Chapter 6

# Tuberculosis – What Makes it a Significant Player at the Wildlife/Livestock/Human Interface?[1]

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## Introduction

Tuberculosis is caused by members of the *Mycobacterium tuberculosis* complex, which consists of *M. tuberculosis, M. bovis*, *M. microti, M. africanum,* and *M. canettii* (Brosch *et al*. 2002). Human tuberculosis is most frequently associated with *M. tuberculosis,* while *M. bovis* can cause disease in a very wide spectrum of domestic and wild animals. In recent years it has become evident that the role of wildlife in the epidemiology of bovine tuberculosis (BTB) has been greatly underestimated, both in developing countries as well as in the developed world.

Once introduced into the wildlife/livestock interface, BTB cannot be eradicated by traditional control programmes and, due to lack of an effective vaccine at present, it is almost impossible for affected countries to prevent further spread of this chronic disease. Compared with the effects in developed countries, where economic losses in the livestock production sector represent the most serious effect of *M. bovis* infection, the range of implications can be much broader in the wildlife/livestock/human interface of developing countries. In the two largest protected areas in South Africa, the Kruger National Park (KNP) and the Hluhluwe-Umfolozi Park (HUP), BTB is now endemic.

The impact of BTB in wildlife is far-reaching, including effects on endangered species. In addition, BTB in wildlife poses a potential health threat to people and livestock in communities along the border of infected ecosystems. This paper examines the consequences and implications of tuberculosis infection at the wildlife/livestock/human interface in terms of human health, threats to livestock, and disease risks for wildlife.

## History of tuberculosis in domestic and wild animals in South Africa

It is assumed that *M. bovis* infection was introduced to South Africa by infected cattle through European settlers but possibly also through cattle imports from Madagascar, Australia, Argentina, and other countries. During the past two centuries, the disease spread slowly within the national cattle population with intraherd prevalence rates ranging from 0.4% to 75% (Huchzermeyer *et al*. 1994). In 1929, the first cases of BTB caused by *M. bovis* were reported in wildlife, namely, in common duiker and greater kudu hunted on farmland in the Eastern Cape (Paine and Martinaglia 1929). Free-ranging wildlife in conserved habitats was first found to be infected in the HUP in 1986 and in the KNP in 1990 (Cooper 1998, Bengis *et al*. 1995). In both ecosystems, the disease had spilled over from domestic cattle during the second half of the 20th century (de Vos *et al*. 2001) and established itself in African buffalo *(Syncerus caffer)* from which it spread to other species including chacma baboon (*Papio ursinus*), warthog (*Phacochoerus aethiopicus*), honey badger (*Mellivora capensis*), and a range of other predator and antelope species (Michel 2002a). In 1997, despite their negative BTB status upon introduction the previous year, buffalo in the Spioenkop Nature Reserve, Kwazulu/Natal Province were diagnosed with *M. bovis* infection. Subsequent monitoring of game species for *M. bovis* infection led to the identification of infected greater kudu in 2000 (Cooper, unpublished data). Tuberculosis caused by *M. tuberculosis* was isolated from free-living suricates (*Suricata suricatta*) in the Northern Cape Province of South Africa and from banded mongooses (*Mungos mungo*) in the Chobe National Park in Botswana during 1999 (Alexander *et al*. 2002).

## The wildlife/livestock/human interface

Throughout the world, domestic cattle are the most common maintenance host for *M. bovis* infection (BTB) from which transmission can occur to wildlife, people, or companion animals. However, wildlife act as major maintenance hosts in many parts of the world, such as New Zealand, where opossums are reservoirs (Julian 1981), and the United Kingdom, where badgers are thought to maintain infection (Cheeseman *et al*. 1989). In Africa, buffalo populations have been proved to act as reservoirs of infection and as a source of infection for other species, including domestic cattle, through either dissemination of bacilli in the environment or predation (Keet *et al*. 1996).

Several other mammals may play an important role in transmission at the wildlife/livestock interface, particularly

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those species that can easily cross fences. Warthogs and greater kudu are a particular concern, given that *M. bovis* infection has been repeatedly diagnosed in these species in South Africa (unpublished data). Greater kudu also have the potential to act as reservoir hosts (Keet *et al*. 2001); buffalo free of BTB became infected with *M. bovis* when introduced to a habitat in which greater kudu were subsequently found to be infected (Cooper, unpublished data). These findings suggest that greater kudu can maintain a tuberculosis epidemic in the absence of buffalo or cattle.

