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CAUSES OF MORTALITY OF FREE-RANGING FLORIDA PANTHERS

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ABSTRACT: The Florida panther (*Puma concolor coryi*) is one of the most endangered mammals, with the entire population estimated to consist of only 30–50 adult animals. Between 1978 and 1999, 73 free-ranging Florida panther carcasses were submitted for postmortem evaluation, of which 47 (64%) were radiocollared and 26 (36%) were uncollared cats. Overall, mortality of panthers >6-mo-old was due to vehicular trauma in 25 (35%), intraspecific aggression in 19 (26%), illegal kill in seven (10%), research activities in two (3%), infectious diseases in two (3%), esophageal tear in one (1%), pleuritis in one (1%), pyothorax in one (1%), aortic aneurysm in one (1%), atrial septal defect in one (1%), and causes of death were undetermined in 13 (18%) due to autolysis. Of the 25 panthers that were killed by vehicular trauma, 20 (80%) died between October and April. This coincides with increased number of winter visitors to south Florida. Among radiocollared panthers, intraspecific aggression was the primary cause of mortality for 19 (41%) dead cats. Of these cats, 16 (84%) were males and 14 (88%) were either less than 3 or more than 8-yr-old. These animals were probably fighting to establish or retain territory. Among the 26 uncollared panthers, vehicular trauma was the primary cause of mortality and was responsible for 16 (62%) deaths. This study documents the causes of mortality and the age, sex, and seasonal mortality trends for both radiocollared and uncollared free-ranging endangered Florida panthers over a 21-yr-period.

Key words: Cougar, felid, Florida panther, mortality, mountain lion, puma, *Puma concolor coryi.*

INTRODUCTION

Long-term comprehensive studies of non-hunting related mortality of free-ranging cougar (*Puma concolor*) populations are extremely difficult due to cougar's large home ranges which usually encompass rugged terrain and their elusive nature (Quigley and Hornocker, 1992; Charlton et al., 1998). Often carcasses cannot be located and retrieved for diagnostic evaluation before scavenging and autolysis occur (Hemker et al., 1984). Causes mortality of free-ranging cougars include intraspecific aggression, infectious diseases, starvation, trauma from prey, vehicular trauma, research activities, drowning, electrocution, rattlesnake bite, atrial septal defects, aortic aneurysm, old age, and hunter harvest (Gashwiler and Robinette, 1957; Hornocker, 1970; McBride, 1976; McCauley, 1977; Sitton, 1977; Anderson, 1983; Logan 1983; Hemker et al., 1984; Logan et al., 1986, 1996; Lindzey et al., 1988, 1989; Spreadbury, 1989; Maehr et al., 1991b; Ross and Jalkotzy, 1992; Cunningham et al., 1995; Ross et al., 1995; Charlton et al., 1998; Rotstein et al., 2000a).

The Florida panther (*P. concolor coryi*), a subspecies of cougar, once inhabited the entire southeastern United States and was contiguous with other cougar subspecies (Goldman, 1946; Belden, 1986). Until 1966, the Florida panther was hunted for sport and to protect livestock from predation. Records indicate that at least 55 panthers were killed prior to 1958 and seven from 1966 to 1976 (McCauley, 1977). The panther also has been affected by landscape changes that include fragmentation and habitat loss from human housing and road development, conversion of land use to citrus groves, and introduction of exotic plants and animals (Belden et al., 1988). Since 1967, the Florida panther has been federally protected as an endangered species and the current population is estimated to consist of 50 adult cats (Belden, 1986). These animals inhabit the Big Cypress Swamp and Everglades ecosystems of southern Florida.

Field studies on the panther have been conducted since 1976 and have provided information on habitat, home range requirements, food habits, reproduction, and health (Forrester et al., 1985; Maehr et al., 1989, 1990, 1991a, b, 1995; Greiner et al., 1989; Roelke et al., 1993; Glass et al., 1994; Wehinger et al., 1995; Lamm et al., 1997; Rotstein et al., 1999a, b, 2000a, b; Cunningham et al., 1999). Prior mortality research on the panther focused on geographic and temporal patterns, especially related to highway collisions (Maehr et al., 1991b). This retrospective study examines the causes of mortality of 73 free-ranging Florida panthers, as well as the age, sex, and seasonal mortality trends over a 21-yr-period.

