Chapter 20

Impacts of Wildlife Infections on Human and Livestock Health with Special Reference to Tanzania: Implications for Protected Area Management[1]

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Introduction

Human, domestic animal, and wildlife medicine are usually viewed as separate disciplines; however, this distinction is largely irrelevant in the field of epidemiology, because many pathogens are generalists, infecting multiple host species. The majority of human pathogens (62%) also infect animal hosts (Taylor *et al*. 2001) and nearly half (44%) are also known to infect wildlife (Cleaveland, Laurenson *et al*. 2001). Similarly, most of the pathogens that have caused recent epidemics in wildlife infect a wide range of hosts (Cleaveland, Hess *et al*. 2001). A particular concern for conservationists is the ability of these generalist pathogens to spill over from more abundant reservoir hosts (e.g., domestic animals) to infect small, vulnerable wildlife populations (Daszak *et al*. 2000, Laurenson *et al*. 2005).

In terms of wildlife management and infectious diseases, the focus of concern in recent years has been the direct threat of disease epidemics to the survival and health of endangered wildlife populations. However wildlife infections have far-ranging impacts that extend beyond these direct disease threats to encompass issues relating to public health, livestock production, and rural livelihoods, each of which has important consequences for wildlife management.

Wildlife infections and emerging human diseases

Although we understand very little about the dynamics of infectious agents in most wildlife populations, there is growing evidence that wildlife plays a key role in the emergence of human diseases. Reviews commonly note that many emerging human diseases are zoonotic (i.e., can be transmitted between animals and humans) and also involve wildlife (Morse 1995, Murphy 1998, Palmer *et al*. 1998, Chomel 1998, Daszak *et al*. 2000, Feldmann *et al*. 2002, Ludwig *et al*. 2003). Well-documented examples include viruses (such as West Nile virus, avian influenza virus, and the Hendra, Nipah, and Hantaviruses), bacterial pathogens (such as *Borrelia burgdorferi* of Lyme disease), and protozoa (such as *Trypanosoma* spp found in Africa). Recently, consumption of wildlife has been identified in the zoonotic transmission of hepatitis E (Tei *et al*. 2003), and emergence from wildlife hosts has been suggested as the possible origin of HIV-1 (Gao *et al*. 1999) and HIV-2 (Hirsch *et al*. 1989), as well as the more recent emergence of severe acute respiratory syndrome (SARS) (Pearson *et al*. 2003).

In line with observations of wildlife involvement in many emerging diseases, recent systematic quantification of human pathogens has shown that the ability of a pathogen to infect wildlife is an important risk factor for disease emergence. Thus, human pathogens that can also infect wildlife are more than twice as likely to cause an emerging human disease than those that do not (relative risk=2.44; Cleaveland, Laurenson *et al*. 2001).

Ecological factors that affect patterns of contact and transmission between people and wildlife are commonly cited to explain the growing importance of wildlife infections in human diseases. For example, deforestation, population movements, and intrusion of people and domestic animals into new habitats have resulted in the emergence of several pathogens, such as yellow fever virus, California encephalitis virus (Mahy and Murphy 1998), Ross River virus (Daszak *et al*. 2000), and Marburg and Ebola viruses (Peters *et al*. 1994, Ludwig *et al*. 2003). Weather events and climate change also have the potential for wide-ranging impacts on host/vector/pathogen dynamics, particularly those with complex life cycles (Patz *et al*. 2000, Harvell *et al*. 2002). For example, climate-induced increases in wild rodent density have been linked with the emergence of Hantavirus outbreaks (Glass *et al*. 2002).

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Control and investigation strategies for wildlife reservoirs: problems and implications

The link between wildlife and human health has several important implications for wildlife management. First, the lack of knowledge of infection dynamics in wild animal populations limits the development of effective strategies to minimise human health risks. A common problem relates to the identification of wildlife reservoir hosts of new or reemerging human diseases. Definitive identification of reservoirs is complex and challenging, and wildlife hosts have often been proposed as reservoirs on only weak evidence (Haydon *et al*. 2002). This may result not only in ineffective disease control, but also can sometimes have dire consequences for wildlife. In East Africa, for example, isolation of *Trypanosoma brucei rhodesiense* (the cause of the Rhodesian form of sleeping sickness) from a single bushbuck in the 1950s (Heisch *et al.* 1958) resulted in widespread culling of wildlife.

