compared with the rest of North America. Deer populations and densities of alternative prey species in portions of Florida may be low since pumas in areas of low deer densities are smaller, are in poorer condition, and have lower reproductive rates... ." But, Maehr and Moore (1992) compared growth rates of southwestern Florida panthers to pumas from California, and determined that adult mass and growth rates were not different. They stressed that

California pumas relied heavily on wild hogs, and that deer were not commonly taken. However, several issues should be clarified before any conclusions are drawn regarding Florida panthers as a whole. First, Maehr et al. (1990) were considering only panthers from southwestern Florida, but we consider that panthers from ENP readily fit their curve for growth rate. Second, Maehr et al. (1990) relied on scat data for their estimates of prey importance, and as has been shown in this study, scat data should be separated into scats from kills and scats from other locations whenever possible, because scats that are not from kill sites show a bias toward smaller prey, while scats from kill-sites are more likely biased toward large-size prey. Third, Roelke et al. (1991) have pointed out that much of the poor condition in some southern Florida panthers may be due to high mercury poisoning levels that, again, confuse the question of body condition and size. Fourth, the analysis of duration of stay with prey in the current study revealed no significant difference in the duration of stays for deer and hog, which may mean that as large a portion of a hog's mass was taken as from a deer. Moreover, many hogs are approximately the same size as the deer taken in southern Florida. The results of the current study identify many similarities in the diets of panthers from southwestern and southeastern Florida, and also indicate the importance of drawing data from as many potential sources (i.e. scats and kills) as possible to adequately characterize the diet of this species.

LITERATURE CITED

Ackerman, B. B., F. G. Lindzey, and T. P. Hemker. 1984. Cougar food habits in southern Utah. J. Wildl. Mgmt. 4:147-155.

Anderson, A. E. 1983. A critical review of literature on puma (*Felis concolor*). Spec. Rept. No. 54. Colorado Div. Wildl., Denver. 91 pp.

Belden, R. C. 1983. Florida panther recovery plan implementation - a 1983 progress report. Pages 159-172 *in* S.D. Miller and D.D. Everett, eds. Cats of the world: Biology, conservation, and management. Natl. Wildl. Fed., Washington, DC.

Boulay, M. C. 1992. Mortality and recruitment of white-tailed deer fawns in the wet prairie/tree island habitat of the Everglades. M.S. thesis. Univ. Florida. Gainesville. 77 pp.

Chapman, J. A., and G. A. Feldhammer. 1982. Wild mammals of North America. Johns Hopkins Univ. Press, Baltimore, MD. 1147 pp.

Eisenberg, J.F., and M.E. Sunquist. 1994. Ecology of white-tailed deer in eastern Everglades National Park. Final Rept. Everglades National Park, unpubl. doc., Homestead FL 26 pp. + appendices.

Harlow, R.F., and F. K. Jones, Jr. 1965. The white-tailed deer in Florida. Florida Game Fresh Water Fish Comm. Tech. Bull. 9. Tallahassee. 240 pp.

Hornocker, M.G. 1970. An analysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. Widl. Monogr. 21. 39 pp.

Iriarte, J.A., W. L. Franklin, W. E. Johnson, and K. H. Redford. 1990. Biogeographic variation of food habits and body size of the American puma. Oecologia. 85:185-190.

Jordan, D. 1990. Mercury contamination: Another threat to the Florida panther. Endangered Species Tech. Bull. 15, No. 2.

Karanth, K. U., and M.E. Sunquist. 1995. Prey selection by tiger, leopard, and dhole in tropical forests. J. Animal Ecol. 64: 439-450.

Land, E. D. 1991. Big Cypress deer/panther relationships: Deer mortality. Final rept.–1 July 1986-30 June 1991 (Study No. E-1-11 II-E-5b). Florida Game Fresh Water Fish Comm., Tallahassee. 24 pp.

Maehr, D. S., R. C. Belden, E. D. Land, and L. Wilkins. 1990. Food habits of panthers in southwest Florida. J. Wildl. Mgmt. 54:420-423.

Maehr, D. S., and C. T. Moore. 1992. Models of mass growth for 3 North American cougar populations. J. Wildl. Mgmt. 56:700-707.

