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Authors: Fiorello, Christine V., Noss, Andrew J., Deem, Sharon L., Maffei, Leonardo, and Dubovi, Edward J.

Source: Journal of Wildlife Diseases, 43(3) : 551-557

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-43.3.551

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Journal of Wildlife Diseases, 43(3), 2007, pp. 551–557
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Serosurvey of Small Carnivores in the Bolivian Chaco

Christine V. Fiorello,[1,4,6] Andrew J. Noss,[2] Sharon L. Deem,[1,5] Leonardo Maffei,[2] and Edward J. Dubovi[3]
[1] Field Veterinary Program, Wildlife Conservation Society, 185th Street and Southern Boulevard, Bronx, New York 10460, USA; [2] Bolivia Program, Wildlife Conservation Society, Casilla 6272, Santa Cruz, Bolivia; [3] New York State Animal Health Diagnostic Laboratory, College of Veterinary Medicine, Cornell University, Ithaca, New York 14853, USA; [4] Present address: Department of Small Animal Clinical Sciences, University of Florida, College of Veterinary Medicine, P.O. Box 100126, Gainesville, Florida 32610, USA; [5] Present address: National Zoological Park, Smithsonian National Zoological Park, 3001 Connecticut Avenue, Washington, DC 20008, USA; [6] Corresponding author (email: fiorelloc@mail.vetmed.ufl.edu)

ABSTRACT: Five species of Bolivian carnivores, including nine Geoffroy's cats (*Oncifelis geoffroyi*), ten ocelots (*Leopardus pardalis*), one jaguarundi (*Herpailurus yaguarondi*), nine pampas foxes (*Pseudalopex gymnocercus*), and five crab-eating foxes (*Cerdocyon thous*) were sampled between March 2001 and April 2005 and tested for antibodies to common pathogens of domestic carnivores. Carnivores were trapped in three areas: a village, the region between human settlements and a protected area, and within Kaa-Iya National Park, Bolivia. Antibodies to canine distemper virus were detected in ocelots and pampas foxes. Antibodies to canine parvovirus were detected in pampas foxes and crab-eating foxes. Geoffroy's cats and all of the ocelots tested positive for antibodies to feline calicivirus (FCV), while fewer than half of Geoffroy's cats and no ocelots had antibodies to feline panleukopenia (FPV). These results confirm that these species of Bolivian carnivores are not naïve to common pathogens of domestic carnivores, and seropositive animals were found in villages as well as in the national park.

Key words: Bolivia, calicivirus, canine distemper virus, carnivores, Chaco, conservation, parvovirus, serology.

Baseline information on potential pathogen exposure is critical for monitoring the population health of threatened wildlife species (Munson and Karesh, 2002). Nonnative species, including domestic animals, are frequently implicated as reservoirs of diseases that may cause significant population declines of wildlife (Alexander et al., 1993; Laurenson et al., 1998; Cleaveland et al., 2000). Carnivores are at special risk from disease because of their close phylogenetic relationship with domestic dogs and cats (Cleaveland et al., 2001). Antibody prevalences to common carnivore pathogens are high in Bolivian dogs and cats (Fiorello et al., 2004, 2006), indicating that wild carnivores in contact with domestic carnivores may be exposed to numerous pathogens.

Bolivia's Kaa-Iya del Gran Chaco National Park, a large protected area of tropical dry forest, has a high diversity of carnivores, including Geoffroy's cats (*Oncifelis geoffroyi*), pumas (*Puma concolor*), ocelots (*Leopardus pardalis*), jaguarundis (*Herpailurus yaguarondi*), jaguars (*Panthera onca*), pampas foxes (*Pseudalopex gymnocercus*), and crab-eating foxes (*Cerdocyon thous*) (Taber et al., 1997; Maffei et al., 2004). The western border of the park is contiguous with the Isoseño-Guaraní indigenous territory (Tierra de Comunitaria Origen, or TCO). Human activities, especially hunting, are relatively intense in the area of the TCO between the park and the villages (here termed the buffer zone) (Noss, 1999; Noss et al., 2003).

