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SEROSURVEY FOR SELECTED VIRAL INFECTIONS IN FREE-RANGING JAGUARS (*PANTHERA ONCA*) AND DOMESTIC CARNIVORES IN BRAZILIAN CERRADO, PANTANAL, AND AMAZON

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ABSTRACT: We investigated the exposure of jaguar (*Panthera onca*) populations and domestic carnivores to selected viral infections in the Cerrado, Amazon, and Pantanal biomes of Brazil. Between February 2000 and January 2010, we collected serum samples from 31 jaguars, 174 dogs (*Canis lupus familiaris*), and 35 domestic cats (*Felis catus*). Serologic analyses for antibodies to rabies virus, canine distemper virus (CDV), feline immunodeficiency virus (FIV), and for feline leukemia virus (FeLV) antigen were conducted. The jaguars from Cerrado and Pantantal were exposed to rabies virus, while the jaguars from the Pantanal and the dogs from all three areas were exposed to CDV. Two cats from the Amazonian site were antigen-positive for FeLV, but no jaguars had FeLV antigen or FIV antibody. Canine distemper and rabies viruses should be carefully monitored and considered potential threats to these jaguar populations. Currently FIV and FeLV do not appear to represent a health threat for jaguar populations in this area. Domestic dogs and cats in these areas should be vaccinated, and the movement of domestic animals around protected areas should be restricted.

Key words: Brazil, canine distemper virus, feline immunodeficiency virus, feline leukemia virus, jaguars, *Panthera onca*, rabies virus, wild felids.

INTRODUCTION

Diseases can cause significant population declines in wildlife and represent a threat to biodiversity, although to a lesser degree than habitat fragmentation and hunting (Pedersen et al., 2007; Smith et al., 2009). Anthropogenic factors that influence the occurrence or emergence of diseases include fragmentation and conversion of natural habitats and increased human presence near natural areas, resulting in increased contact between domestic and wild animals (Smith et al., 2009; Medina-Vogel, 2010).

Due to their lethality, viruses are considered the most significant infectious pathogens for carnivores (Murray et al., 1999). Canine distemper virus (CDV) was responsible for population declines in African wild dogs (*Lycaon pictus*; Alexander and Appel, 1994), black-footed ferrets (*Mustela nigripes*; Williams et al., 1988), and lions (*Panthera leo*) coinfected with *Babesia* spp. (Roelke-Parker et al., 1996; Munson et al., 2008). Rabies virus caused population declines in Ethiopian wolves (*Canis simensis*; Sillero-Zubiri et al., 1986) and African wild dogs (Gascoyne et al., 1993), and feline leukemia virus (FeLV) reduced populations of the Iberian lynx (*Lynx pardinus*; López et al., 2009). In many of these outbreaks, domestic animals were the main sources of infection, and, without their presence, the infection most likely would not have spread or persisted in wildlife (Pedersen et al., 2007).

The jaguar (*Panthera onca*), the largest terrestrial predator in the tropical Americas, is considered near-threatened (IUCN, 2010). Approximately 50% of the jaguar's current distribution is within Brazil (Zeller, 2007). As a top predator, jaguars play an important role in the ecosystems in which they live (Soulé and Terborgh, 1999). They require large areas with good quality habitat and abundant prey and are sensitive to anthropogenic environmental perturbations (Weber and Rabinowitz, 1996). The presence of jaguars in an area is an indicator of a highly conserved condition.

Although several epidemiologic studies in free-ranging wild carnivores have been conducted in Brazil (Filoni et al., 2006; Nava et al., 2008; Jorge et al., 2010), little is known about the potential role of diseases in wild jaguar populations. We used serosurveys to investigate the circulation, as indicated by antibodies, to CDV, feline immunodeficiency virus (FIV), and rabies virus, and FeLV antigen, in free-ranging jaguars, domestic dogs (*Canis lupus familiaris*), and cats (*Felis catus*) in Brazilian Cerrado, Pantanal, and Amazon.

