Infectious Diseases Subdue Serengeti Lions

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**Infectious diseases stalk wildlife in the Serengeti,
and climate change may be an accessory.**

Nocturnal hunters, lionesses in a lion pride usually do the killing. They often look for their next meal from tree-lined vantage points, such as beneath umbrella-shaped acacias like those pictured here. Photograph: Guenter Guni.

It must be the wind, this almost-keen-ing that rises and falls every minute or two. But guards outside the door tell a different story. Here at a lodge in Tanzania's Serengeti National Park, one watchman after another lines a curving brick walkway leading to rooms.

Not far from a guest door, a *simba*, as he's called in Swahili, roars. Near the lion—beyond the lodge lights and under a grove of umbrella-shaped acacia trees—recline several lionesses. Perhaps the lionesses, premier nocturnal hunters of

the savanna, await their prey. Zebras, among their favored meals, frequent the grasslands surrounding the lodge. The roars continue but sound no nearer. For tonight, peaceful coexistence of lions and people reigns, at least in this part of the 14,500-square-kilometer Serengeti National Park.

Multiple diseases threaten Serengeti lions

Lions face serious threats to their future, some head-on, others lurking in the

grasses, unseen until it's almost too late. From growing numbers of people living along the Serengeti perimeter to the effects of infectious diseases and climate change, the king of beasts (*Panthera leo*) leads an uneasy life, according to Craig Packer, a biologist at the University of Minnesota who has studied the Serengeti's lions for three decades. Sometimes, he says, lions face a double whammy.

For example, lions are subject to simultaneous outbreaks of canine distemper virus (CDV) and babesiosis. CDV, a

disease that results in encephalitis and pneumonia, is transmitted by domestic dogs; babesiosis is carried by a tick-borne blood parasite called *Babesia*. In 1994 and 2001, two “perfect storms” of extreme drought followed by heavy seasonal rains set up the right conditions for CDV and babesiosis outbreaks to converge.

When the drought was over and rains fell, *Babesia*-carrying ticks flourished. They infested Cape buffalo that were by then starved for food; the herbivores couldn't find enough vegetation during the drought. When the babesiosis-infected buffalo died, lions fed on their carcasses, leading to babesiosis in lions already exposed to CDV. “CDV or babesiosis alone aren't threats to lions,” Packer says. “It's the combination of CDV with a high level of exposure to *Babesia* that killed the lions in 1994 and 2001. Although the intense babesiosis is ultimately what did it, these cofactors were completely synchronized by drought.”

In 1994, one-third of the Serengeti lion population—more than 1000 lions—died. In 2001, the much smaller nearby Ngorongoro Crater population, around 100 lions, suffered a similar high percentage of losses. “Should drought occur in the future at the same time as lions are exposed to masses of *Babesia*-carrying ticks—and there is a synchronous CDV epidemic—lions will once again suffer very high mortality,” says Packer.

If extreme weather events become more frequent as a result of global climate change, says veterinary pathologist Linda Munson of the University of California, Davis, “disease may become a major threat to animal populations that have been historically stable.”

Diseases once thought to have limited impacts, such as babesiosis, should be watched closely, she says. Environmental conditions may tip the scales and result in significantly greater impacts, even in wide open places like the Serengeti.

Africa's endless plain: The lion's domain

The Serengeti is Africa's largest savanna ecosystem. Savannas—tropical and subtropical grasslands with scattered bushes

Living primarily in savanna and other grasslands, lions are very social compared with other felids. Groups of lionesses usually rest together, often atop kopjes, or rock piles, that dot the Serengeti landscape. Photograph: Peter Malsbury.

and trees—are one of the largest biomes on Earth, making up more than 20 percent of the planet's land surface. Most savanna is located in Africa, with a smaller amount in South America, India, and Australia. Savannas are found near the equator where it's warm but relatively dry, and are subject to seasonal drought.

“The very name Serengeti conjures up a vast vision of open spaces and phenomenal abundance, of vast herds free to wander immense plains that stretch on forever,” wrote Packer and Stephen Polasky, also of the University of Minnesota, in *Serengeti III: Human Impacts on Ecosystem Dynamics*. “[But] the Serengeti, despite its apparently endless bounty, is an ecological island in a rising sea of humanity.... Our grandchildren may only know Serengeti as a faintly exotic word, like Atlantis or Eden.”