*Mycobacterium bovis* can be transmitted to people (zoonotic tuberculosis) by one of two major routes – either through aerosol transmission during close contact with infected cattle or by the alimentary route, mainly through consumption of unpasteurised milk. Although zoonotic tuberculosis has become uncommon in developed countries, it represented one of the largest public health problems during the first half of the 20th century. Before an eradication scheme was implemented in Germany, 90% of the cattle herds there were infected (Meissner and Schroeder 1974). Regional variations in incidence rates demonstrated that the frequency of zoonotic tuberculosis depended on the incidence of BTB in cattle (Goerttler and Weber 1954). In persons younger than 30, 2.5%–31.8% of tuberculosis cases were caused by *M. bovis,* and the frequency of zoonotic tuberculosis was eight times higher among children in rural areas than among town children. The percentage of pulmonary tuberculosis due to *M. bovis* was highest among persons who milked or tended cattle and reached 29.3% in the region with the highest BTB incidence in cattle (Braun and Lebek 1958, Schmiedel 1968).

The breakthrough in the eradication of BTB was achieved through mandated tuberculin testing and compulsory pasteurisation of milk. The rapid success in combating cattle tuberculosis was, however, not immediately paralleled by a decline in zoonotic tuberculosis cases, especially in adults. Possible explanations include long periods of latency in adult *M. bovis* infection and reactivation of previous foci of infection acquired before compulsory pasteurisation (Meissner and Schroeder 1974, Cotter *et al*. 1996).

In contrast, in the developing world, the BTB status of cattle populations is often undetermined, and limited control measures are applied. In South Africa, commercial dairy herds are tested regularly and producers are required to pasteurise any bulk milk before its sale. Due to a lack of resources and logistic problems, however, only limited testing of beef herds and communal cattle herds is currently performed, and meat inspection at abattoirs is used to identify and control individual outbreaks of BTB on commercial farms (van Vollenhoven, personal communication). In contrast, animals and animal products used in communal areas are largely excluded from veterinary public health monitoring and control measures. As a result, of the 1.7 million inhabitants of the magisterial districts adjacent to the KNP and HUP, an estimated 165,000 people live in close contact with livestock and on a daily basis consume livestock products ranging from unpasteurised milk to meat and offal (Michel 2002b).

The chronic nature of BTB in cattle permits spread of the disease long before its presence is even suspected. As a direct consequence, people exposed to either the infected animal or infected products are at risk of contracting zoonotic tuberculosis. This risk increases significantly with the presence of progressive immunodeficiency due to human immunodeficiency virus (HIV) infection (Raviglione *et al*. 1995). In addition to the adverse effect of HIV on TB resistance, an adverse effect of TB on HIV resistance is suggested by studies that show that the host immune response to *M. tuberculosis* enhances HIV replication and might accelerate the natural progression of HIV infection (Maher *et al*. 2002).

While generally about 10% of people who become infected with *M. tuberculosis* develop clinical tuberculosis, it was estimated in 2001 that at least 1.6 million of the 5 million HIV-positive South Africans will develop tuberculosis and that increased vulnerability leading to at least 31%–50% of new tuberculosis cases every year is attributable to HIV infection (Hausler 2001, Corbett *et al*. 2003, Maartens 2001). In Hlabisa Hospital, situated in rural Kwazulu/Natal in a district neighboring the HUP, the number of African HIV-positive patients with tuberculosis increased from 6 in 1989, to 451 in 1993 (Walker *et al*. 2003). It is possible that some of these cases were caused by *M. bovis*; examination of acid-fast bacilli in sputum smears, which forms the cornerstone of tuberculosis diagnosis in Africa, does not permit differentiation between *M. tuberculosis* and *M. bovis*.

Another potential, although less important, route by which people can contract zoonotic tuberculosis is the consumption of wildlife meat (legally and illegally hunted), some of which escapes veterinary inspection. While commercial game-meat production in South Africa is controlled by the legislation on "Slaughter, production and export of game meat," the informal small-scale sale of game meat is difficult to control. During extensive droughts, food shortages, and political instabilities, poaching activities increase sharply in game reserves and can result in infected meat entering the human food chain (Humbabush Foundation 2002).

People are not only victims of tuberculosis but also potential sources of infection at the wildlife/human interface. As recently shown, people can serve as a source of *M. tuberculosis* to free-living wildlife (Alexander *et al*. 2002). It raises the question whether human intervention, including ecotourism despite its undisputed economic and conservation benefits, may negatively affect susceptible wildlife populations through the introduction of infectious diseases.

## Conclusions

Although the contribution of zoonotic tuberculosis to the human tuberculosis epidemic is currently unknown, the interaction between HIV and tuberculosis raises major concerns about the potential impact of *M. bovis* infection in people. On the one hand, tuberculosis is the commonest cause of HIV-related death in many HIV-affected settings and, on the other hand, HIV infection is driving the tuberculosis epidemic in sub-Saharan Africa. With insufficient or no control measures

in place to detect and eradicate BTB in wildlife, a large, highly susceptible human population is at risk of continual exposure to *M. bovis* by several potential transmission routes. Infection rates as high as those reported from Europe both before and soon after World War II should be considered a possible consequence of widespread *M. bovis* infection at the wildlife/livestock/human interface.

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