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## Contents

**Acknowledgements** ........................................................................................................................... 3

**Foreword** ............................................................................................................................................. 7

---

**Bolivia – integrated disease prevention for livestock, people and conservation** ......................... 9
*E. Alandia, M. Uhart, A. Terrazas, R. Wallace & W.B. Karesh*

**Economic benefits and challenges for sustainable approaches to managing human/wildlife interaction**

The value of wildlife tourism: perspectives from sub-Saharan Africa ............................................... 19
*P. Chardonnet & S. Le Bel*

How to improve wildlife production in South Africa .............................................................................. 39
*K. du Toit & O.L. van Schalkwyk*

The unregulated and informal trade in wildlife: implications for biodiversity and health .................... 51
*W.B. Karesh, K.M. Smith & M.V. Asmussen*

**Illustrating contributions to public health**

From forecasting to control of emerging infectious diseases of zoonotic origin: linking animal and human health systems .............................................................. 59

Wildlife, wild food, food security and human society ............................................................................ 71
*R. Kock, R. Alders & R. Wallace*

Policy opportunities for linking animal and human health .................................................................. 81
*J.G. Murray & S.M. Aviso*

**Illustrating relationships of wildlife, domestic animal health and production**

Domestic animal health programmes to protect wildlife ...................................................................... 91
*S. Cleaveland, J. Keyyu, H. Auty, T. Lembo, K. Hampson, F.J. Lankester & R. Kazwala*

Land-use paradigms, wildlife and livestock: southern African challenges, choices and potential ways forward ................................................................. 101
*D.H.M Cumming & M.W. Atkinson*

**Illustrating strategies for efficient surveillance and management of animal diseases**

Assuring transparency .............................................................................................................................. 113
*K. Ben Jebara*

Managing disease outbreaks .................................................................................................................. 117
*G.K. Brückner*

---

*Compendium of the OIE Global Conference on Wildlife*
Capacity-building: issues and opportunities ................................................................. 123
F.A. Leighton

National wildlife disease surveillance systems .......................................................... 133
M. Artois, K. Ben Jebara, E. Warns-Petit & F.A. Leighton

Safety and challenges of international trade

Transfrontier conservation areas – compatibility with animal and human health:
a southern African perspective .................................................................................. 143
R.G. Bengis & L.-M. de Klerk-Lorist

Building competence and confidence – the Performance of Veterinary Services (PVS) Pathway
(PVS evaluation and PVS gap analysis, legislation) ..................................................... 151
A. Dehove

Alien invasive species: issues related to wildlife and domestic animal trade ............... 163
P.-P. Pastoret & F. Moutou

The health of wildlife: the role and needs of zoological conservation organisations .... 169
R.A. Cook

Contributions of biodiversity conservation and wildlife management to health

Integrative approaches to disease control: the value of international collaborations .... 175

The need for sound and sustainable policy in an interconnected world:
science-based guidance from the OIE ........................................................................ 181
M.K. Glynn

Recommendations ...................................................................................................... 189
Our world is changing very rapidly; the human population is steadily growing, and so is the demand for food, in both quantitative and qualitative terms, and in particular for animal protein (a more than 50% increase by 2030 according to the estimates of certain experts), especially in the emerging economies where over a billion people are overcoming poverty and joining the middle classes. Natural conservation policies must be put in place to cope with expanding urbanisation, pressure on natural habitats and competition for natural resources.

Unprecedented movements of animals and people enable pathogens to colonise many different parts of the planet and to move faster than the incubation period of epizootics.

Health risks for humans, domestic animals and wildlife are evolving very quickly because of all these developments and, at the same time, the awareness of the absolute need to safeguard biodiversity is, fortunately, on the rise on all continents.

Faced with these challenges, global, regional and national health and environmental policies must be reconsidered, and new tools, as well as new forms of cooperation and synergies between stakeholders, must be found. One of the objectives of the conference was to bring together all the professions, stakeholders and players concerned and to harness determination in order to help forge these new tools and policies.

The OIE is carrying out several activities with that aim. A standing Working Group on Wildlife Diseases has, since 1994, been working in collaboration with all our specialist commissions. Along with our Collaborating Centres and Reference Laboratories, it provides the scientific bases to the OIE's work to move forward along several parallel paths:

- Information and transparency regarding the animal disease situation in the world. 178 countries are connected to our WAHIS/WAHID World Animal Health Information System, open to all for consultation;
- Protection of importing countries thanks to WTO-recognised OIE standards to manage the risks linked to international trade in animals and animal products;
- Adoption by all Member Countries of quality standards for veterinary services, in particular regarding the capacity to ensure early detection and rapid response to animal diseases throughout their territory;
- Use of a tool for evaluation and gap analysis with regard to these quality standards (PVS Pathway), already in use in 110 countries;
- The PVS Pathway is recognised by donors (World Bank, European Union) as a tool to assist developing countries in complying with quality standards;
- Appointment of National Focal Points for Wildlife in all countries (178). A unique network in the world;
- Establishment and implementation by our regional bureaus of a world information/training catalogue (capacity building) for the benefit of all National Focal Points, updated every two years to help countries harmonise their strategies;
- Implementation of a global partnership with all stakeholders:
– inter-governmental organisations (Food and Agriculture Organization of the United Nations [FAO], World Health Organization [WHO]) with which the OIE has an official agreement;
– United Environment Programme (UNEP), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), International Union for Conservation of Nature (IUCN), with which the OIE intends to reinforce collaboration;
– non-governmental organisations such as Wildlife Conservation Society (WCS), EcoHealth Alliance, Wildlife Health Centre (University of California, Davis School of Veterinary Medicine), International Council for Game and Wildlife Conservation (CIC).

The conference covered all these subjects, and recommendations were presented in the plenary session at the last day. They are included in this publication as an appendix.

I trust this compendium provides a state of art vision on where we are and where we should go to incorporate wildlife and biodiversity protection into our efforts to promote animal health and welfare and veterinary public health worldwide.

Dr Bernard Vallat
Director General of the OIE
Bolivia – integrated disease prevention for livestock, people and conservation

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Summary

Domestic animal diseases have the potential to significantly affect wildlife populations and human livelihoods, either as a result of direct impacts on their health, or by decreasing the amount of game available for subsistence hunters. The closer the contact between domestic animals, wildlife and human populations, the bigger the risk of disease transmission becomes. The Wildlife Conservation Society (WCS) has a long-term partnership with the Takana communities of Bolivia, working in alliance with the Takana People’s Indigenous Council to develop their capacity to sustainably manage their territory. The core of WCS’s approach is to provide a framework for achieving governance, while offering support for community-based, sustainable, resource-management initiatives. These include a wildlife monitoring system which tracks sustainability of subsistence hunting, and a wildlife health programme focused on improving domestic animal health and husbandry. Fostering community-based sustainable natural-resource-management initiatives is also expected to reduce environmental impacts. The overall goal of this health programme is to engage local stakeholders and promote biodiversity conservation, focusing on key aspects of ecosystem health. The strategies are to: create capacity in animal husbandry and disease management; establish a surveillance network for domestic and wild animal diseases; set up husbandry records; establish communal veterinary pharmacies; provide on-site technical assistance for communal livestock-rearing projects, and identify and promote the use of native medicinal plants as alternatives to pharmaceuticals.

After five years, positive outcomes include base-line information on domestic and wild animal diseases, improved health care for domestic animals, increased demand for training and medicinal plant studies, trained technicians carrying out treatments in their communities, and more readily available information on disease outbreaks in remote areas. Observed benefits for the wellbeing of indigenous peoples comprise steadily available sources of protein, diversification of income sources, a reduction in the prevalence of zoonotic diseases, and promotion of sustainable management of natural resources. This strong foundation now allows for the incorporation of these community-based programmes into national animal and public health strategies.

The approach taken through this programme has highlighted the importance of empowering local stakeholders to identify and implement solutions that are easily adaptable to their culture and needs.
It has also shown the benefits of applying a broad ‘One Health’ approach when addressing health issues at the wildlife/human/livestock interface, to ensure both disease prevention and conservation.

Keywords


Introduction

Bolivia is considered to have one of the highest levels of biodiversity in the world (1). The tropical lowlands of Bolivia are home to more than 30 indigenous groups (10). Among them are the Takana indigenous people whose territory is located immediately adjacent to and within the Madidi Integrated Management Natural Area and National Park (Fig. 1). The livelihood of the Takana people has traditionally been based on small-scale agriculture, hunting, fishing and the harvest of a variety of non-timber forest products (3). However, since colonial times, their access to natural resources has gradually been reduced as a result of the influx of non-indigenous people to this particular area and a series of immigrations due to economic booms in the extraction of rubber, quinine, wildlife skins and timber. Hence, over the last couple of decades, many Takana communities have had to modify their traditional livelihoods, including rearing domestic animals, such as poultry, cattle and swine, to supplement their dietary needs. This has created a new interface, where people and their domestic animals now live in close proximity with wildlife. Several studies have shown that domestic animal diseases have the potential to significantly affect wildlife populations and human livelihoods, either as a result of direct impacts on their health, or by decreasing the amount of game available for subsistence hunters (4, 5, 8, 9).

The Wildlife Conservation Society (WCS) began working in the Greater Madidi–Tambopata landscape in May 1999 and, since February 2000, has worked with the Takana communities of Bolivia through a partnership with the Takana People’s Indigenous Council (CIPTA), to develop capacity for the sustainable management of their territory, the Takana Tierra Comunitaria de Origen (Takana TCO) or Takana Indigenous Territory. The core of WCS’s approach is to provide technical and financial support to build governance capacity for territorial management, while offering more specific assistance for a range of community-based sustainable resource-management initiatives, including honey production from native bees, monitoring subsistence hunting and fishing, sustainable harvesting of the spectacled caiman (Caiman crocodilus), timber management, handicrafts production, promotion of ecotourism activities, and a health programme to improve domestic animal health and husbandry and aid zoonotic disease control, using the ‘One Health’ concept.

