

The contribution of veterinary medicine to public health and poverty reduction in developing countries

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Veterinaria Italiana 2014, **50** (2), 117-129. doi: 10.12834/VetIt.1405.323

Accepted: 14.05.2014 | Available on line: 30.06.2014

Keywords

Africa,
Diseases,
Livelihoods,
Livestock Production,
One Health,
Poverty alleviation.

Summary

Few studies have explicitly examined the linkages between human health, animal disease control and poverty alleviation. This paper reviews the contribution that veterinary medicine can make to poverty alleviation in sub-Saharan Africa. Our analysis attempts to explore aspects of this contribution under five themes: food production; food safety; impact and control of zoonotic infections; promotion of ecotourism; and environmental protection. While these areas of human activity have, more or less, fallen under the influence of the veterinary profession to varying degrees, we attempt to unify this mandate using a 'One Health' narrative, for the purpose of providing clarity on the linkages between the veterinary and other professions, livestock production and poverty alleviation. Future opportunities for improving health and reducing poverty in the context of developing African countries are also discussed. We conclude that veterinary science is uniquely positioned to play a key role in both poverty reduction and the promotion of health, a role that can be enhanced through the reorientation of the profession's goals and the creation of synergies with allied and related professions.

Il contributo della medicina veterinaria per la salute pubblica e la riduzione della povertà nei paesi in via di sviluppo

Parole chiave

Africa,
Allevamento,
Animale,
One Health,
Patologia,
Povertà,
Scienze veterinarie.

Riassunto

Le relazioni tra salute umana, controllo delle patologie animali e programmi di riduzione della povertà raramente sono state oggetto di analisi. Questo articolo analizza il contributo che la medicina veterinaria può fornire ai processi di riduzione della povertà nell'Africa sub-sahariana. In particolare, vengono analizzate le implicazioni della medicina veterinaria su: produzione di alimenti, igiene alimentare, impatto e controllo delle zoonosi, promozione di ecoturismo e protezione dell'ambiente. Lo studio ha l'obiettivo di riconsiderare questi aspetti sulla base dell'approccio "One Health" e di chiarire le relazioni che la professione veterinaria ha con le altre professioni, gli allevamenti animali e i programmi di riduzione della povertà. L'articolo esamina le opportunità future per migliorare le condizioni di salute e ridurre il sottosviluppo nei paesi africani, evidenziando il ruolo determinante delle scienze veterinarie. Ruolo che può essere ancor più potenziato attraverso la ridefinizione degli obiettivi professionali e la creazione di sinergie con le altre professioni.

Introduction

The 'One World, One Health' framework supports an integrated approach for addressing the surveillance of, and response to, human, animal and environmental health concerns. First articulated by William Osler and Rudolf Virchow over a century ago (Kahn *et al.*, 2007), 'One Health' was re-introduced to the world in Schwabe's 'Veterinary Medicine and Human Health' (AVMA 2008; Battelli and Mantovani, 2011). Its contemporary precepts were articulated at a symposium organised by the Wildlife Conservation Society (WCS) in New York in 2004 (WCS 2013). While the inextricable linkages between human and animal health and their shared environment have been outlined in the literature, context-specific illustrations of the need to maximise the benefits of a holistic approach to animal and human health in the Sub-Saharan African context are still required.

In the war against infectious diseases, physicians in Sub-Saharan Africa often face what seem to be insurmountable odds; odds which could be improved by a partnership between the veterinary and environmental professions to explore and address Africa's social determinants of health. At the same time, the veterinary profession in Sub-Saharan Africa, however, faces unique context-specific challenges. Following the International Monetary Fund Structural Adjustment Programmes of the late 80s and 90s, animal health programmes, which used to be government run, were relegated to the private sector so to scale down the role of public administration involved in the management of veterinary service (Cheneau *et al.* 2004). However, in many contexts, the disincentives of working in rural or low input areas led to detrimental consequences for overall animal health and production.

On the one hand, the vulnerability of rural areas makes them a key source of both human and animal infectious diseases; a situation worsened by the paucity of rural veterinary support. On the other hand, under commercial settings of Sub-Saharan Africa, the information technology boom of the 21st century allowed farmers to become much more educated than they used to be, having access to specialised information through formal and informal educational resources, making the farmers less likely to consult veterinarians on areas such as cattle, pig and poultry production and other husbandry practices. The veterinary profession in Sub-Saharan Africa has therefore suffered severe setbacks as the need for specialist veterinary care in animal production has decreased.

