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Short communication

Do female jaguars (*Panthera onca* Linnaeus, 1758) deliberately avoid camera traps?

Ana Carolina Srbek-Araujo [a,b,*]

[a] *Laboratório de Ecologia e Conservação de Biodiversidade, Programa de Pós-graduação em Ecologia de Ecossistemas, Universidade Vila Velha – UVV, Rua Comissário José Dantas de Melo, no 21, Bairro Boa Vista, Vila Velha, Espírito Santo, CEP 29.102-920, Brazil*
[b] *Instituto SerraDiCal de Pesquisa e Conservação, Belo Horizonte, Minas Gerais, Brazil*

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ABSTRACT

Female jaguars have lower capture rates because they move less, have smaller territories and use habitat differently than males. Also, I found evidence that suggests that females may avoid camera traps and thus cause a sex bias in camera trap records. Most records of females (83%) were from the first year of a 54 month study (2005–2013), and 79% of those were during the first six months of camera trapping. Males were also captured at a greater rate during the first six months of sampling (39% of all records), and they were recorded continuously when camera traps were installed on roads (in contrast to females). A previous study found individual heterogeneity in capture probability and estimated 78% annual survival probability for the local population over five sampling periods. If population size was declining, a bias towards a greater rate of decline in females (or the disappearance of only females) is unlikely (males continued to be captured), and does not explain the fourfold reduction in the capture success of females after the first six months of sampling (four females were present throughout the entire first period). The deliberate tendency of females to avoid camera traps, more than males, as I suggest here, may cause a bias in determining both population size and sex ratios in jaguars, as well as an important underestimation of reproduction, thereby biasing estimates of population structure. This issue is important when using camera-traps to examine feline population biology and requires further evaluation.

Female jaguars (*Panthera onca* Linnaeus, 1758) ususlly have lower capture probabilities than males in camera trap studies, and this pattern is often attributed to females having smaller territories and moving less (Salom-Pérez et al., 2007). This pattern may account for the lower capture (trap encounter) rates, independently of camera-trap placement (Sollmann et al., 2011). Alternately, differential habitat use can also cause differences in the probability of detection of jaguars by sex (Salom-Pérez et al., 2007; Conde et al., 2010; Sollmann et al., 2011). Each of these possibilities will lead to underestimating the number of females (Salom-Pérez et al., 2007). Here, I report on differences in records of female and male jaguars in an Atlantic Forest remnant in southeastern Brazil, and the data suggest that these different capture rates may be due to a tendency by females to avoid camera traps deliberately.

Jaguars were studied in the Vale Nature Reserve (*Reserva Natural Vale*, hereafter RNV), located 30 km north of the Doce River between the municipalities of Linhares and Jaguaré in the state of Espírito Santo, southeastern Brazil. The RNV (19°06′ –19°18′ S, 39°45′–40°19′W) is a private protected area of 22,711 ha, adjacent to three other protected areas, forming a nearly continuous block of native vegetation (Linhares-Sooretama Block, ~50,000 ha). This remnant comprises about 10% of the forest remaining in the entire state (based on data available in FSOSMA and INPE 2014). The RNV is mainly dense lowland forest (*Tabuleiro* forest) with a network of unpaved roads that allow access to most of the reserve. Roads are ~4 m wide and ~126 km in total length (Jesus and Rolim 2005). Road use is restricted to staff and authorized researchers. RNV is surrounded by agriculture activities (mostly by pasture, fruit and coffee) and silviculture of eucalyptus. More detailed information about the study area can be found in Srbek-Araujo and Chiarello (2013).

Data were collected during 54 months of sampling over five sampling periods (June 2005–January 2013). Cam Trakker game cameras (Cam Trak South Inc., USA) were used in the first period; Tigrinus cameras (conventional model; manufactured by Tigrinus

* Corresponding author at: Laboratório de Ecologia e Conservação de Biodiversidade, Programa de Pós-graduação em Ecologia de Ecossistemas, Universidade Vila Velha – UVV, Rua Comissário José Dantas de Melo, nº 21, Bairro Boa Vista, Vila Velha, Espírito Santo, CEP 29.102-920, Brazil.
E-mail address: srbekaraujo@hotmail.com

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Table 1
Description of the sample design used during each sampling period (from June 2005 to January 2013). In Jun 2009–Feb 2010, only the north area was sampled; in all other periods, all three areas were sampled.

Sampling Period	Camera Trap placement	Number of sampling points	Duration (months)	Effort (time/sampling point)	Camera spacing (km)[a]
Jun 2005 –Jun 2006 – 1	Road	30 (10/area)	12	4 months/area (2 wet and 2 dry season)	2.35 (1.96)
Jun 2006 –Aug 2007 – 2	Edge	10	14	Fixed	4.40 (4.05)
Aug 2007 –Oct 2008 – 3	Forest interior	10	14	Fixed	5.14 (3.93)
Jun 2009 –Feb 2010 – 4	Road	8	8	Fixed	2.31 (1.75)
Jul 2012 –Jan 2013 – 5	Road	30 (10/area)[b]	6	2 months/area	2.35 (1.96)

[a] Average distance between adjacent sampling points (the minimum spacing between cameras is shown in parentheses).
[b] Same points sampled during the first period.

Research Equipment, Brazil) were used in the subsequent three periods; and digital Bushnell camera traps (model Trophy Cam; manufactured by Bushnell Inc., USA) in the last period.