The ‘One Health’ approach in Bolivia

The overall goal of the WCS health programme is to engage local stakeholders and promote biodiversity conservation, focusing on key aspects of ecosystem health. For this purpose, WCS works with communities to implement more appropriate husbandry and disease prevention measures for their domestic animals, in order to limit disease transmission between domestic animals, wild animals and people. This also helps to ensure higher animal protein availability for people (both in quantity and quality), and decreases their dependence on harvested wildlife. With this approach, WCS intends to support community livelihoods and sustainable development in these areas.
Fig. 1
The Takana Indigenous Territory, located adjacent to and within the Madidi Integrated Management Natural Area and National Park, La Paz, Bolivia

In the Takana TCO, the first step in this process was to work with a subset of communities, using participatory diagnostic workshops to identify the main problems observed in their domestic animals. During these workshops, community members reported on the most frequent health problems affecting their animals, by drawing disease ‘sketches’ that describe the anatomical location and clinical signs of disease. These observations later guided medical investigations and interventions, such as sampling for disease confirmation and preventive measures.

Using these community diagnoses, an animal health strategy was jointly developed with the Takana communities over a series of participatory workshops. The six ‘strategic pillars’ of the strategy were to:

– create local capacity in animal husbandry and disease management
– establish a surveillance network for domestic and wild animal diseases
– establish a scheme for monitoring husbandry methods for household animals
– provide communal veterinary pharmacies
– provide on-site technical assistance for communal livestock projects
– identify and promote the use of native medicinal plants.

Create local capacity in animal husbandry and disease management

Initially, volunteers (men and women) from five Takana communities were trained with a five-module classroom course and practical hands-on training programme. Topics included the description and clinical signs of the most common diseases of domestic animals; basic husbandry techniques; nutrition and health care; calculation of medication dosages; and basic treatments for diseases such
as gastro-intestinal parasites. By 2009, the training programme established in 2005 had reached 12 of the 19 communities in the Takana TCO. Over five years WCS trained 44 community members (25 women and 19 men) as health technicians or animal health promoters (AHPs). The role of the AHP is to provide basic health care for animals in their communities, manage communal veterinary pharmacies, collect diagnostic samples and apply simple treatments such as antibiotics and deworming agents. Post-training technical support was provided through communication with WCS, either by radio or telephone, and periodic visits of WCS veterinary staff to ensure accurate disease diagnosis and correct application of treatments.

To reinforce the knowledge of the AHPs, and as an immediate source of information for community members, a manual on animal health and husbandry for domestic animals in lowland communities was prepared and printed in 2009. The manual (2), which is easy to understand and user-friendly at various literacy levels, includes the teaching material used in the AHP training courses. An additional outreach initiative was the participative design and production of parasite treatment and vaccination calendars for common domestic species (cattle, horses, pigs and poultry), which were distributed to animal owners and health promoters.

Establish a surveillance network for domestic and wild animal diseases

To identify the main pathogens affecting domestic animals, and to validate the observations of local people of domestic animal diseases, between 2005 and 2009 the WCS tested for 27 different pathogens on 1,029 domestic animals, belonging to five different species reared in 15 Takana communities. No disease of high economic or zoonotic importance was detected during these four years of monitoring, such as foot and mouth disease, avian influenza, brucellosis, classic swine fever or Aujeszky’s disease. Nevertheless, exposure to other zoonotic and non-zoonotic pathogens was documented. These pathogens included Newcastle disease virus, mycoplasmiosis, salmonellosis, infectious bronchitis, infectious rhinotracheitis and infectious bursal disease virus in poultry; cysticercosis, parvovirus, lepto-riposiosis and ascaridia in swine; leptospirosis, anaplasmosis, vesicular stomatitis, piroplasmosis, anaplasmosis and bovine viral diarrhoea in cattle; and ancylostoma and mange in dogs.

Results from these pathogen surveys established the first available base-line information on disease exposure for domestic species reared in the area. This information helped to identify and refine the topics to be included during the AHPs’ training and provided an opportunity to establish open discussions with community members on animal and public health. All results of sampling activities were presented during communal meetings, where the implications of these findings for domestic animal, wildlife and human health were explained. In 2009, these presentations were followed by requests from 12 Takana communities to implement corrective measures, such as parasite treatment of domestic animals, to prevent zoonotic diseases and to avoid disease spillover to the wildlife they also consume. Since that time, two general deworming campaigns have been carried out in 15 of the 19 Takana communities, reaching more than 300 Takana families and 1,300 domestic animals, including dogs, pigs, horses, cows and poultry. Sampling performed before and after the campaign showed a reduction in gastro-intestinal parasite levels and animal-owners expressed their satisfaction with the weight gain and improved condition of their animals. From a sustainability perspective, domestic animal treatments are financially supported by animal-owners, and provide an opportunity to reinforce the AHPs’ training.
Between 2009 and 2010, as a result of the high demand for animal health care and need for technical support for AHPs, WCS funded a locally based veterinarian. Initially, the veterinarian and additional WCS veterinary staff provided most treatments, but gradually this responsibility has been transferred to the trained AHPs. For example, the ratio of WCS veterinarians conducting the communal deworming campaigns, as opposed to AHPs, was 7:8 in 2009, compared to 1:18 in 2010. In 2010, the confidence gained by trainees and local recognition of the important service provided by AHPs resulted in communities deciding that AHPs who participated in domestic animal parasite control campaigns would be financially rewarded for their work, and that this would be paid by the animal-owners. In addition to the costs of medication, which range between 0.01 and 0.07 United States dollars (US$) per treatment, AHPs were paid an additional US$ 0.10 per treated animal. In this way, AHPs received an average of US$ 5 per day for their services, equivalent to half the average daily salary for activities such as tourism or harvesting timber.

The increased knowledge and awareness acquired by AHPs and community members also allowed the establishment and strengthening of a Domestic Animal Surveillance Network, with the participation of animal-owners and AHPs. In this network, the communities report the occurrence of any animal disease to the on-site veterinarian or a designated person at CIPTA, who then coordinates response actions with the community leaders and the WCS veterinary team. In turn, WCS then communicates with the National Veterinary Service (SENASAG) (Fig. 2a), as appropriate, i.e. when the disease is reportable, such as Newcastle disease. The long-term aim is to refine the network to exclude WCS, so that CIPTA can communicate directly with the SENASAG local office, which would then be responsible for implementing appropriate control and prevention measures (Fig. 2b).

This network has allowed the collection of information on domestic animal disease types and their frequency of occurrence in the Takana communities (Fig. 3), which in turn has facilitated better targeting of veterinary interventions. For example, community reports allowed quick interventions to halt the spread of respiratory disease (mainly due to Newcastle disease and infectious bronchitis) and poxvirus in poultry, as well as pyroplasmosis and trypanosomosis in cattle. While the network was originally designed for domestic animal diseases, it is also generating data on wildlife diseases, because people are now more aware of potential diseases in the animals they hunt, and more easily able to recognise them. For instance, in 2010, a Takana community reported an unusually high number of parasites in white-lipped peccary (Tayassu pecari) muscles and were concerned about potential health effects. The response assessment revealed that a non-zoonotic filaria was the causative agent (WCS, unpublished data).

In 2010, to strengthen disease surveillance in wildlife, WCS began working with indigenous subsistence hunters to collect samples from hunted animals. Initial monitoring has yielded a variety of gastro-intestinal parasites in three ungulate species (6) and other hunted mammals and wild birds, including wildlife-specific parasites not previously reported to be found in Bolivia (WCS, unpublished data). Monitoring has also demonstrated the exposure of white-lipped and collared peccaries to diseases such as brucellosis, parvovirus and cysticercosis.
Fig. 2a
Stage 1 of the Domestic Animal Surveillance Network implemented in the Takana Indigenous Territory, La Paz, Bolivia

Fig. 2b
Stage 2 of the Domestic Animal Surveillance Network excludes the Wildlife Conservation Society and links the Veterinary Services directly with the community
Establish household-animal husbandry-monitoring records

The use of simple, visual husbandry monitoring records was implemented by 38 families from five Takana communities in 2005, allowing people to record the number of domestic animals in their homes, those that died or got sick, those that recovered after treatment, and those that were sold or killed for food. This was a key opportunity to provide personalised technical support to families, particularly to women, during data collection. It also gave an understanding of the main husbandry problems faced by animal-owners, which can be summarised as frequent disease outbreaks and insufficient management knowledge. Records showed that the dynamics of the Takana husbandry system differ considerably from conventional systems, in that an increase in the number of domestic animals is not necessarily the main objective for Takana families. On the contrary, their aim is to have animal protein available for family celebrations, income to cover basic needs such as school materials, clothes or human medicines, or simply to supplement their diets when hunting is not possible.

Provide communal veterinary pharmacies

To prevent and treat animal diseases without delay, veterinary medication kits were provided to 11 Takana communities with trained AHPs. The pharmaceuticals in the kits were provided at wholesale cost, and treatments were conducted by the trained AHPs. To ensure the sustainability and proper use of the veterinary kits, the AHPs also learned how to manage funds from medication sales, replace used and expired drugs, and maintain medication inventories. In addition, to ensure rapid replacement of used pharmaceuticals in the communal veterinary kits, WCS helped to establish a small veterinary pharmacy at CIPTA’s main office in 2008. As a result of the low costs of these pharmaceuticals and the good reputation of trained AHPs, requests for both technical advice and for veterinary products from the CIPTA pharmacy have grown consistently. The pharmacy’s sales average US$ 20 per month, mostly for preventive and control products (parasite treatments and vaccines) and antibiotics.