That said, the public good aspect of the veterinary profession has special relevance for the Sub-Saharan African context, particularly in those nations in which the vast majority of the population

is dependent on livestock and agriculture. These populations face a lack of knowledge concerning the veterinary public health risks of uncontrolled zoonoses, the importance of food safety, the need for environmental protection and the negative impacts of limited investments in disease control and quality assurance systems. With international development discourse now shifting towards pro-poor initiatives (e.g. the millennium development goals), whose core objective is the alleviation of poverty, the veterinary profession in Sub-Saharan Africa is presented with an opportunity to refocus its efforts on livelihood advancement through contributions to areas such as sustainable animal health, tourism, trade and advancing the cause of environmental protection. Therefore, veterinarians operating in these countries need to propose and develop control strategies within their mandate that are both effective and context appropriate, taking into account economic, cultural and sociological considerations (Marcotty *et al.* 2009). To achieve this, we suggest using the 'One Health' framework in a livelihoods approach (Scoones 2010). This involves understanding the context and needs of rural communities to define control and response strategies that are equitable, accessible and appropriate.

In this paper, we examine the role of veterinary profession in poverty reduction and public health in resource-poor communities of Sub-Saharan Africa by focusing on five thematic areas: food production and food security; food safety; control of zoonotic infections, environmental protection and the promotion of ecotourism. The overarching question through which we explore these thematic areas is: 'how can the adoption of pro-One Health strategies aid the veterinary profession in effectively contributing to poverty alleviation and rural livelihoods?' Addressing this question requires to consider two preliminary and interlinked questions, whose analysis constitute the conceptual framework for this paper.

1. How does veterinary medicine fit into the complex arena of rural livelihood advancement, animal production, food safety and environmental protection?
2. How can the profession go beyond its animal health limits to positively impact rural livelihoods and poverty alleviation?

Background

Among rural livestock-keeping communities, livestock carry enormous currency, what Smith and colleagues (Smith *et al.* 2001) termed "multifunctionality". Multifunctionality describes the myriad roles that livestock play in the maintenance

of rural livelihoods, as sources of nutrition and assurance of domestic food through the provision of meat and milk; traction power and manure for crops; the maintenance of distinctive rural cultures in their role in marriages (the quoting of dowry in livestock) and traditional ceremonies; and their role in providing social security by offsetting crop failure and acting as banks (Ilemobade 2009; Maudlin *et al.* 2009; Perry *et al.* 1984; Mwacalimba *et al.* 2013). Furthermore, low-scale free range poultry rearing and small ruminant production has been identified both as major sources of protein and alternative income for the poor since they are readily marketable (Dolberg 2003).

The multifunctionality of livestock implies that for most rural livestock keepers in Sub-Saharan Africa, human livelihoods are inextricably linked to the welfare of their stock. Emotional distress is frequent in times of high cattle mortalities, owing to the helplessness farmers feel in the absence of veterinary intervention during high impact disease outbreaks. This is a phenomenon experienced also in high income countries, for example it has been reported that that life after the UK Foot and Mouth (FMD) crisis of 2001 “was accompanied by distress, feelings of bereavement, fear of a new disaster, loss of trust in authority and systems of control, and the undermining of the value of local knowledge” (Mort *et al.* 2008). The authors further noted that “such distress remained largely invisible to the range of ‘official’ inquiries into the disaster” (Mort *et al.* 2008). Such emotional traumas are not easily quantifiable and, thus, do not attract the sympathy of policy-makers who focus only on animal morbidity and mortality without weighing the emotional investment made by livestock owners.

Livestock and livestock production are critical to the welfare and livelihoods of many people living in pastoral and mixed crop-livestock farming communities in developing countries (FAO 2004; WHO 2006). Animals owned by poor farmers in such contexts remain susceptible to a broad spectrum of diseases due to their owners’ inability to meet the cost of disease prevention and production inputs (FAO 2002). Animal health status is a particularly important constraint to poverty alleviation. It can thus be argued that maintaining livestock health, adequate veterinary services can actually bolsters crop production, rural livelihoods and the social and emotional wellbeing of livestock owners (Muma *et al.* 2012). We argue that this can be strengthened via veterinary input in animal production, disease control, food safety and environmental protection. The following sections offer an overview of each of these thematic areas, followed by a description of the role the veterinary profession can play in each of such areas.