MATERIAL AND METHODS

This study was conducted in three regions of Brazil: Emas National Park (ENP) in the Cerrado biome, Caiman Ecological Refuge and Barranco Alto Ranch in the Pantanal biome, and Cantao State Park (CSP) in the transitional area between the Cerrado and Amazon biomes, referred to hereafter as Amazon. The ENP, with an area of 132,000 ha, is one of the largest preserved areas of Cerrado, Brazil's second largest biome, and is considered a biodiversity hotspot (Myers et al., 2000). The region surrounding the park consists of extensive crop plantations and, to a lesser extent, livestock pastures. The park is one of the last refuges for jaguars in the area and is an island of natural vegetation surrounded by agricultural lands. The Pantanal is the largest wetland in the world (Harris et al., 2005). Rural residents engage predominantly in extensive cattle ranching and, in some cases, ecotourism. The Pantanal is one of the largest continuous blocks of habitat for jaguars outside the Amazon region (Sanderson et al., 2002). The CSP, in the transitional area between the Amazon forest and the Cerrado, is also called the Arc of Deforestation because agricultural development expands from here into the Amazon. This area includes important jaguar habitat, and the main economic activity in the surrounding rural properties is livestock ranching. Additionally, indigenous lands are found near this park.

Between February 2000 and May 2009, 30 free-ranging jaguars were captured in the three study areas as part of the long-term jaguar monitoring program conducted by the Brazilian nongovernmental organization Jaguar Conservation Fund. Jaguars were captured using trained hounds or metal cage traps (Furtado et al., 2008). In April 2007, a juvenile jaguar raised by humans in an indigenous reserve near CSP was included in this survey.

Jaguars were anesthetized intramuscularly with a combination of tiletamine-zolazepam (Zoletil®; Virbac S.A., Carros Cedex, France), with an average dose of 9.7 mg/kg. Blood samples were taken by internal femoral vein puncture using vacuum tubes without anticoagulant, and physical examinations were conducted. By direct inspection, we assessed physical condition, state of hydration, and the presence or absence of lesions, fractures, or possible characteristic signs of illness for each individual.

The animals were classified according to tooth wear and body weight as adults (>2 yr) or juveniles (<2 yr). Thirteen individuals were recaptured at average intervals of 426 days (60–1,629 days). All of the adult jaguars were fitted with radiocollars and monitored using radiotelemetry or camera traps. The monitoring period comprised the interval between the date of capture and the last location obtained until November 2008, except for one animal that was monitored until February 2010. During this period, some individuals died (Table 1), but, because we did not have consistent data about the cause of death, this information was not used here.

Between May 2008 and January 2010, blood samples were collected from 174 dogs and 35 domestic cats from rural properties surrounding the jaguar capture areas. The highest possible number of rural properties bordering the protected areas was sampled (Fig. 1). The domestic animal samples were collected without anesthesia by jugular or cephalic vein puncture using vacuum tubes without anticoagulant. In addition, the dog and cat owners were asked to provide information about the

TABLE 1. Site, capture date, monitoring period, and antibody titers of jaguars (*Panthera onca*) in Brazil that had at least one positive result for antibody to canine distemper or rabies virus.

Local	ID[a]	Date	CDV[b]	Rabies	Monitoring period (months)
ENP[c]	150.243	March 2000	–[d]	–	6[f]
		June 2000	–	0.11	
PAN[e]	150.811	October 2003	32	–	24[f]
	150.842	October 2003	16	–	38[f]
		January 2007	–	–	
	151.343	June 2005	–	–	4[f]
		October 2005	8	–	
	151.393	June 2005	32	0.1	39
		January 2008	32	–	
	151.362	December 2005	–	–	35
		April 2008	–	0.1	
	151.374	February 2006	16	–	17[f]
	150.872	February 2006	16	–	31
		June 2006	16	0.24	
		September 2006	–	–	
		November 2007	–	–	
	151.452	April 2006	8	–	7[f]
		July 2006	–	–	
	151.443	June 2006	–	0.12	19
		January 2007	–	0.5	
	151.351	January 2007	16	–	NM[g]
	151.762	November 2007	32	–	NM
	Cub1	November 2007	16	–	NM
	151.824	November 2007	16	0.11	NM
	151.533	November 2008	16	–	14

[a] Individual identification by radiocollar frequency.