There is evidence that wild and domestic carnivores overlap in space in the communities and buffer zone. Hunting in the Isoso almost always involves dogs, and hunters report frequent encounters with foxes on hunting trips (Fiorello et al., 2006). Hunters and their dogs kill wild cats when encountered during hunting, and both local residents and researchers have observed foxes and wild felids enter communities to take chickens and goats (Noss, 1999; Cuéllar, 2000; Noss et al., 2003). Domestic cats are uncommon as pets; however, when they are kept, they live exclusively outdoors (Fiorello, unpubl.). Both wild carnivores and Isoseño hunters preferentially use trails and roads

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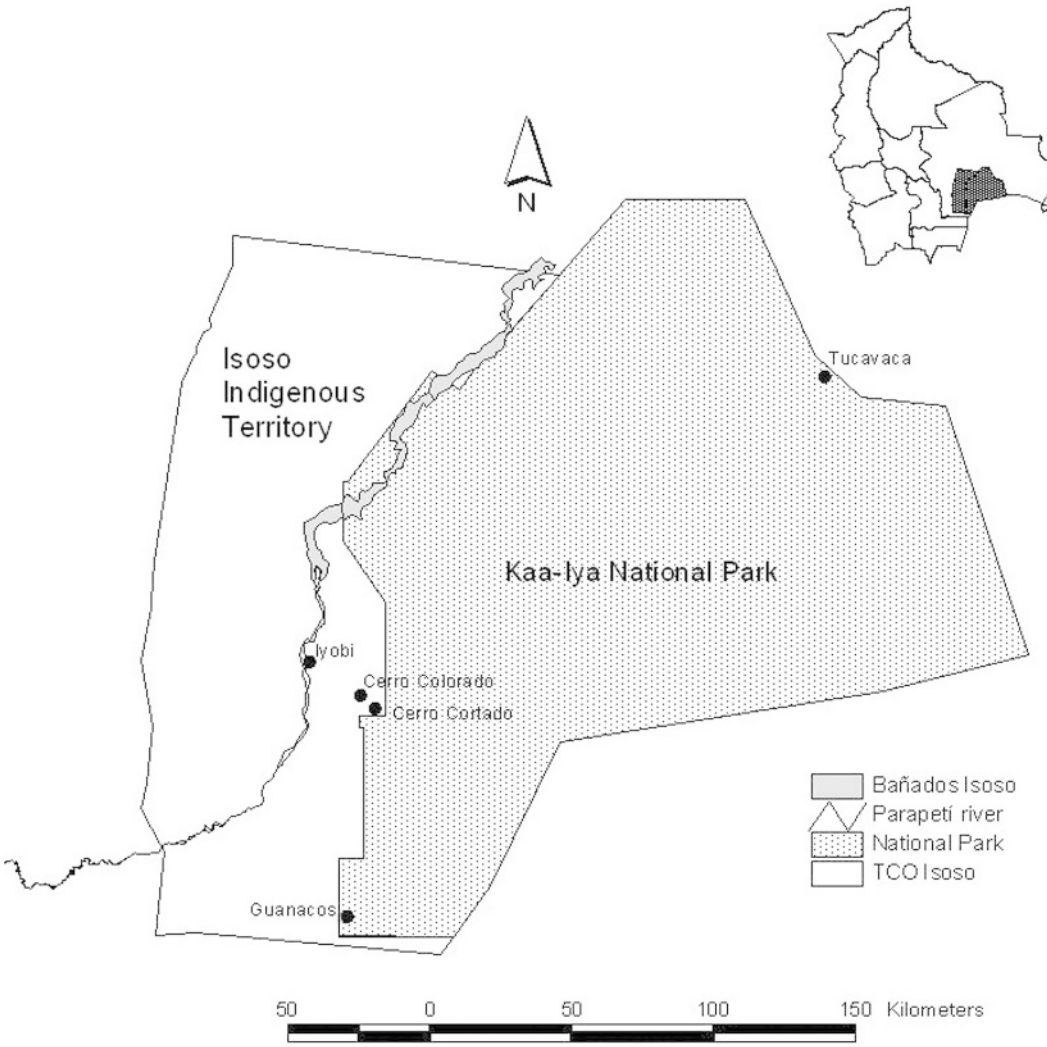


FIGURE 1. Location of Isoseño communities in relation to Kaa-Iya del Gran Chaco National Park, the Parapetí River, and the Isoso indigenous territory. Tucavaca is the park site, Iyobi is the village, and Cerro Cortado, Cerro Colorado, and Guanacos represent buffer zone sites. Inset shows position of detailed area in Bolivia. TCO=Tierra de Comunitaría Origen (indigenous territory).

when traveling through the forest, thereby increasing the likelihood of direct and indirect contact (Maffei et al., 2002, 2003).

