Medicine in the Wild: Strategies towards Healthy and Breeding Wildlife Populations in Kenya

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Introduction

The Kenya Wildlife Service (KWS) has a Veterinary and Capture Services Department at its headquarters in Nairobi, and four satellite clinics strategically located in key conservation areas to ensure quick response and effective monitoring of diseases in wildlife. The department was established in 1990 and has grown from a rudimentary unit to a fully fledged department that is regularly consulted on matters of wildlife health in the eastern Africa region and beyond. It has a staff of 48, comprising 12 veterinarians, 1 ecologist, 1 molecular biologist, 2 animal health technicians, 3 laboratory technicians, 4 drivers, 23 capture rangers, and 2 subordinate staff. The department has been modernizing its operations to meet the ever-evolving challenges in conservation and management of biodiversity.

Strategies applied in managing wildlife diseases

Rapid and accurate diagnosis of conditions and diseases affecting wildlife is essential for facilitating timely treatment, reducing mortalities, and preventing the spread of disease. This also makes it possible to have an early warning of disease outbreaks, including those that could spread to livestock and humans. Besides reducing the cost of such epidemics, such an approach ensures healthy wildlife populations.

The department's main concern is the direct threat of disease epidemics to the survival and health of all wildlife populations, with emphasis on endangered wildlife populations. Also important are issues relating to public health, livestock production, and rural livelihoods, each of which has important consequences for wildlife management.

The approach applied to disease management in wildlife includes diagnosis and treatment of sick animals. Both passive and active surveillance are critical initiatives that mainly focus on diseases that cause mortalities in wildlife, those that have a negative impact on livestock economies and livelihoods, and diseases of public health importance. All outbreaks of diseases are also conclusively investigated and appropriate control and monitoring systems instituted. In addition, KWS undertakes research to better understand disease dynamics in wildlife populations. Holding facilities are used to quarantine animals suspected of harboring infectious diseases before decisions on their fate are made.

In undertaking these initiatives, KWS has a strong network of local, regional, and international partners working in the areas of animal and human health. The network provides

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exciting opportunities to develop innovative, collaborative, and integrated approaches to wildlife management.

KWS has a laboratory with basic diagnostic equipment that can be used for early detection of diseases in wildlife. Further confirmatory diagnoses that require advanced procedures are usually sought from other major reference laboratories within and outside Kenya. There are efforts to enhance the KWS's diagnostic capacity through training of laboratory personnel as well as procurement of laboratory equipment. A molecular laboratory that is expected to be fully operational by mid-2012 will enhance disease diagnosis, control, and management.

Important diseases in wildlife in Kenya

Table 1 lists some of the important diseases in wildlife in Kenya that are being monitored by KWS.

Table 1. Wildlife diseases of national and international importance being monitored by KWS.