[b] Canine distemper virus.

[c] Emas National Park.

[d] Negative.

[e] Pantanal.

[f] Animal died during monitoring.

[g] NM = Not monitored.

vaccination status of their animals. The jaguar and domestic animal samples were transported to the field laboratory, and the blood was centrifuged for 5 min at 1,200 × G. The serum was removed, aliquoted, and stored at −20 C.

We determined the exposure of jaguars and dogs to CDV; the exposure of jaguars, dogs, and cats to rabies virus; and the exposure of jaguars and domestic cats to FIV and FeLV. Due to limited serum quantities, not all tests were performed on all domestic animals. Antibodies to CDV were detected using a serum neutralization microscopic test (Appel and Robson, 1973) performed at the Biovet Laboratory in Vargem Grande Paulista, São Paulo, Brazil. Titers ≥8 were considered positive (Courtenay et al., 2001). For detection of antibodies against rabies virus, the rapid fluorescent focus inhibition test was used (Smith et al., 1996) at the Pasteur Institute of São Paulo. For domestic dogs and cats, which are usually vaccinated against rabies, a titer ≥0.50 IU/mL was the cutoff, as recommended by the World Health Organization (1992). For free-ranging jaguars, which never had contact with rabies vaccine, titers ≥0.10 IU/mL were considered positive (Hill et al., 1992; Jorge et al., 2010). Sera were tested for antibodies against FIV and FeLV antigen using the commercially available immunoassay Snap™ Combo FeLV Antigen/FIV Antibody Test Kit (IDEXX Laboratories, Westbrook, Maine, USA), according to the manufacturer's recommendations, at the Laboratory of Bacterial Zoonoses, Department of Preventive Veterinary Medicine and Animal Health, School of Veterinary Medicine and Animal Science, University of São Paulo.

