Chapter

Diseases as Impediments to Livestock Production and Wildlife Conservation Goals

Y.J. Atuman, C.A. Kudi, P.A. Abdu, O.O. Okubanjo and A. Abubakar

Abstract

Disease outbreaks, epidemics or pandemics have been of importance for human and animal health worldwide and sparked enormous public interest. These outbreaks might be caused by known endemic pathogens or by emerging or re-emerging pathogens. Wildlife are the major reservoirs and responsible for most of these outbreaks. They play significant role in the transmission of several livestock diseases and pathogen spill-over may occur in complex socio-ecological systems at the wildlife-domestic animal interface which have been seldom studied. Interspecific pathogen spill-over at the wildlife-livestock interface have been of growing concern in the scientific community over the past years due to their impact on wildlife, livestock and human health. In this section the epidemiology of some viral infections (Foot and Mouth Disease and rabies), bacterial infections (Tuberculosis and brucellosis) and parasites (haemo and endo-parasites) at the wildlife-livestock interface and potential impacts to livestock production and conservation goal is described.

Keywords: wildlife, livestock, diseases, conservation goals, public health

1. Introduction

Disease transmission is one of the major obstacles for the survival of wildlife and livestock in sub-Saharan Africa [1–3]. Movements of both human and animals occur across boundaries that separate farming and wildlife activities, and this results into direct and/or indirect contact between wild and domestic animals, potentially leading to diseases transmission. This is considered the major challenge of people living in areas where wildlife and domestic animals frequently come into contact. Movement of livestock and wildlife across the boundaries of protected areas provides ideal condition for the transmission of pathogens in either direction from wildlife to livestock and vice-versa [2]. At the edges of protected areas, the occurrence of diseases in wildlife and livestock can be categorized into wildlife-maintained diseases, in which wildlife are resistant or silent carriers of the infection and the second is multi-species diseases, which have serious outcomes for both wildlife and livestock [3]. The role of wildlife as disease reservoir is well established, their involvement in the occurrence of vector-borne infections in domestic animals has gained renewed interest as emerging and re-emerging infections occurring worldwide at an increasing rate [4–6]. Wildlife may also act as introductory or transporting hosts as a result of their movement to new regions, e.g. Rift Valley Fever virus and African horse sickness virus. They may also act as amplifying hosts with spill-over to domestic animals, e.g. African horse sickness [7]. Other important wildlife- maintained diseases include Foot and Mouth Disease (FMD), Malignant Catarrhal Fever, trypanosomiasis, theileriosis, ehrlichiosis, lumpy skin disease [2]. Multi-species diseases mostly have fatal outcome in both wildlife and domestic animals and are frequently zoonotic, i.e. transmitted among wildlife, livestock and humans. They include anthrax, rabies, brucellosis and bovine tuberculosis [2, 3]. Pathogens from wildlife can be modified to cause severe outbreaks in humans and animals due to gradual change of many related factors like environment and ecological factors [8, 9]. These factors include heavy rainfall, change in the onset of the rainy season (and thus an alteration of the interplay between rainfalls and reproduction of vectors and reservoir hosts) and changes in wind patterns [9, 10]. Changes in biodiversity, land use and climate in particular have been identified as the major drivers of disease emergence [4, 6, 11]. Loss of biodiversity, alterations of natural habitats as well as land use and cover changes are linked to emerging of 50% of zoonoses [4]. Elevation of ambient temperature might facilitate the proliferation of insects like mosquitoes [9] which may lead to increase in prevalence of some insect-borne livestock diseases such as Rift Valley Fever (RVF) and African Horse Sickness (AHS) [9, 12]. Most domesticated and wild animals perform optimally at temperatures between 10 and 30°C [13]. At temperatures above 30°C, most domestic and wild animals would reduce their feed intake by 3–5% for each unit temperature increase [14]. Changes in temperature also trigger the secretion of stress hormones which suppress immunological responses including the function of the white blood cells, tipping the host-pathogen interactions in favor of the pathogen [14].