MATERIALS AND METHODS

The study population included 73 free-ranging Florida panthers which inhabited peninsular southern Florida (south of 27°00′N) from 1978 through 1999. Excluded from this study were free-ranging animals collected prior to 1978 because of incomplete records, neonatal animals, captive panthers, and two captive panthers that died within 2 mo of release to the wild. Panthers were >6 mo of age and were tracked and treed with dogs (Maehr et al., 1989). A CO_2 powered rifle (Telinject, Saugus, California, USA) was used to deliver anesthetic via a 3 cc dart with a 1.5 × 30 mm uncollared needle. Numerous anesthetic drugs and doses were used over the years (acepromazine, ketamine [Ketaset, Fort Dodge Laboratories, Fort Dodge, Iowa, USA], tiletamine hydrochloride/zolazopam hydrochloride [Telazol, Fort Dodge Laboratories], diazepam, midazolam [Versed, Roche Laboratories, Mutley, New Jersey, USA], and xylazine [Rompun, Bayer Corporation, Shawnee Mission, Kansas, USA]). Panthers were caught in a net, and if needed, a portable wildlife cushion as they fell from trees (McCown et al., 1990). Occasionally an anesthetized cat would remain in a tree and a biologist had to climb up and lower the cat to the ground with a rope. Panthers usually were recaptured at 2-yr intervals, however this ranged from 6 mo to 5 yr.

At capture, animals were fitted with a mortality sensing radiocollar (Telonics, Inc., Mesa, Arizona, USA) and tattooed. A physical examination was conducted to assess general health and physical condition. Subcutaneous and/or intravenous isotonic fluids were administered and biomedical samples were collected. Most panthers were vaccinated for rabies (Imrab, Rhone Merieux, Athens, Georgia, USA), and panleukopenia, calicivirus, and rhinopneumonitis (Fel-O-Vax PCT, Fort Dodge Laboratories). Anthelmintics administered included ivermectin (Ivomec, Merck & Company, Rahway, New Jersey, USA) and praziquantel (Droncit, Bayer Corporation). Some panthers received long acting penicillin, vitamins, and iron dextran. Panthers were implanted with subcutaneous transponder identification chips (Infopet, Burnsville, Minnesota, USA) and weighed. Animals were aged based on records of capture as a kitten or estimated from patterns of tooth wear which were compared with tooth wear patterns of known age animals.

Radiocollared panthers were monitored three times a week by aerial telemetry. Radio collars were equipped with an activity and mortality switch. When a mortality signal was detected during aerial telemetry, aerial and ground investigations were conducted to determine the animal's status. Dead uncollared panthers usually were found by members of the public who reported them to the Florida Fish & Wildlife Conservation Commission (Naples, Florida, USA). Occasionally, a panther with vehicular trauma died on the way to a treatment facility.

Carcasses varied in degree of postmortem decomposition. They were usually put in clean plastic bags, placed on ice, and delivered to the necropsy facility. A few carcasses were frozen prior to diagnostic evaluation. Carcasses were transported to either the University of Florida (College of Veterinary Medicine, Department of Pathobiology, Gainesville, Florida), Florida Fish & Wildlife Conservation Commission field offices (Gainesville or Naples, Florida), Southeastern Cooperative Wildlife Disease Study (College of Veterinary Medicine, University of Georgia, Athens, Georgia, USA), or the University of Miami (Comparative Pathology Laboratory, Miami, Florida). Supplemental histopathology was conducted by the Wyoming State Veterinary Laboratory (University of Wyoming, Laramie, Wyoming, USA) and the National Zoological Park (Washington, D.C., USA).