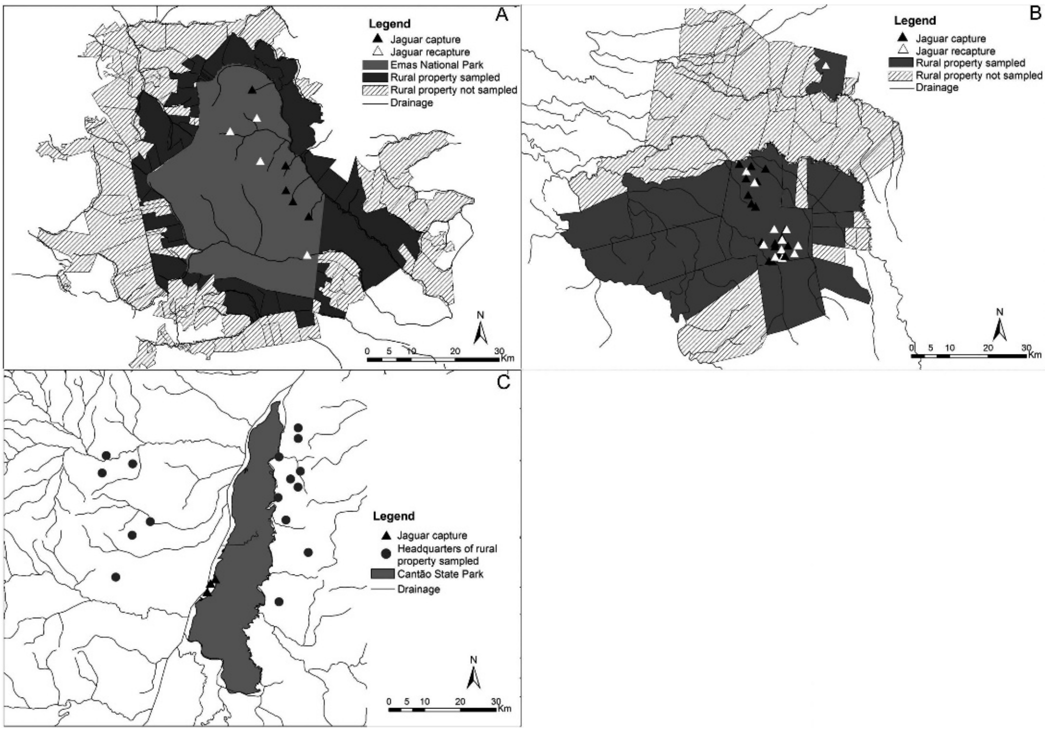

FIGURE 1. Locations of jaguar (*Panthera onca*) capture/recapture sites and rural properties where domestic animals were sampled at (A) Emas National Park, (B) the Pantanal, and (C) Cantão State Park, Brazil, February 2000 to January 2010.

Results are presented by species and study area. For statistical analysis, animals that had at least one positive result were considered positive. Multiple samples from the same animal were not used to avoid pseudoreplication and ensure data independence (Paterson and Lello, 2003). For interpretation of the changes in antibody titers for the same individual, only fourfold or greater geometric changes were considered significant (Thrusfield, 2004). The jaguar monitoring data allowed for the characterization of habitat use by antibody-positive jaguars. The properties were characterized as with or without positive individuals. We used a logistic regression to test sex and age effects on serology-positive status and to compare results between species. The models were implemented using R software v. 2.10.1 (R Development Core Team, 2009). Due to the small sample size of jaguars in ENP and CSP, it was not possible to compare among study areas. Table 2 presents coefficient estimates and their standard errors, 95% confidence intervals, and *P* values for each model applied. Coefficients with *P* values <0.05 were considered as having a significant effect on the probability of an individual being found positive.

Capture and sampling procedures were compliant with the Ethical Principles in Animal Research adopted by the Bioethic Commission of the School of Veterinary Medicine and Animal Science of the University of São Paulo (Protocol 1471/2008).

RESULTS

All but one of the 30 sampled jaguars were in excellent or good physical condition, with an appropriate body weight (according to Seymour, 1989) and no clinical signs of disease. One female and four male jaguars were captured in ENP, of which three were adults and two juveniles. All individuals were antibody-negative for rabies virus and CDV upon first capture, but one seroconverted to rabies virus when recaptured after 3 mo (Table 1). The other three jaguars that

TABLE 2. Parameters estimated by logistic regression testing the effects of sex (β_1) and age (β_2) on the detection of antibodies (positive or negative) to canine distemper (CD) and rabies viruses in Brazilian jaguars (*Panthera onca*) and testing the effect of species (β_1) on the detection of CD and rabies virus antibodies. Reference categories: for sex—female, for age—juvenile, and for species—dogs (*Canis lupus familiaris*).

Virus	Parameter	Estimate	Standard error	P	95% CI
Rabies	Intercept	−1.324	0.795	0.096	[−3.221; 0.073]
	β_1 (male)	−1.529	1.208	0.206	[−4.605; 0.571]
	β_2 (adult)	0.528	1.015	0.603	[−1.398; 2.730]
Rabies	Intercept	−1.299	0.206	<0.001	[−1.720; −0.910]
	β_1 (cat)[a]	−0.821	0.645	0.203	[−2.302; 0.312]
	β_1 (jaguar)	−0.128	0.499	0.798	[−1.188; 0.799]
CD	Intercept	0.306	0.654	0.640	[−1.682; 0.967]
	β_1 (male)[b]	−1.988	0.968	0.040	[−4.158; −0.243]
	β_2 (adult)	0.789	0.881	0.371	[−0.884; 2.622]
CD	Intercept	−0.372	0.154	0.016	[−0.677; −0.072]
	β_1 (jaguar)	−0.087	0.340	0.827	[−0.894; 0.686]

[a] Felis catus.

[b] Statistically significant.

were recaptured 4–54 mo later remained negative for rabies virus and CDV antibodies. In CSP, one male and three female jaguars were sampled, of which three were adults and one was a juvenile. All were negative for antibodies to rabies virus and CDV. The locations of these jaguars were not obtained due to radio-collar malfunction.