Provide on-site technical assistance for communal livestock-rearing projects

At the request of CIPTA, WCS began to support three community-based cooperative projects involving livestock and poultry. The aim of these small-scale projects was to provide alternative year-
round protein sources, and improve community livelihoods by creating surplus products for sale (such as meat and eggs). During these projects, WCS provided technical advice to control and prevent diseases, trained some members as AHPs to ensure proper health management, worked to improve husbandry practices, and liaised with cooperative members to establish operational rules. Although some of these projects failed due to internal community problems, the knowledge acquired by many project members on animal husbandry and health is still being applied to their domestic animals.

**Identify and promote the use of native medicinal plants**

Taking a cue from traditional local knowledge, WCS tested a couple of medicinal plants on domestic animals with the aim of providing a sustainable and affordable alternative to pharmaceuticals, reducing the dependence of indigenous people on external technical advice and commercial medicinal products. Over time this approach also aims to reduce drug residues in the environment and potential drug-resistant pathogens, while increasing the value of local plant diversity to encourage their conservation. One of the studies conducted tested the effectiveness of the fruit and resin of bibosi, a local *Ficus* spp. tree, for the treatment of gastro-intestinal parasites in pigs. The results showed the effectiveness of bibosi in controlling gastro-intestinal nematodes such as *Ascaris suum*, *Strongylus* spp., *Strongyloides ramsoni* and *Trichuris* spp. (7). The study’s positive outcomes led to requests from Takana communities for similar studies on other local plants.

**Conclusions**

After five years, WCS’s participative approach has demonstrated encouraging results which include base-line information on domestic and wild animal diseases, improved health care for domestic animals, an increased number of trained technicians carrying out treatments in their communities, increased demand for training and medicinal plant studies and more readily available information on disease outbreaks in remote areas. In addition, the programme has contributed to the well being of indigenous people by ensuring more consistently available supplies of protein, particularly in communities where hunting success is low, as well as diversifying their income sources. Since successful outcomes were not certain at the beginning of this programme, using external resources to develop and test it seemed to be a logical first step before diverting the capacity of government agencies. With the success of this approach now clear, community support enlisted, and government involvement and interest heightened, the next steps include the incorporation of these community-based programmes into national animal and public health strategies.

This programme has highlighted the importance of empowering local stakeholders to identify and implement solutions that are easily adaptable to their culture and needs. It has also shown the benefits of applying a broad ‘One Health’ approach when addressing health issues at the wildlife/human/livestock interface, to ensure both disease prevention and conservation. As such, it promotes sustainable management concepts, which are part of the Takana traditional legacy.

**References**


The value of wildlife tourism: perspectives from sub-Saharan Africa

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Summary

Various authors have used different categories to estimate the value of wildlife, e.g. direct and indirect use values, option values, ethical values, etc. In this paper, the authors address the value of wildlife-based tourism. With the development of the world tourism industry, the value of nature-oriented tourism is increasing on all continents, and especially in sub-Saharan Africa. The value of such tourism is often understood as the direct economic benefits that come from ‘the tourist dollar’ and contribute to the generation of income for the country and its inhabitants. However, there are other ways to value wildlife which are not sufficiently taken into account, i.e. the diverse benefits provided by ecosystem services, such as the ecological value of species to a healthy ecosystem, their nutritional value and cultural value, etc. Wildlife tourism in sub-Saharan Africa is largely supported by Protected Areas (PAs), with their broad range of different categories, which are clearly the backbone of the industry.

One leg of wildlife tourism is the wildlife-viewing tourism in natural habitats. In sub-Saharan Africa, this type of tourism mainly occurs in PAs of the public domain, principally national parks (NPs). It also occurs at a few other locations, such as game ranches which are privately owned, or communal conservancies which are community-based, both found mainly in Southern Africa. With a few notable exceptions, a majority of NPs are struggling to fulfil their conservation mandate, due to a lack of financial and human resources for their management: very few of them attract enough tourists to cover their management costs. At present, most NPs require external funding to support their day-to-day running and achieve their conservation aims. This is nothing new. Protected areas cannot be justified solely by their direct economic outputs; the entire range of benefits that they provide must be considered.

The other leg of wildlife tourism is hunting tourism. This type of tourism mainly occurs in publicly owned PAs, which are officially gazetted and earmarked as hunting areas (HAs) under various names (e.g. game reserves, hunting blocks, Coutadas, Zones de Chasse, Domaines de Chasse, etc.). In a few Southern African countries, hunting tourism is also carried out on private and communal land. These HAs, overall much bigger than NPs, often act as buffer zones around and ecological corridors between NPs. They are usually privately managed and financed and thus their contribution helps to reduce the financial burden on the government, of conserving and managing its biodiversity assets in these areas. Government budgets for conservation are often under-resourced, being low on the list of
national development priorities. Thus, improved professionalism and efficiency in the hunting tourism industry could substantially increase the ability to conserve huge tracts of natural habitat, with all of their biodiversity and ecosystems services, while increasing economic benefits to the local people and Government.

However, most PAs are under threat from humans, caused by growing populations and their increasing need for land and natural resources. In developing countries, concerned with food security and poverty alleviation, poaching is a widespread threat to PAs. The often massive quantity of bushmeat taken from both inside and outside PAs represents a kind of 'hidden' value, since it is largely unknown, overlooked and often illegal. When this direct consumption of game for food becomes unsustainable, due to over-harvesting the resource, its value becomes negative and counter-productive to wildlife tourism. Agriculture encroachment is a severe threat to PAs because it is converting natural habitats, destroying biodiversity and compromising ecosystem services. Pastoral encroachment is a relatively new threat to NPs and HAs, and this issue is often neglected in management schemes although it is happening more frequently. The two different types of PAs, NPs and HAs, complement each other very well in their common function of resisting the biological collapse affecting vast areas of sub-Saharan Africa.

Keywords


Introduction

Various authors have used very different categories to try to estimate the value of wildlife, e.g. direct values comprising consumptive use value and production use value and indirect values comprising non-consumptive use value, option value and ethical value (24). The focus of this paper will be on sub-Saharan Africa and different perspectives on the value of (i) wildlife-based tourism, (ii) protected areas and (iii) wildlife itself.

The growing development of tourism

Tourism throughout the world

Tourism is one of the world’s leading industries, accounting for 5% of the world’s gross domestic product (GDP) and 30% of the world’s export of commercial services. Furthermore, the industry is growing: the value of travel and tourism is expected to rise from 7.9 billion United States dollars (US$) in 2008 to US$ 14.8 billion by 2018. The contribution of the travel and tourism economy to global employment is expected to rise from 238 million jobs in 2008 to 296 million jobs (1 in every 11 jobs) by 2018 (38). The number of international arrivals has grown from a mere 25 million international arrivals in 1950 to an estimated 806 million in 2005, corresponding to an average annual growth rate of 6.5% (43). The UNWTO Tourism 2020 Vision forecasts that international arrivals will reach nearly 1.6 billion by the year 2020. In terms of total tourist arrivals, the top three receiving regions in 2020 will be Europe (717 million tourists), East Asia and the Pacific (397 million) and the Americas (282 million), followed by Africa, the Middle East and South Asia. With such impressive growth, the tourism industry appears to be one of the most remarkable economic and social phenomena of the beginning of this century. With the development of the world tourism industry, the value of nature-oriented tourism is rising on all continents: already, in 1999, 7% of all international travel expenditure was related to
nature tourism, which was also one of the fastest-growing segments within the international tourism market (9).

**Tourism in Africa**

The African region boasts a number of major assets (e.g. nearly one-third of the world’s terrestrial biodiversity, more than one-fifth of the world’s terrestrial surface area and 15% of the world’s population). However, its share of the world’s tourism is still tiny, with only 4% of international arrivals. Nevertheless, tourism in Africa is showing steady growth, higher than the world’s average. While tourist arrivals declined globally in 2009 because of the financial crisis, Africa was the only region that showed the opposite trend, with a 5% increase (38).

The tourism industry in Africa is unevenly distributed, ranging from virtually none in some unstable and/or poor countries to a very important activity in some emerging economies. North Africa (mainly beach tourism) and southern Africa are, by far, the two leading sub-regions of the continent. In sub-Saharan Africa, southern Africa dominates the industry, followed by East Africa and, quite far behind, by Central and West Africa (38) (Fig. 1).

Sub-Saharan Africa is now emerging as a popular destination for visitors and a promising source of development. According to the World Travel and Tourism Council, travel and tourism are expected to contribute over 9% to the African region’s GDP over the next decade.

Besides beach tourism, nature-based tourism is a major component of the tourism industry in sub-Saharan Africa. Wildlife-based tourism offers a very wide and diverse range of products, e.g. nature-based tourism with a wildlife component, visits to locations with good wildlife presence, visits to artificial attractions based on wildlife, habitat-specific tours, animal watching, thrill-offering tours, hunting/fishing tours, ecotourism (31).

![International tourist arrivals in SSA](image_url)

**Fig. 1**

*International tourist arrivals in sub-Saharan Africa. Adapted from (38)*

Available at: www.unwto.org/
Protected areas and wildlife-based tourism in sub-Saharan Africa

Protected areas as the backbone of wildlife-based tourism

Wildlife-based tourism and protected areas (PAs) are closely interrelated in sub-Saharan Africa: wildlife-based tourism would not exist without PAs, which are really the backbone of the industry. In return, PAs need wildlife-based tourism, which is their main income-generating activity. Beyond the well-known I to VI categories of the International Union for Conservation of Nature (IUCN), PAs cover a wide range of parks and other bodies featuring different patterns of wildlife-based tourism (www.iucn.org/about/work/programmes/pa/pa_products/wcpa_categories/ accessed on January 2012), e.g.:

- PAs support various forms of wildlife-based tourism:
  i) wildlife-viewing tourism, a non-consumptive form of wildlife-based tourism, occurs in all types of PAs with particular emphasis on national parks
  ii) hunting tourism, a consumptive form of wildlife-based tourism, occurs in many types of PAs (hunting areas, conservancies, game ranches), but not in most national parks

- PAs have differing forms of legal status:
  i) public PAs, e.g. national parks and hunting areas
  ii) communal PAs, e.g. communal conservancies
  iii) private PAs, e.g. private wildlife ranches.