Veterinary medicine and poverty alleviation

Contribution to food production

Food production and food security are critical components of rural livelihoods in Sub-Saharan Africa. In crop-livestock production systems, animal traction power is a vital input in the production cycle (Perry *et al.* 1984). It has been demonstrated that when oxen are available for cultivation, maize production is increased 4 to 5 times (Connor 1989). However, cattle kept by rural populations remain vulnerable to diseases and adverse climatic conditions, which all tend to impact negatively on rural welfare and food security (WHO 2006). Serious livestock epidemics have the potential to threaten entire crop-livestock production systems by adversely affecting those communities whose livelihoods actively depend on animal draft power.

The impact of the now eradicated Rinderpest virus on human communities is an example of how a livestock disease can change the course of nations. The broad impact of infectious diseases is not unique to Africa. The 2001 Foot and Mouth Disease (FMD) outbreak in the UK provides another example of how a nation’s economy can be severely affected by livestock diseases. Foot and Mouth Disease is reported to have brought about losses to agriculture and the food chain amounting to £ 3.1 billion. The majority of costs went towards compensation for slaughtered livestock, waste disposal and clean-up, while agricultural producers were expected to suffer losses estimated at £ 355 million, representing about 20% of the estimated total income from UK farming in 2001 (Thompson *et al.* 2002). A 2002 study conducted by the National Audit Office estimated the direct costs of the outbreak at £ 3 billion and the indirect costs at £ 5 billion (Oxford Analytica 2012).

In Ethiopia, when oxen numbers were halved by trypanosomosis, production of cereals also fell. Further losses of oxen forced cultivators to abandon fertile areas for higher ground (Slingenberg 1992). As an alternative, small ruminant keeping has been suggested for such communities, due to their higher disease tolerance and resilience to drought and other adverse climatic conditions (Omondi *et al.* 2008). However, in many parts of Sub-Saharan Africa, cattle remain central to the livelihoods and identity of crop keeping rural communities. They are also valued for their input in crop production, higher sale price and milk production potential compared to sheep and goats.

Livestock movement bans are usually instituted during severe disease outbreaks of conditions such as FMD or Contagious Bovine Pleuropneumonia (CBPP)

(Pineda-Krch *et al.* 2010; Woolhouse 2003). These movement restrictions incapacitate subsistence farmers by denying them the opportunity to obtain returns on livestock and their products, which are critical sources of income (Pineda-Krch *et al.* 2010; Woolhouse 2003). Movement bans also restrict access to pasture and water, often located long distances from households that practice transhumant grazing and nomadic pastoralism systems.

When livestock movement bans are implemented just before the crop planting season, farmers often fail to raise funds needed to obtain farming inputs such as seed and fertilizer. Funds are usually acquired through the sale of livestock at markets far from their homes. Movement bans also lead to problems in food security. In West Africa for instance, an interstate ban on the movement of poultry and poultry products instituted following an outbreak of avian influenza ultimately led to regions with low poultry production unable to obtain poultry and poultry meat from the high poultry producing areas (Dolberg 2003). The result was the reduced availability of the cheapest and commonest source of protein for low-income consumers (Dolberg 2003).

Often, outbreaks which occur in Sub-Saharan Africa are not due to a failure to detect disease occurrences, they rather follow a lack of appropriate response tools for early detection by veterinarians or qualified animal health technicians. There is a direct correlation between consistent up-scaled veterinary service delivery and food availability. This has been seen in developed economies in which there is a rapid response to disease outbreaks and effective monitoring and surveillance systems. An example is the control of FMD in Japan where outbreaks are rapidly quelled because of financial investments in the veterinary services (Muroga *et al.* 2012; Sugiura *et al.* 2006). Well-established interventions such as vaccination of cattle against diseases of economic importance like FMD, Contagious Bovine Pleuropneumonia (CBPP), brucellosis and avian influenza, as well as the promotion of good husbandry practices and community orientated bio-sanitation are among the most effective tools of controlling livestock diseases and thus provide an important adjuvant to poverty alleviation in rural communities.

Contribution to food safety

With the increase of the world's population, a global food crisis has been foreseen, with developing nations identified as future significant contributors to food production, particularly from livestock and livestock products (Delgado *et al.* 1999). There is now an increased global awareness of food borne diseases and the importance of food safety in

many parts of the world (Knight *et al.* 2003). The importance of food safety cannot be overstated. Milk and other animal products must be safe, sound and wholesome if they are to contribute to the creation of healthy societies, which is essential for national productivity (Choudhury *et al.* 2013). Most developing countries suffer chronic food safety problems, mainly attributed to poor food safety governance systems; insufficient food hygiene education; poor and non-existent waste disposal systems; abundant insect and animal disease reservoirs and vectors of disease agents; and inadequate human and financial resources to invest in food safety. Furthermore, in many developing countries, veterinary drug controls are inadequate and food safety assurance systems such as the Hazard Analysis Critical Control Point (HACCP) or the farm-to-fork concept of food safety have not been implemented along many food supply chains, making it difficult to assure food safety.