Carcasses were weighed, sexed, and an approximate age was determined. Some carcasses were too decomposed for collection of complete data. Some panthers were radiographed prior to necropsy. Animals were skinned and necropsied. Sections of major tissues were usually collected for histopathology. These tissues were fixed in 10% buffered formalin, embedded in paraffin, sectioned at 5–7 μm, and stained with hematoxylin and eosin. Special stains were utilized as necessary. Tissues were evaluated by light microscopy. Additional diagnostic tests were utilized as appropriate and included parasitology, bacteriology, virology, and toxicology.

RESULTS

Of the 73 free-ranging Florida panthers recovered for necropsy, 47 (64%) were radiocollared and 26 (36%) were uncollared. When categorized by both age and sex, there were 19 (26%) adult females, four (5%) juvenile females, 32 (44%) adult males, 11 (15%) juvenile males, and seven (10%) of undetermined age and/or sex. The radiocollared group was composed of 14 (30%) adult females, 25 (53%) adult males, and eight (17%) juvenile males; while the uncollared group had five (19%) adult females, four (15%) juvenile females, seven (27%) adult males, three (12%) juvenile males, and seven (27%) of undetermined age and/or sex.

Primary causes of mortality were determined on 60 (82%) of the 73 panther carcasses (Table 1). Vehicular trauma was the predominant documented cause of mortality for panthers. Of the 25 cats hit by cars, 20 (80%) died between October and April, while only five (20%) were hit between June and September. Of the 25 panthers that died this way, there were nine (36%) females, 14 (56%) males, and two (8%) of undetermined sex. Of these there were 15 (60%) adults, eight (32%) juveniles, and two (8%) of undetermined age. When both age and sex were counted together, overall vehicular trauma of the 25 panthers included four (16%) adult females, four (16%) juvenile females, 10 (40%) adult males, four (16%) juvenile males, and three (12%) undetermined.

TABLE 1. Causes of mortality of free-ranging Florida panthers (*Puma concolor coryi*) from 1978–99.

Cause of mortality	Number of radio-collared panthers	Number of uncollared panthers	Total free-ranging panthers
Vehicular trauma	9	16	25 (35%)
Intraspecific aggression	19		19 (26%)
Illegal kill		7	7 (10%)
Research activities	2		2 (3%)
Infectious disease	2		2 (3%)
Atrial septal heart defect	1		1 (1%)
Aortic aneurysm	1		1 (1%)
Esophageal tear	1		1 (1%)
Pleuritis	1		1 (1%)
Pyothorax	1		1 (1%)
Undetermined (autolytic/scavenged)	10	3	13 (18%)
Total	47	26	73

Intraspecific aggression, was the second highest cause of mortality in panthers but was only documented in radiocollared cats and consisted of two distinct bite patterns. One was a bite to the head in which the panther's canine penetrated through the skull into brain causing immediate death. The other pattern entailed multiple bite wounds to one or more distal limbs which became infected and led to septicemia and death usually within 7–10 days. Of the 19 panthers that died from intraspecific aggression, there were two (11%) females over 11-yr-old, one (5%) female under 3-yr-old, five (26%) males over 8-yr-old, two (11%) males 5-yr-old, and nine (47%) males under 3-yr-old. Seasonally, only four (21%) panthers died between March and July, while 15 (79%) died between August and February.

Seven uncollared panthers were illegally killed by gun shot. These were two (29%) adult females, two (29%) adult males, and three (42%) of undetermined sex and age.

Two radiocollared panthers died as a result of research activities to monitor the population. An adult female died due to either a negative anesthetic drug reaction or a dose miscalculation. The panther had received a combination of acepromazine and ketamine via intramuscular dart and died approximately 8 min later. At necropsy, the animal had acute pulmonary edema. The other panther was a 10-mo-old male that had an anesthetic dart penetrate the skin of the caudal abdomen. Despite aggressive antibiotic therapy, the animal died two days later from peritonitis.