The objective of this survey was to determine if small carnivores in the Bolivian Chaco are exposed to common domestic carnivore pathogens. Wild carnivores were captured between March 2001 and April 2005 using box traps and were serologically tested for antibodies to these pathogens. Baited traps were placed along dirt roads and trails at five locations: within the community of Iyobi (IYB); in the buffer zone (BZ) at three research camps; and within the park (Fig. 1). Iyobi has a human population of several hundred and an economy based on subsistence hunting and agriculture. Two of the research camps were located west of the park, and the third was on the southwest border of the park. Tucavaca is well within the park and at least 30 km from the nearest cattle ranch. The prohibition of hunting at Tucavaca appears well-en-

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TABLE 1. Methodologies and positive cutoff values used by commercial laboratories to detect disease exposure or infection. All tests were performed on serum at the Cornell Veterinary Diagnostic Laboratory, Ithaca, New York, USA.

Pathogen	Methodology[a]	Positive cutoff
Canine adenovirus	antibody SN	1:4
Canine coronavirus	antibody SN	1:8
Canine distemper virus	antibody SN	1:8
Canine herpesvirus	antibody SN	1:8
Canine parvovirus	antibody HAI	1:10
Feline calicivirus	antibody SN	1:8
Feline coronavirus	antibody KELA	1:8
Feline herpesvirus	antibody SN	1:8
Feline immunodeficiency virus	antibody ELISA	P/N
FIV confirmatory	Western blot	P/N
Feline leukemia virus	antigen ELISA	P/N
Feline panleukopenia virus	antibody HAI	1:10
Leptospira interrogans	antibody MA	1:100
Brucella canis	slide agglutination/AGID	P/N

[a] SN = serum neutralization, HAI = hemagglutination-inhibition, KELA = kinetic enzyme-linked immunosorbent assay, ELISA = enzyme-linked immunosorbent assay, MA = micro-agglutination, AGID = agar gel immunodiffusion, P/N = test scored as positive or negative.

forced at this time, although hunting did occur there throughout the 1980s.

Isoseño parabiologists and hunters assisted in choosing sites for the traps to maximize captures. Trapped carnivores were immobilized with either a combination of medetomidine and ketamine (ocelots and Geoffroy's cats), or a premixed combination of tiletamine and zolazepam (Telazol®, Fort Dodge Animal Health, Fort Dodge, Iowa; canids and jaguarundi). Details of trapping, immobilization, and sampling can be found elsewhere (Fiorello, 2004). Blood in serum separator tubes was centrifuged within 2–4 hr of collection. Serum was removed, placed into cryotubes, and stored in liquid nitrogen until transport to the USA. Cryotubes were packed in ice for transport and then stored at −80 C until analysis.

Serologic test methods used by commercial laboratories are listed in Table 1. None of the tests used has been validated for nondomestic carnivores. All species were tested for canine distemper virus (CDV), and *Leptospirosis interrogans* (serovars pomona, icterohaemorrhagiae, hardjo, grippotyphosa, and canicola). Canids were additionally tested for canine adenovirus (CAV), canine coronavirus (CCV), canine herpesvirus (CHV), canine parvovirus (CPV), and *Brucella canis*. Felids were additionally tested for feline calicivirus (FCV), feline coronavirus (FCoV), feline herpesvirus (FHV), feline immunodeficiency virus (FIV), feline leukemia virus (FeLV), and feline panleukopenia virus (FPV). Due to limited serum quantities, not all tests were performed on all individuals.

Carnivores were captured at all locations, but species were not randomly distributed across sites. Geoffroy's cats and pampas foxes were captured in the village and the BZ; ocelots and crab-eating foxes were captured in the BZ and the park; and the jaguarundi was captured in the BZ. Thirty-four individuals of five species (ocelots $n=10$, Geoffroy's cats $n=9$, pampas foxes $n=9$, crab-eating foxes $n=5$, and jaguarundi $n=1$) were sampled.

