

Note on the diet of the jaguar in central Brazil

Rahel Sollmann · Julie Betsch ·
Mariana Malzoni Furtado · Heribert Hofer ·
Anah T. A. Jácomo · Francisco Palomares ·
Severine Roques · Natália Mundim Tôres ·
Carly Vynne · Leandro Silveira

Received: 21 November 2012 / Revised: 26 February 2013 / Accepted: 28 February 2013 / Published online: 14 March 2013
© Springer-Verlag Berlin Heidelberg 2013

Abstract Diet of the jaguar *Panthera onca* in the Cerrado, central Brazil, was investigated based on a sample of genetically identified jaguar scats. At least nine prey species were observed in 35 scat samples. Giant anteaters *Myrmecophaga tridactyla* contributed more than 75 % of biomass to the observed diet. Tapirs *Tapirus terrestris* and peccaries *Tayassu pecari* and *Pecari tajacu* contributed approximately 6 % to jaguar diet each, and small mammals contributed least to the jaguar diet. At 0.121, dietary niche breadth was narrower than reported in most other studies. Due to their physical characteristics and abundance, giant anteaters are likely the most profitable prey for jaguars in Emas National Park, and as an important prey, they should be included in jaguar conservation efforts.

Keywords Cerrado · Giant anteater · *Myrmecophaga tridactyla* · *Panthera onca* · Peccaries · Tapirs · *Tapirus terrestris*

Introduction

Many carnivore species are of conservation concern due to habitat conversion and conflict with humans. Depletion of a carnivore's prey base can reduce its population size and lead to local extinction (Karanth and Chellam 2009). Thus, understanding dietary requirements of carnivores is a prerequisite for their conservation.

The jaguar *Panthera onca* (Linnaeus, 1758) is the largest cat of the American continent. With more than 80

Communicated by C. Gortázar

R. Sollmann · M. M. Furtado · A. T. A. Jácomo · N. M. Tôres ·
L. Silveira
Jaguar Conservation Fund/Instituto Onça-Pintada, Mineiros,
Brazil

R. Sollmann · H. Hofer
Leibniz Institute for Zoo and Wildlife Research, Berlin, Germany

J. Betsch
College of Forestry and Conservation, University of Montana,
Missoula, MT, USA

M. M. Furtado
Universidade de São Paulo, Faculdade de Medicina Veterinária e
Zootecnia, São Paulo, Brazil

F. Palomares · S. Roques
Department of Conservation Biology, Estación Biológica de
Doñana (CSIC), Sevilla, Spain

N. M. Tôres
Departamento de Biologia Geral, Universidade Federal de Goiás,
Goiânia, Brazil

C. Vynne
Department of Biology, University of Washington, 24 Kincaid
Hall,
Seattle, WA, USA

R. Sollmann (✉)
Department of Forestry and Environmental Resources, North
Carolina State University, Campus Box 7646, Raleigh, NC 27695-
8003, USA
e-mail: rsollma@ncsu.edu

documented prey species (Seymour 1989), jaguars are opportunistic predators that feed preferably on medium to large prey species (Lopez-González and Miller 2002; Oliveira 2002). The jaguar is classified as ‘near threatened’ owing to decreasing population trends (IUCN 2011). Its range has reduced by approximately 45 % over the last century (Zeller 2007). Here, we investigate jaguar diet in the Cerrado grasslands of central Brazil, where the species remains little studied and is classified as endangered (Moraes Jr. 2012).

Material and methods

The Cerrado covers 21 % of Brazil; over the last 35 years, more than half has been transformed into cultivated land (Klink and Machado 2005). Emas National Park (ENP) is located in south-western Goiás (18°19' S, 52°45' W), in a highly productive agricultural region. Its 1,320 km² protect large tracts of grassland plains with patches of shrub fields, marshes and riparian forest. During the wet season (October to March), rainfall averages 1,500 mm. There is very little precipitation during the rest of the year.

We quantified jaguar diet based on 39 genetically identified jaguar scats collected with the aid of scat detector dogs (14 collected by the Jaguar Conservation Fund—JCF—in 2009 (Sollmann 2011) and analysed as described in Roques et al. (2011); 25 collected and analysed as described in Vynne et al. (2011, 2012) between 2004 and 2008) along 3,500 km of transects in ENP. Because yearly sample sizes were too small for separate analysis, we pooled samples across years. Genetic fingerprinting showed that samples belonged to at least 12 individuals (CV and JCF, unpublished data).