Camera traps were placed in three areas within the reserve (north, south and west) at selected points regularly spaced. In the first, fourth and fifth periods, cameras were placed along unpaved roads and separated by 3.6 km (based on the size of the smallest home range estimated for jaguars, following Silver et al., 2004). In the second period, cameras were placed at 100–200 m from roads margins (edges), and in the third period, about 500 m from the nearest road (forest interior). In the second and third periods, greater distances were used to cover a larger area of the reserve. The sampling design is summarized in Table 1.

For analysis, I calculated sampling effort (number of camera traps × number of sampling days; Srbek-Araujo and Chiarello, 2005) and estimated capture success as the number of jaguars photographed per camera per day (number of records of jaguar per sampling effort × 100; adapted from Srbek-Araujo and Chiarello (2005)). I considered only the first photograph of the species obtained from the same sampling point within 1 h as a valid record (Srbek-Araujo and Chiarello, 2013), except when jaguars from consecutive records were identified as different individuals. In these cases, the first record of every individual during 1 h was considered as a valid event.

A total of 145 independent records (photographs or videos) of jaguars were obtained between June 2005 and January 2013. Of these, 55% were male (n = 80), 36% were female (n = 52) and 9% were unidentifiable (n = 13; Table 2). The sex ratio of adult jaguars photographed during the first period was 1:2 (male:female). Two sub-adults were photographed in the first period (one male and one female), and only adults were photographed in the remaining sampling periods. There was no evidence of cubs during the entire study (for details, see Srbek-Araujo and Chiarello, 2017).

Ninety seven percent of all photographs were on roads, with 1–45 (mean = 15; mean for males = 26.3, mean for females = 10.4) photographs per individual recorded. Individuals were recorded more often in this than in other, similar, studies (e.g. Soisalo and Cavalcanti 2006; Astete 2012), and here more female than male jaguars (number of individuals) were captured by camera traps than eslwhere (e.g. Silver et al., 2004; Soisalo and Cavalcanti, 2006; Salom-Pérez et al., 2007; Sollmann et al., 2011; Astete, 2012).

Most photographs of females were recorded during the first period of study (83% of the total, n = 43; Table 2), of which 79% (n = 34) were from the first six months of sampling (capture success = 2.24; Fig. 1a). In this period, five females were recorded (6.8 records/individual), and in the following six months, four females were recorded (2.3 records/individual, n = 9 photographs, 21%, capture success = 0.59; Fig. 1b). Three females were recorded off roads, and only three photographs of females were obtained, all during the second period. Only one female was photographed when camera traps were again placed along roads (fourth period, Fig. 1). This same female was also photographed in the first period of sampling and at that occasion it was a sub-adult. No females were recorded during the third and last periods (Table 2, Fig. 1). In the first period, males were also more frequently photographed in the first six months of sampling (n = 32, 84% of the total annual; Fig. 1). However, the three males photographed in this period were also successfully recorded during the fourth period, and two during the fifth period, both with camera traps placed on roads (Table 2, Fig. 1). Only one new individual jaguar was recorded after the first sampling period (sex unidentified; Table 2).

While the difference in the capture probability or capture success by sex is expected (Salom-Pérez et al., 2007; Conde et al., 2010; Sollmann et al., 2011), sexual differences in habitat use is probably the reason for this difference. Females may be less likely than males to use human-made trails and roads (Salom-Pérez et al., 2007; Conde et al., 2010; Sollmann et al., 2011) and are photographed more often away from roads, while the effect of roads on males occurrence is negligible (Conde et al., 2010). However, greater female capture success early in this study suggests that, at first, females did not avoid roads in the RNV (the first study period was the very first sampling with camera traps in the region). Thus, the subsequently reduced capture rates (after six months of sampling in the first period or after the first contacts of jaguars with camera traps in all three RNV areas) suggest that females began to avoid camera traps following exposure to traps (Fig. 1). Even with the reduced capture success, four of the five females were present throughout the entire first period (first and second semesters of sampling; Fig. 1).

I examined the status of this jaguar population previously with the same data and the best model to estimated abundance was the heterogeneity model (Mh; Srbek-Araujo and Chiarello, 2017). This model assumes a different capture probability for each individual and so is more biologically realistic because it incorporates behavioral responses to trapping (Karanth 1995; Karanth and Nichols 1998). Due to the small sample size and capture rates over time, determining the effect of sex on detectability or capture probability was not possible using Cormack–Jolly–Seber (Srbek-Araujo and Chiarello, 2017). The local jaguar capture probability was 18% which differs between individuals (at least those in the RNV; Srbek-Araujo and Chiarello, 2017).

While a matrix of pasture surrounds much of the RNV, jaguars have not been implicated in recent cattle predation, nor in any other conflict with humans (Srbek-Araujo and Chiarello, 2017). Only one record shows that two jaguars were killed for taking cattle in 1971 in Linhares (Lorenzutti and Almeida 2006). During the present sampling, annual survival probability was estimated at 78% (Srbek-Araujo and Chiarello, 2017). Additionally, using fecal sampling and microsatellite markers (fecal samples collected from November 2006 to October 2008), 11 individual genotypes of jaguars were identified in the RNV (Srbek-Araujo et al., 2013). Five genotypes were from samples collected in 2008 (months 31–40 of the camera-trapping intervals), four of which were not found in previous years by genetic analysis. These data show that jaguars (certainly including females) were in the study area, but camera traps failed to record them. If after that the population size was declining, it is inexplicable that only females were lost from the study area, noting that males continued to be captured. And, if females were exposed