In order for communities to reap the benefits of increased livestock production, there is need to structure veterinary support in rural Africa towards the prevention of the introduction of biological (disease agents), chemical (antibiotic residues and pesticides) and physical (radioactive materials) hazards along the food chain. The safety of food of animal origin, however, begins with production (Wood *et al.* 1998). Increased livestock production and food safety must therefore be seen as the core objectives of the veterinary profession's contribution to food security. In the 21st century, no livestock veterinarian should feel comfortable only in controlling animal diseases in rural areas. In the execution of their duties, they should also take keen interest in the viability, sustainability and growth of livestock production, and ultimately in the protection of humans from hazards and the promotion of human advancement. The inspection of animals at slaughter provides a valuable contribution to surveillance for diseases of animal and public health importance (OIE 2010). By applying their skills and knowledge in abattoirs, veterinarians contribute to public health mainly through the control of zoonoses and diseases transmissible to humans through food and preventing human exposure to antibiotics and other chemical pollutants that are likely to enter the food chain. There is also need for veterinarians to be actively involved in the regulation of antibiotic and anthelmintic drug used in animals to reduce the risk of the development of drug resistant organisms potentially harmful to human health (Geerts and Gryseels 2000; WHO 2006). This requires a shift from the classical approach of controlling animal diseases to full engagement in the production of food that is safe, sound and wholesome.

Food of animal origin often serves as a vehicle for many food-borne diseases. The education and

training of veterinarians in animal health and food hygiene means that they are uniquely equipped to play a central role in ensuring food safety, especially the safety of foods of animal origin (OIE 2010). However, in many African countries, the mandate to assure the safety of food of animal origin falls under multiple jurisdictions: Ministries of Health, Ministries of Local Government and Ministries of Agriculture. This can result in professional rivalries that impact negatively the operationalization of food safety governance. To ensure that foodborne hazards can be managed, veterinarians in developing nations need therefore to seek legislative reform to realign mandates and competencies towards cooperation and synergism among stakeholders along the food production value chain.

Contribution to zoonoses prevention and control

The global public health community now recognizes that control of diseases in animals is the principal means of reducing human exposure to the majority of emerging infectious diseases (EIDs) (Levings 2012). A recent study involving 1415 human pathogens, observed that 61% of these were of zoonotic origin (Taylor *et al.* 2001). A large proportion of the zoonotic EIDs are believed to be in the developing world (Cleaveland *et al.* 2007; Faye and Lancelot 2006; Palmer 2007; Pappas *et al.* 2008). The emergence of zoonotic EIDs such as Severe Acute Respiratory Syndrome (SARS), highly pathogenic avian influenza and West Nile Virus, have brought the world's attention to the need for effective and efficient veterinary services to avert the global economic losses associated with pandemic-scale infectious disease threats, as well reducing human morbidity and mortality (Bengis *et al.* 2004; Kahn *et al.* 2009; Mazet *et al.* 2009).

Although it is understood that many animal diseases and zoonoses negatively affect people's livelihoods, the impacts of these diseases may, in some circumstances, be largely underreported, thus underestimating their incidence and artificially downgrading their importance on the policy agendas of both governments and funding agencies (Maudlin *et al.* 2009; Dorny *et al.* 2009; Welburn *et al.* 2009). Many zoonotic diseases that were once thought to be insignificant and generally neglected are re-emerging and are likely to become increasingly important (Cleaveland *et al.* 2007; Aluwong and Bello 2010). For instance, parasitic zoonoses remain a major health problem in poor communities in unsanitary environments (Dorny *et al.* 2009; Aramayo *et al.* 2009; Casapia 2006). There is also an increase in the incidence of non-typhoidal Salmonellosis as well as other enteric infections whose source of transmission are largely

of animal origin in rural communities in developing countries (see Morpeth *et al.* 2009). The risk groups most susceptible, such as HIV-infected individuals, the elderly and children below the age of 3, are all increasing.