In the Pantanal, 15 female and seven male jaguars were captured, of which 14 were adults and eight were juveniles. At the time of the first capture, 19 jaguars were negative, and three were positive for antibody to rabies virus. For CDV antibody, 11 jaguars were negative, and 11 were positive at first capture. Two jaguars recaptured 6 and 15 mo later remained negative for antibodies to rabies virus and CDV. Antibody titers for jaguars that had at least one positive result for antibodies to rabies virus or CDV are listed in Table 1.

No jaguars (n=31) from the three study areas was positive for FIV antibody or FeLV antigen. The female jaguars had significantly higher CDV antibody prevalence than the males (P=0.040; Table 2). There were no other significant associations with sex or age class of the jaguars for antibodies to CDV or rabies virus, and no significant associations of viral exposure with species (Table 2). Logistic regressions were not performed for FIV and FeLV due to the absence of individuals positive for FIV antibodies and an extremely small number of individuals of the same species positive for FeLV antigen. Table 3 provides the total antibody prevalence for all viruses tested for jaguars and domestic carnivores. According to the owners, most of the dogs were vaccinated against rabies, but few were vaccinated against CDV (Table 4).

In ENP, the rabies virus antibody-positive jaguars used areas inside and outside the park (Fig. 2). In the Pantanal, jaguars positive for CDV and rabies virus antibodies moved onto properties with no antibody-positive domestic carnivores, and antibody-positive and negative jaguars used the same environment (Fig. 3).

DISCUSSION

Based on physical examinations, jaguars from the three sites appeared healthy. As indicated by the presence of antibody, the jaguars from the Cerrado and Pantantal were exposed to rabies virus, while the jaguars from the Pantanal and the dogs from all three areas were exposed to CDV. Two cats from the Amazonian site had

TABLE 3. Prevalence [positive/examined (%)] of antibodies to canine distemper virus (CDV), rabies virus (RV), and feline immunodeficiency virus (FIV), and antigen to feline leukemia virus (FeLV) in jaguars (*Panthera onca*), domestic dogs (*Canis lupus familiaris*), and cats (*Felis catus*) sampled between February 2000 and January 2010 at three study areas in Brazil.

	Jaguars	Domestic dogs		Domestic cats	
Virus	Animals	Animals	Farms	Animals	Farms
Emas National Park					
CDV	0/5 (0)	30/83 (36)	15/34 (44)	–[a]	–
RV	1/5 (20)	21/66 (32)	15/31 (48)	0/9 (0)	0/7 (0)
FIV	0/5 (0)	–	–	0/11 (0)	0/9 (0)
FeLV	0/5 (0)	–	–	0/11 (0)	0/9 (0)
Pantanal					
CDV	12/22 (54.5)	15/28 (53.6)	6/7 (86)	–	–
RV	5/22 (22.7)	5/24 (20.8)	3/7 (43)	2/10 (20)	2/6 (33)
FIV	0/22 (0)	–	–	0/11 (0)	0/6 (0)
FeLV	0/22 (0)	–	–	0/11 (0)	0/6 (0)
Cantão State Park					
CDV	0/4 (0)	26/63 (41.3)	13/16 (81)	–	–
RV	0/4 (0)	4/50 (8)	3/14 (21)	1/9 (11)	1/6 (17)
FIV	0/4 (0)	–	–	0/13 (0)	0/8 (0)
FeLV	0/4 (0)	–	–	2/13 (15)	2/8 (25)

[a] Dash = not analyzed.

FeLV antigen, but no jaguars had FeLV antigen or FIV antibody.

Rabies

The presence of ≥0.10 IU/mL antibody titers against rabies virus in six jaguars suggests exposure in ENP and the Pantanal. These results also agree with previous reports of nonlethal exposure to rabies virus in jaguars (Piccinini and Freitas, 1985; Jorge et al., 2010). Because the antibody-positive jaguars in this study did not show clinical signs of rabies during their capture, and these jaguars moved normally for periods of 6–39 mo, we conclude that none of them were lethaly infected. Additionally, the presence of a jaguar showing an increased antibody titer (0.5 IU/mL at the time of recapture) suggests genuine exposure to the virus.