We identified non-digested prey remains to the lowest possible taxonomic level using a reference collection (Quadros 2002). For each prey species i , we counted the frequency of occurrence in the scats f_i ; when a scat sample contained remains of more than one species, these were counted as fractional contributions to the frequency of the respective species (Link and Karanth 1994). We calculated relative scat frequency fr_i as

$$fr_i = f_i / \sum f.$$

To estimate the contribution of biomass of each species, we applied the method by Wachter et al. (2012) who, based on feeding trials with cheetahs, established a regression formula to calculate biomass consumed per field collectable scat, y , as a function of live weight of prey species, x , taking into account that this relationship is not linear:

$$y = 2.358 \times (1 - \exp(-0.075x)).$$

Table 1 Prey species identified in 35 jaguar scats from Emas National Park, central Brazil

Species	f	fr	MPW (kg)	BPS (kg)	b
Tapir	2.00	0.06	239	2.36	0.08
Peccary	2.00	0.06	24.5	1.98	0.07
Giant anteater	26.17	0.74	30.5	2.12	0.76
Agouti	1.17	0.03	2.9	0.46	0.01
Opossum	0.33	0.01	1.25	0.21	<0.01
Domestic cattle	1.00	0.03	175	–	0.05
Capybara	0.50	0.01	50	2.30	0.03
Unidentified felid ^a	1.33	0.04	–	–	–
Unidentified bird/reptile ^a	0.50	0.01	–	–	–

f absolute scat frequency, fr relative scat frequency, MPW mean prey weight according to unpublished data by the Jaguar Conservation Fund (unpublished data) and Reis et al. (2006), BPS biomass consumed per field collectable scat, following Wachter et al. (2012), b relative biomass consumed

^a Not considered in calculations involving biomass because body weight could not be determined

We calculated relative biomass consumed b_i as

$$b_i = fr_i y_i / \sum fr \times y.$$

We obtained body weight of prey species from field data from ENP (JCF, unpublished data) and Reis et al. (2006). To estimate dietary niche breadth, we calculated Levins' index B (Levins 1968):

$$B = 1 / \sum b^2.$$

We standardized B according to Hurlbert (1978):

$$B_A = (B - 1) / (I - 1),$$

where I is the total number of species in the diet. We performed all calculations in the free software R version 2.13.0 (R Development Core Team 2011).

Results

Four scats did not contain identifiable prey remains. In the remaining 35 scats, giant anteater *Myrmecophaga tridactyla* was the dominant prey species, contributing 76 % to the consumed biomass. We also found remains of tapir (*Tapirus terrestris*), capybara (*Hydrochaeris hydrochaeris*), opossum (*Didelphis albiventris*), domestic cattle (*Bos taurus*), peccaries (*Tayassu pecari* or *Pecari tajacu*), agouti (*Dasyprocta* sp.) and unidentified birds/reptiles and felids (Table 1). Since the felid and bird/reptile remains could not be identified to genus

level, these were excluded from further analyses. Standardized niche breadth was 0.121.

Discussion

Although the results from our small data set collected across several years and seasons need to be interpreted with care, with over 75 % of consumed biomass giant anteaters seemed the most important prey species of jaguars in ENP. Though large (30 kg), these solitary foragers are well below a jaguar's own body weight and thus unlikely to inflict serious injury, which is one of the main foraging costs for large predators (Berger-Tal et al. 2009). As jaguar population density in ENP is as low as 0.3–0.6 individuals/100 km² (Sollmann et al. 2011) and there are 20 to 40 giant anteaters per 100 km² (Miranda et al. 2006), they may be sufficiently abundant to become the stock prey of the jaguar.

A strong preference of the giant anteater by the jaguar has not been observed before. In general, jaguar dietary niches are broader than the 0.121 observed in the present study (Leite and Galvão 2002; Núñez et al. 2002; Scognamiglio et al. 2003; Azevedo and Murray 2007; Azevedo 2008). Only Foster et al. (2009) observed a similarly narrow niche in undisturbed forests in Belize, where armadillos made the largest contribution to jaguar diet. However, the small sample size in the present study (Foster et al. 2010) and the fact that we excluded unidentified species from niche breadth analysis may have contributed to the narrow niche we observed.