The symbiotic relationship between rural communities and their livestock in developing countries, evinced by the inevitable proximity of the 2 species, is a favourable environment for the transmission of zoonoses (Perry 1984; Mfinanga *et al.* 2003). The risk of contracting zoonoses from wildlife is higher in these poor communities whose people and livestock interact with wildlife, commonly referred to as wildlife-livestock interface areas (Karesh *et al.* 2005). Wildlife-livestock interfaces pose a challenge to human, animal and environmental health practitioners due to the complex and continuous cycle of disease transmission that such areas foster (Malama *et al.* 2013). In the Southern Province of Zambia, for instance, livestock owners trek their cattle to water sources located mostly in and around wildlife sanctuaries during the dry season or along nomadic tracks with year round interaction between livestock and wildlife. This provides opportunities for livestock exposure to parasites, diseases and their vectors while sharing pasture and water sources with wildlife (Muma *et al.* 2007; Munyeme *et al.* 2008; Muma *et al.* 2006). In Nigeria, a well characterized *Mycobacterium bovis* isolate was identified in humans constantly exposed to cattle, and similarly, a well characterized *Mycobacterium tuberculosis* isolate was isolated from a goat (Jenkins *et al.* 2011). In Zambia, two studies (Muma *et al.* 2007 and Munyeme *et al.* 2008) demonstrated that cattle interaction with the Kafue lechwe antelope (*Kobus lechwe kafuensis*) was an important risk factor associated with increased *Brucella* spp. and *M. bovis* infections respectively, in cattle on the Kafue flats. In this same area, an association was earlier observed between keeping cattle and the having a tuberculosis infected person in a household (Cook *et al.* 1996). It is probable that diseases in both wildlife and cattle, if unchecked, could have serious repercussions for human health (Oloya *et al.* 2008; Kazwala *et al.* 1998; Cleaveland *et al.* 2007; Mwacalimba *et al.* 2013). The cost-benefit analysis performed by Mwacalimba and colleagues (Mwacalimba *et al.* 2013) suggests that, albeit difficult, a combined control of tuberculosis in lechwe and cattle in this interface would have the added benefit of controlling its zoonotic impact and overall disease prevalence in the area.

Another example is rabies, which is estimated to kill approximately 50,000 people around the globe annually (Meslin *et al.* 2000). In a human rabies survey conducted in Zimbabwe, over 90% of the cases were due to dog bites, with jackals (*Canis adustus* and *C. mesomelas*) and honey

badgers (*Mellivora capensis*) contributing less to the positive cases (Pfukenyi *et al.* 2007). While the condition has both sylvatic and domestic cycles, the control of this disease in domestic animals is likely to reduce its incidence in humans. The repercussions of these and similar zoonoses include increased health costs for already impoverished communities; reduced labour outputs from infirm members of the community, reduced output from diseased livestock and increased animal health costs.

Most infectious diseases are poorly controlled in both animals and humans in many sub-Saharan states. Some of the factors responsible include limited veterinary resources due to low budgetary allocations from central treasuries, insufficient diagnostic tools for rapid field detection of animal diseases; dysfunctional laboratories; poor surveillance systems as well as inefficient disease reporting systems and poor attitudes among public service providers (Muuka *et al.* 2013). One Health approaches may ensure a speedy response to such threats, forestalling the spread of zoonoses to in-contact communities and beyond. Because poor health delivery systems attract community attention and threaten political fortunes, human health enjoys strong political will over a number of other sectors in most sub-Saharan countries. Unless policy-makers begin to see the benefits of holistic preventive medicine, there will always be an attraction to curative therapy in humans due to its immediate and visible impact on the affected communities and countries. The implementation of holistic preventive medicine therefore requires unwavering political will and the sound implementation of integrated health programmes.

Despite continued resource challenges and minimal government attention to veterinary services and research in recent years, the veterinary profession in many African countries has made major contributions to the body of knowledge on zoonoses through research in various aspects of disease epidemiology (Cadmus *et al.* 2004; Muma *et al.* 2006, Oloya *et al.* 2006; Munyeme *et al.* 2009; Matope *et al.* 2010), such as risk factors for transmission in domestic animals and wildlife (Munyeme *et al.* 2008; Matope *et al.* 2010; Kabagambe *et al.* 2001; Kazwala *et al.* 2001); phenotypic and molecular characteristics of zoonotic agents (Cadmus *et al.* 2006; Hilty *et al.* 2005; Kazwala *et al.* 2006; Oloya *et al.* 2008; Michel *et al.* 2008); and cost-benefit analysis of zoonoses control (Mwacalimba *et al.* 2013). Such research is useful for informing the development of disease control policies tailored to the primary healthcare needs of rural Sub-Saharan Africa. By embracing a 'One Health' approach, it is envisaged that the collaboration between veterinarians, medical and paramedical professionals will strengthen national, regional and international strategies for zoonoses

control (Kahn *et al.* 2009; Mazet *et al.* 2009). Indeed, because of the convergence of human and animal diseases, a common approach to biosecurity has become essential (Kahn *et al.* 2009; Muma *et al.* 2012). But often, there is little utilisation of knowledge generated by researchers due to non-existent knowledge exchange platforms between the knowledge generators (Universities and research institutions) and the end users (policy-makers and the general public).