Disease: Etiological Agent	Status in Wildlife in Kenya
Rinderpest; Morbillivirus	Previously restricted to the Somali ecosystem (northeastern Kenya, southeastern Ethiopia, and Somalia) due to collapse of surveillance and vaccination programs in Somalia after the disintegration of government in 1990. Disease confirmed eradicated in 2009 through sero-surveillance of cattle and wildlife according to the OIE pathway. Kenya now accredited free from infection. Post-accreditation sampling ongoing, however.
Peste des Petits Ruminants (PPR); Morbillivirus	Emerging after the eradication of rinderpest, possibly due to loss of cross-protection because the two diseases are caused by a virus of the same genus. Serological evidence in wild small ruminants demonstrated.
Rift Valley fever; Phlebovirus	A zoonotic disease, sporadic outbreaks experienced after long inter-epidemic periods. The epidemiological role of wildlife not clearly understood. Reported to have affected gerenuk and gazelles in the 2001 outbreak. Studies in wildlife ongoing. Associated with high rainfall and flooding.
Foot and mouth disease; Aphthovirus	Buffaloes persistent carriers of SAT-1 and SAT-2 serotypes. Endemic in many wildlife populations.
African swine fever; African swine fever virus	Free-ranging porcine species, especially warthogs, are asymptomatic carriers of the virus. Widespread and endemic in wildlife populations.
Malignant catarrhal fever; Alcelaphine herpesvirus-1	Wildebeests are reservoirs. Disease limited to areas where cattle and wildebeests interact. It is an emerging issue in Masai land where there is high interaction of wildebeests and cattle. It is fatal in cattle.
Rabies; Lyssavirus	Outbreaks partially responsible for near-extinction of endangered wild dogs in the Masai Mara-Serengeti ecosystem. Transmitted from wildlife to domestic animals and vice versa. Fatal in all mammalian species. Many wildlife species susceptible. Endemic in many areas.
Trypanosomiasis; *Trypanosoma* species	Wildlife including elephant, rhino, buffalo, warthog, hippo, and various artiodactyls are maintenance hosts and are trypanotolerant but can show high infection rates with various trypanosome species. Confirmed to have caused mortalities in immunologically naive rhinos translocated to tsetse-infested areas such as Meru National Park and Masai Mara National Reserve.
Anthrax; *Bacillus anthracis*	Sporadic cases and outbreaks in wildlife reported in many areas. Diverse species involved.
Brucellosis; *Brucella* species	Low prevalence of antibodies in wild bovids reported. Not thought to be a major problem in wildlife, although subtle impacts on fertility may be easy to miss. Prevalence and incidence studies in wildlife inadequate, however. Need for more studies to determine the impacts in wildlife.
African horse sickness; Orbivirus	Endemic in zebra, the wild maintenance host. Prevalence rate of antibodies in elephants is high but role of elephants as maintenance hosts seems unlikely.
Bovine tuberculosis; *Mycobacterium bovis*	Low prevalence rates in baboons and buffaloes reported. More studies ongoing, particularly in areas of high wildlife and livestock interactions.
Canine distemper virus; Morbillivirus	Disease of wild carnivores and domestic dogs. Important for rare and endangered carnivores such as wild dog. Important co-infection with protozoa causing enhanced pathology and disease in other species such as lions. Increased incidence in felines suggests emergence of this virus in the cat family.

Selected cases of disease management

In the last three years, KWS has undertaken numerous disease management initiatives, often in collaboration with other stakeholders. A few selected cases are discussed below.

Rabies in wildlife. Rabies, which means "rage" or "madness" in Latin, is one of the oldest zoonotic diseases, having been described in hunting dogs as early as 2300 BC. It is caused by global RNA viruses in the genus *Lyssavirus*. Humans are dead-end hosts, infection being always fatal, with just one reported case of human survival following infection (Willoughby et al. 2005). An estimated 55,000 people die every year from rabies worldwide, mostly in Asian and African countries where canine rabies is endemic.

In Kenya, the African wild dog, hyena, jackal (Figure 1), and the domestic dog are the predominant species for rabies infection and transmission. Rabies is a threat to many wildlife species in Kenya, particularly the endangered African wild dog. There were serious outbreaks in different wild dog populations in Kenya in the 1980s that significantly contributed to the species' decline. Vaccination of endangered canids has been proposed as a conservation tool to respond to acute disease outbreaks threatening the survival of critical populations and has been used successfully on a number of occasions. KWS has embarked on rabies vaccine trials in wild dogs in several areas where wildlife interact highly with domestic animals and humans. The objective is to determine the efficacy and safety of existing rabies vaccines in protecting wild dog species in case of any disease outbreak. Domestic dogs and cats have also been vaccinated in areas surrounding national parks and reserves in an attempt to block rabies transmission from domestic dogs to wildlife. Suspected cases of rabies in wildlife are usually acted upon by imposing quarantine, administering euthanasia, and performing confirmatory diagnostic tests before instituting adequate prevention and control measures against the disease.