Two radiocollared panthers died of infectious disease. An unvaccinated 3-yr-old male panther died of rabies. Histology of the brain revealed subacute diffuse nonsuppurative perivascular encephalitis with eosinophilic intracytoplasmic neuronal inclusions indicating rabies. Immunofluorscence testing supported this diagnosis. The virus was typed and found to be a raccoon (*Procyon lotor*) strain. The only other panther documented to have died from infectious disease was a 3.5-yr-old male that died acutely from pseudorabies (Glass et al., 1994). The animal had dark red fluid in the esophagus, stomach, and peritoneal and thoracic cavities. The duodenum contained multiple pinpoint erosions through the mucosa and the meningeal vessels were engorged with blood. Pseudorabies virus was recovered by cell culture of brain tissue. Swine (*Sus scrofa*) was the probable source of infection.

One radiocollared panther's death was attributed to a congenital heart defect. The 5-yr-old male died acutely and had an atrial septal defect, acute extensive hemorrhage of both lungs, and pulmonary congestion and edema.

Four radiocollared panthers died of unusual causes. A 12-yr-old female panther died of a dissecting thoracic aortic aneurysm that ruptured causing massive hemorrhage into the thoracic cavity. The aorta had a severe necrohemorrhagic arteritis with a pleocellular infiltrate of lymphocytes, macrophages, and neutrophils. A 4-yr-old male panther had a ruptured esophagus of undetermined cause associated with severe, diffuse esophagitis. This inflammation was believed to have caused weakening and thinning of the wall of a mid-dorsal vessel which also ruptured causing severe blood loss and death. An 8-yr-old female panther died from severe diffuse hemorrhagic fibrinous pleuritis, most likely of bacterial origin, that resulted in pulmonary atelectasis. A 4-yr-old male panther died of subacute diffuse severe pyothorax associated with foreign material (saw grass).

DISCUSSION

In the management of most free-ranging wildlife species, the health of the population is considered more important than that of the individual. However, the Florida panther is an exception because population size is small, and the health of each individual is of concern. There is a bias in carcass recovery of non-radiocollared panther carcasses. Animals that die away from a major road probably remain undiscovered. Highway mortality is one of the most visible sources of mortality for free-ranging wildlife (Lotz et al., 1996). This bias leads to an interesting conclusion. Since there were 16 uncollared panthers found dead by roads as a result of vehicular trauma compared to nine radiocollared panthers, there is a possibility that the uncollared population is larger than the radiocollared population.

As in an earlier study, we found that the majority (80%) of the radiocollared and uncollared cats that were killed from vehicular trauma died between October and April (Maehr et al., 1991b). This time frame coincides with increased number of winter visitors to southern Florida (Maehr et al., 1991b). The majority of the cats hit were males, which are known to have larger home range territories than females (Maehr et al., 1991a). This may also be the result of these animals searching to establish new or larger territories. Efforts to reduce vehicular trauma to panthers and other wildlife in southern Florida has led to the construction of highway underpasses to serve as wildlife crossings (Foster and

Humphrey, 1995; Lotz et al., 1996). Remote infrared motion cameras have demonstrated that panthers, as well as many other wildlife species utilize these underpasses (Lotz et al., 1996).

Intraspecific aggression has been documented to occur in other cougar populations (Anderson, 1983; Logan et al., 1996). Intraspecific aggression was the highest natural cause of mortality in the panthers, but was only documented in radiocollared cats. It would be virtually impossible to find the carcass of a free-ranging uncollared panther that died of intraspecific aggression before scavengers or autolysis affected its suitability for post-mortem examination. The majority of cats that died of intraspecific aggression were either young males that were probably trying to establish a territory or older males that were probably defending and losing territories. It is possible that the prevalence of intraspecific aggression within the panther population has been increased by habitat limitation (Maehr et al., 1991b).

Of the panthers killed illegally, all were shot and were uncollared. All of these carcasses were found incidentally. A bias may exist here; individuals who illegally shoot uncollared cats might not shoot a radiocollared cat out of concern of being traced and caught.

