Short note

Fernando R. Tortato*, Allison L. Devlin, Ricardo L. P. Boulhosa and Rafael Hoogesteijn

Relative rarity of small wild cats in the Brazilian Pantanal

https://doi.org/10.1515/mammalia-2019-0151
Received December 13, 2019; accepted June 2, 2020; published online July 29, 2020

Abstract: Small wild cats (SWC) are naturally cryptic species. The current study presents occurrence information and capture-rates on four SWC species found in the Brazilian Pantanal. The most commonly recorded SWC by camera trap was *Leopardus pardalis*. *Leopardus colocolo* and *Puma yagouaroundi* were relatively rare, while *Leopardus guttulus* was not recorded in any survey year. We interpret our findings based on the potential competitive influences of *L. pardalis* and practical implications of camera trap survey design. We recommend that future studies should design camera trap grids with spacing appropriate for SWC to more directly address questions on local population status and interspecific interactions.

Keywords: camera trap; *Leopardus sp.*; Ocelot effect; Pantanal; *Puma yagouaroundi*; small wild cats (SWC).

Small wild cats (SWC) are cryptic and primarily nocturnal species that naturally occur in low densities such that field observations are rare (Hunter 2011; Sunquist and Sunquist 2002). Located in the center of South America, the Pantanal floodplain is one of the largest inland wetlands in the world (Harris et al. 2005; Junk et al. 2006) and is included in the range of four SWC species: pampas cat *Leopardus colocolo*; oncilla *Leopardus guttulus*; ocelot *Leopardus pardalis*; and jaguarundi *Puma yagouaroundi* (Nascimento and Feijó 2017; Rodrigues et al. 2002). Although Geoffroy's cat *Leopardus geoffroyi* and margay *Leopardus wiedii* have been recorded in this region, these species were not included in the current study as they only occur along the periphery of the Pantanal (Rodrigues et al. 2002; Tomás et al. 2010).

One of the most effective methods to detect naturally rare and elusive species includes the use of non-invasive technology such as remotely triggered camera traps (Karanth and Nichols 1998; Porfírio et al. 2018; Srbek-Araujo and Chiarello 2005; Tobler et al. 2008; Tomás et al. 2003). Over the past 16 years, camera trap surveys conducted in the Pantanal have provided insights into the distribution of *L. colocolo* (Godoi et al. 2010), temporal niche partitioning between *L. pardalis* and *P. yagouaroundi* (Bianchi et al. 2016; Porfírio et al. 2018), and density estimates of *L. pardalis* (Trolle and Kéry 2003; Trolle and Kéry 2005). Among these species, *L. guttulus* is the most data deficient (Tomás et al. 2010). The presence of *L. guttulus* in the Pantanal was first verified in 1988 with a skin (Figure 1) collected in the Poconé region (Mato Grosso, Brazil) and currently housed in the scientific collection of the Emili Goeldi Museum (catalogue number MPEG22193; Belém, Brazil; Nascimento and Feijó 2017). There has since been only one verified photographic record of *L. guttulus* obtained by camera trap (Trolle 2003).

Herein, we analyzed camera trap data from long-term annual surveys to estimate the capture rate (([photographic records/survey effort] × 100); Carbone et al. 2001) of SWC at two cattle ranches (Fazenda São Bento, Mato Grosso do Sul, Brazil; Fazenda Jofre Velho, Mato Grosso, Brazil) in the Porto Jofre region of the northern Brazilian Pantanal. Camera trap surveys were designed for the study of jaguars *Panthera onca*; (i.e., minimum distance of 2,500 m between each station or 2–3 cameras per female jaguar home range; camera trap height ~40 cm above ground level; Soisalo and Cavalcanti 2006) and covered a total area of up to 300 km^2. We only counted independent records of SWC (i.e., photographs recorded at ≥ 1 h intervals) and compared our records with those from other studies conducted in the Pantanal (Table 1). As it is considered

***Corresponding author: Fernando R. Tortato**, Panthera, 8 West 40th St. 18th Floor, New York, NY 10018, USA,
E-mail: ftortato@panthera.org. https://orcid.org/0000-0003-1901-5037
Allison L. Devlin: Panthera, 8 West 40th St. 18th Floor, New York, NY 10018, USA; Wildlife Biology Program, W.A. Franke College of Forestry and Conservation, University of Montana, 32 Campus Drive, Missoula, MT 59812, USA
Ricardo L. P. Boulhosa: Instituto Pró-Carnívoros, Av. Horácio Neto, 1030, Atibaia, SP, 12945-010, Brazil
Rafael Hoogesteijn: Panthera, 8 West 40th St. 18th Floor, New York, NY 10018, USA