Both tapirs and peccaries made relatively low contributions (6–7 % of consumed biomass) to the jaguar diet in ENP. Most studies report tapirs as an infrequently taken prey (Novack et al. 2005), which may be a consequence of tapirs being larger than the jaguar. In contrast, peccaries are often cited as important prey (Polisar et al. 2003; Azevedo and Murray 2007; Cavalcanti and Gese 2010). The low frequency of occurrence in scats could be a function of the overall small sample size. Alternatively, jaguars may prey less intensely on the group-living peccaries in ENP because of the abundance of the more vulnerable giant anteater. Small mammals (agoutis and opossums) played a secondary role in jaguar diet in ENP, which is expected for this large predator (Lopez-González and Miller 2002).

Giant anteaters have undergone a steady population decline in the region of ENP over the last decades (Collevatti et al. 2007); peccaries are frequently killed in the park's surroundings in retaliation to crop raiding (Jácomo 2004). Since the conservation of large felids depends on the conservation of their prey, these and other prey species should be included in future jaguar research and conservation efforts in ENP.

Acknowledgments This study received financial support from the Disney Worldwide Conservation Fund, Fundação Monsanto, the Earthwatch Institute, the Memphis Zoo, the Leibniz Institute for Zoo and Wildlife Research, the Fundación BBVA (project BIOCON 05 – 100/06) and Idea Wild. RS received a scholarship from the German Academic Exchange Service (DAAD). We thank ICMBio for granting permission to work in ENP and ENP management for logistical support. We thank the kennels Canil Caraibas and HR for their technical support regarding the scat detector dogs. We are indebted to the entire Jaguar Conservation Fund team, all Earthwatch volunteers and interns, and especially Raphael Almeida, Tiago Boscarato and Grasiela Porfirio for the help with field work and scat analysis. We thank Mirjam Nadjafzadeh for comments on the manuscript.

References

- Azevedo FC (2008) Food habits and livestock depredation of sympatric jaguars and pumas in the Iguacu National Park area, south Brazil. *Biotropica* 40:494–500
- Azevedo FC, Murray DL (2007) Spatial organization and food habits of jaguars (*Panthera onca*) in a floodplain forest. *Biol Conserv* 137:391–402
- Berger-Tal O, Mukherjee S, Kotler B, Brown J (2009) Look before you leap: is risk of injury a foraging cost? *Behav Ecol Sociobiol* 63:1821–1827
- Cavalcanti S, Gese EM (2010) Kill rates and predation patterns of jaguars (*Panthera onca*) in the southern Pantanal, Brazil. *J Mammal* 91:722–736
- Collevatti RG, Leite KC, Miranda GH, Rodrigues FH (2007) Evidence of high inbreeding in a population of the endangered giant anteater, *Myrmecophaga tridactyla* (Myrmecophagidae), from Emas National Park, Brazil. *Genet Mol Biol* 30:112–120
- Foster RJ, Harmsen BJ, Valdes B, Pomilla C, Doncaster CP (2009) Food habits of sympatric jaguars and pumas across a gradient of human disturbance. *J Zoology* 280:309–318
- Foster RJ, Harmsen BJ, Doncaster CP (2010) Sample-size effects on diet analysis from scats of jaguars and pumas. *Mammalia* 74:317–321
- Hurlbert SH (1978) The measurement of niche overlap and some relatives. *Ecology* 59:67–77
- IUCN (2011) IUCN red list of threatened species. Version 2011.2. <www.iucnredlist.org>. Accessed 14 Dec 2011
- Jácomo AT (2004) Ecologia, manejo e conservação do queixada (*Tayassu pecari*) no Parque Nacional das Emas e em propriedades rurais do seu entorno. Ph.D. thesis, Universidade de Brasília, Brasília, Brazil
- Karanth KU, Chellam R (2009) Carnivore conservation at the crossroads. *Oryx* 43:1–2
- Klink CA, Machado RB (2005) Conservation of the Brazilian Cerrado. *Conserv Biol* 19:707–713
- Leite MR, Galvão F (2002) El jaguar, el puma y el hombre en tres áreas protegidas del Bosque Atlántico costero de Paraná, Brasil. In: Medellín RA, Equihua C, Chetkiewicz CL, Crawshaw PG Jr, Rabinowitz AR, Redford KH, Robinson JG, Sanderson EW, Taber A (eds) *El jaguar en el nuevo milenio*, Ediciones Científicas Universitarias. Universidad Nacional Autónoma de México/Wildlife Conservation Society, New York, pp 237–250
- Levins R (1968) Evolution in changing environments: some theoretical explorations. Princeton University Press, Princeton
- Link WA, Karanth KU (1994) Correcting for overdispersion in tests of prey selectivity. *Ecology* 75:2456–2459