The risk of injury and/or death of an animal exists anytime an animal is captured and handled, and this risk greatly increases in a largely uncontrolled field capture of a large dangerous predator. Between 1981 and 1998, 72 free-ranging Florida panthers were anesthetized multiple times (1–10 times per cat) for a total of 183 capture events. Direct or indirect capture related mortality only occurred twice (0.01%).

Small populations may be particularly vulnerable to disease outbreaks and inbreeding (Ralls and Ballou, 1979; O'Brien et al., 1985, 1990; Williams et al., 1988). Florida panthers are solitary in nature and the risk of spread of an infectious disease that could significantly impact the remaining population is low (Maehr et al., 1991a, 1995). The two mortalities caused by infectious diseases (rabies and pseudorabies) were caused by pathogens that probably would not be transmitted through the population. The most likely source of these diseases was through catching and consuming infected raccoon and swine, which are common prey of panthers (Maehr et al., 1990; Glass et al., 1994). The panther that died of rabies represents the first reported case of rabies to occur in a free-ranging cougar.

The institution of a vaccination program for radiocollared panthers against rabies, calicivirus, panleukopenia, and rhinotracheitis may be preventing or limiting these particular diseases. Studies were initiated in 1998 to retrospectively evaluate blood samples for antibody responses to vaccination.

Detrimental effects associated with inbreeding may include congenital anomalies, increased disease susceptibility, decreased neonatal survivability, lowered reproduction, and a decreased ability to adapt genetically to environmental changes (O'Brien et al., 1985; Lacy, 1993). Some Florida panthers had congenital heart defects, kinked tails, cowlicks, and cryptorchidism (Roelke and Glass, 1992; Roelke et al., 1993; Cunningham et al., 1999). Six of 33 (18%) captive and free-ranging panthers necropsied by veterinary pathologists between 1985 and 1998 had an atrial septal defect (Cunningham et al., 1999). One free-ranging panther died of an atrial septal defect and this defect possibly contributed to three other deaths.

A 12-yr-old, otherwise healthy, free-ranging panther died of an aortic aneurysm (Rotstein et al., 2000a). While aortic aneurysms have been reported in non-felid captive wild and domestic species (Stout and Bohorquez, 1972; Graham, 1977; Kenny et al., 1994; Steverink et al., 1995; Baptiste et al., 1997), this is the first time it has been reported in a free-ranging mammal.

Mercury toxicity has been mentioned as adversely affecting panthers and a proposed exposure pathway identified (Facemire et al., 1995); yet there has never been a documented case of mercury toxicosis directly causing mortality in a Florida panther (Roelke et al., 1991). Some free-ranging panthers have, at times, had blood and hair mercury levels of concern, and thus, studies are underway to attempt to evaluate mercury sources and determine if adverse subclinical effects may be occurring in panthers (Florida Panther Interagency Committee, 1989).

Most free-ranging Florida panthers in this retrospective study were in good health and body condition. While most carcasses were recovered and promptly necropsied, a few were frozen first. This process could have created histopathologic artifacts or possibly reduced recovery of some infectious organisms. Yet, there was no indication of immunosuppression or clinical or postmortem evidence that environmental contaminants have directly caused mortality. Rather, mortality was predominantly caused by human activities (vehicular collisions and poaching) and by intraspecific aggression. However, further study is needed to determine if anthropogenic impacts on panther habitat result in an unnaturally high rate of intraspecific aggression.

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LITERATURE CITED

ANDERSON, A. E. 1983. A critical review of literature on puma (*Felis concolor*). Special report number 54. Colorado Division of Wildlife, Denver, Colorado. 91 pp.

BAPTISTE, K. E., R. L. PYLE, J. L. ROBERTSON, W. PIERSON, C. LARSEN, AND L. WARTHEN. 1997. Dissecting aortic aneurysm associated with a right ventricular arteriovenous shunt in a mature ostrich (*Struthio camelus*). Journal of Avian medicine and Surgery 11: 194–200.

BELDEN, R. C. 1986. Florida panther recovery plan implementation—A 1983 progress report. *In* Cats of the world: Biology, conservation, and management, D. Miller and D. D. Everett (eds.). Caesar Kleberg Wildlife Research Institute, Kingsville, Texas, pp. 159–172.

