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NEWSLETTER

The Common Feline Pathogens of African Wild Cats[©]

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Summer 2013

Vol. 12 Number 3

In This Issue:

After having just returned from a wonderful African safari tour in Kenya and Tanzania, the Summer 2013 issue of the NVL Newsletter will discuss the prevalence, in African wild cats, of the common domestic cat pathogens (feline leukemia virus, feline immunodeficiency virus and *Bartonella*).



Introduction:

Evelyn Zuckerman and I (Dr. Hardy) were seated comfortably on our transatlantic flight home, after a wonderful African safari to Amboseli National Park, Lake Manyara National Park, Ngorogoro Crater, the Maasai Mara Serengeti, and the historic site of the origin of humans from Africa, the site where the Leakeys unearthed their fossil skeletons. We visited the continent where humans and domestic cats originated. More than likely, the infectious pathogens of early hominins and other animals evolved, due to climate changes, with their hosts to the present day and some became zoonotic pathogens.^{1,2}

On the flight I was reading David Quammen's new book "Spillover," about the origins in animals of most of our new zoonotic diseases while I was racking my brain for a topic for our summer NVL newsletter. It took only about 15 minutes before the proverbial light went on to connect our early research, on African big cats, with our safari and the origin of zoonoses such as *Bartonella* that veterinarians often encounter. I realized that our FeLV research collaboration with Don Francis, a physician at Harvard with Max Essex in the 1970s, linked our cat work with Don who was later sent to investigate the first Ebola zoonotic outbreak in Africa. After having just photographed leopards, cheetahs and lions up close, I recalled the collaborations and publications with Steve O'Brien, Moritz Van Vuuren and Steve Osofsky on testing Africa's big cats for the common domestic cat pathogens.

Steve O'Brien has done pioneering research on the genetics and origin of domestic cats and FeLV which led him to groundbreaking research on the occurrence in humans, of cell receptors for susceptibility to HIV. We collaborated with Moritz Van Vuuren from South Africa on the occurrence of feline retroviruses in African big cats. We also collaborated with Steve Osofsky and his wife, who at the time were wildlife

veterinarians working in Botswana. Now Steve is the Director of Wildlife Health Policy at the Wildlife Conservation Society and is trying to save Africa's wildlife using modern economic strategies www.wcs-ahead.org. Years later, to experience these magnificent cats and other



The great migration of wildebeest & zebra in the Serengeti



The crossing of the crocodile infested Mara River. Photos- Dr. Hardy

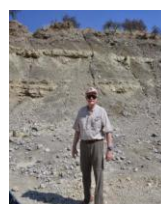
animals, including the great migration of wildebeest and zebra in their natural environment, was truly inspiring. Our trip also brought us to the Olduvai Gorge site where the Leakey's discovered some of the earliest hominin fossils relating to the evolution of humans. It was very moving to be actually standing at this scientifically historic site.



Olduvai Gorge- Tanzania and Louis Leakey

Origin of Humans:

East Africa, and possibly the Olduvai Gorge area in Tanzania, is the site for the origin of humans and cats. It is better-known as 'The Cradle of Mankind' and it was excavated by Louis and Mary Leakey in the 1950s.



Dr. Hardy at the Olduvai Gorge, Tanzania, the multilayer site of early hominin habitation from where present day humans evolved.

Deposits exposed in the sides of the gorge cover a time span from about 2.1 million to 15,000 years ago. They have yielded the fossil remains of more than 60 hominins (members of the human lineage), providing the most continuous known record of human evolution during the past 2 million years. One theory proposes that as the African climate changed and became drier, apes and hominins came out of the forest to scurry upright in the grassland savannas in search of food.^{1,2} As humans continued to evolve they spread to eventually settle in the Fertile Crescent, a curved area encompassing the Middle East- parts of Iraq, Syria, Lebanon, Jordan, Israel, and northern Egypt. The area was known as the Cradle of Civilization and the birthplace of agriculture, urbanization, writing, trade, science,

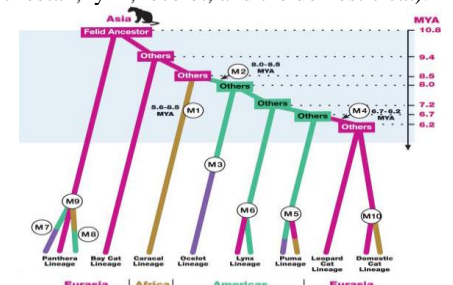


Fertile Crescent- green shaded area.

and organized religions (Christian, Jewish, and Muslim). The area was first populated in 10,000 BCE when agriculture and domestication of animals began.