None of the canids had detectable antibodies to CCV ($n=14$), CHV ($n=14$), or *B. canis* ($n=3$). None of the felids sampled had detectable antigen from FeLV ($n=20$), or antibodies to FIV ($n=20$), FCoV ($n=20$), or *L. interrogans* ($n=18$). Results for assays that included at

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TABLE 2. Number of seropositive animals over number tested for each serologic test for all carnivore species captured in the Bolivian Chaco during the study.

Species	*n*	Agent[a]						
		CAV	CDV	CPV	FCV	FHV	FPV	Lepto
Ocelot	10	n/a	7/10	n/a	10/10	0/10	0/10	0/8
Geoffroy's cat	9	n/a	0/9	n/a	4/9	1/9	4/9	0/9
Jaguarundi	1	n/a	0/1	n/a	0/1	0/1	0/1	0/1
Crab-eating fox	5	1/5	0/5	4/5	n/a	n/a	n/a	0/5
Pampas fox	9	0/9	4/9	5/9	n/a	n/a	n/a	1/9

[a] CAV = canine adenovirus, CDV = canine distemper virus, CPV = canine parvovirus, FCV = feline calicivirus, FHV = feline herpesvirus, FPV = feline panleukopenia virus, Lepto = *Leptospira interrogans*.

least one positive individual are shown in Table 2.

Among the Geoffroy's cats captured in the village, most were positive for FCV (4/4) and FPV (3/4) antibodies (Table 2). In contrast, only one of five Geoffroy's cats captured in the BZ had antibodies to any disease agent. None of the Geoffroy's cats had antibodies to CDV. Most ocelots were positive for FCV (9/10) and CDV (7/10) antibodies, but none had antibodies to FPV or FHV. Exposure to feline herpesvirus was found in one Geoffroy's cat. Interestingly, antibodies to FHV were not found in any domestic cats in Bolivia (Fiorello, unpubl.; Fiorello et al., 2004).

Antibodies to CPV were common in both canid species, but only pampas foxes had detectable CDV antibodies (Table 2). Antibodies to *L. interrogans*, serovar grippotyphosa were found in one pampas fox captured in the BZ. The only CAV-positive animal was a crab-eating fox captured in the park.

Feline panleukopenia virus infection appears to be endemic in the Bolivian domestic cat population. All six domestic cats sampled from the Isoso villages had positive titers to FPV (Fiorello, unpubl.); similarly, all 14 domestic cats sampled in northwestern Bolivia were positive (Fiorello et al., 2004). Although no ocelots in this study had positive FPV titers, there is no doubt that ocelots will mount measurable titers to FPV; in fact, two ocelots from the Santa Cruz Zoological Park were sampled in 2002 and both had high positive titers to FPV (Fiorello, unpubl.).

Ocelots from both the BZ and park, where domestic cats are absent, were positive for FCV. This suggests that FCV is endemic in the ocelot population and infection is not acquired via contact with domestic cats. Like FPV, antibodies to FCV were found in all six domestic cats sampled in the Chaco (Fiorello, unpubl.) and 13 of 14 cats sampled in northwestern Bolivia (Fiorello et al., 2004).

The jaguarundi was negative on all tests. This may indicate either a true lack of exposure to disease agents or a failure of the assays to detect jaguarundi antibodies. Although some serosurveys have included captive jaguarundis (Carpenter and O'Brien, 1995; Filoni et al., 2003), very little information on serology of this species is available.

Exposure to canine pathogens was common; this is consistent with results reported from similar studies of wild canids in North America and Africa (Garcelon et al., 1992; Holzman et al., 1992; Standley and McCue, 1997; Laurenson et al., 1998). Our findings contrast with results reported for crab-eating foxes in the Brazilian Amazon, where none of 37 foxes had CDV or CPV antibodies (Courtenay et al., 2001). A recent survey of free-ranging maned wolves captured in Bolivia found evidence of exposure to CDV, CAV, CPV, CCV, and *Leptospira interrogans* (Deem and Emmons, 2005).