Mech, L. D. 1983. Handbook of animal radio-tracking. Univ. Minnesota Press, Minneapolis. 107 pp.

Miller, K.E. 1993. Habitat use by white-tailed deer in the Everglades: tree islands in a seasonally flooded landscape. M.S. Thesis. Univ. Florida, Gainesville. 105 pp.

Roelke, M. E., D. P. Schultz, C. F. Facemire, S. F. Sundlof, and H. E. Royals. 1991. Mercury contamination in Florida panthers. A report of the Florida Panther Technical Subcommittee to the Florida Panther Interagency Committee, December 1991.

Severinghaus, C. W. 1949. Tooth development and wear as criteria of age in white-tailed deer. J. Wildl. Mgmt. 13:195-216.

Shaw, H. G. 1983. Mountain lion field guide. Spec. Rept. 9. Arizona Game Fish Dept., Phoenix. 38 pp.

Smith, T. R. and O. L. Bass, Jr. 1994. Landscape, white-tailed deer, and the distribution of Florida panthers in the Everglades. Pages 693-708 *in* S. Davis and J. Ogden, ed. Everglades. The Ecosystem and its Restoration. St. Lucie Press. Delray Beach FL.

Smith, T. R., C. G. Hunter, J. F. Eisenberg, and M. E. Sunquist. 1996. Ecology of white-tailed deer in eastern Everglades National Park: An overview. Bull. Florida Museum Nat. Hist.. 39(4):141-172.

Sokal R. R, and F. J. Rohlf. 1995. Biometry. Third Ed. W. H. Freeman and Co. New York. 887 + xix.

Spalding, D.J. and J. Lesowski. 1971. Winter food of the cougar in south-central British Columbia. J. Wildl. Mgmt. 35: 378-381.

Contributions to the BULLETIN OF THE FLORIDA MUSEUM OF NATURAL HISTORY may be in any field of biology. Manuscripts dealing with natural history or systematic problems involving the southeastern United States or the New World tropics are solicited especially. Manuscripts should be of medium length--circa 35-200 pages (10,500-60,000 words). Examination for suitability is made by an Editorial Board.

The BULLETIN is distributed worldwide through institutional standing orders and exchanges. It is considered the responsibility of the author to distribute his paper to all interested individuals. To aid in this, the author(s) receive(s) 50 copies free, and he/she(they) may purchase additional separates at cost if ordered when page proof is returned. The author is also responsible for any charges incurred for alterations made by him on galley or page proofs. The Museum will send an invoice to the author for this amount upon completion of publication.

PREPARATION OF MANUSCRIPT

Contributors should consult recent numbers of the BULLETIN for preferred style and format. Highly recommended as a guide is the CBE Style Manual, 3rd Edition, 1972 (American Institute of Biological Sciences, Washington, D.C.).

Manuscripts must be submitted in duplicate and satisfy the following minimal requirements. They must be double-spaced throughout, including tables, figure captions, and literature citations. Figure legends and tables should be typed on separate sheets. Also, please submit a copy of the complete text, tables, figure captions, and literature cited on a floppy disk (software used does not matter, but we use Word for Windows).

All illustrations are referred to as figures. They must comply with the following standards: Photographs should be sharp, with good contrast, and printed on glossy paper, or the originals submitted. If the background of photographs (especially those of specimens) is not desired, amberlith should be cut out and used to cover the background. Drawings should be made with dense black waterproof ink on quality paper or illustration board. All figures should have a cover sheet. All lettering will be medium weight, sans-serif type (e.g. Futura Medium, News Gothic) in cutout, dry transfer, or lettering guide letters. Make allowance so that after reduction no lower case letter will be less than 1 mm high (2 mm is preferred) nor any capital letter greater than 5 mm high. The maximum size for figures is 9" x 14" (twice BULLETIN page size); figures should not be less than typepage width (4½"). With soft lead pencil, on the back of each illustration, designate the top and identify each by author's name, manuscript title, and figure number.

All manuscripts not submitted in BULLETIN format will be returned to the author for retyping and/or formatting.

Manuscripts, all editorial matters, and requests for more detailed preparation instructions should be addressed to:

Managing Editor of the BULLETIN
Florida Museum of Natural History
University of Florida
P. O. Box 117800
Gainesville FL 32611-7800, U.S.A.