Feline Coronavirus in African Cheetah Populations

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Management of self-sustaining populations of cheetahs has been problematic, as evidenced by continuing poor health and declining numbers. Infectious disease agents, including feline coronavirus (FCoV), continue to be causes of concern for these populations because of potential health problems and restrictions on moving breeding animals. The 2005 international meeting of the Association of Zoos and Aquaria (AZA) Cheetah Species Survival Plan (SSP) Health Management Group recommended broader surveillance for FCoV infection be conducted among captive populations to 1) determine the prevalence of infection, 2) identify persistently infected animals and 3) assess the effects of FCoV on health.

FIP appears to occur only in a minority of FCoV infections, including in cheethas. However, enteritis associated with FCoV has resulted in mild to severe chronic diarrhea in several felid species, including cheetahs, and has been associated with less specific signs of disease including weight loss, depression, and inappetence. Recent studies have shown an association of FCoV with enterocolitis; ongoing pathology surveillance of the AZA Cheetah SSP population and maintenance of a comprehensive pathology database led to detection of chronic enterocolitis as an emerging problem that may be associated with FCoV infection.

Because of the concern over potential disease development, FCoV infection directly impacts management, most importantly the pairing of breeding animals, and movement of animals among facilities for breeding purposes. Because of the need to maintain genetic diversity in the endangered cheetah, these restrictions on moving infected animals may be a more important consequence of infection than the risk of disease in individual cheetahs. A better understanding of the epidemiology and pathogenesis of this virus in cheetah populations is essential to the management decision-making process.

Establishment and maintenance of a FCoV-free population is not feasible, but managing cheetahs to minimize exposure of naïve animals and minimize disease is a reasonable goal. To this end, a better understanding of the epidemiology and pathogenesis of the virus in cheetah populations will be critical.

Previous studies in African populations:

We tested a total of 342 animals in the Republic of South Africa and Namibia, including 140 wild-caught animals, for evidence of FCoV infection from 1999 through 2001. Past or current infection was evaluated by serology and/or active virus infection evaluated by reverse transcription/nested polymerase chain reaction (RT/nPCR) on feces.

Over 50% of the animals from Southern Africa tested by serology and RT/nPCR had evidence of infection. These results were not limited to captive animals, as 41 of 140 animals originating in wild populations also may have been infected with FCoV. While no conclusions about prevalence nor significance of FCoV in wild populations can be made, as some animals were tested after arrival at the captive institution, the source in all cases was virus from the wild indicating its presence in these populations.

TABLE 1. Results of cheetahs (Acinonyx jubatus) tested by RT/nPCR with or without serology.

Institution	Tested by/Positive by PCR/PCR	Tested by/Positive by IFA/IFA
A	39/15	20/19
B	39/3	39/19
C	104/48	87/86
Total	182/66	146/124

TABLE 4. Results of cheetahs (Acinonyx jubatus) tested by both RT/nPCR and serology.

Institution	PCR+/IFA+	PCR+/IFA-	PCR-/IFA+	PCR-/IFA-
A	1	0	17	1
B	1	2	18	19
C	45	1	41	0
Total	47	3	76	20

TABLE 3. Results of cheetahs testing positive by RT/nPCR at more than one point.

Animal	11/99[a]		8/00		11/00		3/01		4/01		9-11/01[d]	
	PCR	IFA[b]	PCR	IFA	PCR	IFA	PCR	IFA	PCR	IFA	PCR	IFA
1	+	ND[c]	ND	10/10	+	ND	-	ND	-	40/40	ND	ND
2	ND	ND	-	40/40	ND	ND	ND	ND	+	160/80	+	80/40
3	+	ND	-	10/10	-	ND	+	ND	-	ND	ND	ND
4	+	ND	+	40/40	+	ND	-	ND	-	40/40	+	20/10
5	ND	ND	+	10/10	ND	ND	+	ND	-	80/40	-	20/10
6	+	ND	+	40/20	-	ND	+	ND	ND	ND	ND	ND
7	ND	ND	+	20/20	-	ND	+	ND	+	40/40	-	80/40
8	+	ND	+	20/10	-	ND	-	ND	-	20/20	ND	ND
9	+	ND	-	<5/<5	ND	ND	ND	ND	ND	ND	+	10/10
10	-	ND	ND	ND	ND	ND	ND	ND	+	10/10	+	10/10

[a]Dates of testing by month/year.
[b]Serology results for FCoV types I and II-specific antibodies respectively.
[c]ND=not done.
[d]Tested once during the period.

There was a significant difference between the prevalence of sero- and RT/nPCR-positive cheetahs at the South African institutions as compared with the Namibian institution. This may be related to fact that all of the Namibian animals were wild-caught, while most of the South African cats were bred in captivity. Housing and management also differed. In Namibia, the cheetahs are kept in small groups in camps ranging from 10-50 hectares with little or no contact with neighbors. In South Africa, the housing is much more intensive with animals in contact with neighboring animals through fences. In addition, movement of animals to enclosures previously inhabited by other cheetahs is continuous. It is notable that there is a low prevalence of FIP in these institutions in southern Africa. Only one case has been reported despite a high incidence of FCoV infection. A possible explanation for this is that the virus occurring cheetahs in southern Africa is largely nonpathogenic.

Ten of 48 animals tested at more than one time point by RT/nPCR were shedding virus at multiple time points, possibly indicating persistent infection. These persistently infected animals may be an important source of infection for contact animals.

Evidence of FCoV exposure in free-ranging Namibian cheetahs:

With a serosurvey of 81 free-ranging Namibian cheetahs, we determined that 29% had antibodies against FCoV, by using an indirect immunofluorescence assay. No cases of FIP or enterocolitis were detected in an additional 49 cheetahs necropsied from this same population in contrast to seven cases of FIP in an age-matched, captive population. Although this pathology survey was limited in scope and may have

been biased toward healthy animals, the results suggest that FCoV may be more pathogenic in captive animals. Evidence of chronic stress in captive animals may influence the host response to infectious agents such as FCoV.

Screening of samples collected 2006/07:

Of 66 samples collected from Pretoria Zoo, de Wildt Cheetah Conservation Centre, Cheetah Conservation Fund, Cheetah Conservation Botswana, Cango, Ukutula, Entabeui and tested by RT-PCR, only one, from CCB was positive. Five animals from Cango were seropositive out of 32 serum samples tested. Fifteen animals from de Wildt tested seropositive from 49 samples collected in 2006. Of 57 animals tested from Africat in Namibia, one was RT-PCR+ for virus, one was seropositive, and one was both RT-PCR+ and seropositive.

In summary, testing of nearly 150 samples collected in 2006/7 by RT-PCR (testing done in 2007) had a lower incidence of infection (16% compared to nearly 50% in previous study), with 24 cheetahs total showing evidence of current or past infection. Only three animals were actively shedding virus as evidenced by PCR. The testing for AfriCat was consistent with previous testing, showing a relatively low incidence of infection in this population. However, the incidence of infection from cheetahs at de Wildt was significantly lower than previous testing for unknown reasons. Possibilities include testing of different animals, fewer samples tested overall, or decrease in virus circulation. Management practices have not been significantly modified at this institution, so it is unlikely that management impacted the incidence. The samples from the additional locales had been collected from these institutions for the first time, thus no comparison could be made.