Two surveys of domestic dogs in Bolivia

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found that over 90% had antibodies to both CDV and CPV (Fiorello et al., 2004, 2006), and contact between wild carnivores and domestic hunting dogs is common (Fiorello et al., 2006). Based on the present study, we cannot determine if CDV and CPV are endemic in the wild carnivore populations or spilling over from the domestic dog population. The assay used in this study was not validated for crab-eating foxes, but it seems unlikely that the assay would recognize antibodies in pampas foxes but not in the closely related crab-eating foxes. Crab-eating foxes may be less susceptible to infection with CDV, or highly susceptible to fatal disease and unlikely to survive and produce antibodies. In the southeastern United States, sympatric gray and red foxes have very different susceptibilities to CDV; gray foxes are highly susceptible, whereas red foxes are not (Davidson and Nettles, 1997).

The significance of CDV-seropositive ocelots is unknown. Small cats, unlike jaguars and other large cats, are not thought to be susceptible to disease caused by CDV, although some species may seroconvert when infected (Ikeda et al., 2001). Seroconversion of Geoffroy's cats and jaguarundis has not been reported. In the Chaco, the presence of CDV antibodies in felids may serve as a marker of contact with canids, either domestic or wild. If this is so, it provides an alternate explanation for the lack of CDV-positive Geoffroy's cats. Geoffroy's cats discovered in the villages are killed by Isoseño hunting dogs; therefore, these small felids are unlikely to survive an encounter with a dog. They are also likely to avoid interactions with sympatric canids, as their small size (2.5–3.5 kg) makes them vulnerable to predation or interference competition.

We found no evidence of exposure to CCV, CHV, and *B. canis* among the wild canids. North American surveys of coyotes (Holzman et al., 1992), and kit foxes (Standley and McCue, 1997) also failed to find evidence of CCV (coyotes) and *B. canis* (kit foxes and coyotes). Antibodies to CCV and CHV were found in one study of the island fox in California, but the prevalence of both pathogens was low (Garcelon et al., 1992). Only one animal in our study, a crab-eating fox, had antibodies against CAV. The prevalence of antibodies to this virus was moderate to high in coyotes (41%), kit foxes (27%), and island foxes (59%) in the studies cited above.

A single pampas fox had detectable antibodies to *Leptospira interrogans*. Leptospirosis is increasing in both dogs (Ward et al., 2002) and humans (Ochoa et al., 2000), and antibodies to *Leptospira* spp. have been reported for deer, domestic cattle, and domestic dogs in Bolivia (Deem et al., 2004; Fiorello et al., 2004, 2006). *Leptospira interrogans* serovar grippotyphosa is relatively common in domestic dogs in the United States, where it is maintained in a variety of subclinically infected wildlife hosts (Langston and Heuter, 2003).

Additional studies are required to determine the impact of disease on wild carnivore populations in the Chaco, as well as the role of domestic carnivores in the ecology of these pathogens. In the absence of more definitive data, however, it is prudent to consider management strategies that will minimize the risk to wildlife in the park and the BZ. Vaccination of domestic carnivores against common disease agents such as CDV and FPV is a safe and effective method of protecting dogs and cats from serious disease. Although CPV and other viruses may already be endemic in wild carnivore populations, the large domestic carnivore population may facilitate the evolution and spread of different and more virulent strains of these agents. Limiting incursion of dogs into the park and BZ, and vaccinating dogs that regularly enter the BZ, may serve to protect wild carnivores from some pathogens.

Our results document the presence of

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antibodies to common canine and feline pathogens in wild carnivores living in disturbed and pristine portions of the Bolivian Chaco. The use of serology limits us to discussing exposure, and not disease, but it appears that carnivore populations in the Chaco are not naïve to numerous pathogens of conservation concern.

We thank N. Trepp, C. Cuéllar, R. Cuéllar, J. Barrientos, J. Ity, F. Mendoza, F. Soria, L. González, F. Leaños, J. Perú, J. Segundo, P. Brotherton, A. Manharth, and D. Mulkerin for enthusiastic help in the field. D. Rumiz, K. Kahler, L. Starr, V. Greco, A. Yang, B. Karesh, L. Samuels, J. Segundo, W. Ayala, O. Vitingay, and A. Arambiza provided essential logistic support. Two anonymous reviewers provided helpful comments that improved the manuscript. Funding was provided by the Field Veterinary Program, Jaguar Conservation Program Small Grants, and Kaa-Iya Project of Wildlife Conservation Society; the Center for Environmental Research and Conservation; and a National Science Foundation Doctoral Dissertation Improvement Grant (to C.V.F.).

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Received for publication 27 June 2006.

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