Safari-goers in Tanzania hope to see Serengeti wildlife while it's still there. Ironically, human population growth around the edge of the park—a staging area for Serengeti safaris—poses a threat to wildlife through habitat encroachment and spread of infectious diseases. Tanzanians as well as tourists are drawn to the Serengeti perimeter. Job scarcity else-

where leads residents to national parks to find new ways of making a living.

Safari groups make their way into the park in Land Rover after Land Rover, hoping for a glimpse—first and foremost—of the ruler of the Serengeti, the lion. At the appropriately named Simba Kopjes (pronounced “copies”), outcrops of gneiss and granite that form large rock piles, a trio of lionesses nicknamed the three sisters rests in the midday warmth. Their bodies are so close together they appear as one. One lioness lazily lifts her head to look askance at idling vehicles crammed with gawking tourists. Since people aren't allowed out of Land Rovers in the Serengeti, the lioness knows the disturbance won't go beyond impolite staring.

From the vantage point of open-country kopjes, lions often locate carcasses to scavenge. Embankments along rivers and streams are also important hunting locales; these vegetation-lined areas provide lions with cover to stalk prey. When zebras and other animals are plentiful, lions spend 20 hours out of every 24 conserving energy, becoming active in late afternoon. They hunt mainly at night, but if an easy meal presents itself, lions will hunt by day. “Lions select areas where prey is easier to catch, rather

than where prey densities are highest,” says Packer. “‘Catchability’ counts.”

Lions in the Serengeti have been continuously monitored by researchers for more than 30 years. Packer and colleagues primarily study lions living in the south-eastern corner of the park. Two habitats are found in the 2000-square-kilometer area: acacia woodland and open-grass plains. Lions on the plains are fewer and have lower prey availability than their woodlands counterparts, says Packer. Shaded woodlands are home to many of the animals lions hunt.

“At any given time,” Packer says, “field assistants are keeping track of some 250 lions in 15 to 20 prides.” To survive, lions need a water source and a steady supply of prey, so researchers have an idea where they might be found. Monitoring involves locating as many lions as possible. “Prides of lions are territorial,” says Packer, “so we know approximately where to look, but ranges can be as large as 400 kilometers.” The team focuses its efforts on known “hot spots” within each territory, including water holes, riverbanks, and kopjes.

A female from each pride wears a radio collar. When the research team locates a lion, the first step is to identify all the other lions present. Lions are born with a pattern of whisker spots that never changes; these spots mark each one in a population. After the animals are identified, the scientists record information about the lions’ condition: whether they are pregnant, seem ill, make a kill or are feeding on a carcass, or are mating. The lions’ location is recorded on a GPS (global positioning system) unit.

Documenting “interaction events” among carnivores in the Serengeti is among the most important research conducted there. For lions, as well as hyenas and jackals, disease transmission can occur within social units like prides, but also between species during territorial defense, long-distance movements, or kleptoparasitism (stealing kills). “Lions, hyenas, and jackals are often observed at the same kill at the same time,” says Packer. “Disease can spread during squabbles, or just by sharing the same food resource.”

Lions make extensive use of watercourses for hunting. Vegetation-lined rivers and streams in Tanzania provide cover from which to hunt zebras, buffalo, and other prey animals. In the Serengeti, everyone meets not at the water cooler but at the watering hole. Photograph: Michel di Nijs.

Long history of infectious diseases marks the Serengeti

For more than a century, says Packer, infectious diseases have shaped the Serengeti. “The direct and indirect effects of rinderpest, for example, have drawn the modern dimensions of this ecosystem.” Rinderpest was introduced to Africa in the 1880s; it devastated the cattle herds of Tanzania’s native Maasai pastoralists. The disease swept over the region like an uncontrolled brushfire, killing 90 percent of the cattle. According to some estimates, as much as 95 percent of East Africa’s buffalo and wildebeest also died.

Rinderpest appeared and reappeared in skips and jumps between the late 1800s and the 1940s. By 1955, no outbreaks had been detected in wild species. But it was the calm before the storm: rinderpest reappeared in 1957, causing heavy mortality. The last year rinderpest was detected in Serengeti wildebeest was 1962;

in buffalo, 1963. With the development of a vaccine against the disease, 30 rinderpest-free years followed. Then in 1997 signs suggestive of rinderpest were again found in the pastoral cattle that migrate in search of grassland and water during droughts. Immediate vaccination against the disease began throughout Tanzania.