———, W. B. FRANKENBERGER, R. T. MCBRIDE, AND S. T. SCHWIKERT. 1988. Panther habitat use in southern Florida. Journal of Wildlife Management 52: 660–663.

CHARLTON, K. G., D. W. HIRD, AND E. L. FITZHUGH. 1998. Physical condition, morphometrics, and growth characteristics of mountain lions. California Fish and Game 84: 104–111.

CUNNINGHAM, M. W., M. R. DUNBAR, C. D. BUERGELT, B. L. HOMER, M. E. ROELKE-PARKER, S. K. TAYLOR, R. KING, S. B. CITINO, AND C. GLASS. 1999. Atrial septal defects in Florida panthers. Journal of Wildlife Diseases 35: 519–530.

CUNNINGHAM, S. C., L. A. HAYNES, C. GUSTAVSON, AND D. D. HAYWOOD. 1995. Evaluation of the interaction between mountain lions and cattle in the Aravaipa-Klondyke area of southeast Arizona. Technical Report # 17. Arizona Game and Fish Department, Phoenix, Arizona. 64 pp.

FACEMIRE, C. F., T. S. GROSS, AND L. J. GUILLETTE. 1995. Reproductive impairment in the Florida panther: Nature or nurture? Environmental Health Perspectives—Supplement 103: 79–86.

FLORIDA PANTHER INTERAGENCY COMMITTEE. 1989. Status report of mercury contamination in Florida panthers. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida. 52 pp.

FORRESTER, D. J., J. A. CONTI, AND R. C. BELDEN. 1985. Parasites of the Florida panther (*Felis concolor coryi*). Proceeding of the Helminthological Society of Washington 52: 95–97.

FOSTER, M. L., AND S. R. HUMPHREY. 1995. Use of highway underpasses by Florida panthers and other wildlife. Wildlife Society Bulletin 23: 95–100.

GASHWILER, J. S., AND W. L. ROBINETTE. 1957. Accidental fatalities of the Utah cougar. Journal of Mammalogy 38: 123–126.

GLASS, C. M., R. G. MCLEAN, J. B. KATZ, D. S. MAEHR, C. B. CROPP, L. J. KIRK, A. J. MCKEIRNAN, AND J. F. EVERMANN. 1994. Isolation of pseudorabies (Aujeszky's Disease) virus from a Florida panther. Journal of Wildlife Diseases 30: 180–184.

GOLDMAN, E. A. 1946. Classification of the races of puma. *In* The puma, mysterious American cat, S. P. Young and E. A. Goldman (eds.). American Wildlife Institute, Washington, D.C., pp. 175–302.

GRAHAM, C. L. G. 1977. Copper levels in livers of turkeys with naturally occurring aortic rupture. Avian Diseases 21: 113–116.

GREINER, E. C., M. E. ROELKE, C. T. ATKINSON, J. P. DUBEY, AND S. D. WRIGHT. 1989. *Sarcocystis* sp. in muscles of free-ranging Florida panthers and cougars (*Felis concolor*). Journal of Wildlife Diseases 25: 623–628.

HEMKER, T. P., F. G. LINDZEY, AND B. B. ACKERMAN. 1984. Population characteristics and movement patterns of cougars in Southern Utah. Journal of Wildlife Management 48: 1275–1284.

HORNOCKER, M. G. 1970. An analysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. Wildlife Monograph 21. The Wildlife Society, Bethesda, Maryland, 39 pp.

KENNY, D. E., R. C. CAMBRE, T. P. ALVARADO, A. W. PROWTEN, A. F. ALLCHURCH, S. K. MARKS, AND J. R. ZUBA. 1994. Aortic dissection: An important cardiovascular disease in captive gorillas (*Gorilla gorilla gorilla*). Journal of Zoo and Wildlife Medicine 25: 561–568.

LACY, R. C. 1993. Impacts of inbreeding in natural and captive populations of vertebrates: Implications for conservation. Perspectives in Biological Medicine 36: 480–496.