Contribution of veterinarians to environmental protection and improved land utilization

It is estimated that an area of approximately 10 million square kilometres in Africa is infested with tsetse flies which transmit trypanosomes (Connor 1989; Slingenbergh 1992). These vast tracts of land are generally unsuitable for human habitation or the rearing cattle and other livestock. Veterinarians have developed methods to control tsetse flies, especially the savannah species, *Glossina morsitans*. Successful control programmes have been mounted in Southern Africa and large tracts of land have been reclaimed for people to live and farm (Masiga 1998).

With the increasing levels of pollution in African rivers, the use of animals living in close proximity to, or in, these rivers as sentinels of contamination is becoming increasingly important (Myburgh *et al.* 2011; Mariano *et al.* 2009). Significant contributions have been made by veterinarians and biologists in the area of eco-toxicology by monitoring the effects of industrial pollutants and pesticides on humans and animals. Veterinarians, in a bid to save animal populations, have been pivotal in developing protocols for evaluating the levels of environmental pollution. For instance, the effect of mining activities in Zambia on the water population and aquatic life has been a subject of investigation by veterinary researchers (M'kandawire, *et al.* 2012; Mwase *et al.* 2002; Alimli *et al.* 2005).

As developing economies pursue industrial advancement, there is the inevitable but poorly researched challenge of waste management. The increased demand for animal protein caused by increasing incomes in developing nations (Delgado *et al.* 1999) has resulted in the growth of urban animal keeping, commonly known as 'backyard' production. With the world's growing population competing for the same geo-physical resources such as land and water, backyard animal production is likely to increase to meet the growing demand for animal protein. However, this animal production model has created novel challenges in waste disposal as the conventional municipal sewage systems are not designed to deal with the effluent

from livestock production in human residential areas. Veterinarians, through the application of their training and resources, can significantly contribute to research into the design of innovative waste management systems and surveillance tools for monitoring environmental pollution and gauging the impacts of mitigation measures (Sim and Wu 2010; Cabaret *et al.* 2002). However, this can only be feasible if veterinarians work in close collaboration with environmental health professionals in the development of new innovations for mitigating the public health risks associated with animal waste management.

Furthermore, all animals, including domestic livestock and wildlife, can potentially cause environmental degradation through overgrazing if their stock densities exceed land carrying capacities, especially in the semi-arid savannah during, and subsequent to, drought years (Fynn and O'Connor 2000). Veterinarians can contribute to environmental protection by designing efficient livestock stocking and management strategies. They also possess the expertise to do the same in wildlife management, through informing controlled game hunting programmes, culling procedures and the protection of vulnerable species.

Contribution to ecotourism

Like many other countries on the African continent, Zambia provides an example of the ecological diversity that makes Sub-Saharan Africa a competitive candidate for state, private and foreign investment in ecotourism. In-situ conservation in Zambia includes protected National Parks (NP) and Game Management Areas (GMAs) (Saiwana 1995). There are 19 NPs and 32 GMAs covering 8.6% and 22% of Zambia's total landmass respectively. Some of the fauna in the country's conservancies include species like the African wild dog (*Lycaon pictus*), Shoebill stork (*Balaeniceps rex*), Kafue lechwe (*Kobus leche kafuensis*), Black lechwe (*Kobus leche smithemani*) and Ansell's shrew (*Crocidura ansellorum*), which have been listed as endangered species by the International Union for Conservation of Nature (IUCN) (IUCN 2009). GMAs act as buffer zones between NPs and communal lands. Livestock ownership and consumptive utilization of wildlife are permitted in the GMAs (Saiwana 1995).