2. Role of livestock in disease outbreaks at the edges of protected areas

Land use, human and animal movements and grazing by livestock have been considered as major factors responsible for the spread of diseases from domestic animals to wild populations and vice versa [15]. The growth in human population has resulted in greater use of land thereby establishing human settlements around the protected areas and bringing livestock closer to wild populations [11, 15]. Also, increase in the demand for protein has led to expansion of livestock farms and ranches thereby increasing wildlife-livestock interface [15]. Other risk factors for pathogen spread at the wild-domestic animal interface include long distance live animal transportation, live animal markets, and building of dams, bush meat consumption and habitat destruction [16]. These have resulted in the emergence and spread of pathogens that are of economic and public health concern [11, 17–19, 34]. Poor rural households in developing countries often survive on a combination of on-farm and off-farm activities [3]. Use of natural resources from the game parks acts as coping strategy during periods of socio-economic instability or environmental shocks [20]. Wild food products play a major role in societies that experience seasonal food shortages [3], while access to water and grazing resources during the droughts is a matter of survival for livestock in the semi-arid ecosystem of sub-Saharan Africa [21–23]. Competition with wildlife for these scarce resources exacerbates such scarcities for people living at the fringes of protected areas [21, 22, 24]. At the same time, protected areas provide an alternative source of grazing, and thus a 'buffer' during these difficult periods thereby providing opportunities for disease spread from livestock to wildlife through direct and/or indirect contact [3]. Most protected areas bordering human settlements and farmlands in Africa are subjected to growing human-wildlife conflicts and increasing incidences of pathogens transmitted between domestic and wild animals [25, 26]. The cases in point are Yankari Game Reserve (YGR) in Nigeria [25] and Ngorongoro Conservation Area (NCA) in Tanzania [27]. Diseases can be easily transmitted from domestic livestock populations into wild animal populations at the edge of protected areas and whenever a disease condition is established in a wild population, control measures in both the wildlife and livestock populations become much problematic. It has been shown that an infected wildlife reservoir that interacts with livestock causes frequent herd breakdown and substantial economic losses to agricultural sector [28].

3. Role of wildlife in disease outbreaks at the edges of protected areas

Throughout history, wildlife has been an important source of infectious diseases transmissible to humans and domestic animals in virtually all continents [29, 30]. Disease outbreaks might be caused by known endemic pathogens or by emerging or re-emerging pathogens [31]. Wildlife are the major reservoirs and responsible for 70% of these outbreaks [30, 32, 33]. Three-quarters of all emerging infectious diseases of humans are zoonotic, most of which are of wildlife origin, with an increasing incidence since the 1940s [11, 34]. Wildlife play significant role in transmission of several livestock diseases and interspecific viral pathogen spill-over at the wildlife-livestock interface and have been of growing concern in the scientific community over the past years due to their impact on wildlife, livestock and human health [35, 36]. Most infectious diseases associated with wildlife reservoir are typically caused by various bacteria, viruses, and parasites, whereas fungi are of negligible importance [37]. The current rapid ecological changes in the world have negative impact on pathogenic organisms, their vectors and hosts which are equally capable of rapid change [38]. Some of these pathogens may cause significant disease in wild species, but in other cases the wild animals may serve as reservoirs for pathogens which do not induce overt illness in their wild hosts [38]. Wildlife have been recognized as reservoirs of infectious diseases; it is advocated that interdisciplinary wildlife disease surveillance system using modern laboratory techniques be utilized for effective control of disease spread at the edge of protected areas.