Although our results do not allow inferences about the source of infection and the mode of transmission of rabies virus to the jaguars, transmission of the virus is known to occur primarily through the bite of infected animals (Rupprecht, 1999), but can also occur through ingestion of infected carcasses (Ramsden and Johnston, 1975). Because the jaguar is a top predator, transmission via predation on infected animals seems a more likely route. Although it rarely leads to clinical infection, oral transmission of rabies virus results in a long-lasting specific humoral

TABLE 4. Vaccination status of dogs (*Canis lupus familiaris*) and cats (*Felis catus*) sampled near jaguar (*Panthera onca*) habitats in Emas National Park (ENP), Pantanal (PAN), and Cantão State Park (CSP), Brazil, based on information provided by the animal owners.

Parameters	ENP (n=76)	PAN (n=26)	CSP (n=63)
Dogs vaccinated against rabies virus (%)	78	81	78
Dogs vaccinated against CDV (%)	20	4	10
Cats vaccinated against rabies virus (%)	60	83	31
Cats vaccinated against FeLV (%)	0	0	0

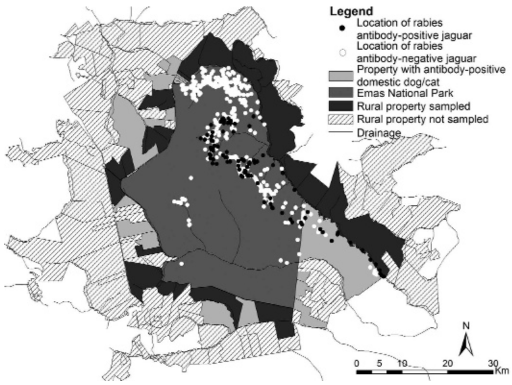

FIGURE 2. Locations of rabies virus antibody-positive and antibody-negative jaguars (*Panthera onca*) and rabies virus antibody-positive domestic cats (*Felis catus*) and dogs (*Canis lupus familiaris*) at Emas National Park, Brazil, February 2000 to January 2010.

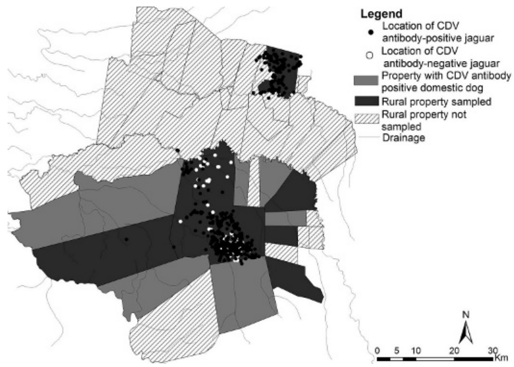

FIGURE 3. Locations of canine distemper virus (CDV) antibody-positive and antibody-negative jaguars (*Panthera onca*) and CDV antibody-positive domestic dogs (*Canis lupus familiaris*) in the Pantanal, Brazil, February 2000 to January 2010.

response, which increases immunity among carnivores (Zhang et al., 2008) and may have occurred in the jaguars of this study.

It is possible that rabies virus is circulating in the domestic or wild animals in ENP and in the Pantanal. Cattle in South America are victims of vampire bats (Brandão, 2009), and, in Brazil, reported cases of rabies in grazing livestock from the central-west region increased between 1997 and 2006 (Rodriguez et al., 2007). Non-dog strains of rabies virus occur in crab-eating foxes (*Cerdocyon thous*) in northeastern Brazil, suggesting the existence of a sylvatic cycle independent of domestic dogs (Carnieli Junior et al., 2006, 2009).