It is worth noting that the last two types (communal and private PAs) occur mainly in the southern African sub-region, where communal conservancies, commercial conservancies and private wildlife ranches are made possible by specific legal provisions, in terms of land tenure, ownership rights and wildlife user rights. These legal provisions are either rare or absent in most countries of the other sub-regions of the continent.

The importance of PAs has brought with it some unintended consequences:

- non-protected areas (or non-gazetted areas) are neglected by most stakeholders in respect to nature conservation. States tend to allocate most of their national conservation budget to PAs; tourism operators tend to invest in and around PAs only; wildlife conservationists and researchers tend to concentrate their work on PAs, and funding agencies tend to support PAs. All these efforts reduce investment and interest in nature conservation outside PAs, i.e. in by far the largest proportion of the earth’s surface;

- PAs are considered by most stakeholders as very important or the most important areas in the remote and landlocked regions where they are often located; as a consequence, too much is often expected from PAs. These expectations are not limited to achievements in conservation but frequently include rural development results, which are often beyond the competence and resources of PAs.

Protected areas and wildlife-viewing tourism

In sub-Saharan Africa today, wildlife-viewing tourism is a major contributor to the national economy in only a limited number of countries. Nature-based tourism generated US$ 3.2 billion in ten out of 14 Southern African Development Community (SADC) countries in 2000/2001 (3). In Kenya, the direct contribution of the global tourism sector (more than three-quarters of tourists to Kenya visit parks and reserves) to the GDP was US$ 1.4 billion (3.2%) in 2007 (21). As a leading country in African tourism, South Africa is achieving impressive performances. During the 2009–2010 financial year, the total number of guests visiting parks surpassed 4.5 million people through the South African National Parks’ (SANParks) gates, an increase of 3.8% from the previous year. For the famous Kruger National
Economic benefits and challenges for sustainable approaches to managing human/wildlife interaction

Park only, the number exceeded 1.4 million visitors, an increase of 7.8% on the previous year. Outstandingly, national citizens (South Africans themselves) accounted for 77.6% of all guests to parks (36), which is very unusual in all other African countries. Another peculiarity of South Africa is the important role played by the private sector in the tourism industry, with the unique development of (i) a large and growing number of private wildlife ranches and (ii) private concessions within public PAs.

With a few notable exceptions, such as in South Africa, most national parks struggle to fulfil their conservation mandate because of the lack of sufficient financial and human resources for their management (15, 20). Very few of them attract enough tourists to cover their management costs: in West Africa, for instance, national parks very seldom attract more than 6,000 visitors a year (19), which is far from enough to cover their investment and management costs. In Gabon, out of the 15,000 foreign visitors to the country each year since 2007, only 1,000 to 1,500 people specifically come to visit the national parks (10). Apart from some specific, privately owned and/or managed enterprises, wildlife-viewing tourism is profitable in very few national parks. Moreover, these parks require a high level of security, easy access, an efficient infrastructure, professional services and at least one outstanding feature, such as a spectacular landscape and/or popular species.

In some cases, too much mass wildlife-viewing tourism may lead to significant environmental and socio-cultural impacts. In Kenya, for example, after a period of unplanned expansion, tourism began to decline in the early 1990s, with the breakdown of the physical infrastructure, environmental deterioration, wildlife–human conflicts, socio-cultural problems and an uneven distribution of benefits (35).

There is nothing new here: most PAs cannot be justified solely by their direct economic contribution. Their whole range of values should be considered, especially their ecosystem services. At present, external funding is needed in most cases to support public PAs and maintain their values.

Protected areas and hunting tourism

Consumptive tourism principally occurs in PAs – mainly in the public domain – that are officially gazetted and specifically earmarked as hunting areas under various names: Coutadas in Portuguese-speaking nations, Zones de Chasse and Secteurs de Chasse in former French colonies, Domaines de Chasse in former Belgian colonies, hunting blocks, game reserves, game controlled areas and wildlife management areas in English-speaking nations. Hunting tourism is also carried out on private and communal land in a few countries, mainly in southern Africa.

While national parks are well documented and publicised, hunting areas are often overlooked as a support to (i) nature conservation and (ii) wildlife-based tourism, despite:

- covering very extensive surface areas, currently much larger than national parks: 1.2 times larger in sub-Saharan Africa and 1.7 times larger in countries where hunting tourism is practised (23, 33). For instance, in Tanzania, national parks cover about 7% of the country (57,840 km²), while the total hunting area covers 33% of the country (295,660 km²) (27);
- often acting as buffer zones for national parks and ecological corridors between them, thus facilitating the functioning of national parks. These two different types of PAs complement each other very well in their common function of resisting the human pressures that affect most of sub-Saharan Africa;
- acting as transition zones between national parks and non-gazetted areas because of their more tolerant management systems: while national parks are generally strictly exclusive and repressive towards human activities within their borders, hunting areas are more community-friendly, with a spectrum of traditional activities permitted inside;
Economic benefits and challenges for sustainable approaches to managing human/wildlife interaction

- reducing the government’s financial burden of conserving and managing its biodiversity assets in hunting areas, a budget that is often under-resourced and frequently comes last in the list of national development priorities. In most cases, the management of hunting areas is privately financed.

Hunting tourism occurs in nearly half of all African countries, fluctuating from one year to another, in between 22 and 25 countries. The hunting tourism industry is unevenly distributed, being mainly concentrated in SADC countries. Out of a minimum of 18,500 tourists a year, throughout the sub-Saharan region, nearly half of these tourists travel to South Africa (45.6%), nearly one-third to Namibia (29.0%), then to Zimbabwe (10.0%) and Tanzania (7.3%), etc. South Africa and Tanzania currently dominate the industry, earning 36% and 29%, respectively, of the gross income generated (3). The hunting tourism industry generates gross revenues of more than US$ 200 million per year in sub-Saharan Africa and is expanding. In Tanzania, direct and indirect tax flow to the government is approximately 44% of the gross income of the industry, i.e. US$ 24 million. In Botswana, 75% of the gross income generated by hunting tourism remains in the country and about half of it stays at the district level, equating to an income of US$ 48.5 per capita in the main hunting districts (3).

Hunting tourism is of major importance to nature conservation in sub-Saharan Africa since it justifies the conservation of vast areas, many of which are unsuitable for alternative wildlife-based land uses, such as photographic ecotourism, because of the lack of access, infrastructure, attractive scenery and/or high densities of viewable wildlife (23). Hunting tourism presents strong comparative advantages:

- compared with wildlife-viewing tourism, hunting tourism is effective in a broader range of situations and has a lower level of requirements
- it generates high revenues from low volumes of tourists in areas unsuitable for wildlife-viewing tourism
- it is generally more resilient to political instability
- it does not preclude some other forms of resource use
- it can help to control problem animals even if this control is not sufficient by itself
- it reduces poaching through private support to public efforts (23).

These advantages are not always fully achieved because of a lack of professionalism among some of the hunting operators. By adopting best practice in every aspect of the profession, the hunting tourism industry could increase its efficiency and more effectively conserve large natural habitats with their biodiversity, while increasing benefits to local people and governments.

Just like national parks, the value of hunting areas is not only economic. This is fortunate because the revenue they bring in per surface unit is far lower than potential alternative revenues from, for example, agriculture and livestock-rearing (18). However, the latter are either destructive to the environment (through the conversion of the natural landscape by agriculture) or degrading (transformation of the natural landscape by pastoralism). As with PAs, and like national parks, hunting areas provide ecosystem services at the global and at the local scale: the huge size of hunting areas makes them massive carbon sinks and enormous reservoirs of biodiversity. The ecosystem services provided by hunting areas to society’s development and the planet’s conservation may represent much larger benefits than the direct economic income they produce.
The value of wildlife and protected areas

Different perceptions

Wildlife is a renewable natural resource with multifaceted values (4). Every single person has his or her own perception of the wildlife resource. These perceptions vary greatly, especially across cultures, to the point that a given value may be considered positive by one and negative by another. In Barth’s theory of value systems, seven distinct spheres of values can be identified in the domain of wildlife exploitation (32):

a) symbolic values  
b) traditional subsistence values  
c) hostile values  
d) economic enterprising values  
e) farming values  
f) pragmatic conservation values  
g) idealistic values.

There are clearly large differences between traditional values, such as (a) and (b); enterprising values, such as (d) and (e); and modern conservation values, such as (f) and (g). While local rural Africans tend to hold values mainly in spheres (a), (b), (c) and a part of (d), westerners tend to predominantly adopt conservation values. According to Rosa and Joubert (32), ‘there is considerable asymmetry in opportunity awareness, know how and capital between western-driven forms of wildlife exploitation, and those of indigenous Africans’.

Economic values

Through a strictly economic prism, wildlife may be regarded as biological capital from which all types of values can be derived, e.g. spiritual, cultural, subsistence and existential; the combination of values assigned to wildlife will tend to determine management objectives to protect and regulate its use (21).

A classic way of categorising the economic values of wildlife is to divide them into consumptive and non-consumptive uses of the wildlife resource (29):

– consumptive use: hunting, live sales, meat, skins, hides, horns, ivory and other products, including trophies and talismans, etc.  
– non-consumptive use: all aspects of ecotourism, game viewing, photographic safaris and other activities, such as catch-and-release sport fishing.

Both classes of tourism (consumptive and non-consumptive) generate taxes for the State, profit for private operators, and shared benefits and advantages for local communities. The global value of wildlife-based tourism is often perceived as restricted to its tangible economic value, i.e. using wildlife to directly generate income. However, a very limited number of PAs present positive economic balances while many more do not. Thus, relying solely on their economic value to justify the continued existence of PAs appears to be a risky approach.