Avian influenza surveillance in wild birds. Migratory wild birds are reservoirs of low pathogenic avian influenza (LPAI) viruses (Alexander 2000) but their role in transmission of highly pathogenic avian influenza (HPAI) viruses is still not clear and requires further investigation and research (Munster et al. 2005; Normile 2006). Kenya lies on a major wild birds' migratory route linking southern Africa, Europe, and the Middle East, and has several important wetlands for migratory species, hence the risk of HPAI occurrence. Surveillance and research on all the avian influenza viruses (including H5N1) in wild birds is implemented by KWS and other partners following the outbreak in Asia in 2006 (Yingst et al. 2006). KWS is involved in the collection of samples of wild birds and their submission to reference laboratories for analyses. To date, no positive cases have been detected. KWS, however, remains alert and continues with passive and active surveillance of the disease.

Figure 1. A silver-backed jackal suspected of rabies infection in Masai Mara National Reserve, Kenya. Photo by Dominic Mijele, 2008.

Eradication of rinderpest. Rinderpest, also known as cattle plague, is historically the most important disease in African wildlife. In eastern Africa, its impact in wild ungulates was significant and a major contributor to the decline of animals in epidemic areas. The result was a negative effect on biodiversity and environmental stability and health. As of a few years ago, the disease had been eradicated in most parts of the world and the remaining suspected foci of infection was the so-called Somali ecosystem, comprising Somalia, northeastern Kenya, and southeastern Ethiopia. These countries were the last in the world to fulfill the OIE pathway[1] to be declared free from rinderpest in 2009. The presence of the disease in this region was attributed to the breakdown of effective surveillance and vaccination programs in Somalia.

Surveillance was important in identifying infections and preventing spread. Wildlife was an integral component in the eradication efforts and served as valuable sentinels for monitoring remaining virus circulation. KWS was supporting the Ministry of Livestock Development in the control by surveillance in wildlife. KWS was also involved in giving technical support to Ethiopia and Somalia in wildlife capture and sampling in order to have simultaneous and comparable surveillance in the entire Somali ecosystem. Following over 10 years of surveillance in both wildlife and livestock with no positive results, Kenya fulfilled the OIE procedures and was certified free from rinderpest in 2009. The eradication strategies were being coordinated by the Global Rinderpest Eradication Program (GREP) established in 1987 by FAO (the Food and Agriculture Organization of the United Nations) with the target of eradicating the disease in the world by 2010.[2]

Trypanosomiasis in black and white rhinoceroses. The black rhinoceros (*Diceros bicornis michaeli*) was exterminated from Meru National Park in the late 1980s by poachers. As part of a restoration program aimed at restocking the park with several species of wildlife and

Figure 2. A young buffalo immobilized for rinderpest disease surveillance in Tsavo National Park, Kenya. Photo by David Ndeereh, 2006.

improving its ecotourism value, both black and white rhinoceroses have been reintroduced into the park in phases between 2002 and 2006. Twenty-one black rhinos and 33 white rhinos (*Ceratotherium simum*) were released into a well-protected sanctuary of about 38.8 km^2 after a few weeks of holding in the bomas. Meru National Park is within a zone infested by the tsetse fly (*Glossina* spp.) and their control was already initiated long before the translocations. This is because the flies are the main vectors of most of the African trypanosomes that cause chronic wasting disease in livestock, wildlife, and humans. The control method, based on pyrethrin-impregnated targets, was to reduce tsetse fly density, which would eventually reduce transmission of trypanosomes. However, three months after release of the first rhinos in the sanctuary, individuals were observed in poor body conditions followed by deaths.

Trypanosomiasis was suspected to be the cause. Investigation involved immobilizing the sick rhinos, collecting blood, and analyzing the samples using molecular methods. *Trypanosome congolense, T. simiae, and T. godfreyi* were identified from the blood of the sick rhinos. It was concluded that the deaths were induced by multifactorial stressors working in synergy. For instance, capture and translocation as well as trypanosome infection are immune suppressors, which could promote development of clinical trypanosomiasis. Since the rhinos were sourced from areas without tsetse flies, it was likely the rhinos were immunologically naïve to trypanosomes. Trypanosome is therefore a factor that can frustrate recovery efforts for the black rhino, and we now recommend prophylaxis at capture when rhinos are to be released into tsetse-infested areas. The sanctuary was also relocated to a different part of the park with less infestation by tsetse. Fly trapping in this new location is still going on in collaboration with the Kenya Trypanosomiasis Research Institute.