The known history of CDV in the Serengeti also extends back several decades. CDV infected African wild dogs in 1968 and black-backed jackals and bat-eared foxes in 1978. Then on 3 February 1994, a group of tourists hovering in a hot-air balloon over the central Serengeti noticed a male lion in distress along the banks of the Seronera River. The lion wasn’t able to stand, and soon died. By May of 1994, more than a third of 250 study lions had died or disappeared; many of the rest had symptoms similar to those of the Seronera River lion. In August, the unknown disease spread to the western part of the Serengeti. It entered Kenya’s Maasai Mara wildlife reserve in October. By year’s end, the total lion population in the Serengeti ecosystem, which reaches across Tanzania into Kenya, had dropped from 3000 to 2000.

Scientists suspected that the disease—identified from blood and tissue samples as CDV—was coming from domestic dogs in villages around the Serengeti perimeter. Tanzanians keep dogs as security guards, to watch over domestic livestock, and to serve as family companions. Blood samples from the dogs indeed showed the presence of CDV.

“Canine distemper is spread mostly by sneezing,” says Packer. “But since lions seldom venture into towns, it was unlikely that the virus had traveled directly to lions from domestic dogs. It was more plausible that the lions had caught the virus from other carnivores—hyenas, jackals, or leopards.” Hyenas and jackals are scavengers that frequent villages, and leopards eat domestic dogs. Lions would come into contact with these infected species at kills.

“The pathogen responsible for CDV belongs to the morbilliviruses,” Packer says. The viruses are easy to catch and can kill up to 80 percent of their victims. An outbreak of CDV in 1993 led to the

deaths of thousands of domestic dogs near the Serengeti. With more than 30,000 domestic dogs living within 10 miles of the Serengeti National Park boundary, and millions more dogs throughout the rest of Tanzania, containing CDV has been a daunting task.

Enter Project Life Lion. Sponsored by the World Society for the Protection of Animals in Boston, scientists affiliated with Project Life Lion, such as Packer, Sarah Cleaveland of the University of Edinburgh, and others, started a program in the late 1990s to vaccinate dogs in villages surrounding the Serengeti against CDV. Through an intensive effort, tens of thousands of domestic dogs have been vaccinated.

CDV and babesiosis aren't the only diseases Serengeti lions contract. They're also at risk of feline herpesvirus, feline immunodeficiency virus (FIV), feline calicivirus, feline parvovirus, and feline coronavirus. Of these, feline herpesvirus and FIV are prevalent and very likely endemic in the lions. Lions and other cats are susceptible to FIV, a virus similar to HIV in humans. FIV attacks a feline's immune system and may be transmitted from one cat to another, usually through bite wounds.

FIV is very common in Serengeti lions. More than 90 percent have tested positive for the disease. The virus is also rampant in Ngorongoro Crater, where it is found in 93 percent of lions. But FIV seems to have no effect on the lions. "If FIV had compromised the immune systems of lions as it does those of domestic cats," says Packer, "there would be higher death rates from other diseases, and/or more rapid progression of disease, when lions are infected with both FIV and another disease." However, he says, the data don't show higher death or disease rates in FIV-positive lions compared with FIV-negative lions.

The best explanation, he says, lies in evolutionary adaptation. FIV could have been in the environment for thousands of years. Some lions may have a genetic trait that allows them to survive FIV infection. "These lions would have had a survival and reproductive advantage," Packer says, "leading to the spread of the trait through natural selection."

Veterinarians Magai Kaare and Sarah Cleaveland expanded the dog vaccination program to include areas to the east of Serengeti National Park. Initially, only domestic dog densities to the west of the Serengeti were considered high enough to be a reservoir for rabies, but Kaare and Cleaveland realized that human population growth on the eastern side had changed the playing field.

Photograph: Craig Packer.

If FIV and lions coevolved, rendering the virus benign in these carnivores, they may have something to teach us about HIV in people. Studies of FIV in lions, says Packer, will help researchers in their quest to develop an HIV vaccine for humans.

Diseases continue to plague Serengeti National Park

Among the latest threats faced by Serengeti lions, along with other African animals—including humans—is rabies. The disease is caused by a virus and is transmitted through the bite or scratch of an infected animal. The first description of rabies is in the Babylon Codex, written in 23 BC. The disease thrived from ancient times until the end of the 19th century, when in 1885, Louis Pasteur developed a postexposure rabies vaccine for humans.

More than 120 years later, the disease still plagues humans, especially in developing countries in Africa, Southeast Asia, and Latin America. According to the World Health Organization, more than three

billion people in 85 countries and territories worldwide are at risk of rabies. Some 10 million people receive postexposure rabies vaccines each year. Around the world, one person dies of rabies every 10 minutes, and of the total killed each day, 100 are children. Almost 25,000 people in Africa die from rabies each year.