We could not distinguish between vaccination-induced and naturally acquired antibodies in the domestic carnivores we sampled. However, given that most of the owners reported vaccinating their pets, rabies antibodies in the dogs were attributed to vaccination. Nevertheless, the low frequencies of antibody-positive dogs (8–32%) suggest failure in annual revaccination (Bronson et al., 2008) or misinformation about the vaccination status by pet owners. Given the low percentage of dogs with protective antibodies, the dogs may be susceptible to infection and able to transmit virus. The low titers in the jaguars suggest that, although exposed to the virus, the jaguar does not play an important role in the natural transmission cycle.

Canine distemper virus

The domestic dogs from the three study areas and the jaguars captured in the Pantanal were exposed to CDV. Prevalence of antibody to CDV in the jaguars from the Pantanal was high (55%), similar to the results found by Nava et al. (2008) in jaguars from the Atlantic Forest (60%). Exposure to CDV has also been reported in captive jaguars with clinical disease, and a CDV-caused jaguar death was recorded in the early 1990s in a zoo in the United States (Appel et al., 1994). The CDV antibody titers found in the jaguars in this study were lower than those reported for the Atlantic Forest free-ranging jaguars (32–82; Nava et al., 2008) and the captive jaguar in the United States (100 and 200; Appel et al., 1994) but similar to those reported for pumas and ocelots in the northern Pantanal (Jorge, 2008). Although CDV is known to cause significant population declines in lions on the Serengeti (Roelke-Parker et al., 1996), most of the antibody-positive jaguars were monitored for 4–39 mo, indicating that they were not fatally affected or weakened by CDV infection.

Most of the rural properties sampled in the Pantanal (86%) and in the area surrounding CSP (81%) had at least one CDV antibody-positive domestic dog, showing the wide distribution of the virus in these regions. In Brazil, prevalences apparently higher than what we found were described by Dezengrini et al. (2007), and similar prevalences were reported by Del Puerto et al. (2010) and Hass et al. (2008). In Bolivia, similar prevalences to what we found were also described in domestic carnivores on the border of a protected area (Fiorello et al., 2004). The antibodies circulating in these dogs may have been acquired by natural exposure to the agent, given the low number of dogs vaccinated against CDV.

Dogs from our sampling areas were not commonly vaccinated for CDV. Unvaccinated dogs represent a potential threat to the jaguar populations because areas where these species overlap may favor the spread of CDV (Roelke-Parker et al., 1996). However, only the jaguars from the Pantanal had detectable antibody to CDV. This region is unique among the three areas surveyed in that it consists only of rural properties where domestic dogs can move freely. In contrast, ENP and CSP are protected areas where the entry of domestic dogs is not allowed. Nevertheless, dogs did enter the parks, but were mostly restricted to the borders of rural properties. Our results agree with those of Nava et al. (2008), who found CDV antibody-positive jaguars only where domestic animals had access.

CDV can be transmitted by direct or indirect contact, but the virus survives for only a few hours in the environment (1–3 hr at 37 C; Appel, 1987). Another hypothesis suggests that wild animals act as transitional hosts (Roelke-Parker et al., 1996). The CDV occurrence map for the Pantanal (Fig. 2) shows the movement of CDV antibody-positive jaguars onto properties with no antibody-positive dogs. This suggests that the jaguars could be infected by other wildlife. Figure 2 further shows that antibody-positive and negative jaguars use the same environment, suggesting that, even at high densities (Soisalo and Cavalcanti, 2006), the solitary habits of the jaguars (Seymour, 1989) contribute to low intraspecific CDV transmission.

The finding of more female jaguars exposed to CDV than males was not expected; there is no reported association between sex and CDV in domestic dogs (Twark and Dodds, 2000). Our finding might be an artifact of the small sample size. Confirmation of our results will require additional studies.

Because exposure of jaguars to CDV could be due to either contact with domestic dogs or contact with wildlife, molecular comparison of the virus strains circulating in these populations should be a target of further investigations. Although there are few reports of CDV causing death of jaguars, CDV circulation in these jaguar populations requires attention, especially because of the severity of CDV infection when associated with coinfection with other pathogens, as described in free-ranging lions in the Serengeti (Munson et al., 2008).

