Eur J Wildl Res (2010) 56:939–942
DOI 10.1007/s10344-010-0423-8

SHORT COMMUNICATION

Causes of mortality in a Geoffroy's cat population—a long-term survey using diverse recording methods

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Received: 23 March 2010 / Revised: 16 July 2010 / Accepted: 28 July 2010 / Published online: 10 August 2010

Abstract We present quantitative data on the impact of different causes of mortality in a Geoffroy's cat (*Leopardus geoffroyi*) population inhabiting a protected area and adjacent cattle ranches in central Argentina. Between December 2000 and January 2009, we used three methods to collect data on causes of mortality in both the park and the ranches: (1) information obtained from 35 radio-collared Geoffroy's cats monitored from 1 to 19 months; (2) a systematic survey of the areas to find non-collared dead animals; and (3) interviews of qualified informants. Deaths of radio-collared individuals in the park were due to predation by puma (*Puma concolor*) or starvation, whereas deaths in the ranches were attributed to starvation and predation by domestic dogs. The death of eight emigrant cats was attributed mainly to poaching. Cause of death of 39 non-collared Geoffroy's cats was determined; deaths in the ranches were mainly due to predation by domestic dogs and poaching, whereas deaths in the park were attributed to predation by puma, poaching, and vehicle collision. Grouping all sources of information, human-related mortality accounted for most (62%) of Geoffroy's cat deaths recorded during this study, with poaching and predation by dogs being the main causes of mortality. This study in Geoffroy's cats is the first long-term survey of causes of mortality for a population of a small felid species in South America.

Keywords Argentina · Causes of mortality · Geoffroy's cat · Lihué Calel · Radio-telemetry

Communicated by C. Gortázar

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Introduction

For conservation strategies to be effective, a thorough assessment of cause-specific mortality of a species is necessary. The extent of knowledge on this issue is poor for most felids, but human-related mortality is currently considered the largest contributor to the reduction of most felid populations even inside protected areas (i.e., Woodroffe and Ginsberg 1998). For example, poaching and hunting have high impact on populations of the Eurasian lynx (*Lynx lynx*; Andrén et al. 2006), and road accidents are the leading cause of death for the small population of ocelots (*Leopardus pardalis*) in Texas (Haines et al. 2006).

Geoffroy's cat (*Leopardus geoffroyi*) is a small neotropical felid listed as near threatened (Nowell 2002) that inhabits a wide variety of habitats (Perovic and Pereira 2006). The impact of different threats on Geoffroy's cat populations has been poorly quantified. However, occasional records and anecdotal reports show that this species is usually a target of hunting by rural people either for its skin, meat or to prevent predation on poultry (Pereira

Table 1 Causes of mortality of radio-collared and non-collared Geoffroy's cats in Lihué Calel National Park and adjacent cattle ranches, Argentina during 2000–2009

Cause of death	Radio-collared cats			Non-collared cats	
	Residents[a]		Emigrants[b]	Park	Ranches
	Park	Ranches			
Predation by puma	3			3	
Starvation	2	4	1		
Poaching			5	2	8
Predation by dogs		1			12
Road kill			1	2	5
Unknown		1	1	7	
Total	5	6	8	14	25

[a] Animals that died in the park or ranch study areas

[b] Animals that died during their emigration from the study areas

2009). For over 10 years, we have been studying the ecology and demography of a Geoffroy's cat population inhabiting a protected area and adjacent cattle ranches in central Argentina. In this report, we present quantitative data on the impact of different sources of mortality for this population, segregating areas by land use and considering a variety of information sources to determine causes of mortality.

Study areas

The study was conducted in Lihué Calel National Park (37° 57′S, 65°33′W) and two adjacent cattle ranches in La Pampa province, central Argentina. The vegetation is characterized by a mosaic of creosote bush (*Larrea* sp.) flats, grasslands, and mixed shrub patches. Mean daily temperatures are 7.8°C in winter and 25.4°C in summer, and mean annual rainfall is 498±141 mm (data from the park weather station). Two drought periods occurred during our study, the first in 2003 (149 mm) and the second in 2005–2008 (mean annual rainfall 337.1±19.0 mm).

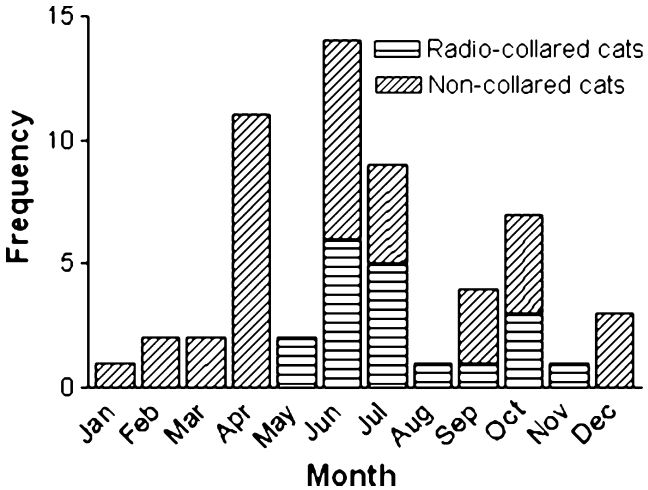

Fig. 1 Number of deaths of radio-collared and non-collared Geoffroy's cats relative to the month of the year in Lihué Calel National Park and adjacent cattle ranches, Argentina during 2000–2009

Materials and methods

In both the national park and the cattle ranches, we used different methods to collect data on causes of mortality for Geoffroy's cats. First, between 2002 and 2008 we captured and radio-collared 35 Geoffroy's cats, which were monitored for 1 to 19 months (Pereira et al. 2006; Pereira 2009). Cats were captured using Tomahawk live traps and only adults were fitted with collars with activity or mortality switches. These cats were monitored at least three times a month. When a mortality signal was detected, the individual was immediately located to determine cause of death through an inspection of the carcass and field evidence at the recovery site. If no evidence was found at this stage, we performed a necropsy.