4. Epidemiology of some wildlife-related viral infections at the edges of protected areas

The role of African wildlife in the occurrence of infectious diseases in domestic animals has gained renewed interest as emerging and re-emerging infections increase worldwide [7, 27, 39]. Viral diseases originating from wild animals are widely considered the major threats to public health and transmission of such viral pathogens from wildlife to other domestic animals and humans remains an important scientific challenge hampered by pathogen detection limitations in wild species [40]. Viral pathogens spill over at the edge of protected areas particularly in remote communities/areas is mostly under-reported and the disease events occur undetected [41]. Characterizing epidemiologic features of viral transmission at the wildlife-livestock interface has also revealed a number of high-risk human activities that have enabled virus spill-over in situations that facilitate close contact among wild and domestic animals and people. Domestication of animals, human encroachment into wildlife habitats and hunting of wild animals are key anthropogenic activities driving viral disease emergence at the global scale and in most instances these activities have contributed to wildlife population declines and extinction [42]. It is recommended that in-depth investigation of the epidemiology of viral infections at the edges of protected areas should be intensified to assess the risks of viral disease emergence for effective disease prevention and control measures. Foot and Mouth Disease, Rift Valley Fever and Rabies, discussed hereunder, are three of the viral wildlife-related viral infections which are common at the edges of wildlife protected areas in Sub-Saharan Africa.

4.1 Foot and Mouth Disease (FMD)

Foot and Mouth Disease is one of the most economically important transboundary diseases of animals in the world and it is extremely difficult to control due to involvement of wildlife as reservoir host [43, 44]. In wildlife, pathogenesis of FMD varies from a completely inapparent to a rare acutely lethal infection and this makes diagnosis difficult [36, 44, 45]. The transmission of FMDV in sub-Saharan Africa is mainly driven by two epidemiological cycles: one in which wildlife plays a significant role in maintaining and spreading the disease to other susceptible wild and/or domestic ruminants [46]. Whilst with the second cycle, the virus is solely transmitted within domestic populations and hence is independent of wildlife [36].

FMD is currently found in limited areas (small pockets/regions) of Europe and also in Africa, Middle East, and Asia and has contributed significantly to decline of wildlife and livestock populations in those regions [2, 26]. Presence of antibodies against the FMDV in several wildlife species has been documented in studies conducted in different African countries including South Africa, Nigeria and Tanzania [28, 47–49]. Fifty-one FMD outbreaks occurred involving buffalo (*Syncerus caffer*), impala (*Aepyceros melampus*) and elephant (*Loxodonta africana*) in the Kruger National Park (KNP) and adjacent areas of South Africa between 1970s and 2000s, of which 16 were SAT1, 31 were SAT2, 4 were SAT3 and 3 were not serotyped and the outbreaks spilled over to other species of wild animals and livestock [50]. Previous findings also established that monitoring of FMD in wild animals like impala and buffalo is important because they can serve as a source of infection for livestock [48, 51, 52]. Recent studies in Nigeria showed that, presence of wildlife population along the protected areas where cloven hoofed species come into contact with livestock contributed to high FMDV seropositivity in livestock due to spill-over of FMDV from wildlife to livestock [49, 53]. Similar studies in Tanzania revealed a high exposure patterns in buffalo populations in Ngorongoro Conservation Area, Serengeti, Katavi and Tarangire National Parks [54]. The results suggest that wildlife could play an important role in the epidemiology of FMD.

4.2 Rift Valley fever virus (RVF)

This is an emerging zoonotic disease of public and animal health concern [55–59]. It is endemic in many countries in Sub-Saharan Africa and is responsible for severe outbreaks in livestock characterized by a sudden onset of abortions and high neonatal mortality which results in significant economic losses [55, 60]. The virus was first identified in 1931 during an investigation into an epidemic among sheep on a farm in the Rift Valley of Kenya [61]. Many African wildlife species have tested positive for antibody against RVFV, including: topi (*Damaliscus korrigum*); red-fronted gazelle (*Eudorcas rufifrons*); dama gazelle (*Nanger dama*); scimitar-horned oryx (*Oryx dammah*); common reedbuck (*Redunca redunca*); African buffalo (*Synceruscaffer*); Dorcas gazelle (*Gazella dorcas*); Thomson's gazelle (*Gazella* *thomsonii*); gerenuk (*Litocraniuswalleri*); lesser kudu (*Tragelaphus strepsiceros*); impala (*Aepyceros melampus*); sable antelope (*Hippotragus niger*); waterbuck (*Kobus ellipsiprymnus*); warthog (*Phacochoerus aethiopicus*); African bush elephant (*Loxodonta africana*); giraffe (*Giraffa camelopardalis*); Burchell's zebra (*Equus burchellii*); and black rhinoceros (*Diceros bicornis*) [62, 63]. Although serological evidence suggests that a large number of African wildlife species might play a role in the epidemiology of RVF, their possible role in the cryptic maintenance of the virus is poorly understood [62, 64].