According to Kojwang (21), nature-based tourism is still not directly reflected in national accounts and is hardly recognised as an industry through budgetary allocations and supportive policies: it does not fit into the classification system and is hidden within different industries.
Nature-based tourism is often considered by decision-makers and local communities as the main justification for the existence of PAs. However, very few public PAs are economically balanced, i.e. managing to cover both their investment costs and running costs from tourism revenues, and that is before profitability is even mentioned. A large proportion of PAs are actually a burden on government budgets. Moreover, even when economic benefits do exist, few are shared with local communities. As a consequence, PAs often generate frustration, dissatisfaction and even resentment among local stakeholders, who doubt their relevance. In Kenya, Norton-Griffiths and Said (28) demonstrated that the clear differentials between the returns to agricultural production, livestock production and wildlife production are so great that the benefits from agricultural and pastoral production overwhelm those from wildlife, even in the areas most visited by wildlife tourists. The most lucrative wildlife uses, from the conservation viewpoint, are the concession and access fees paid to landholders by the tourism cartels – potentially between US$ 20 million to US$ 100 million a year, vastly less than the rents from either livestock or agricultural production.

One outstanding exception is the success story of the communal conservancies in Namibia. As explained by Weaver et al. (39), the passage of the 1996 communal area conservancy legislation has provided both incentives and motivation for communal area residents across Namibia to conserve wildlife resources. Communities who form conservancies are now managing and making use of their wildlife through a number of means (photographic tourism, trophy hunting, various forms of meat-harvesting, live game sales). The resulting cash and in-kind benefits have fostered a deeper appreciation of the value of wildlife and stimulated communities to incorporate wildlife conservation practices into their daily livelihood strategies. Consequently, unprecedented recoveries of wildlife are occurring across Namibia’s communal areas, while economic and financial benefits to communities are continuously increasing.

Overall, however, the value of PAs in sub-Saharan Africa, when estimated only on financial revenues, appears insufficient to justify these areas. Nonetheless, PAs have many other values that are essential, despite being too often overlooked, i.e. the important and diverse values of all ecosystem services, including ecological value, nutritional value, cultural value, etc.

The values of ecosystem services

The economic function of wildlife tourism is no doubt crucial, although its conservation function to help justify PAs is also of great importance for biodiversity conservation and climate regulation.

With or without nature-based tourism, whether wildlife-based tourism is profitable or not, whether it is consumptive or non-consumptive, every single PA performs the function of setting aside large tracts of land for nature conservation. Since the creation of PAs, this function has been acknowledged as being instrumental for conserving biodiversity as a whole: PAs are widely recognised as the most efficient conservation tool that exists today.

More recently, this function has been recognised as crucial for delivering ecosystem services. Ecosystem services delivered by PAs are both global in their range (e.g. adaptation to climate change through maintenance of carbon sinks, preservation of genetic richness through conservation of biodiversity) and local in their range (e.g. watershed management, regulation of local climate, support to livelihoods, contribution to food security).

The value of these ecosystem services has not been readily recognised by previous studies of PAs, maybe because it is not considered as an economic value in the strict sense, of producing direct income-generating revenues. However, recent studies provide evidence that the benefits from ecosystem services in PAs to local communities are often greater than those from tourism revenue-sharing, e.g. whether legal or not, gathering wild plants and harvesting fish and game in and around
PAs bring in more benefits than tourism (19). In these cases, traditional and informal benefits overtake conventional formal benefits.

The production of meat from wild animals (bushmeat) may be considered one of the services provided by ecosystems, including PAs. When its legal and illegal components are added together, the global production of bushmeat makes it a very important industry in sub-Saharan Africa, with consumption of about 1.2 million tons a year in the Congo Basin (41) and approaching 2 million tons a year overall. Bushmeat substantially contributes to food security and traditional livelihoods, more so in forest ecosystems than in savannah ecosystems, where livestock are more accessible. In some countries, this industry is increasing with the growth in population and urbanisation, raising the growing concern of sustainability. When poaching wild meat threatens the wildlife resource, which is often the case, the bushmeat industry enters into direct competition with wildlife-based tourism, either consumptive or non-consumptive. Indirect competition occurs when taking bushmeat competes with large carnivores targeting the same animals as prey. In Ghana alone, the annual bushmeat market is estimated at US$ 250 million, higher than the value of the entire hunting tourism sector in sub-Saharan Africa (3). Paradoxically, the bushmeat industry represents a real ecosystem service while nonetheless being an informal and illegal economy. Rosa and Joubert (32) develop the concept of a dual wildlife economy: one informal, dominated by poaching, the other formal and based on non-consumptive exploitation, founded on tourism.

As stated above, the insufficient benefit-sharing from tourism in many PAs is a source of resentment among neighbouring communities. This resentment is stronger in situations where access to land and natural resources is restricted and even worse when it is denied. For this reason, payment for environmental services (PES) is a new and very important tool for conserving natural ecosystems, especially in PAs with no or limited tourism income. The relatively new concept of PES aims to achieve conservation outcomes in a similar way to the more common integrated conservation and development projects, although PES is more direct, more cost-effective and less complex institutionally (14). For instance, the well-known Zimbabwe Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) generated, during 1989 to 2001, over US$ 20 million of transfers to the participating communities, 89% of which came from hunting tourism. Twelve of the 37 districts with authority to market wildlife produced 97% of all CAMPFIRE revenues, reflecting the variability in wildlife resources and local institutional arrangements (14). CAMPFIRE paved the way to a wide range of similar programmes over the whole continent.

**Threats to wildlife, protected areas and wildlife-based tourism**

**Impact of threats**

Threats to wildlife are also threats to PAs as wildlife is a vital constituent of their ecosystems. Threats to PAs are threats to wildlife-based tourism, which very much relies on the integrity of PAs. The intention in this section is not to exhaustively cover the whole spectrum of threats to wildlife, but simply to raise awareness by presenting some of the most prominent. Threats to wildlife may be simply described as:

- **direct threats responsible for the physical destruction of the wildlife itself, e.g.**
  - i) poaching, e.g. game harvesting when that is illegal
  - ii) disease, e.g. often caused by domestic animals contaminating wild ones, as a result of increased livestock/wildlife interaction.

- **indirect threats due to either degrading or destroying wildlife habitats:**
  - i) habitat degradation, e.g. by pastoral encroachment
  - ii) habitat conversion, e.g. by agricultural encroachment.
Impact on wildlife

Declines in large mammal populations in Africa’s PAs have been described by Craigie et al. (8). By using a database of 583 population abundance time series for 69 species of large mammals in 78 PAs, a multi-species index of overall changes in population abundance was developed, revealing an average decline of 59% in wildlife population abundance between 1970 and 2005. However, large regional differences exist, with southern African PAs typically maintaining their populations and western African PAs suffering the most severe declines. According to the same authors, these results indicate that African PAs have generally failed to mitigate human-induced threats to African large mammal populations, even though they also show some successes.

Following the authors above, Scholte (34) further documented the large-mammal population decline in Africa’s PAs in two particular sub-regions of the continent that are usually under-documented, West Africa and Central Africa. He notably describes the underlying drivers of the difference between sub-regions, especially the prolonged decline in rainfall coinciding with increased human pressure in West and Central Africa.

At the country level, a telling example of the decline in wildlife has been given by Western et al. (40) in Kenya. Estimates show a nationwide decline of 38% in wildlife numbers between 1977 and 1997, and a loss of 41% of wildlife populations in the combined national parks over the same period (Fig. 2). Interestingly, the losses in national parks reflect, in part, the poor coverage of seasonal ungulate migrations and, for the largest parks, the effect of climate change and the difficulty of protecting large remote parks. As evidence, wildlife declines appear similar both inside and outside national parks, so that ‘... parks and reserves have not insulated wildlife from the steep country-wide declines of the last 30 years’ (40).

![Graph showing population estimate over decades](image)

**Fig. 2**

The evolution in Kenya of total wildlife populations in national parks over three decades, between 1977 and 1997, with matching external ecosystem counts

These parks include Tsavo East, Tsavo West, Amboseli and Nairobi but exclude Meru and Nakuru. Doi:10.1371/journal.pone.0006140.g002 (40).
Impact on people

Most PAs are exposed to tremendous pressure from growing human populations and their need for development. In developing countries, concerned with food security and poverty alleviation, land and natural resources are even more sought after than in developed countries, at least at the individual and household levels.

Since one of the main mandates of PAs is to preserve land and natural resources from human exploitation, PAs are often regarded by many stakeholders as obstacles to development. In developing countries, PAs are often perceived by local communities as constraints to their traditional lifestyle and subsistence livelihoods. In these countries, the management of PAs becomes extremely tricky, due to the huge challenge of tackling the over-harvesting of their resources while, at the same time, maintaining good relationships with neighbouring communities.

The common ‘tough approach’ adopted by many PAs, based on exclusion, coercion and repression, tends to partition the world into, on the one hand, impenetrable sanctuaries within PAs and, on the other, areas characterised by carelessness and lack of restraint outside PAs. Such a ‘sanctuary’ approach tends to create ‘enemies of conservation’ (11).

In Barth’s theory of spheres of values, the contradictions between the values of indigenous Africans and those of westerners are responsible for a conflict of interest between the consumptive commodification of wildlife by the communities that neighbour PAs and the non-consumptive uses of wildlife by PAs themselves (32). A dual economy results; one dominated by poaching, the other by tourism, and this dual economy increases with human demography. As a consequence, ‘wildlife numbers are plummeting faster than ever at a time when the growth of PAs has never been greater’ (32).