Origin of Cats:

Felidae is the biological family of cats; a member of this family is called a felid. The first felids emerged during the Oligocene, about 25 million years ago. The most familiar felid, the domestic cat, first became associated with humans about 10,000 years ago. The family also includes all other wild cats, including the big cats. Existing felids belong to one of two subfamilies: *Pantherinae* (which includes the tiger, lion, jaguar, and leopard), and *Felinae* (which includes the cougar, cheetah, lynx, ocelot, and the domestic cat).^{3,4}



Evolution of cats, Reference 3

The radiation of modern felines began with the divergence of the *Panthera* lineage. From this common ancestor all the big cats emerged 6.4 million years ago—lions, jaguars, leopards, tigers, snow and clouded leopards. They were quickly followed by three Asian species and three African species. The final feline to appear was the domestic cat, which emerged between 6.2 to 6.7 million years ago.

Domestic Cats: Domestic cats were derived from at least 5 founders of *Felis silvestris*, the European wild cat (Figure left—courtesy Wikipedia), and humans dispersed their descendants throughout the world.^{3,4} Dogs and farm animals were domesticated before cats, and cats appear to have been domesticated about 9,500 years ago to control rodents that were feeding on grain storage sites.



European wild cat (Figure left—courtesy Wikipedia), and humans dispersed their descendants throughout the world.^{3,4} Dogs and farm animals were domesticated before cats, and cats appear to have been domesticated about

Lions: Lion fossils trace to the Late Pliocene in Eastern Africa and the Early Pleistocene in Eastern and Southern Africa coincident with the flourishing of grasslands, 2–1.5 million years ago.⁵



Male lions, Photo- Dr. Hardy

By the Mid Pleistocene (500,000 years ago), lions occupied Europe and by Late Pleistocene, 130,000–10,000 years ago) lions had the greatest intercontinental distribution, excluding humans, for a large land mammal, ranging from Africa into Eurasia and the Americas. Lions were eliminated from Europe 2,000 years ago and within the last 150 years from the Middle East and North Africa. Today, there are less than 50,000 free-ranging lions living only in sub-Saharan Africa and the Gir Forest, India

Cheetahs: Cheetahs evolved about 5.5 million years ago along with the golden cats and pumas. The cheetah (*Acinonyx jubatus*) is a large feline (family *Felidae*, subfamily *Felinae*) inhabiting most of Africa and parts of the Middle East. It is the only surviving member of the genus *Acinonyx*. Cheetahs are inbred and have unusually low genetic variability.⁶



Dr. O'Brien's Book on Cheetah Evolution

As Steve O'Brien has discovered and explained elegantly in his excellent book "Tears of the Cheetah," cheetahs have evolved through 2 bottlenecks where their genetic pool was very small resulting in little genetic diversity in the present day cheetahs.⁶

Leopards:



Female leopard- Photo-Dr. Hardy

believed to have lived about 6.5 million years ago. Leopards appear to

be related to lions, tigers, snow leopards, jaguars, and clouded leopards.³

The Pathogens:

African wild cats and their pathogens evolved together. Endogenous retroviruses were transmitted across species and then evolved in their new feline species. FIV-like viruses evolved in many African, and other wild cats and became non-pathogenic in these cats.⁷⁻¹⁴ Unlike FIV, the human HIV lentivirus derived zoonotically from chimps recently, has caused a worldwide epidemic killing millions of people. *Bartonella* is also found in several species of African wildcats and seems to have evolved separately in them. Although not a feline pathogen, the canine distemper virus killed many lions in the Serengeti in the 1990s and bovine TB continues to take its toll on African lions.^{15,16}

FeLV: To date, no FeLV has been found in any free ranging African wildcats although there have been several infected with FeLV while living in zoos.⁷⁻¹⁴ The endogenous FeLV sequences are present only in the members of the genus *Felis*. Similar sequences are found in rats whose ancestors must have infected an ancestor of domestic cats after they diverged from the rest of the cat family. Domestic cat DNA also harbors RD-114 endogenous sequences obtained from baboon ancestors in ancient Africa.

FIV: The FIV-like virus found in African cats (FIV-ple) is similar to the one we found in cougars in North America and quite different from the pet cat FIV.¹⁷ FIV is endemic in 9 *Felidae* and one *Hyaenidae* species.⁷⁻¹⁴ The prevalence varies depending on the geographic location and appears to have evolved along with each cat species. The virus is non-pathogenic in these African cats, much like we observed in the pumas in British Columbia, Canada.⁸⁻¹⁰ In collaboration with Steve Osofsky and Karen Hirsch we found 8/31 (26%) lions, 3/18 (17%) leopards, and 1/4 (25%) cheetahs infected in Botswana in 1996.⁸ In 2003, with Moritz Van Vuuren, we found FIV infection common in free-ranging lions in Kruger National Park, SA 18/22 (82%), Botswana 20/22 (91%), Zimbabwe 7/22 (32%) but in none of the 18 lions from Hluhluwe-Umfolozi, SA.¹⁰

Bartonella:

Bartonella have evolved with their animal hosts (co-evolution) for millions of years. This group of bacteria has a fascinating history in veterinary and human medicine and most warm blooded animals are infected with one of the 26 species of *Bartonella*. Few studies have been done on the prevalence of *Bartonella* in free-ranging African big cats. One study found serologic evidence of exposure in 19/113 (17%) African lions and 23/74 (31%) cheetahs- the country of origin was not specified. 5% of 58 lions and 6% of 17 cheetahs were considered bacteremic by TaqMan PCR.¹⁸ The other study of 62 lions on a game ranch in South Africa found 18 (29%) were antibody positive by IFA.¹⁹

Origin of Zoonotic Pathogens:

Africa was and is a hot bed of human, animal, and microbe evolution and it is no wonder that

many of our new zoonotic diseases are arising from animals on the African continent. HIV and Ebola virus are but two that have arisen from Africa and more will probably follow.