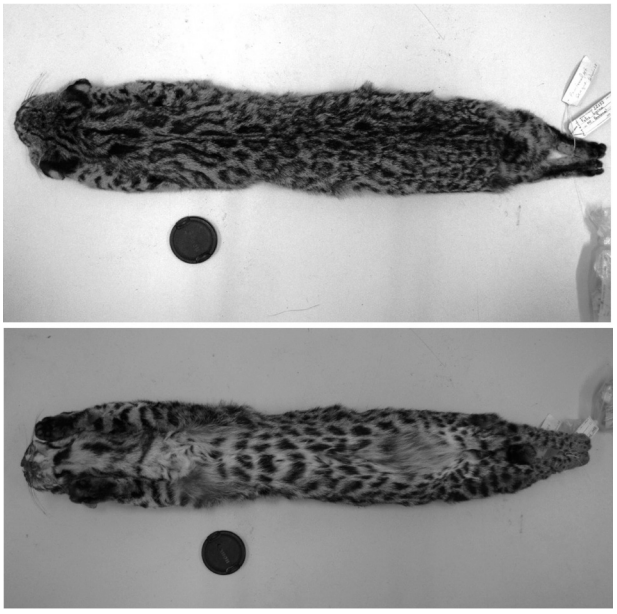

Figure 1: *Leopardus guttulus* skin collected in 1988 from the Pantanal of Poconé, Mato Grosso state, and housed in the Emilio Goeldi Museum (catalogue number MPEG22193; Belém, Brazil). Photo credit: Fábio Nascimento.

the rarest SWC species in the Pantanal, we also included visual observations of *L. guttulus* made by felid researchers between 1994 and 2018 in the same region sampled by camera trap surveys.

We conducted 17 independent surveys from 2011 through 2018 with a total effort of 7559 trap nights. We recorded 1236 independent photos of *L. pardalis*, 20 of *P. yagouaroundi*, and one of *L. colocolo*. Between 1994 and 2018, 13 visual records of *L. guttulus* occurred in the same region sampled by camera traps (Table 2). All observations were less than 60 km from the site where the individual *L. guttulus* was first collected in 1988 (Figure 1; Nascimento and Feijó 2017); all subsequent visual records of *L. guttulus* occurred during field surveys (i.e., transects; night spotlighting) along the edge of forested areas. Ecotourism guides in the region (Tortato and Izzo 2017) reported observations of *L. guttulus* in lodges near the study area. However, the authors did not receive photographic confirmation of the sightings and thus did not include the observations in the current study. Due to the phenotypic similarity between spotted SWC species *L. guttulus* and juvenile *L. pardalis*, our 13 direct visual records of *L. guttulus* are considered likely but not confirmed.

Capture rates for *L. colocolo*, *L. guttulus*, and *P. yagouaroundi* estimated in this study were similar to those from other areas of the Pantanal (Table 1). Among all studies, *L. pardalis* was one of the most frequently recorded carnivore species (Porfírio et al. 2018; Trolle, 2003). The capture rate of *L. pardalis* in this study, however, was 2.45 times higher than reported in the literature (Table 1).

According to Arita et al. (1990), the rarity of Neotropical forest mammals can be divided into four categories: restricted distribution and high density; wide distribution and high density; restricted distribution and low density; and wide distribution and low density. The majority of SWC species in the Pantanal most closely align with the category of wide distribution and low density (Arita et al. 1990). The rarity of *L. guttulus* and other SWC observed in the Pantanal were similarly found in Bolivia, where *Leopardus tigrinus* and *L. colocolo* were first confirmed only in 2001 (Pacheco et al. 2001) and 2012 (Luque et al. 2012), respectively. In Colombia, between 1970 and 2011 there were only 16 confirmed records of *L. tigrinus* (Payán-Garrido and

Table 1: Summary of study design and species-specific capture rates ((photographic records/survey effort) × 100) from studies conducted on each small wild cat (SWC) species in the Pantanal.

Study details	Study site				
	A	B	C	D	E
Design					
Distance between stations (m)	*NI*	500	1,000	1,500	2,500
Sampled area (km^2)	20	43	20	*NI*	300
Grid-based sampling	No	Yes	Yes	No	Yes
Species					
Leopardus pardalis	30 (6.66)	68 (3.04)	13 (2.30)	176 (1.39)	1,236 (16.35)
Puma yagouaroundi	0 (0)	7 (0.31)	5 (0.89)	15 (0.12)	20 (0.26)
Leopardus colocolo	0 (0)	2 (0.09)	1 (0.18)	0 (0)	1 (0.01)
Leopardus guttulus	1 (0.22)	0 (0)	0 (0)	0 (0)	0 (0)
Total number of records	450	2,238	564	12,703	7,559

Species-specific values are reported as total number of records with capture rates in parentheses. Study sites: A (Trolle 2003); B (Bianchi 2009); C (Bolzan 2011); D (Porfírio et al. 2018); and E (this study). *NI*: Not Informed.

Table 2: Visual records of *Leopardus guttulus* in the northern region of the Pantanal from 1998 to 2018.