Anthrax in the endangered Grevy's zebra and Rothschild giraffe. Anthrax is a disease caused by the bacterium *Bacillus anthracis* which causes acute and peracute deaths in domestic and wild animals. Anthrax is endemic in sub-Saharan Africa and is one of the diseases that cause significant mortalities of multiple wildlife species across Africa. In 2005–2006, anthrax caused the deaths of about 53 Grevy's zebra (*Equus zebra*). The death of that number was quite significant since the remaining global wild population is just about 2,500, which occupy the arid community lands in northern Kenya.

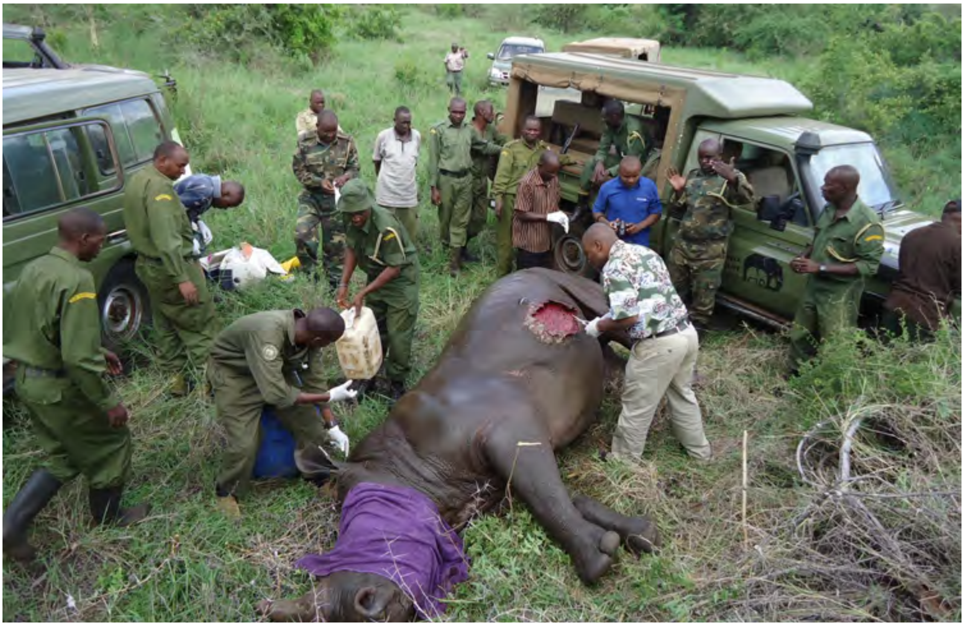
When the outbreak occurred, both control and preventive measures were taken to contain the disease that was threatening to extirpate this population. For control, all carcasses were searched and buried six feet deep and covered with lime. However in order to protect the surviving herds, for the very first time in Kenya, 650 free-ranging Grevy's zebra were vaccinated. The vaccines were delivered through darts that fell off after discharging the vaccine Blanthrax. After vaccination, the deaths stopped and since then there have been no other deaths in this population. In view of the conservation status of the species, a multidisciplinary disease response committee comprising KWS and other stakeholders has been formed to conduct surveillance, research, and response on diseases affecting it.

In July 2011, anthrax was also confirmed to be the cause of the deaths of 11 Rothschild giraffes (*Giraffa camelopardalis rothschildii*) out of a population of 44 in Mwea National Reserve in eastern Kenya. There are three subspecies of giraffes in Kenya, namely, the Masai, reticulated, and Rothschild. The latter subspecies is endangered, with 650 individuals remaining in the wild. Anthrax was therefore a great threat to survival of this species. The remaining animals were vaccinated using Blanthrax. Post-vaccination monitoring of the vaccinated herd did not show overt ill effects of the vaccine; notably, the deaths ceased.