LAMM, M. G., M. E. ROELKE, E. C. GREINER, AND C. K. STEIBLE. 1997. Microfiliaria in the free-ranging Florida panther (*Felis concolor coryi*). Journal of the Helminthological Society of Washington 64: 137–141.

LINDZEY, F. G., B. B. ACKERMAN, D. BARNHURST, AND T. P. HEMKER. 1988. Survival rates of mountain lions in southern Utah. Journal of Wildlife Management 52: 664–667.

———, ———, ———, T. BECKER, T. P. HEMKER, S. P. LAING, C. MECHAM, AND W. D. VANSICKLE. 1989. Boulder-Escalante cougar project: Final report. Utah Division of Wildlife Resources, Salt Lake City, Utah, 92 pp.

LOGAN, K. A. 1983. Mountain lion population and habitat characteristics in the Big Horn Mountains of Wyoming. M.S. Thesis, University of Wyoming, Laramie, Wyoming, 101 pp.

———, L. L. IRWIN, AND R. SKINNER. 1986. Characteristics of a hunted mountain lion population in Wyoming. Journal of Wildlife Management 50: 648–654.

———, L. L. SWEANOR, T. K. RUTH, AND M. HORNOCKER. 1996. Cougars of the San Andres Mountains, New Mexico: Final report. New Mexico Department of Game & Fish, Santa Fe, New Mexico, 208 pp.

LOTZ, M. A., E. D. LAND, AND K. G. JOHNSON. 1996. Evaluation of State Road 29 wildlife crossings: Final report, Study # 7583. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, 18 pp.

MAEHR, J. C. ROOF, E. D. LAND, J. W. MCCOWN, R. C. BELDEN, AND W. B. FRANKENBERGER. 1989. Fates of wild hogs released into occupied Florida panther home ranges. Florida Field Naturalist 17: 42–43.

———, R. C. BELDEN, E. D. LAND, AND L. WILKINS. 1990. Food habits of panthers in southwest Florida. The Journal of Wildlife Management 54: 420–423.

———, E. D. LAND, AND J. C. ROOF. 1991a. Social ecology of Florida panthers. National Geographic Research and Exploration 7: 414–431.

———, ———, AND M. E. ROELKE. 1991b. Mortality patterns of panthers in southwest Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 45: 201–207.

———, E. C. GREINER, J. E. LANIER, AND D. MURPHY. 1995. Notoedric mange in the Florida panther. Journal of Wildlife Diseases 31: 251–254.

MCBRIDE, R. T. 1976. The status and ecology of the mountain lion *Felis concolor stanleyana* of the Texas-Mexico border. M.S. Thesis, Sul Ross University, Alpine, Texas. 160 pp.

MCCAULEY, M. N. 1977. Current population and distribution status of the panther, *Felis concolor,* in Florida. M.A. Thesis, University of South Florida, Tampa, Florida. 58 pp.

MCCOWN, J. W., D. S. MAEHR, AND J. ROBOSKI. 1990. A portable cushion as a wildlife capture aid. Wildlife Society Bulletin 18: 34–36.

O'BRIEN, S. J., M. E. ROELKE, L. MARKER, A. NEWMAN, C. A. WINKLER, D. MELTZER, L. COLBY, J. F. EVERMAN, M. BUSH, AND D. E. WILDT. 1985. Genetic basis for species vulnerability in the cheetah. Science 227: 428–434.

———, ———, N. NUKI, K. RICHARDS, W. JOHNSON, W. L. FRANKLIN, A. ANDERSON, O. L. BASS, R. C. BELDEN, AND J. S. MARTENSON. 1990. Genetic introgression with the Florida panther (*Felis concolor coryi*). National Geographic Research and Explorer 6: 485–494.

QUIGLEY, H. B., AND M. G. HORNOCKER. 1992. Large carnivore ecology: From where do we come and to where shall we go? *In* Wildlife 2001: Populations, D. R. McCullough and R. H. Barrett (eds.). Elsevier Applied Science, New York, New York, pp. 1089–1097.

