Diseases and Their Role for Jaguar Conservation

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Recent declines in free-ranging wildlife populations have highlighted the potentially devastating effect of infectious disease. Diseases are an increasing threat to wild felids due to habitat restriction and encroachment from domestic animals. Domestic animals can directly or indirectly enter in contact with natural felid populations, potentially disseminating pathogens and altering disease patterns. Although wildlife populations can have the ability to cope with perturbations such as diseases, the relative increase in mortality and morbidity in dwindling populations and the introduction of new pathogens can exert important effects on demography, creating great concern for any endangered species. However, the potential role of diseases in wild carnivore populations is still poorly understood, and this is especially true for the jaguar *Panthera onca*.

Although habitat fragmentation and hunting are considered the main threats to wildlife, diseases are an increasing concern for many of the most endangered carnivores (Laurenson *et al.* 2005). Diseases have always been present in wild felid populations, but can be devastating when occurring in populations that are already small or in decline, or suffering from malnutrition, stress or inbreeding (Murray *et al.* 1999). Emergence of more pathogenic strains, co-infections with other pathogens (Munson *et al.* 2007) and alterations in host-pathogen relationships can occur at any time. These can be responsible for epizooties, which may occur suddenly and with potentially disastrous consequences for endangered populations (Scott 1988; Cleaveland *et al*. 2006). In addition, environmental and demographic pattern alterations can cause the emergence and reemergence of infectious diseases and increase the occurrence of degenerative, neoplasic and genetic diseases (Daszak *et al.* 2000).

The transmission of infectious diseases between domestic and free-ranging carnivores is becoming increasingly common (Murray 1999). Jaguars and domestic animals occupying the same or adjacent environments can share much of the same pathogens (Fig. 1). The most important factor probably is the contact between domestic and wild carnivore populations at the interface of their ranges (Bengis *et al.* 2002), favoring the dissemination of infectious agents (Murray *et al*. 1999; Cleaveland *et al*. 2000; Daszak *et al*. 2000). Livestock predation represents an additional route of transmission of pathogens. Considering generalist infectious pathogens, domestic animals elevate the number of susceptible hosts, thus potentially elevating local prevalence of infectious diseases.

Wild animals dying of disease are rarely found; this is especially true for large carnivores like jaguars, which occur at low densities and have secretive behavior patterns (Murray *et al*. 1999). Thus, it is not just difficult to find appropriate biological material for epidemiological studies but also to justify to the authorities the importance of these studies or intervention in distressed wildlife populations (Artois 2001). One of the major tasks for effective disease monitoring programs for wild animals is the detection of early stages of new or reemerging diseases, essential for making correct decisions, avoiding serious losses of wildlife and minimizing economic and zoonotic impacts in livestock and humans (Morner *et al*. 2002; Dobson & Foufopoulos 2001; Bengis *et al*. 2002).

This paper presents a brief review concerning infectious and non infectious diseases reported in jaguars as available in current literature and focuses on the importance of addressing disease issues in jaguar conservation projects.

Fig. 1. Interaction between jaguar and cattle, occupying the same environment in the Brazilian Pantanal (Photo Jaguar Conservation Fund/Instituto Onça-Pintada).

Fig. 2. Blood collection from the femoral vein of a jaguar (Photo Jaguar Conservation Fund/ Instituto Onça-Pintada).

Infectious diseases

It is consensual that all members of the family Felidae are thought to be susceptible to the same pathogens (Fowler 1986). However, ecological and physiological patterns vary among wild felids and may be responsible for different patterns observed in the evolution of infectious diseases in felid species. In this paper we provide information collected from indexed databases regarding pathogens to which the jaguar has been reported exposed or infected both in captivity and in the wild. We have not attempted to present all pathogens to which jaguars might be susceptible, as it would be an impossible task due to spill-over from other species and the constant potential of change and emergence of pathogens. Similarly, we have not attempted to rank the presented pathogens as posing high or low risk of impact on host dynamics, neither to population nor individual levels, as profoundly significant differences exist among studies.

The selected diseases presented here should be interpreted with caution, as most studies consisted of case reports or serological surveys (Fig. 2): Serological surveys for antibody detection are indicative of previous exposure to a particular disease agent or class of agents that share similar antigenic properties, but seldom yield information on time of exposure, morbidity or mortality. Molecular detection and culture methods allow for identification of infectious agents actually present in the animal. In both cases, correlation between the agents detected and development of disease depends on additional information, such as clinical examinations, necropsies, and histopathologic evaluations.

Among microparasites (viruses, bacteria, protozoa and fungi), the viruses have drawn considerable attention. Fifteen years ago, the Canine distemper virus (CDV), a common pathogenic virus of canids, was proven to be fatal to felids: it killed 30% of free-ranging lions in the Serengeti (Roelke-Parker *et al*. 1996) and caused epizooties in captive felids in the Panthera genus in North America, including a jaguar (Appel *et al*. 1994). In Brazil, first evidence of CDV exposure in free-ranging jaguars was recently reported by Nava (2007) in the Atlantic Forest, possibly associated with the presence of domestic dogs.