Feline immunodeficiency virus

We found no serologic evidence that jaguars or domestic cats in our study areas had been exposed to FIV. In domestic cats, FIV is transmitted through saliva by biting (Hosie et al., 2009). The mode of transmission is most likely similar for wild felids (Troyer et al., 2008); thus the solitary habits of jaguars (Seymour, 1989) do not favor transmission. While FIV has been reported in domestic cats in southeastern Brazil (Caxito et al., 2006; Mendes-de-Almeida et al., 2007; Macieira et al., 2008), to our knowledge, there are no such reports for the north or central-west regions.

Negative findings for FIV in populations with low prevalence of infection, as in our study area, are generally accurate (Hosie et al., 2009). Serologic tests perform better for detection of FIV exposure than does PCR, which has shown discrepant results, a sensitivity and specificity of approximately 40–100% (Bienzle et al., 2004), and failures to detect some genetic variants of the virus (Ravazzolo and Costa, 2007; Hosie et al., 2009).

Our results are similar to those of Nava (2008) in jaguars in the Atlantic Forest and Olmsted et al. (1992) in jaguars in captivity. However, there are reports of FIV exposure in captive jaguars (Barr et al., 1989; Brown et al., 1993), and FIV has been detected in jaguars in Brazil (Leal and Ravazzolo, 1988).

Feline leukemia virus

Although FeLV antigen was identified in two domestic cats neighboring CSP, there was no evidence that the virus was present in the jaguar populations of the three study areas. The absence of FeLV in jaguars, as detected in this study, was also reported by Nava (2008) for free-ranging jaguars from the Atlantic Forest. However, FeLV infection was reported by Schmitt et al. (2003), and the detection of proviral DNA was reported by Guimarães et al. (2009), in both captive jaguars in southern and southeastern Brazil, respectively.

The antigen-positive domestic cats were in good physical condition at the time of blood collection. These animals could have been in a FeLV viremia transient stage, in which they are able to produce an efficient immune response and eliminate the infection (Rojko and Kociba, 1991; Barr, 1996). In Brazil, the occurrence of FeLV in domestic cats has been confirmed in the states of Rio de Janeiro and São Paulo with antigen prevalences up to 39.4% (Souza et al., 2002; Mendes-de-Almeida et al., 2007; Macieira et al., 2008).

The domestic cat is the main transmitter of FeLV. Given the virus' fragility in the environment, most cases reported in wild felids result from direct contact with domestic cats (Jessup et al., 1983; Kennedy-Stoskopf, 1999; Ravazzolo and Costa, 2007; López et al., 2009). Again, it is possible that the solitary habits of jaguars provide little opportunity for virus transmission. Additionally, studies of diet in CSP did not provide evidence that domestic cats were a food item for jaguars (Nuno, 2007). The good physical condition of jaguars in our study confirms the negative results for FeLV. The presence of FeLV in the domestic cats from the areas surrounding CSP should be investigated more thoroughly.

In conclusion, CDV and rabies virus should be carefully monitored in jaguars and considered potential threats to their populations. Given the known impact of CDV in several species of wild carnivores, exposure of jaguars to CDV in the Pantanal is relevant and justifies further investigation focused mainly on the characterization of the sources of infection. Excluding the possibility of false positives, the most plausible form of natural exposure to rabies virus for jaguars seems to be contact with an attenuated virus present in carcasses of domestic or wild animals that died of rabies. Although we cannot rule out the presence of FIV in the studied populations due to the low number of felines sampled, the results suggest that this virus is not a threat to the jaguar populations in the three areas. The presence of FeLV antigen in domestic cats in the areas surrounding CSP should be monitored, but FeLV does not seem to present a current threat to these jaguars.

Risks of transmission of pathogens from domestic animals to jaguars could be mitigated through vaccination of domestic dogs against rabies virus and CDV and domestic cats against rabies virus and FeLV, prohibition of domestic animals inside conservation units, restrictions on the movement of domestic animals around preserves, and eradication of feral dogs and cats. The importance of proper management should also be emphasized to farm owners and employees and conservation unit managers, and information about diseases that could be transmitted between domestic and wild animals should be provided.

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