References:

1. Summers, BA Climate Change and Animal Disease. *Vet Pathol* 46:1185-1186, 2009.
2. Gibbons, A. Human Evolution. How a Fickle Climate Made Us Human. *Science* 341:474-479, 2013.
3. Johnson, WE. et al. Late Miocene Radiation of Modern Felidae: A Genetic Assessment. *Science* 311:73-77, 2006.
4. Driscoll, CA, et al. The Near Eastern Origin of Cat Domestication. *Science* 317: 519-523, 2007.
5. Antunes A, Troyer JL, Roelke ME, Pecon-Slattery J, Packer C, et al. (2008) The Evolutionary Dynamics of the Lion *Panthera leo* Revealed by Host and Viral Population Genomics. *PLoS Genet* 4(11): e1000251. doi:10.1371/journal.pgen.1000251
6. Menotti-Raymond, M, and O'Brien, SJ, Dating the genetic bottleneck of the African cheetah. *Proc Natl Acad Sci USA*, 90:3172-3176, 1993.
7. Brown, EW, Olmsted, RA, Martenson, JS and O'Brien, SJ. Exposure of FIV and FIPV in Wild and Captive Cheetahs. *Zoo Biology* 12:135-142, 1993.
8. Osofsky, SA, Hirsch, KJ, Zuckerman, EE, and Hardy, WD, JR. Feline lentivirus and feline oncovirus status of free-ranging lions (*Panthera leo*), leopards (*Panthera pardus*), and cheetahs (*Acinonyx jubatus*) in Botswana: A regional perspective. *J. Zoo Wildl. Med.* 27: 453-467, 1996.
9. VandeWoude S., O'Brien, S.J., Langelier, K., Hardy, WD, JR., Slattery, JP, Zuckerman, EE, Hoover, EA. Growth of lion and puma lentiviruses in domestic cat cells and comparisons with FIV. *Virology* 233: 185-192, 1997.
10. Van Vuuren, M, STYLIANIDES, E, KANIA, SA, Zuckerman, EE and Hardy, WD. Evaluation of an indirect enzyme-linked immunosorbent assay for the detection of feline lentivirus reactive antibodies in wild felids, employing a puma lentivirus-derived synthetic peptide antigen. *Onderstepoort Journal of Veterinary Research* 70: 1–6, 2003.
11. Munson, L., et al., Serosurvey of viral infections in free-ranging Namibian cheetahs (*Acinonyx Jubatus*). *J Wildlife Dis* 40:23-31, 2004.
12. Troyer, JL, et al., Seroprevalence and Genomic Divergence of Circulating Strains of Feline Immunodeficiency Virus among *Felidae* and *Hyaenidae* Species. *J. Virol* 79:8282-8294, 2005.
13. Roelke, ME, et al., Pathological manifestations of feline immunodeficiency virus (FIV) infection in wild African lions. *Virology* 390:1-12, 2009.
14. Thalwitzer, S., et al., Seroprevalence to Viral Pathogens in Free-Ranging and Captive Cheetahs (*Acinonyx jubatus*) on Namibian Farmland. *Clin Vaccine Immunol* 17:232-238, 2010.
15. Roelke-Parker, ME, et al., A canine distemper virus epidemic in Serengeti lions (*Panthera leo*). *Nature* 379:441-445, 1996.
16. Michel AL, et al. Wildlife tuberculosis in South African conservation areas: implications and challenges. *Vet Microbiol.* 112:91-100, 2006.
17. Hardy, WD, JR, Zuckerman, EE and Langelier, K. Possible "trans-species" transmission of a feline lentivirus from Pumas (*Felis concolor*) to domestic cats (*Felis catus*). September 7-13, 1996, Abstract 335, AIDS Research and Human Retroviruses.
18. Molia, et al, Prevalence of *Bartonella* infection in wild African lions (*Panthera leo*) and cheetahs (*Acinonyx jubatus*). *Vet Microbiol* 20:31-41, 2004.
19. Pretorius, A-M, Kuyil, JM, Isherwood, DR, and Birtles, RJ. *Bartonella henselae* in African Lion, South Africa. *Emerg Infect Dis* 10:2257-2258, 2004.

Bartonella references can be obtained at:

www.nlm.nih.gov/or natvetlab.com

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