4.3 Rabies

Rabies is endemic in several African countries. It is a vaccine-preventable fatal viral disease of human and mammals [65] and is responsible for numerous human deaths. Dogs are the major reservoirs and primary source of rabies virus transmission to both humans and other animals in most developing countries [37]. Other domestic and wild animals are typically infected through secondary transmission of rabies virus variants that are maintained by dogs or in some cases variants of rabies virus maintained by wild carnivore hosts [66]. Rabies virus is widely distributed and affects various animals [67, 68]. In North America and Europe, wildlife species have replaced dogs as the most important reservoirs of rabies and new viral etiologic agents continue to emerge [68–70]. However, in Nigeria and other African countries, there has been a low but consistent number of positive cases from wildlife species which were reported over the years [26, 71–78]. Human activities at the fringes of game reserves in most parts of Africa where domestic dogs are used for hunting purposes and provision of security to livestock and farm crops against problem wildlife species [25, 79]. Majority of the dogs found at the fringes of game reserves are not adequately taken care of in terms of vaccination, feeding and provision of shelter and mostly roam about to scavenge for food creating opportunities for contact with wildlife [25]. Rabies antigens detected in jackals and mongooses in Bauchi State, Nigeria were associated with spill-over from dogs at the fringes of Yankari Game Reserve (YGR) and Sumu Wildlife Park (SWP) [25]. It is also important to note that while dogs' impacts to wildlife is likely to occur at individual level the results may still have important implications for wildlife populations. RABV has affected mammalian species at an elevated extinction risk from multiple taxonomic orders (Carnivora, Chiroptera, Primates and Proboscidea). For certain species, such as the African wild dog (*Lycaon pictus*) and Ethiopian wolf (*Canis simensis*), RABV outbreaks have led directly to severe decreases in population size and local endangerment or extinction [80]. For other species of conservationconcern, occasional rabies cases may contribute to overall population declines in conjunction with other pressures, such as habitat fragmentation, decreased food availability and illegal killing. Both endemic strains of domestic dog RABV and sylvatic RABV strains have been implicated in the infection of many of these taxa, which is important information in terms of conservation and control [77]. Once stable control of RABV is achieved in domestic dogs, remaining rabies threats to wildlife conservation can be addressed more effectively.

5. Epidemiology of some wildlife-related bacterial infections at the fringes of game reserves

Transmission of bacterial disease that can be spread between wild and livestock animals at the edge of protected areas occurs directly via physical contact and or indirectly via environmental exposure, with devastating consequences for human and animal health, as well as pastoral economies [81]. The wildlife–livestock interface, is recognized overtime as the driver for inter-species bacterial pathogens transmission between animals and subsequent potential spill-over to humans, whereas habitat loss which is associated with altering the abundance, richness of the wildlife ecosystem and movement patterns of the wildlife species can directly or indirectly influence wildlife-livestock interfaces [81]. Bovine tuberculosis and Brucellosis are representative of the bacterial diseases transmitted between wildlife and domestic species.