Rabies also devastates wildlife populations. In the 1990s, rabies drove African wild dogs to local extinction in Tanzania and Kenya. In these very social dogs, when one individual becomes infected with rabies, its entire pack is likely to die. The disease also killed half the adult female bat-eared foxes, and some 20 percent of the adult male foxes, in the central Serengeti. Concerns were raised that the Serengeti's wild carnivore species might act as a reservoir for rabies.

Domestic dogs, however, once again turned out to be the culprit, report Cleaveland, Tiziana Lembo, and Magai Kaare, of the Tanzania Wildlife Research Institute, and other scientists. Domestic dogs alone are perpetuating rabies, says Cleaveland, who is also director of the

Through the Afya Serengeti Project, tens of thousands of domestic dogs—recently discovered as the reservoir for rabies—are being vaccinated against the disease. Villagers bring their dogs to dedicated vaccination areas, where the dogs receive rabies vaccine and a collar denoting that they’re protected against rabies. Photograph: Suzanne McNabb.

Afya Serengeti Project (*Afya Serengeti* means “health for Serengeti” in Swahili). The effort is an outgrowth of Project Life Lion.

“We’re again working with Tanzanians living near the Serengeti to ensure widespread vaccination of domestic dogs, this time against rabies,” Cleaveland says. “Vaccinating the dogs should also eliminate the virus in transient hosts [people, livestock, wildlife], breaking the cycle.” Domestic dogs that have been vaccinated are marked with a plastic collar to signify their protection from rabies. From 2003

through 2008, between 30,000 and 50,000 dogs were vaccinated against rabies each year.

By its second year, the Afya Serengeti Project had reduced the number of people needing hospital care for bites from rabid dogs by 82 percent. The results have been phenomenal, say Tanzanian health workers. Thanks to the project’s efforts, the World Health Organization has selected Tanzania as the site for a trial national rabies control program.

The challenge now, say scientists, is to sustain vaccination coverage and

For more information, visit these sites:

www.lionresearch.org/main.html

www.afya.org/project.asp

www.who.int/rabies/en

Lions, like this male, are members of the family Felidae; they’re one of four big cats—lion, tiger, jaguar, and leopard—in the genus Panthera. Wild lions currently live in sub-Saharan Africa, with a critically endangered remnant population in northwestern India. Photograph: David T. Gomez.

extend it to all villages near the Serengeti. “Control of domestic dog rabies in the Serengeti will eliminate rabies in all other species, including humans, livestock, and wildlife,” says Cleaveland. She and others found that wild species such as lions are not independently able to maintain rabies cycles, allowing rabies control measures to be targeted solely at domestic dog populations. “The finding has considerable applications for designing disease control programs,” says Packer, “and minimizing extinction threats to wild carnivores.”

It has worked already for the African wild dog. Several packs of African wild dogs again roam the Serengeti. The Serengeti ecosystem is the wild dogs’ best hope of long-term survival; thousands of square kilometers of protected area allow the wide-ranging wild dogs to avoid conflict with livestock farmers. “It’s important to look at an ecosystem in its entirety,” says Cleaveland. “Humans and wildlife are both part of the ecosystem. Protecting wildlife health has benefits for humans. The same holds true for protecting human health and wildlife.”

Changing climate looms over the Serengeti's future

The lion's mane, that iconic symbol of the Serengeti, ultimately may indicate large-scale trouble on the horizon. If lion manes become light-colored rather than dark, and short instead of long, global warming may have moved into the Serengeti with a vengeance. Packer and scientist Peyton West determined that male lions have lighter, shorter manes in hotter seasons, years, and habitats. "Heat appears to be the dominant ecological factor shaping the lion's mane," Packer says.

Long-term forecasts predict an increase of 1.3 to 4.6 degrees Celsius in the Serengeti region by 2080. As a result, lions with dark, luxurious manes may fade into Serengeti history.

"Marcel Proust once said that the most extraordinary journey would be to see the same familiar places through the eyes of another person," writes Packer in his award-winning book, *Into Africa*. "But

what if we could see ourselves through the eyes of another species?" With global warming on the horizon, and infectious diseases following closely behind, what lions may be revealing is our own future.

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Author's note: Magai Kaare was recently killed in a car accident in Tanzania. His presence and contributions will be missed by all in the Afya Serengeti Project.