RALLS, K. B., AND J. BALLOU. 1979. Inbreeding and juvenile mortality in small populations of ungulates. Science 206: 1101–1103.

ROELKE, M. E., D. P. SCHULTZ, C. F. FACEMIRE, S. F. SUNDLOF, AND H. E. ROYALS. 1991. Mercury contamination in Florida panthers. Florida Panther Technical Subcommittee, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida. 50 pp.

———, AND C. M. GLASS. 1992. Florida panther biomedical investigations. Annual Performance Report, Endangered Species Project E-1 II-E-7 7506. Florida Game and Fresh Water Fish Commission, Gainesville, Florida, 35 pp.

———, D. J. FORRESTER, E. R. JACOBSON, G. V. KOL-

LIAS, F. W. SCOTT, M. C. BARR, J. F. EVERMANN, AND E. C. PIRTLE. 1993. Seroprevalence of infectious disease agents in free-ranging Florida panthers (*Felis concolor coryi*). Journal of Wildlife Diseases 29: 36–49.

———, J. S. MARTENSON, AND S. J. O'BRIEN. 1993. The consequences of demographic reduction and genetic depletion in the endangered Florida panther. Current Biology 3: 340–350.

ROSS, P. I., AND M. G. JALKOTZY. 1992. Characteristics of a hunted population of cougars in southwestern Alberta. Journal of Wildlife Management 56: 417–426.

———, ———, AND P. DAOUST. 1995. Fatal trauma sustained by cougars, *Felis concolor,* while attacking prey in southern Alberta. The Canadian Field-Naturalist 109: 261–263.

ROTSTEIN, D. S., S. K. TAYLOR, J. W. HARVEY, AND J. BEAN. 1999a. Hematologic effects of cytauxzoonosis in Florida panthers and Texas cougars in Florida. Journal of Wildlife Diseases 35: 613–617.

———, R. THOMAS, K. HELMICK, S. B. CITINO, S. K. TAYLOR, AND M. R. DUNBAR. 1999b. Dermatophyte infections in free-ranging Florida panthers (*Felis concolor coryi*). Journal of Zoo and Wildlife Medicine 30: 281–284.

———, S. K. TAYLOR, G. D. BOSSART, AND D. MILLER. 2000a. Dissecting thoracic aortic aneurysm in a free-ranging Florida panther (*Puma concolor coryi*). Journal of Zoo and Wildlife Medicine 31: 208–210.

———, ———, J. BRADLEY, AND E. B. BREITSCHWERDT. 2000b. Prevalence of *Bartonella henselae* antibody in Florida panthers. Journal of Wildlife Diseases 36: 157–160.

SITTON, L. W. 1977. California mountain lion investigations with recommendations for management: Final report to the State Legislature, P-R Project W-51-R. California Fish and Game Department, Sacramento, California, 35 pp.

SPREADBURY, B. 1989. Cougar ecology and related management implications and strategies in southeastern British Columbia. M. E. D. University of Calgary, Calgary, Alberta, Canada, 105 pp.

STEVERINK, P. J., R. KUIPER, AND E. GRUYS. 1995. Aneurysm of the cranial mesenteric artery in a cow. Veterinary Record 136: 69–72.

STOUT, C., AND F. BOHORQUEZ. 1972. Arteriosclerosis and other vascular diseases in zoo and laboratory animals. *In* Research animals and medicine, L. T. Harmisson (ed.). United States Department of Health Education and Welfare, Washington, D.C., pp. 841–853.

WEHINGER, K. A., M. E. ROELKE, AND E. C. GREINER. 1995. Ixodid ticks from panthers and bobcats in Florida. Journal of Wildlife Diseases 31: 480–485.

WILLIAMS, E. S., E. T. THORNE, M. J. G. APPEL, AND D. W. BELITSY. 1988. Canine distemper in black-footed ferrets (*Mustela nigripes*) from Wyoming. Journal of Wildlife Diseases 24: 385–398.

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