5.1 Bovine tuberculosis (bTB)

Bovine tuberculosis (bTB) is caused by *Mycobacterium bovis* (*M. bovis*). It is a chronic, infectious and contagious disease of livestock, wildlife and humans [82, 83]. The disease is an important public health concern worldwide, especially in developing countries, due to deficiency in preventive and/or control measures [83, 84]. Members of the closely related phylogenic grouping of *Mycobacterium* known collectively as the *Mycobacterium tuberculosis* complex may cause tuberculosis in a range of species including human. Some members of this group are predominately found in human (*M. tuberculosis*, *M. africanum*, *M. canetti*) or rodent pathogens (*M. microti*), whereas, others have wide host spectrum (*M. bovis*, *M. caprae*) [85]. The respiratory route is accepted as the primary method of infection spread in all species. However, it is clear that there are other less common methods of spread such as oral [85]. African Wildlife were said to have been infected with Bovine tuberculosis from infected imported cattle and the disease is now endemic in wildlife [86, 87]. In Ireland and Great Britain, badgers (*Taxidea taxus*) maintain the infection, whereas the brushtail possum (*Trichosurus vulpecula*) constitutes a main wildlife reservoir in New Zealand. In parts of Michigan, bovine tuberculosis is endemic among white-tailed deer (*Odocoileus virginianus*), whereas in Europe, both wild boars and various deer species can be a reservoir of the pathogen [88]. The natural movement of these reservoir animals increases the spread of the disease to domestic animals and thereby posing a major public health impact [88].

Bovine tuberculosis in Antelopes has been reported in Nigeria [89]. This is not surprising, as there had been evidence of exposure in similar antelope species in other countries [89, 90]. In Africa, both wildlife and livestock share the rich pasture resources available at the edges of protected areas, thus creating an ideal condition for transmission of Tuberculosis through contact with infected animals. Also, poaching and slaughter of cattle for meat could contribute in the spread of infection of these disease among animals and humans far away from the game reserve from infected tissues and contamination of the environment. Pastoralists and agro-pastoralists are considered high risk groups for contracting bTB and brucellosis due to their close association with livestock and diets rich in animal products [91]. Both diseases have been reported in many wildlife, livestock and human interfaces in Africa [92–94]. Bovine tuberculosis's main route of transmission is through aerosol, hence, people engaging in tourism and ecotourism to the game reserves are also at risk. This is more so because of the human population growth and associated changes, as well as competition for grazing lands, have made wildlife-livestock disease transmission more likely by reducing the spatial separation between livestock operations and wildlife habitat [95].

5.2 Brucellosis

The disease primarily affects domestic animals including cattle, pigs, sheep, goats and occasionally horses. In wildlife, the prevalence could be low but there is always a clear epidemiological link between wildlife and domestic animals [96]. *Brucella* organism was first described as far back 1887 as *Micrococcus melitensis* [96]. The causative organism was later renamed *Brucella melitensis* and has been rated by WHO as one of the most important zoonoses, as it is very pathogenic to humans, causing the disease known as Malta fever (also known as Mediterranean or undulating fever) [96]. The ability of Brucella organisms to be transmitted, rapidly and efficiently, over long distances and the socio-economic impact of the disease in both human and livestock necessitated the increased awareness of the existence of the disease worldwide [97]. A lot of wild animals are also affected with Brucellosis [98, 99] and the disease is increasingly important in wildlife conservation, particularly when endangered species are involved [99].

6. Epidemiology of wildlife related parasitic infections at the fringes of game reserves

Parasites play an important role in the dynamics of wildlife populations [100]. They can cause substantial losses in production or even acute clinical signs and death [101]. There is abundant evidence of parasitic infections in wildlife worldwide and studies have demonstrated that they may be carriers of gastrointestinal parasites [102–106], ectoparasites [107, 108] and haemoparasites [109–111]. Many wildlife species are capable of living with high parasite loads without any apparent ill-effect on their health [112]. The impact of spill-over of human and livestock parasites to naïve species of wildlife and spill-back from wildlife is another emerging threat of potential public health and economic significance to humans, wildlife and livestock [113]. Ticks suck blood of their hosts resulting into severe anemia, loss of production, weakness and immunosuppression [114, 115] as well as damages to hides and skin leading to significant financial losses to livestock farmers [116]. Production losses due to ticks and tick-borne diseases around the globe were put at US$ 13.9 to US$ 18.7 billion annually [117]. With the establishment of zoos and conservation areas [118, 119], wildlife-livestock interface is found in proximity to many protected areas in Africa [26].