Poaching

Poaching, the illegal harvesting of wildlife, encompasses various realities that may feel very different to the people concerned. Poaching targets large mammals, which are the cornerstone of wildlife-viewing tourism, as well as of hunting tourism. Poaching also targets small game, such as mega-rodsents (e.g. the crested porcupine, cane rat or grasscutter, giant Gambian rat) or duikers (e.g. blue duiker), all of them (i) with a higher resilience to hunting pressure, (ii) with little appeal for tourists, and (iii) often regarded as agricultural pests. Poaching ranges from large commercial poaching to local traditional hunting. Traditional hunting is conducted for either subsistence or commercial purposes or both. The trade component of poaching is rising with human demography and urbanisation. In general, with a few exceptions, poaching activity is escalating.

Most of the time, when a PA is officially declared and gazetted in a given area, any hunting and fishing practised by local communities in that particular area – usually for centuries – becomes poaching, i.e. a crime. Not surprisingly, many neighbouring communities – often displaced from the area – keep hunting and fishing the land they used to exploit, especially:

- when they have few alternative livelihood choices, and
- when hunting and fishing are deeply rooted in their traditional culture.

The often massive quantity of bushmeat taken from both inside and outside PAs represents a sort of hidden value, as the amount is largely either unknown or overlooked. Where and when the consumptive use of game for food becomes unsustainable because of over-harvesting, its value becomes negative and counterproductive to wildlife tourism. In addition to decreasing wildlife abundance and diversity, poaching tends to increase the fleeing distance of large mammals, thus reducing the attractiveness of the area to ecotourists.
Agricultural encroachment

Agricultural development transforms wild landscapes into domesticated landscapes. Because of the brutal nature of the transformation, the ecosystem is subject to a destructive conversion, a process that is more severe than ecological degradation alone. As agricultural development is unquestioned and growing, this problem poses a serious challenge for decision-makers and stakeholders.

For instance, in a 30-km radius around the W-Arly-Pendjari (WAP) complex in Benin, Burkina Faso and Niger, more than 14.5% (3,514.4 km²) of natural savannah has been lost in the 18 years between 1984 and 2002 (6, 7). In the Benin part of the WAP complex, the loss of natural vegetation reached 17.3% during the same period.

In West and Central Africa, most savannah PAs are situated in the Sahelo-Sudanian eco-region, where cotton is grown. In several West African countries, cotton is one of the main cash crops and sources of foreign currency, and production has been steadily growing (Fig. 3). Since growing cotton requires large amounts of land, it is destroying vast areas of natural habitat. As an example, Banikoara, located at the southern border of the W Biosphere Reserve, is the first cotton-producing commune in Benin. The land area devoted to cotton has multiplied there by 1.6 and cotton production has increased 2.7-fold in the ten-year period between 1998 and 2008. In the same commune, the human population increased by 4.6% a year between 1992 and 2002 and doubled in the area closest to the Reserve during the same period (1).

![Graph showing cotton production in West and Central Africa over four decades, between 1961 and 2001](www.fao.org)

**Fig. 3**

*Evolution of cotton production in West and Central Africa over four decades, between 1961 and 2001 (13). Available at: www.fao.org/

Similarly, in Zimbabwe's Mid-Zambesi Valley, rapid changes in land use over the past 30 years have substantially decreased wildlife habitat, with adverse consequences for elephant and buffalo numbers. Farmland there has expanded faster than the human population. Baudron *et al.* (2) demonstrated that the paramount driver of such a change is the expansion in cotton growing, rather than an increase in cattle production following tsetse-control operations.

Furthermore, cotton farming is a major source of ecosystem pollution, degrading water quality and affecting flora, fish and wild large herbivores, as demonstrated by Issa (2004) in the Pendjari and W Biosphere Reserves in Benin. Wild large carnivores, at the tip of the trophic chain, are expected to be even more exposed.

According to Norton-Griffiths and Said (28), a simple elasticity analysis suggests that, for every 1% increase in land supporting cultivation in Kenya, a corresponding decrease of 0.85% occurs in...
wildlife density. In Kenya’s rangelands that receive more than 800 mm of annual rainfall, given the huge discrepancies between the returns from agricultural and livestock production versus those from wildlife production, wildlife must be considered to be at a very high risk of elimination.

The expansion of cultivation into wild lands exacerbates the occurrence of human/wildlife conflicts and increases their magnitude. A wide variety of wildlife species conflict with farming activities (22). Beyond the economic losses affecting rural farmers’ subsistence and livelihoods, human/wildlife conflicts also have a social dimension, which is complex, intangible and difficult to quantify, although it is substantial (12). Thus, human/wildlife conflicts play a major role in the perceptions and tolerance of local communities nearby PAs and, ultimately, in the success of conservation strategies.

In fact, human/wildlife conflicts are often considered to be growing threats to PAs and wildlife. For communities living next to PAs, interactions with wildlife have inevitably led to sources of conflict, for as long as humans and wild animals have shared landscapes and resources. Human/wildlife conflicts result in adverse effects on:

- human life, in many economic, social and cultural aspects
- wildlife conservation
- the environment.

According to Baudron et al. (2), conserving biodiversity without jeopardising agricultural production will require an integrated approach, including technical and institutional innovation and the development and enforcement of policies and regulations to promote sustainable intensification and constrain further clearance of land for agriculture in order to ‘spare’ land for wildlife.

**Pastoral encroachment**

Pastoral encroachment is a growing threat to national parks and hunting areas that is often neglected in management schemes, although it is on the increase. The antagonism arises from:

- direct negative interactions between wild and domestic animals, including disease transmission
- competition over feed and water resources (13).

The current rapid increase in livestock numbers in sub-Saharan Africa (faostat.fao.org/) (Fig. 4) is the result of about 50 years of relatively successful livestock development programmes, the modernisation of veterinary science and the attractiveness of cattle ownership for urban and rural dwellers, etc. In particular, the recent eradication of rinderpest (17, 42) has removed one of the main constraints to cattle demography since the end of the 19th Century.

**Fig. 4**

*Evolution in sub-Saharan Africa of:*

1) the surface area of grazing rangeland (pasture in millions of hectares)
2) the global livestock herd (in millions of FAO livestock units [LU])
3) an index of pastures used by livestock (in km² pasture per 100 FAO livestock units). Available at: www.faostat.fao.org/
In the meantime, the amount of land supporting cattle grazing has remained remarkably stable worldwide (www.fao.org/). Traditional pastoral rangelands have been reduced by the expansion of cultivation and the multiplication of PAs; in West and Central Africa, pastoralists are progressively being squeezed between desertification in the north and the agricultural pioneer frontier in the south; and little new ground is available because of ecological constraints, such as unsuitable forested landscape. As a consequence, the ratio of pasture surface area per head of cattle is steadily dropping, resulting in increased grazing pressure per surface unit, ecological degradation of rangeland, impoverishment of the average livestock herder and rising conflicts between pastoralists and other stakeholders. The real development of cooperation schemes between agriculturalists and pastoralists, notable for a more efficient use of agricultural by-products, does not fully compensate for the shortage of natural pasture.

In their often desperate search for grazing areas, cattle-herders are being driven to illegally enter into PAs, a rising phenomenon that has become a sort of invasion in some areas of West and Central Africa. This has largely been facilitated by the progress in controlling trypanosomiasis, which used to prevent cattle penetrating into PAs often established in marginal tsetse-infested landscape. Domestic cattle have a negative impact on wild herbivores through:

– food competition, especially for species with a predominantly grazing diet, such as the African buffalo
– spatial avoidance, especially for elephants (with exceptions, such as the Gourma’s elephants in Mali), because of the association with overall human disturbance (16).

Pastoral development is responsible for the transformation of natural ecosystems into modified ecosystems, with eroded biodiversity. Herds cause wide-scale land degradation through overgrazing, compaction and erosion, with particular problems in the dry lands (13). Furthermore, as pastoralists are gaining access to wild lands and PAs where lions live, and villagers are farming right up to the edge of national parks, the potential for an increase in lion attacks on livestock and people is obvious. With such an increased interface between people and lions, the human/lion conflict is increasing, even in areas where the lion population is not thriving (5).

In Kenya, according to Norton-Griffiths and Said (28), wildlife has had pernicious effects on livestock production. While wildlife adds perhaps only 6% to the total operating costs of a livestock operation, this can represent anywhere up to 50% of the net operating profits; in other words, eliminating wildlife can effectively double the operating profits of livestock production.

The far eastern region of the Central African Republic provides a telling example of this (26) (Figs 5a, 5b & 5c):

– no cattle were present in the region before the last few decades. Recently, mobile pastoralists have expanded their transhumance into the region inhabited by sedentary agro-hunters, and settled and developed their activities;
– the natural landscape, made up of a forest/savannah mosaic, is being progressively transformed, with a slightly progressive expansion of the savannah, caused by the intensive use of fire by herders;
– the PAs (one wildlife reserve, one community-based hunting area and a dozen hunting blocks) are being encroached upon by pastoralists;
– wild herbivores are being poached by cattle-herders as bushmeat, to complement their diet and to spare their livestock;
Fig. 5
Recent human encroachment onto protected areas of the Mbomou and Haut-Mbomou Préfectures, South-Eastern Central African Republic (25)

Fig. 5a
Protected areas gazetted as wildlife reserves (Réserves de faune), community-based hunting areas (Zones cynégétiques villageoises) and hunting blocks (Secteurs de chasse)

- wild predators are being harassed and persecuted by cattle-herders: shot, snared, poisoned, netted and speared.