The most common viruses that affect the domestic cat have been reported in jaguars. The Feline leukemia virus (FeLV), mostly fatal in domestic cats, does not appear to be endemic in captive or free ranging wild populations (Kennedy-Stoskopf 2003), except for the European wild cat (Daniels *et al.* 1999, Fromont *et al*. 2000). In Brazil, captive jaguars have been shown exposed to the FeLV (Schmitt *et al*. 2003). Antibodies to Feline immunodeficiency virus (FIV) or closely related lentiviruses have been found in most felid species, including captive (Barr 1989) and free-ranging jaguars (Murray *et al*. 1999). The FIV is a lentivirus of domestic cats that causes immunodeficiencies and neurological signals (Worley 2001) but seropositive wild felids do not show overt clinical signs (Kennedy-Stoskopf 2003). In Brazil, evidence of FIV infection was detected in jaguars (Leal & Ravazzollo 1998). Another important virus, the Feline coronavirus (FCoV), responsible for the feline infectious peritonitis (FIP), a fatal immune mediated systemic disease that occurs worldwide (Simmons et al. 2005), has been reported in captive jaguars in Brazil, similarly to all other neotropic felid species in captivity and in a free-ranging ocelot in Brazil (Schmitt *et al*. 2003; Filoni *et al*. 2006). Most FCoV infected felids do not develop FIP, and may remain sources of infection. Some felid species, like the cheetah, have been shown more susceptible to fatal systemic disease (Evermann *et al*. 1988). To date, free-ranging (Fiorello 2006) and captive jaguars (Cubas 1996) have been found seropositive to Feline parvoviruses (FPV) as well. The FPV infection in felids may range from asymptomatic to varying degrees of unspecific clinical signs, gastroenteritis and a decrease in blood cells that can be lethal (Barker & Parrish 2001). Evidence of exposure to Feline herpesvirus (FHV 1) has been found in captive Brazilian jaguars (Batista *et al*. 2005).

Among zoonotic bacteria, *Leptospira* sp, *Brucella* sp and *Bartonella henselae* were already reported affecting jaguars. The *Leptospira* sp, responsible for causing a mild to severe disease, does not appear to be a major problem for felid species. Captive (Côrrea 2000, Guerra Neto *et al*. 2004) and free-ranging jaguars (Furtado *et al*. 2007; Nava 2008) in Brazil have been reported seropositive to *Leptospira* sp. Nava (2008) reported seropositive free-ranging jaguars for *Brucella* sp, an important zoonosis affecting livestock. Brazilian free-ranging felids may be a reservoir for *Bartonella henselae* (Filoni *et al.*

2006), which causes cat scratch disease in humans. Captive jaguars have been shown antibody positive to *B. henselae* (Yamamoto *et al.* 1998), and recently, Guimarães *et al.* (2008) detected this bacteria in a captive jaguar in Brazil. Captive jaguars have also been shown seropositive to the anthrax bacterium, *Bacillus antracis* (Abdulla *et al.* 1982).

Evidence of infection with the fungus *Pythium insidiosum* has been reported for jaguars (Camus *et al.* 2004).

Considering protozoa, captive (Silva *et al.* 2001) and free-ranging jaguars (Furtado *et al*. 2007) were reported as seropositive to *Toxoplasma gondii* in Brazil, but clinical signs have not been found. Felids are the only definitive host for Toxoplasmosis (Frenkel *et al*. 1970), but little is known about the role of wild felids in the natural epidemiology of *T. gondii* infection and its role as cause of mortality in wild felines.

Although macroparasites of free-ranging jaguars have not been extensively studied, a wide variety of endoparasites have been reported (Patton *et al*. 1986) and the nematode *Dirofilaria immitis*, the heart worm, has been observed in free-ranging jaguars (Otto 1974). Few records are available about ectoparasites of free-ranging jaguars (Durden *et al*. 2006; Sinkoc *et al.* 1998; Labruna *et al*. 2005) although they can be possible vectors for other microparasites.

Fig. 3. Fracture of the upper left canine tooth of an adult female jaguar presenting exposure of necrotic pulp (Photo Jaguar Conservation Fund/Instituto Onça-Pintada).