Second, even when wildlife reservoirs have been identified and disease control considered desirable in the face of human health risks, the options for control are limited and often have implications for wildlife welfare. Many strategies, such as culling and creation of barriers, invariably result in harm to wild animals. But conventional approaches to animal disease control, such as vaccination or treatment to reduce transmission (e.g., of sleeping sickness in cattle) 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. Nonetheless, the success of oral rabies vaccination campaigns in wildlife in Europe and North America demonstrates the huge potential of oral vaccines to control wildlife infections and reduce human health risks.

Although culling animals to control infectious diseases has a strong basis in epidemiological theory (Matthews *et al.* 2003), the culling of wildlife has rarely been successful in practice for a variety of practical, logistic, and ethical reasons. Before oral vaccines for rabies were introduced, culling remained the mainstay of rabies control in red foxes in Europe but was never demonstrated as an efficient method of disease control (Artois *et al.* 2001). Culling of badgers and opossums to control bovine tuberculosis (BTB) in wildlife reservoirs in the United Kingdom and New Zealand remains the subject of intense debate. Similarly, suggestions to contain BTB in buffalo in Kruger National Park, South Africa, through selective culling of high-prevalence herds have been criticised on epidemiological, ecological, and practical grounds (de Lisle *et al.* 2002). Nonlethal approaches, such as wildlife vaccination, wildlife sterilisation, and farm management practices (Krebs *et al.* 1997, Hutchings and Harris 1997, Buddle *et al.* 2000) have been suggested as alternative approaches for control of BTB in the United Kingdom, for example, and current research includes studies that evaluate the likely effectiveness of these strategies (Krebs *et al.* 1997, Delahay *et al.* 2003).

A third issue is that epidemiological investigations to identify wildlife sources of human diseases may have adverse impacts. For example, widespread killing and sampling of large numbers of small mammals has been justified in the search for wildlife reservoirs of Ebola virus in the Democratic Republic of Congo (Leirs *et al.* 1999) and Central African Republic (Morvan *et al.* 2000). In these types of studies, balancing the need to identify wildlife reservoirs of human diseases against potential adverse impacts on wild populations is an issue that should clearly involve both public health agencies and wildlife managers. Further consideration should perhaps be given to conservation and animal welfare ethics, as is done in grant applications involving laboratory experimentation and in clinical trials on human subjects.

Indirect effects: the example of wildlife tourism

A further consequence of wildlife involvement in human diseases is the potential threat to the wildlife tourism industry. The economic damage caused by a decline in visitors to countries suffering from SARS and Ebola virus clearly highlights this potential threat. Equally clear is the important lesson learnt from the SARS epidemic about the need for open exchange and dissemination of epidemiological data of public health importance. Balancing these requirements presents a dilemma for managers of wildlife areas and needs to be openly discussed.

A creditable approach has been taken by the veterinary unit of Tanzania National Parks, which reacted promptly to recent outbreaks of sleeping sickness and anthrax to contain threats to wildlife, to reduce risks of transmission to people, and to identify wildlife sources of infection (Mlengeya *et al.* 1998, Jelinek *et al.* 2002, Mlengeya and Lyaruu 2005). Furthermore, timely dissemination of information in the public domain facilitated the prompt diagnosis and treatment of people who developed clinical signs of sleeping sickness after leaving East Africa. Neither of these disease outbreaks appears to have affected tourist numbers in Tanzania. However, what advice should be given to park managers in their approach to diseases such as Ebola or Marburg that may generate greater alarm and impact on the tourist industry? Additional dilemmas will invariably arise as sensitive molecular tests increasingly allow detection of human pathogens (or pathogen material) in an expanding range of wildlife hosts. The epidemiological interpretation of these results and appropriate management of potential disease risks pose major challenges to wildlife veterinarians.

In summary, the recognition of wildlife as hosts and reservoirs of emerging human diseases poses considerable challenges to wildlife managers and the public health sector, not only because very little is currently known about the dynamics of wildlife diseases but also because the limited options for investigation and control of these infections are often harmful to wildlife. To date, there has been very little interaction between the two sectors, but the interface between wildlife and public health provides exciting opportunities for professionals to develop innovative, collaborative, and integrated approaches to wildlife management that will mitigate disease risks for people and minimise adverse impacts on wildlife populations.