In recent years, wildlife populations in the NPs and GMAs have significantly reduced due to poaching, infectious disease outbreaks and the over-exploitation of natural resources by expanding human populations (Siamudaala *et al.* 2004). In order to save wildlife, governments in many Sub-Saharan African states are promoting ex-situ conservation which involves private rearing of wildlife outside

state-owned protected areas (Siamudaala *et al.* 2004). Currently, Zambia has more than 100 game ranches and over 10 large crocodile farms. The number of aviaries is also slowly increasing (Siamudaala 2004). The negative impact of tick-borne diseases and trypanosomosis (transmitted by tsetse flies that cover over 30% of the landmass in Zambia) on livestock production have accelerated the shift from cattle ranching to game ranching, because game are trypano-tolerant. The involvement of the private sector in the rearing of endangered species such as the Kafue and Black lechwe serves as a back-up, increasing the declining populations of these *Kobus leche* sub-species.

Wildlife, however, serve as important disease reservoirs. Examples include FMD and theileriosis in buffalo; malignant catarrhal fever in wildebeests and African swine fever in warthogs (Masiga 1998). These diseases constrain the expansion of the wildlife industry in many sub-Saharan countries (Munang'andu *et al.* 2006; Siamudaala *et al.* 2003). In one instance, an outbreak of anthrax in Malilangwe conservancy in Zimbabwe in 2004 nearly wiped out the entire population (n=500) of kudu (*Tragelopus strepsiceros*) and a number of other antelopes such as the nyala (*Tragelaphus angasi*), bushbuck (*Tragelaphus scriptus*), water buck (*Kobus ellipsprymus*) and roan antelope (*Hippotragus equinus*), suffering losses of approximately 68%, 48%, 44% and 42% of their populations, respectively (Clegg *et al.* 2007). The disease further killed livestock in adjacent wildlife-livestock interface areas (Clegg *et al.* 2007). Other examples include the canine distemper epidemics in East Africa which are believed to have resulted in disturbed wild animal population dynamics with negative environmental repercussions (Roelke-Parker *et al.* 1996). Ex-situ conservation also presents infectious disease threats such as the report of tuberculosis in Kafue lechwe and in a bushbuck (*Tragelaphus scriptus*) on a game ranch in the Central Province of Zambia (Zieger *et al.* 1998).

Wildlife conservation not only brings the threat of wildlife diseases to livestock, but also to humans, making the multi-species transmission infections highly probable. The resultant complex cycle of infectious disease transmission can have catastrophic effects on all species involved. For instance, the introduction of bovine tuberculosis from cattle to the Kafue lechwe, as well as the introduction of rabies and canine distemper from domestic dogs to wild dogs has contributed to the significant reduction of these species, subsequently leading to their inclusion on the IUCN red list of threatened species (IUCN 2009). A case of transmission of human tuberculosis to monkeys has been reported in South Africa (Michel 2003). Anthrax outbreaks in the Luangwa National Park of Zambia have contributed

to the decline of several wildlife species, including wild dogs (Turnbull *et al.* 1991). A significant problem is that wildlife conservation usually occurs in areas remote to veterinary services (Siamudaala 2004). Consequently, game is consumed and wildlife trophies are handled without veterinary clearance. For instance, in 2011, an outbreak of anthrax in hippos (*Hippopotamus amphibious*) in the Luangwa National Park resulted in human infections and environmental contamination in Chama district of Western province in Zambia (Hangombe *et al.* 2012). It was reported that all the patients involved in the outbreak had a history of having consumed or touched anthrax-infected hippo meat. A combined team of veterinary and medical professionals investigated the outbreak and implemented control measures offering an example of 'One Health' approach to the control of zoonoses. Zoonoses such as anthrax not only threaten the existence of wildlife resources, they also threaten tourism.

These concerns gain an international dimension in the implementation of Trans-frontier Conservational Areas (TFCAs) currently being advocated and developed within the Southern African Development Community (SADC). Trans-frontier Conservation Areas are large natural systems of one or more protected areas straddling 2 or more countries. The concept of creating TFCAs is recognised as an important tool for promoting the conservation of biodiversity and protection of endangered animal species. This conservation model also presents the risk of sharing of infectious diseases between humans, livestock and wildlife. The mitigation of this risk requires significant veterinary input in TFCA implementation.

Ecotourism is defined as "responsible travel to natural areas that conserves the environment and improves the well-being of local people" (The International Ecotourism Society, TIES 1990). Tourism is not only important for state revenue, since facilities for game viewing and hunting safaris tend to be located in rural areas, it also offers rural communities opportunities for gainful employment, and a market for their agricultural produce and crafts. Such investments greatly contribute to poverty reduction.