The long-term sustainability of biodiversity conservation in PAs invaded by livestock is dependent on:

- applying protective rules and legislation
- the largely shared perception that PAs are legitimate, and
- a consensual vision of land management with negotiation mechanisms established at both local and regional levels, which take into account wildlife conservation and the seasonal migrations of wildlife and livestock (37).
Fig. 5b
Development of pastoral herding: grazing rangeland and official and informal transhumance corridors

Fig. 5c
Development of commercial poaching: main poaching grounds and main poachers’ paths
**Prospects**

The steady growth of the tourism industry in sub-Saharan Africa, especially of nature-based tourism, offers an outstanding opportunity for developing PAs and improving the conservation status of wildlife. However, two conditions must be fulfilled:

- the wildlife resource still needs to be effectively conserved:
  
  i) according to Scholte (34), PAs require a three- to ten-fold increase in their operational budget, as well as a dramatic increase in their institutional, human and local capacity to handle such scaled-up support;

  ii) the same author doubts the ‘myth of wild Africa’ today: he predicts that, outside a handful of very large conservation areas, indigenous wildlife will ultimately remain in the form of, for example, private, profit-driven wildlife ranches or well controlled PAs where species such as gorillas and chimpanzees have become used to humans;

  iii) in Kenya, Mutu (2005, in 40) shows that wildlife populations in private and community sanctuaries are stable or increasing, in contrast to the declines in PAs and country-wide. Western et al. (40) point to: ‘the need for new policies that combine national, private and community initiatives in order to sustain large free-ranging herbivore populations at an ecosystem and landscape scale’;

  iv) the maintenance of a partitioned and segregated landscape in distinct compartments (different categories of PAs and non-PAs) needs serious improvement in land-use planning and practices.

- the local rural societies need to be part of the scheme:
  
  i) according to Rosa and Joubert (32), ‘entrepreneurs [should be] able to exploit synergies between traditional value systems, that see wildlife as a resource to be harvested for subsistence and local profit, and new forces of commercial entrepreneurialism in Africa where the need for self-advancement and economic development is highly valued’;

  ii) as a possible response to this recommendation, Novelli et al. (29) propose an approach where: ‘ecotourism embraces forms of consumptive tourism, which can prove to be beneficial to the economy, the environment and local communities’. If such an approach is adopted, local communities and entrepreneurs should engage in more sustainable forms of wildlife exploitation.

To be strategic, wildlife-based tourism must be beneficial to the economy, to the environment and to local communities. However, for such a strategy to succeed, it is now extremely urgent to improve existing practices and introduce innovative ways to truly involve local rural societies in the global economic world and to overcome the biological collapse.

**References**


How to improve wildlife production in South Africa

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Summary

The authors discuss the history of the South African (SA) wildlife industry and factors that have stimulated or hampered its development, and make recommendations to potentially improve the industry. A major problem faced in South Africa is the fragmentation of the wildlife industry into a production sector (agriculture) and a conservation sector (environmental). The fact that the nine decentralised SA provincial nature conservation and agriculture departments do not have a system in place to coordinate the industry further complicates this fragmentation. This has resulted in a situation where regulatory bodies involved with nature conservation/environmental affairs, agriculture and Veterinary Services are spread across nine provinces, giving a total of 27 independent regulatory bodies that must communicate with the private sector. The resultant shortage of information caused by this fragmentation raises questions that must be answered on a national level to manage this national asset. The role of a central data repository/information system, managed under an independent trust, is discussed as a potential solution to these problems.

Keywords

Conservation – Database – History – Monetary value – Veterinary science – Wildlife production systems.

Historical background of game ranching

The first record of a farmer fencing off part of his farm to protect wildlife is described by FitzSimons (7), as follows. ‘It appears that in 1837, Mr Alexander van der Byl of the farm ‘Nacht Wacht’ enclosed 6,000 acres (2,428 ha) of ground on the western side of the Karsriver about 10 km from Bredasdorp town. Twenty-seven bontebok (Damaliscus pygargus pygargus) were first enclosed at a stocking rate of about one bontebok per 89 hectares. The camp was enclosed partly with galvanised wire and iron strands, partly with a stone wall and partly by the Kars River, which runs in an arc until reaching Nacht Wacht, where it becomes marshy for 14 km until flowing into Zeekoeivlei, 15 km south of Bredasdorp before entering Zoetendalsvlei, 8 km further on its course and 22 km from Bredasdorp.’ These 27 bontebok increased to 180 animals over an 80-year period. Pienaar (6) states that 200 farmers with 300 farms protected the game on their properties in the Transvaal by announcing it in the Government Gazette (Staats Courant). This included 62 farms in the Lydenburg district, 57 in Waterberg, 43 in Pretoria and 23 in the Wakker-stroom district. One such farm, Rolfontein (Staats Courant No. 476 of 3 June 1873, p. 3), belonged to a farmer called Robertson in the Wakkerstroom district. He sent wagons to Pietermaritzburg to collect barbed wire and to the Lowveld for wooden posts, to fence 500 morgen (428.35 ha) for his horses during 1867. This was the first fenced camp in the eastern Transvaal and the game soon found it a safe haven and multiplied quickly.
Wallace (9) stated the following of the eland: 'The eland in the wild state is generally supposed to be 'extinct' in Cape Colony, Natal, Orange Free State, Griqualand West and the Transvaal and almost all countries watered by the tributaries of the Limpopo west of the Matabele country, but is reported to exist in Griqualand East, on the spur of the Drakensberg'. It has been domesticated in the Cape Colony, as shown by the photograph in Figure 1 below, probably the first record of farming with eland in the literature.

![Photo of eland in 1896](image)

**Fig. 1**
*Domestication of eland in 1896 (9)*

**Eras of game conservation in South Africa**

A list of approximate eras in South Africa's conservation history might run as follows (5):

- 1652–1850: hunters and travellers collecting specimens from the interior for museums. Scientists described animals
- 1851–1930: wild animals were removed to establish farms and killed by hunters and traders
- 1901–1930: the first National Parks were proclaimed and legislation established: the Act on National Parks (Conservation)
- 1931–1960: breeding of endangered species takes place in National Parks/Provinces
- 1961–1980: improvement of capture techniques and introduction of the first populations of wildlife onto private property
- 1981–2000: the private sector begins to play a prominent role in conservation
The above eras deal with the major influences on numbers of wildlife in southern Africa. First came the early collectors of specimens for museums who described the animals scientifically to the world. This was followed by commercial hunting that nearly wiped out wildlife in southern Africa. The National Parks Act helped to save endangered species such as the Cape mountain zebra (*Equus zebra zebra*), black wildebeest (*Connochaetes gnou*) and the bontebok (*D. pygargus pygargus*), in collaboration with farmers. These success stories illustrate the importance of the farmer’s role in conservation.

Another factor that had a severe impact on the numbers of wildlife was the outbreak of rinderpest between 1888 and 1902. This disease wiped out millions of cattle, and untold numbers of wild ruminants and swine in Africa. To make matters worse, one disease control measure to control tsetse-borne trypanosomiasis (nagana) was to depopulate the land of wildlife hosts. The measure employed to combat nagana focused on creating strips of land that were free of wildlife (hosts of the fly). The theory was that if the area were free of game the tsetse fly would not be able to survive. Du Plessis (4) and Wilson (10) reported (Table I) that nearly 800,000 animals were killed in southern Africa between 1920 and 1965, in an attempt to achieve this goal.

**Table I**

*Game killed in Southern Africa in tsetse control operations (1920 to 1965) (4, 10)*

<table>
<thead>
<tr>
<th>Species</th>
<th>Bechuanaland</th>
<th>Natal (SA)</th>
<th>Rhodesia</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duiker</td>
<td>5,901</td>
<td>23,458</td>
<td>201,269</td>
<td>230,628</td>
</tr>
<tr>
<td>Kudu</td>
<td>8,480</td>
<td>1,726</td>
<td>89,088</td>
<td>99,294</td>
</tr>
<tr>
<td>Warthog</td>
<td>10,395</td>
<td>16,506</td>
<td>76,187</td>
<td>103,088</td>
</tr>
<tr>
<td>Bushbuck</td>
<td>0</td>
<td>24,427</td>
<td>40,520</td>
<td>64,947</td>
</tr>
<tr>
<td>Sable antelope</td>
<td>0</td>
<td>0</td>
<td>37,657</td>
<td>37,657</td>
</tr>
<tr>
<td>Impala</td>
<td>5,053</td>
<td>19</td>
<td>36,724</td>
<td>41,796</td>
</tr>
<tr>
<td>Sharpe’s grysbok</td>
<td>0</td>
<td>0</td>
<td>34,898</td>
<td>34,898</td>
</tr>
<tr>
<td>Bushpig</td>
<td>0</td>
<td>526</td>
<td>22,733</td>
<td>23,259</td>
</tr>
<tr>
<td>Reedbuck</td>
<td>3,304</td>
<td>3,738</td>
<td>19,143</td>
<td>26,185</td>
</tr>
<tr>
<td>Klipspringer</td>
<td>0</td>
<td>102</td>
<td>14,464</td>
<td>14,566</td>
</tr>
<tr>
<td>Waterbuck</td>
<td>0</td>
<td>1,539</td>
<td>14,085</td>
<td>15,624</td>
</tr>
<tr>
<td>Eland</td>
<td>0</td>
<td>0</td>
<td>10,274</td>
<td>10,274</td>
</tr>
<tr>
<td>Burchell's zebra</td>
<td>0</td>
<td>16,961</td>
<td>9,284</td>
<td>26,245</td>
</tr>
<tr>
<td>Buffalo</td>
<td>8,635</td>
<td>157</td>
<td>6,597</td>
<td>15,389</td>
</tr>
<tr>
<td>Steenbok</td>
<td>2,620</td>
<td>2,302</td>
<td>6,087</td>
<td>11,009</td>
</tr>
<tr>
<td>Roan antelope</td>
<td>0</td>
<td>0</td>
<td>5,525</td>
<td>5,525</td>
</tr>
<tr>
<td>Oribi</td>
<td>0</td>
<td>0</td>
<td>3,177</td>
<td>3,177</td>
</tr>
<tr>
<td>Tsessebe</td>
<td>1,791</td>
<td>0</td>
<td>2,819</td>
<td>4,610</td>
</tr>
<tr>
<td>Hartbeest</td>
<td>0</td>
<td>0</td>
<td>1,138</td>
<td>1,138</td>
</tr>
<tr>
<td>Black rhinoceros</td>
<td>0</td>
<td>0</td>
<td>374</td>
<td>374</td>
</tr>
<tr>
<td>Livingstone’s suni</td>
<td>0</td>
<td>0</td>
<td>167</td>
<td>167</td>
</tr>
<tr>
<td>Nyala</td>
<td>0</td>
<td>39</td>
<td>134</td>
<td>173</td>
</tr>
<tr>
<td>Blue wildebeest</td>
<td>2,829</td>
<td>1,715</td>
<td>56</td>
<td>4,600</td>
</tr>
<tr>
<td>Hippopotamus</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Giraffe</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Gemsbok</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mountain reedbuck</td>
<td>0</td>
<td>3,519</td>
<td>0</td>
<td>3,519</td>
</tr>
<tr>
<td>Total</td>
<td>49,008</td>
<td>96,734</td>
<td>632,410</td>
<td>778,152</td>
</tr>
</tbody>
</table>
These control measures targeted specifically *Glossina morsitans*, *G. pallidipes* and *G. brevipalpis*. These culling operations were only partially successful because it was impossible to eliminate all mammals in the specific area. Eventually, other techniques, such as bush clearing, and spot and later aerial application of insecticide, had to be employed to achieve this goal.