Parasitic infections transmitted between livestock and wildlife pose a significant risk to wildlife conservation efforts and constrain livestock productivity in tropical regions of the world [120]. The emergence of infectious diseases with zoonotic potential has dominated investigations and commentary on wildlife pathogens [26, 121]. In terms of conservation, it is unfortunate that by doing so, not only have studies on the biodiversity and ecology of wildlife parasites been neglected, but control efforts have also been hampered [122]. In Africa, biodiversity conservation and the expansion of livestock production have increased the risk of transmitting vector-borne infections between wildlife and livestock [7]. In addition to the physical injury caused by parasites, some serve as hosts of many viral, rickettsial, bacterial and protozoan diseases [123–125]. In Nigeria, wildlife conservation areas such as Yankari Game Reserve (YGR) and Sumu Wildlife Park (SWP) are natural heritage and means of generating revenue [126]; and parasitic infections may constrain the health of the variety of wildlife species in these conservation areas. There is abundant evidence of haemoparsitic infections in wildlife worldwide, in some circumstances displaying high prevalence with some of them serving as reservoirs for the haemoparasites [125]. There are wide ranges of potential vectors that may allow these parasites to maintain endemic sylvatic life-cycles in their geographical distribution area [127, 128]. This could potentially lead to the transmission of infection to domestic species, especially in peri-urban and urban environments [125]. Wildlife species are reservoirs of parasitic infections and have the ability to expand their geographical ranges, thus increasing intra- and interspecies contact risk with domestic animals and spread of infective parasites [125, 129]. However, a high prevalence of infection alone does not demonstrate that the species in question acts as a reservoir, some wildlife are not abundant, and probably unable to maintain a pathogen in the absence of domestic species reservoirs [125]. The epidemiology of multilocular echinococcosis, caused by the small tapeworm *Echinococcus multilocularis*, has also been influenced by the translocation of animals where the main hosts especially foxes, the intermediate hosts small rodents and human accidental hosts were found to be positive with *E. multilocularis* [129–131]. Wildlife species were found to be infested with various ticks as *Amblyoma, Rhipicephalus, Hyaloma* and *Boophilus* genus during study in Nigeria and other African countries and such tick infestation has been suggested as the cause of mortality in several ungulate species [132–134].

Wildlife management systems in most game reserves and game parks which subjects them to continuous challenge of vectors, scarcities of feeds and stress from environmental and climate variations coupled with illegal livestock and human activities are compounding factors to efforts at controlling parasitic infections in those areas.

7. Conclusion

Disease outbreaks have affected human and animal health throughout times, and wildlife has always played a role. The ecological changes influencing the epidemiology of wildlife-related viral, bacterial and parasitic infections can be of natural or anthropogenic origin. These include, but are not limited to, human population expansion and encroachment, reforestation and other habitat changes, pollution, and environmental and climatic changes. The movement of pathogens, vectors, and domestic animals including humans is another factor influencing the epidemiology of wildlife-related disease (viral, bacteria and parasitic) outbreaks. Such movements are commonly encountered at the edges of protected areas due to availability of rich resources and bring about interactions at the wild/domestic animals/humans' interfaces with conflicts and potential for pathogen spread at the interface. These are emerging threats to wildlife conservation goals and livestock and human health. It is suggested that preventive measures should be geared towards improved disease surveillance among domestic and wild animals at the edges of protected areas using improved diagnostic techniques, vector control and implementation of restrictions on anthropogenic animal movement, concomitant with public enlightenment campaign and behavioral change. More so, collaborative, multisectoral, and transdisciplinary approach to surveillance and control of emerging and re-emerging diseases at the edge of protected areas at local, regional, national, and global levels should be intensified.

Author details

Y.J. Atuman[1]*, C.A. Kudi[2], P.A. Abdu[2], O.O. Okubanjo[3] and A. Abubakar[4]

1 National Veterinary Research Institute Vom Outstation Laboratory, Bauchi, Bauchi State, Nigeria

2 Department of Veterinary Medicine, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria

3 Department of Veterinary Parasitology and Entomology, Ahmadu Bello University, Zaria, Nigeria

4 Force Animal Branch Department, Nigeria Police Force Headquarters, Abuja, Nigeria

*Address all correspondence to: atumanyj@yahoo.com

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