Dermatitis in white and black rhinoceroses. An outbreak of dermatitis in both white and black rhinoceroses in Meru National Park occurred in May 2011. Large wounds as wide as 35 cm by 30 cm were seen in some individuals of both species (Figure 3). Black rhinos usually have cutaneous wounds caused by a filarial worm, *Stephanofilaria*. However, the lesions caused by these worms are often superficial and relatively small (<5 cm wide). Although filarial nematodes infect various thick-skinned animals such as hippopotamuses, black rhinos, and buffalo, they have never been reported in white rhinos. The wounds were deep below the epidermis and histopathology analysis indicated eosinophilia, which corresponds to a parasitic infection. The infected individuals were immobilized and injected with Ivermectin, an anti-parasitic drug. Although the wounds of treated individuals healed, new infections emerged in other individuals. One infected rhino that had expansive wounds died, which showed that the infection is a threat to the already-declined population of black rhinos in Kenya. It should be noted that the identity of the causal parasite or its life-cycle remains unknown but investigation is continuing.

Mange in cheetah. Cheetah is one of the most graceful of the large wild cats that attract many tourists in Kenya, yet its population is declining at an alarming rate. Habitat loss is thought to be a key factor that is driving the downward trend of the cheetah population. However, it is likely that the overall decline is multifactorial. Disease is one of the significant factors known to decrease population growth of species globally. In Kenya, the cheetah population in Masai Mara National Reserve is of significant value, being one of the cohesive pop-

Figure 3. Treating a black rhino with cutaneous lesions in Meru National Park, Kenya. KWS photo.



ulations and a major attraction in this globally famous site. Unknown by many, this population is persistently sick, infested by parasitic mites (e.g., *Sarcoptes scabiei)* that cause a skin disease called mange. The population is frequently treated by Ivermectin, which is effective, but the animals are usually reinfected. In a recent study to determine the transmission cycle of the mites, it was noted that the Thomson's gazelle was similarly infested by mites. This was a significant observation because the gazelles are the preferred prey of the cheetahs. It therefore suggests that the mite transmission pathway is sustained by the predator–prey interactions, and points to the source of persistent reinfections. It is therefore fateful that mite infection, if untreated, causes death in cheetahs. The mite is a microscopic parasite, neglected by many, but it is a real threat to the survival of cheetahs in the Masai Mara.

Bovine tuberculosis. Bovine tuberculosis (BTB) is caused by a bacterium, *Mycobacterium bovis*, an infectious organism that is emerging as a threat to diverse wildlife populations in Africa. Ungulates, cheetah, and lion are some of the wild species threatened by BTB infection in South Africa. The prevalence of BTB in domestic and wild animals in Kenya is not known. With the Friedrich Loeffler Institute of Germany, KWS is investigating the prevalence of the disease in cattle and buffalo in key areas where wildlife and livestock interact highly.

Clostridial enterotoxemia in black rhinoceroses. Between May and July 2010, nine eastern black rhinoceroses (*Diceros bicornis michaeli*), a critically endangered species, developed a peracute syndrome characterized by severe abdominal pain manifested by struggling, labored breathing, and sudden death in the Pyramid Black Rhino Sanctuary in Laikipia. Investigation revealed clostridial enterotoxemia, a rare condition reported in free-ranging wildlife as the etiological agent. The condition is caused by production of toxins by *Clostridium perfringens*, a gram-positive and spore-forming bacteria.

Clostridium species are normal gastrointestinal tract (GIT) flora, and the factors that trigger the development of the disease are not well understood. However, it is presumed that some alteration in the normal GIT environment permits excessive multiplication of the bacteria, which produce the toxins capable of causing intestinal damage and systemic effects such as shock. The sanctuary experienced a devastating drought in 2009 which almost wiped out the populations of the grazer species. It was estimated that over 600 impalas and 400 buffalo (representing over 95% of each species) died, but there were no losses of rhinos as a result of the drought. The sanctuary later received higher-than-normal rainfall during the long rains of April 2010, leading to overgrowth of foliage. In the absence of grazers, particularly the buffalo, this resulted in markedly noticeable changes in the diversity of thriving flora in the area. It is presumed that these changes resulted in unusual amounts of green plants in the digestive system of the rhinos. These highly digestible plants with high amounts of proteins and carbohydrates and little fiber, possibly along with other predisposing factors that were not identified, played a role in changing the normal gut environment in the rhinos, triggering the proliferation of *C. perfringens*.