- Lopez-González CA, Miller BJ (2002) Do jaguars (*Panthera onca*) depend on large prey? *West N Am Naturalist* 62:218–222
- Miranda GHB, Tomas WM, Valladares-Padua CB, Rodrigues FHG (2006) Giant anteater population survey in Emas National Park, Brazil: a proposed monitoring program. *Endangered Species UPDATE* 23:96–103
- Moraes EA Jr (2012) The status of the jaguar in the Cerrado. *Cat News Special Issue* 7:25–28
- Novack AJ, Main MB, Sunquist ME, Labisky RF (2005) Foraging ecology of jaguar (*Panthera onca*) and puma (*Puma concolor*) in hunted and non-hunted sites within the Maya Biosphere Reserve, Guatemala. *J Zoology* 267:167–178
- Núñez R, Miller B, Lindzey F (2002) Ecología del jaguar en la reserva de la biosfera Chamela-Cuixmala, Jalisco, México. In: Medellín RA, Equihua C, Chetkiewicz CL, Crawshaw PG Jr, Rabinowitz AR, Redford KH, Robinson JG, Sanderson EW, Taber A (eds) *El jaguar en el nuevo milenio*, Ediciones Científicas Universitarias. Universidad Nacional Autónoma de México/Wildlife Conservation Society, New York, pp 107–126
- Oliveira TG (2002) Comparative feeding ecology of the jaguar and puma in the Neotropics. In: Medellín RA, Equihua C, Chetkiewicz CL, Crawshaw PG Jr, Rabinowitz AR, Redford KH, Robinson JG, Sanderson EW, Taber A (eds) *El jaguar en el nuevo milenio*, Ediciones Científicas Universitarias. Universidad Nacional Autónoma de México/Wildlife Conservation Society, New York, pp 265–288
- Polisar J, Maxit I, Scognamillo D, Farrell L, Sunquist ME, Eisenberg JF (2003) Jaguars, pumas, their prey base, and cattle ranching: ecological interpretations of a management problem. *Biol Conserv* 109:297–310
- Quadros J (2002) Identificação microscópica de pelos de mamíferos brasileiros e sua aplicação no estudo da dieta de carnívoros. M.S. thesis, Universidade Federal do Paraná, Curitiba, Brasil
- R Development Core Team (2011) R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna
- Reis NR, Peracchi AL, Pedro WA, Lima IP (eds) (2006) *Mamíferos do Brasil*. Londrina, Brazil
- Roques S, Adrados B, Chavez C, Keller C, Magnusson W, Palomares F, Godoy J (2011) Identification of Neotropical felid faeces using RCP-PCR. *Mol Ecol Resour* 11:171–175
- Scognamillo D, Maxit IE, Sunquist M, Polisar J (2003) Coexistence of jaguar (*Panthera onca*) and puma (*Puma concolor*) in a mosaic landscape in the Venezuelan llanos. *J Zoology* 259:269–279
- Seymour KL (1989) *Panthera onca*. *Mammalian species* 340:1–9
- Sollmann R (2011) Ecology and conservation of the jaguar (*Panthera onca*) in the Cerrado grasslands of central Brazil. Ph.D. thesis, Freie Universität Berlin, Berlin, Germany
- Sollmann R, Furtado MM, Gardner B, Hofer H, Jacomo AT, Tôrres NM, Silveira L (2011) Improving density estimates for elusive carnivores: accounting for sex-specific detection and movements using spatial capture-recapture models for jaguars in central Brazil. *Biol Conserv* 144:1017–1024
- Vynne C, Keim JL, Machado RB, Marinho-Filho J, Silveira L, Groom MJ, Wasser SK (2011) Resource selection and its implications for wide-ranging mammals of the Brazilian Cerrado. *PLoS One* 6: e28939
- Vynne C, Baker MR, Breuer ZK, Wasser SK (2012) Factors influencing degradation of DNA and hormones in maned wolf scat. *Anim Conserv* 15:184–194
- Wachter B, Blanc A-S, Melzheimer J, Hoener OP, Jago M, Hofer H (2012) An advanced method to assess the diet of free-ranging large carnivores based on scats. *PLoS One* 7(6):e38066
- Zeller K (2007) *Jaguars in the new millennium data set update: the state of the jaguar in 2006*. Wildlife Conservation Society, New York