Wildlife infections and livestock health

As is the case with emerging human diseases, the ability of pathogens to infect wildlife hosts is a significant risk factor for the emergence of livestock diseases (Cleaveland, Laurenson *et al*. 2001). Similarly, pathogens that infect wildlife are significantly more likely to be among those listed by the Office International des Épizooties, i.e., those pathogens that have serious socioeconomic and/or public health consequences at national and international levels. More than 70% of these disease agents infect wildlife hosts, including those of rinderpest, foot and mouth disease, African swine fever, theileriosis, brucellosis, and BTB (Cleaveland, Laurenson *et al*. 2001).

Interactions between domestic livestock and wildlife populations are a key issue in livestock economies worldwide, and in East and southern Africa in particular, where many communities live in close contact with wildlife. Several excellent reviews discuss the pathogens that coinfect livestock and wildlife and their role in livestock diseases (Bigalke 1994, Fröhlich *et al*. 2002, Bengis *et al*. 2002, Kock *et al*. 2002). Transmission of infection from wildlife reservoirs has the potential to decimate livestock economies and to exacerbate problems of rural poverty caused by declining livestock production – situations that invariably generate conflict between people and wildlife. A clear example is the enduring debate over the impact on wildlife of game fences constructed to prevent transmission of foot and mouth disease from buffalo to cattle.

In southern Africa, the value of the beef export market is a huge financial incentive to separate wildlife reservoirs from cattle by constructing game fences. In contrast, in Tanzania, the tourism sector has greater economic weight and relatively few efforts have been made to protect the livestock sector from diseases transmitted from wildlife. For example, in the Ngorongoro Conservation Area, Maasai cattle must be moved away from prime grazing lands in the short-grass plains to avoid malignant catarrhal fever, a fatal disease of cattle that is spread primarily by wildebeest calves, which are asymptomatic carriers of the virus (Plowright 1990, Machange 1997). Confinement of Maasai cattle in non-productive highland pastures has far-ranging impacts, increasing the pressure on fragile highland ecosystems and exacerbating the problem of tick-borne and directly transmitted diseases (Field *et al*. 1997; Misana 1997; Cleaveland, Kusiluka *et al*. 2001).

The resulting decline in livestock production has been a major factor behind the expansion in cultivation, a form of land use that is generally considered incompatible with both traditional pastoralism and wildlife conservation. Although conservationists often perceive livestock as a threat to wildlife, a greater threat is likely to arise if traditional livestock-keeping practices are replaced by large-scale cultivation. Innovative programmes that support the needs of both pastoral development and wildlife conservation could provide considerable benefits for both sectors.

Livestock disease as a contributory factor to rural poverty and a threat to biodiversity

Rural poverty is a key factor underlying long-term threats to biodiversity. Recent studies from communities adjacent to the Serengeti National Park, for example, demonstrate a strong inverse relationship between livestock ownership (or access to these resources) and involvement in game-meat hunting (Campbell 2001). This suggests that the requirement for dietary protein and cash income among resource-poor farmers is a driving force behind local game hunting. Livestock development programmes could provide alternative sources of protein to replace demand for wildlife meat in these areas, but livestock production in these areas is severely constrained by infectious diseases, including diseases transmitted from wildlife, such as trypanosomiasis (IFAD 1995). The establishment of effective veterinary services in these areas has the potential to improve rural livelihoods and reduce demand for wild animal products and thus illegal hunting activities. However, further work is still required to assess the impact of improved livestock production on levels of wildlife hunting in the Serengeti.

Conclusions

Infectious diseases of wildlife have far-ranging impacts, with important implications for public health, wildlife conservation, and rural economies. The complexity of issues surrounding wildlife diseases poses great challenges for the management of wildlife and protected areas. The need for disease surveillance is well recognised but, even in the public health sector, surveillance has never been a high priority. Wildlife veterinary units are generally poorly funded, and disease surveillance is rudimentary or nonexistent in almost all wildlife populations, even in the developed world. Lack of knowledge about wildlife diseases and their infection dynamics invariably hampers attempts to control, prevent, or eliminate those diseases that threaten human health and biodiversity.

To understand and control emerging infectious diseases of both people and animals, it is necessary to bridge artificial divisions between human and veterinary medicine, and to develop consistent, integrated approaches that incorporate expertise from wildlife managers, ecologists, conservation biologists, and environmental scientists.

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