Non-infectious diseases

Data about non-infectious diseases in jaguars are even scarcer than for infectious diseases. In Brazil, even captive populations of jaguars are poorly clinically assessed and consistent programs designed to evaluate their health are lacking. A retrospective study about the morbidity and mortality of captive jaguars has been conducted in North America, and detected dental, gastrointestinal, integumentary and musculoskeletal diseases as being the most common causes of morbidity (Hope & Deem 2006). Likewise, a high incidence of neoplasia was detected in captive jaguars, possibly associated with longevity and husbandry in the captivity (Paul *et al*. 2002; Castro *et al*. 2003; Ramos-Vara *et al*. 2000). Degenerative spinal disorders (Kolmstetter *et al.* 2000) and impairment of hearing (Ulehlova *et al*. 1984) have been described in captive jaguars too. For free-ranging jaguars, incidence of dental fractures, especially in the canines, was observed in the Brazilian Pantanal (Jaguar Conservation Fund - JCF unpublished data; Fig. 3), Amazon and Atlantic Forest biomes (Rossi Jr. 2007). Considering that free-ranging jaguars frequently kill by biting through the skull between the ears (Schaller & Vasconcelos 1978), the oral evaluation is an important part of their physical examination.

Perspectives

The scarcity of indexed information on occurrence of infectious and non infectious diseases in jaguars supports the thesis that investigation of health aspects should be a relevant part of any project directed towards conservation of this endangered species. Available data on the subject is fragmentary, largely consists of case reports and cross-sectional serological surveys, and relied on small samples. In addition, comparison of results from the existing surveys is difficult as different lab methods have been used and the selection of pathogens was opportunistic, arbitrary or directed by availability of funding and diagnostic tests. Unfortunately, more comprehensive studies and long term studies addressing the occurrence and effects of diseases are still lacking for wild jaguars.

While we consider that all survey designs are important, only detailed long term studies can provide a suitable understanding of the role of diseases in jaguar populations. The best approach would be interdisciplinary, interconnecting population studies with studies on pathogenesis of diseases and identification and characterization of pathogens. To achieve this, systematic data gathering on biological and clinical aspects in different geographical locations and designed for a growing number of pathogens, close monitoring of disease outbreaks and appropriate utilization of diagnostic methods are required. Studies on infectious diseases in free-ranging jaguars should be extended to prey species, livestock, and domestic carnivores (Fig. 4). Captive jaguars should also be considered in studies aiming to understand the role of diseases for the species as they represent a valuable potential genetic reservoir for future restocking into nature.

Thus, we consider that not only adequate personnel and laboratorial support should be available to serve this demand, but also that constant funding resources are necessary. Fortunately, cooperation between universities and non governmental institutions has been

Fig. 4. Epidemiological studies in free-ranging jaguars should be extended to domestic carnivores, as they represent a potential source of pathogens (Photo Jaguar Conservation Fund/Instituto Onça-Pintada).

a fruitful trend in Brazil. A central storage facility for biological material already exists for wild felids in Brazil represented by the National Center for Research and Conservation of Wild Predators (Centro Nacional para Pesquisa e Conservação de Predadores Naturais - CENAP), supported by the government. Non-governmental organizations are unifying their efforts towards conservation of jaguars through partnerships with diagnostic laboratories from universities. The Association Mata Ciliar was one of the institutions that started the systematic work with captive neotropical felids including jaguars, and continues to do so. The role of disease in wild jaguar populations in an ecological context is currently being addressed in various jaguar conservation projects in Brazil. To date, the Jaguar Conservation Fund (JCF) has an ongoing project assessing the health status of free-ranging jaguar populations in three Brazilian biomes: Cerrado, Pantanal and Amazon, through capturing, collecting biological samples (Figs 5 and 6) and radio-collaring jaguars. Samples from cattle and domestic dogs from the same areas are being collected to contrast the results from jaguar samples (Furtado *et al.* 2007). In addition, the JCF is developing a study with jaguar skulls to understand if and how oral injuries compromise the species' predatory behavior. In Southeastern Brazil, the Ecological Research Institute - IPÊ develops an epidemiological project in the Atlantic Forest where jaguars, their prey, and domestic animals are being sampled to study the occurrence of infectious diseases and epidemiological consequences of forest fragmentation (Nava 2008). The Instituto Pró-Carnívoros is also initiating a project in the southern Pantanal to investigate the occurrence of selected infectious agents in free-ranging jaguars.

Conclusion

Although little information is currently available about the impact of diseases on jaguar population, it is broadly accepted that surveillances and monitoring programs are required for an adequate understanding of disease dynamics in wild jaguar. Only such monitoring will provide timely identification of increases in pathogens effects and allow for actions and further analyses to resolve possible outbreaks. Diseases should always be considered as an important factor in conservation biology.

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Fig. 5. Testing biochemical properties of a captured jaguar's urine in the Pantanal of Mato Grosso do Sul (Photo Jaguar Conservation Fund/Instituto Onça-Pintada).

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Fig. 6. Taking a blood sample from a jaguar during capture within a JCF project investigating epidemiology and possible disease transmission between jaguars and domestic livestock (Photo Jaguar Conservation Fund/Instituto Onça-Pintada).

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