Date	Site	Time (24:00 h)	Coordinates (WGS84 decimal degrees)	
			X	Y
1988	Rio Cassange*	-	−57.22202	−17.08216
May 1996	Estrada da Base	Night	−56.96554	−17.13772
May 1998	Fazenda São João	19:58	−56.67616	−16.89141
July 1998	Fazenda São João	21:13	−56.70981	−16.87963
July 1998	Fazenda São João	5:33	−56.68768	−16.88473
August 1998	Transpantaneira	18:05	−56.92126	−17.19879
February 1999	Transpantaneira	19:54	−56.93286	−17.14326
July 1999	Fazenda São João	23:55	−56.66485	−16.99328
July 1999	Fazenda São João	01:06	−56.69626	−16.88093
November 2001	Fazenda Santa Inês	07:22	−57.15377	−16.63085
July 2009	Fazenda São Bento	19:40	−56.73716	−17.32642
September 2011	Fazenda São Bento	20:00	−56.74627	−17.35416
August 2012	Fazenda São Bento	21:15	−56.74295	−17.32960
October 2018	Estrada da Base	22:00	−56.93986	−17.11786

The first confirmed record of *L. guttulus* in the Pantanal was an adult male collected in 1988 and deposited at the Emilio Goeldi Museum (catalogue number MPEG22193; Belém, Brazil; Nascimento and Feijó, 2017).
*Nascimento and Feijó 2017.

González-Maya 2011). Due to its morphological similarity with other species of spotted cats (e.g., juvenile *L. pardalis*), cryptic habits, and overall data deficiency, the distribution of *L. guttulus* in the Pantanal is difficult to accurately map (Rodrigues et al. 2002). However, the visual observations of *L. guttulus* occurred in similar geographic region and habitat composition as the specimen collected in 1988. Such observations can assist in directing future survey efforts to better understand the occurrence and ecology of this rare species.

The relatively high density of *L. pardalis* in the Pantanal (Trolle and Kéry 2005) may be a contributing factor to the low detectability and density of other SWC species, likely due to potential intraguild competition termed the "Ocelot effect" (Oliveira et al. 2010). Prior studies indicate that *L. pardalis* may be a competitor or even be a potential predator of *L. guttulus*, *L. colocolo*, and *P. yagouaroundi* (Oliveira and Pereira 2013). For example, *L. guttulus* shifts activity patterns to avoid overlap with *L. pardalis* (Oliveira-Santos et al. 2012), indicating potential intraspecific conflict or predator effect.

Survey design may have also contributed to the observed relative rarity of the SWC species. Minor changes in the spacing of sampled sites can influence species-specific detection rates (Srbek-Araujo and Chiarello 2013; Trolle and Kéry 2005). In our review (Table 1), each study used a different survey design, thus making comparisons difficult. For logistic reasons, most studies deploy camera traps along trails and roads, thus neglecting a question- or design-driven distribution of cameras across the landscape (e.g., random or grid-based sampling for density or occupancy analyses; MacKenzie and Royle 2005; Sollmann et al. 2012; Tobler and Powell 2013). This bias in sampling design may affect estimates for elusive species like wild cats (Tobler and Powell 2013). The majority of studies conducted in the Pantanal did not use a random sampling design. In Asia, Wearn et al. (2013) compared data from random and non-random camera trap placement, and found that the non-random survey design resulted in underestimated abundances of *Catopuma badia*.

Placement of camera traps on- versus off-road can also influence the probability of detection. In the Neotropics, roads and trails are differentially used by species including *P. onca* and *Puma concolor*, whereby *P. onca* used roads more frequently than *P. concolor* (Harmsen et al. 2010). Intraspecific variations in detection rates have been found between males and females of *P. onca*, whereby males were significantly more detectable on roads versus females (Sollmann et al. 2011). In SWC, the detection rate of *L. pardalis* was higher on roads versus forested trails (Srbek-Araujo and Chiarello 2013).

The present study provides support for potential contributing factors to the relative rarity of *L. colocolo*, *L. guttulus*, and *P. yagouaroundi* in the Pantanal. Due to low capture rates, future research should design surveys with camera trap spacing and efforts appropriate for SWC. Insights gained through camera trap surveys will provide better understanding of SWC ecology, including site-specific to range wide distribution and density, population rates and traits, and interspecific interactions. Ultimately,

understanding SWC distribution and the factors that contribute to their persistence across a given landscape will help provide more scientifically accurate conservation assessments and guide future management plans.

Acknowledgments: The authors would like to thank the ranch employees of Fazenda São Bento (MS, Brazil) and Fazenda Jofre Velho (MT, Brazil) who assisted in the field activities. We thank Fabio Nascimento for kindly providing the photo of *Leopardus guttulus* from the collection of the Emilio Goeldi Museum (Belém, Brazil).
Author contribution: All the authors have accepted responsibility for the entire content of this submitted manuscript and approved submission.
Research funding: None declared.
Conflict of interest statement: The authors declare no conflicts of interest regarding this article.

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