Between December 2000 and January 2009, we recorded causes of death for several non-collared Geoffroy's cats by surveying the area to find dead animals or by interviewing qualified informants (park rangers, local ranchers, other scientists). Although these methods of data collection allowed us to complement our information on mortality causes, data obtained through these sources should be considered carefully; the nature of these complementary methods could bias the significance of different mortality causes because death events are differentially detected. For example, while a road-killed animal may be easily noticed or found by a park ranger or a rancher, the carcass of a cat that died due to starvation may be difficult to find, since cats usually tend to seek shelter in clumps of thick vegetation when dying (J. Pereira, personal observation). However, these additional sources of information allowed us to assess the impact of mortality factors poorly detected through radio-tracking (e.g., predation by dogs). For analysis, data was separated into two groups: (1) information obtained from radio-collared animals and (2) informa-

tion obtained from non-collared animals. Given the bias acknowledged for the second group, no statistical comparison of the data was made.

Results

Nineteen out of 35 individuals fitted with radio collars died during the course of the study; a cause of death was determined in 17 cases. Mortality in the park was due to predation by puma or starvation, whereas deaths in the ranches were attributed to starvation and predation by domestic dogs (Table 1). The cause of death of eight emigrant cats was recorded and most of these deaths were attributed to poaching (Table 1). Deaths were concentrated mainly in the winter period (Fig. 1); deaths due to starvation occurred during 2003 and 2007.

Seventy-three non-collared Geoffroy's cat deaths were recorded, but carcass examination was performed and cause of death was established in only 39 cases. Deaths in the ranches were mainly due to predation by domestic dogs and poaching, whereas deaths in the park were attributed to predation by puma, poaching, and vehicle collision (Table 1).

Discussion

Grouping all sources of information, human-related mortality accounted for most (62%) of Geoffroy's cat deaths recorded during this study, with poaching and predation by dogs as the main causes of mortality. Efforts to trap Geoffroy's cats by local people seem to have increased in recent years in response to increasing activity in the fur market in the region (J. Pereira, personal observation). However, because this activity is illegal, many ranchers are reluctant to report the capture of a Geoffroy's cat. Several radio-collared animals disappeared during the monitoring period. Although it is possible that some transmitters failed, it is also possible that some animals were poached and their transmitters destroyed, as was suggested by ranchers who acted as informants during this study. This would suggest that the impact of poaching by rural residents may be underestimated.

Predation by domestic dogs can be an important source of mortality for wildlife (Barnett and Rudd 1983). In our study area, dogs usually accompany ranchers during their travels through their properties, but they are also free to roam at night. Since dogs are bred by ranchers typically for hunting (J. Pereira, personal observation), they have specialized traits for finding and catching prey, making them predators of several wildlife species, including Geoffroy's cats.

Interspecific competition among carnivores usually leads to intraguild mortality with the largest competitor preying on the smaller (Donadío and Buskirk 2006) primarily when resources are scarce. Accordingly, events of Geoffroy's cat predation by puma were recorded during periods of drought (2003 and 2007–2008) and low food abundance. On the other hand, deaths due to starvation occurred during the coldest months in the driest years of the study. The winter period in the region is the most critical from the standpoint of trophic resources (Pereira 2009), and a poor diet can affect both ecological and physiological aspects. Felids require large amounts of energy to sustain activities such as body maintenance, resource acquisition, and growth (McNab 1989), and low temperatures increase the energy investment in thermoregulation, which typically is even more accentuated in nocturnal predators (Chappell 1980). Thus, prey shortages for Geoffroy's cats recorded during the winters of 2003 and 2007 (Pereira et al. 2006; Pereira 2009) coupled with the higher energy requirements of individuals to move under adverse weather conditions may have resulted in nutritional stress, significant negative energy balance, weight loss, debilitation and, ultimately, death.

Since poaching and predation by dogs were the most common causes of mortality recorded, enforcement of anti-poaching laws and a broader education program about the correct management of domestic animals need to be addressed to conserve Geoffroy's cats in this region. To the best of our knowledge, this study in Geoffroy's cats is the first long-term survey of causes of mortality for a population of a small felid species in South America.

Acknowledgments We thank several volunteers, park rangers, and ranchers for their assistance during fieldwork and to the staff of the WCS for performing histopathology analysis. This study was funded by The Rufford Foundation, WCS–Global Health Program, Dirección de Recursos Naturales de La Pampa, Cleveland Metroparks Zoo, Roger Williams Park Zoo, and Amersfoort Zoo.

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