How do considerations of wildlife conservation, ecotourism and hunting add to this discussion on livelihoods, health and the role that veterinary medicine could play in poverty reduction? It is in the mêlée of infectious disease threats that the veterinary profession must reorient itself to proactively support ecotourism. Siamudaala (2004) has argued that veterinary services play a pivotal role in poverty alleviation among local communities in and around wildlife protected areas. Under such circumstances, the challenge

for the veterinary fraternity is to design disease control and conservation strategies that allow for the co-existence of wildlife and livestock not only in interface areas, but also in game-ranches where wildlife exists in close proximity to livestock (Haigh 1996). Veterinarians and para-veterinarians are also involved in the establishment and maintenance of *ex-situ* conservancies, thus contributing to wealth creation. They are involved in carrying out ecological audits to determine the carrying capacity and type of fauna and area chosen to be a game ranch is able to support the wildlife species to be introduced. They also carry out veterinary audits to determine the disease profile and vector species found in ecosystems chosen for the establishment of *ex-situ* conservancies (Munang'andu 2000). Veterinarians are responsible for the translocation of animals from NPs, GMAs or other private properties to the new conservancies. On established game ranches, disease surveillance and monitoring is carried out during safari hunting, capture operations, or cropping of excess stock (Munang'andu *et al.* 2006). Therefore, veterinarians are well placed to implement the prevention and control measures necessary to avert the negative impacts of emergence of diseases in and from wildlife. However, additional skills are required in risk analysis for veterinarians to help stakeholders in wildlife conservation to take into account the sanitary and phytosanitary measures necessary for safe animal translocation and health management.

Discussion: veterinary activities in the 21st century

We can now summarise how the veterinary profession can go beyond its 'animal treatment' role to positively impact production, rural livelihoods and poverty alleviation. It is important that veterinarians in Sub-Saharan Africa are equipped with novel and interdisciplinary skill sets that appropriately meet the contemporary challenges of holistic animal, human and environmental health. A review of veterinary curricula to include 'One Health' precepts within a livelihoods framework should be an urgent undertaking, if Sub-Saharan African veterinarians are to remain relevant to the context in which they live and work. This should also include competence in analysing the costs and benefits of the control strategies they institute, to assure the best response to the needs of the society (Swan and Kriek 2009; Kock 1996). Many disease control campaigns have been conducted without a full assessment of their economic impacts both in terms of the cost of conducting the exercise, disposal, and the effects of other related non-agriculture industries such as tourism (Sugiura *et al.* 2001; Thompson *et al.* 2002).

Wildlife and nature conservation are important in the conservation of the world's biodiversity. Veterinarians can be particularly instrumental in monitoring wildlife diseases and designing disease control strategies (Kock 1996). However, the challenges of infectious disease control and eco-conservation require that veterinarians no longer remain isolated as a profession but, instead, engage and collaborate with other professionals in allied fields. In the 21st century, animal health and production, in its various forms, remains an important asset in Sub-Saharan Africa. Despite the differences in approaches and mandates among the professions dealing with human, animal and environmental health, cooperation between the disciplines that link this triad of people, animals and their shared environment is critical in assuring sustainable policies for health and poverty reduction. The burden of veterinary responsibility will only grow with the increasing incidence of emerging and re-emerging diseases. The strengthening of national veterinary services should thus be viewed as fundamental to the surveillance and control of domestic, wild animal and zoonotic diseases.

Policy-makers in Sub-Saharan Africa should not ignore the various sociological roles that livestock play in developing countries. For instance, understanding community perceptions and interpretations of animal diseases in rural

African settings provides a significant tool for disease surveillance and the institution of control interventions (Muuka *et al.* 2012). Therefore, in order to change policymaker perceptions towards livestock, veterinarians cannot take the view that the control of animal diseases in African countries is solely an exercise of laboratory science. It should also include an application of human anthropology (Marcotty *et al.* 2009; Muuka *et al.* 2012) and politics (Green 2012; Mwacalimba 2012; Mwacalimba and Green 2014).

In conclusion, in adapting the 'One Health' approach to the Sub-Saharan African context, veterinarians need to be cognizant of the fact that animal health is one, albeit important, pathway for the improvement to human health and welfare. The veterinary profession should therefore refocus its energies on adopting new knowledge and new partnerships. It should identify and understand the various economic constraints and challenges that the veterinary profession faces in contributing efficiently to human development, public health, animal production, draught power and wildlife conservation (Swan *et al.* 2009). Veterinary science is uniquely positioned to play a key role in both poverty reduction and the promotion of global health. This role can be enhanced through the reorientation of the profession's goals and the creation of synergies with allied and related professions.

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