To avert more losses, all breeding females and young rhinos (totaling 10 animals) were removed from the sanctuary, vaccinated with a multivalent bacterin-toxoid, and covered with antibiotics. The objective was to reduce exposure to the trigger factors leading to the disease. Two adult bulls were vaccinated, covered with antibiotics, left on site, and monitored closely. These measures arrested further mortalities.

Emerging issues and challenges in managing diseases in wildlife

There are several challenges that are evolving in management of diseases in wildlife populations. One of these is the emergence of new infections. Although very little is understood about the dynamics of diseases in most wildlife populations, evidence demonstrates that wildlife plays a key role in emergence of many diseases. According to Jones et al. (2008), emerging infectious diseases are dominated by zoonoses (60.3%) and the majority of them (71.8%) have a wildlife origin. There are many possible reasons for disease emergence, such the consumption of wildlife, as well as ecological factors that affect patterns of contact between livestock and humans with wildlife: for example, deforestation, population movements, and intrusion of people and domestic animals into new habitats. Another reason is shifting weather patterns due to climate change that affects host–vector–pathogen dynamics. In these days of rapid human and animal movements, as well as threats of bioterrorism, diseases may spread from one continent to another very fast.

Another emerging challenge is the increasing interactions between domestic animals, humans, and wildlife. Interactions are a key issue in livestock economies in Kenya, where many communities live in close contact with wildlife. These interactions are increasing due to a number of reasons, including rising human population and frequent droughts, which is bringing wild animals, livestock, and humans into closer proximity at watering points and pastures. Because wildlife is generally susceptible to the same disease agents as domestic animals, it is suffering a spillover of diseases from domestic animals.

In order to address these emerging challenges, KWS is expanding the range of diseases under its surveillance programs. Surveillance is intended to act as an early warning system for any disease outbreaks. Focus is mainly on diseases that cause wildlife mortalities, those that impact on livestock, and those of public health importance.

Appropriate management of diseases in wildlife poses major challenges to wildlife veterinarians. There is still inadequate knowledge of disease dynamics in wild animal populations, which limits the development of effective strategies. Options for disease control are also limited and often have implications for wildlife welfare. Many strategies, such as culling and creation of barriers (for example, disease-free zones), invariably results in harm to wild animals. Conventional approaches to animal disease control, such as vaccination or treatment to reduce transmission, also have limitations in wildlife populations. Specific vaccines and treatments are often unavailable or untested for use in wildlife, and delivery in field settings is beset by logistic, financial, and ethical considerations. Disease management in wildlife populations is also an expensive venture in terms of required resources, such as immobilization drugs and darting equipment. Wildlife is also often found in remote areas and difficult terrain. Interventions therefore require immense resources in terms of transport: robust vehicles are needed for use in rugged terrain, and sometimes a helicopter for darting. In addition, laboratory capacity is still limited for diagnosis of most diseases.

Conclusion

The emergence of diseases, coupled by the rapid spread of infectious pathogens across continents, demands revolutionary changes in approach. We envisage use of systems that can detect early or predict emergence of existing, introduced, or novel pathogens. To attain this, we will need to incorporate advanced molecular diagnostic platforms and create links with institutions that provide remote sensing outputs for use in predicting disease outbreaks. We also realize that our veterinary and laboratory teams need to be constantly honed with current epidemiological skills.

Endnotes

1. The "OIE Pathway" is the common name for FAO's international system that verifies the steps needed to be taken in order to achieve national and global eradication of rinderpest. "OIE" refers to the Office International des Epizooties, which in May 2003 became the World Organization for Animal Health but kept its historical acronym.
2. In June 2011, FAO declared rinderpest to be finally eradicated—only the second time in history (after smallpox) that a disease had been wiped from the face of the earth. The last known case of rinderpest was in a wild buffalo tested in Meru National Park in Kenya in 2001 (McNeil 2011).

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