By 1966 there were only an estimated 600,000 head of game left in South Africa (SA). Three main factors have led to the increase of game numbers since the 1960s; namely: private ownership of wild animals, the animal withdrawal scheme and improved scientific techniques in the capture, translocation and introduction of wildlife into new regions.

The growth of the game ranch industry can be measured by the total of game ranches in the country. During 1965 there were four fenced game ranches in former north-western Transvaal. Forty years later, there were 5,061 farms registered in nine SA provinces with exemption permits for the keeping of game. This equates to a thousand-fold increase of ranches over a 40-year period. The number of farms with exemption permits registered in the different provinces are as follows (8):

- Limpopo: 2,480
- Northern Cape: 986
- Eastern Cape: 624
- Northwest: 340
- Mpumalanga: 205
- Free State: 180
- KwaZulu–Natal: 92
- Western Cape: 82.

The current estimation is that there are 9,000 game farmers in South Africa. The use of arable land in South Africa can be seen in Table II.

### Table II

**Land use in South Africa**

<table>
<thead>
<tr>
<th>Land sector</th>
<th>Hectares</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government-protected areas</td>
<td>7,500,000</td>
<td>6.1%</td>
</tr>
<tr>
<td>Private wildlife ranches</td>
<td>20,500,000</td>
<td>16.8%</td>
</tr>
<tr>
<td>Total under conservation management</td>
<td>28,000,000</td>
<td>22.9%</td>
</tr>
<tr>
<td>Total agricultural land</td>
<td>100,600,000</td>
<td>82.2%</td>
</tr>
<tr>
<td>Total area of South Africa</td>
<td>122,340,100</td>
<td>100%</td>
</tr>
</tbody>
</table>

Since 1964 there has been a shift in animal numbers, as illustrated in Table III. The numbers of farm animals (cattle, sheep and goats) dropped drastically; cattle dropped by 4.2 million; sheep by 11.7 million and goats by 2.06 million, totalling nearly 18 million fewer animals. If these farm animals were replaced with wildlife, it can be assumed that today there could potentially be the wildlife equivalent of 18.6 million farm animals on game ranches in South Africa, assuming the ecological carrying capacity has stayed the same.

### Table III

**Change in livestock numbers between 1964 and 2007**

<table>
<thead>
<tr>
<th></th>
<th>Cattle</th>
<th>Sheep</th>
<th>Goats</th>
<th>Game</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>12,243,000</td>
<td>39,717,000</td>
<td>5,667,000</td>
<td>575,422</td>
</tr>
<tr>
<td>2007</td>
<td>8,000,000</td>
<td>28,000,000</td>
<td>2,500,000</td>
<td>18,016,000</td>
</tr>
<tr>
<td>Change in numbers</td>
<td>−4,243,000</td>
<td>−11,717,000</td>
<td>−2,056,000</td>
<td>+18,591,422</td>
</tr>
</tbody>
</table>
History of veterinary training

The following information is an abstract from www.nda.agric.za/vetweb/history (10):

‘The Dutch East Indian Company was established in the Cape as a source of fresh supplies for passing ships, but for more than 200 years, there was no permanent veterinarian in South Africa. During this period visiting British military veterinarians were the only representatives of the profession in this country.’

‘During 1870, after an outbreak of babesiosis in Natal, efforts were made to establish a state Veterinary Service to control this destructive disease. In 1874 a colonial veterinarian, Samuel Wiltshire, MRCVS, was appointed to help control this disease, with his head office in Pietermaritzburg.’

‘During 1876 the Cape of Good Hope also appointed a colonial veterinarian, Prof. William Catton Branford, MRCVS. His attempts to control diseases appeared to be more successful. He recorded the difference between lung sickness, tuberculosis, glanders, sheep-scab and mange.’… ‘He was very conservation-minded and made several far-reaching recommendations to the Cape of Good Hope Government when he left the country in 1879:

– all cases of glanders to be destroyed and buried
– a closed season for hunting birds to be introduced to give them a chance to breed
– the burning of the veld to be prohibited.’

‘Apart from our own indigenous pests and plagues, a number of diseases were introduced into South Africa from overseas;

1854: lung sickness was brought to the Cape Colony by a bull imported from Holland. During 1881 a large-scale outbreak of lung sickness amongst Angora goats was traced back to a consignment of Angora goats imported from Somerset West the previous year by H. David & Co. The eradication of the disease consisted of slaughtering and destroying the 6,162 goats, with a total value of £ 2,878.

1892: rabies was brought to South Africa from England by an Airedale terrier. The disease was quickly transmitted to the local dogs and from there it spread to wild animals and it is currently endemic to certain regions in the country.’

‘During 1892 Dr Duncan Hutcheon, who succeeded Prof. Branford, was hoping that foot and mouth disease in the then Bechuanaland and Griqualand West would not spread further to the Cape. However, during the following year, the disease was spread by slaughter cattle transported by rail from this region and by 1894 it had apparently already spread to all four provinces.

‘By the end of the 19th Century, a State Veterinary Service had become a matter of great urgency for the South African livestock industry. The Veterinary Department of the Orange River Colony was established in 1896 after the outbreak of rinderpest, when Dr Otto Henning was seconded to take charge of control duties in this regard. In the Zuid-Afrikaansche Republiek (Transvaal) a Veterinary Department was only established in 1897 with the appointment of Sir Arnold Theiler.

‘During 1908, shortly before the four South African Provinces were unified (1910), the Veterinary Departments of the four provinces merged to form the Veterinary Services of the Union of South Africa. Dr Arnold Theiler was the first Director of the new Division of Veterinary Services. The aim of the Veterinary Services was to combat the unique animal disease problems of the country.’
Important historical events of veterinary science training in South Africa:

- 1891: the Government of the Cape of Good Hope opened the first veterinary research laboratory in Grahamstown
- 1897: the Governments of the Zuid-Afrikaansche Republiek = South African Republic (ZAR) and Natal established two more laboratories at Daspoort and Allerton, respectively
- 1899: the Medical and Chemists’ Act was introduced in Natal, which provided for the registration of veterinarians
- 1903/4: the municipalities of Johannesburg, Durban and Cape Town appointed veterinarians
- 1908: the Research Laboratories at Onderstepoort started their research
- 1919: the Transvaal University College in Pretoria invited Dr Arnold Theiler to establish a Faculty of Veterinary Science in South Africa at Onderstepoort and he became the first dean
- 1920: training of veterinarians in South Africa was officially launched and the first students who qualified in 1924 were: J.I. Quinn, J.G. Williams, C.E. Maré, W.J.B. Green, J.H.R. Bisschop, G. Martinaglia and P.S. Snyman.

Training wildlife veterinarians

At present, the training of veterinarians in South Africa is based on the concept that graduates must be able to treat animals on a multi-species basis. Specialisation only takes place at a post-graduate level. During 1988, the first formal training of wildlife veterinarians started under the sponsorship of the Price Forbes Chair in Wildlife Diseases, under Prof. David Meltzer. Training was aimed at educating clinicians but, with a huge demand for the capture and translocation of wild animals, short game-capture courses were initiated to help train private veterinarians. The increase in veterinary knowledge of wildlife subjects, such as disease epidemiology, pathology and parasitology, required the implementation of research projects at the Master’s level, as well as a specialist clinical qualification, both of which were developed at the Faculty of Veterinary Science (FVS), Onderstepoort, University of Pretoria. Between 1988 and 2006, eight MMed. Vet. (Fer) students and 15 MSc students qualified in the Wildlife Unit at the Faculty. The training of more than 150 private veterinarians in the chemical capture of wild animals was also conducted at this unit during the same period (5). In 1990, Dr Eddie Young became the first private wildlife veterinarian in South Africa, followed in the same year by the author (J.G. du Toit). Currently, more than 100 veterinarians perform wildlife work in South Africa, while more than 100 veterinary students finish their studies each year at FVS, still the only veterinary school in South Africa.

Wildlife production systems

Cultural hunting industry

The culture of the Boer (the term used for the Afrikaaner settlers and farmers of SA) is to hunt, and from there come the well-known words, ‘Die Boer en sy Roer’ (the farmer and his rifle [sic]). Hunting for food can never be classified as a sport, since this constitutes a cultural action rather than a sport. Therefore, it is not surprising that the cultural (recreational) hunting industry makes the biggest contribution towards the South African wildlife economy. In a study done during 2005 by the Northwest University (Institute for Tourism and Leisure Studies), questionnaires were sent to 18,000 local hunters. It was found that a recreational hunter in South Africa spends about 11,622 rand (R) per annum on animals (1 Euro = 10 rand) and a further R 4,130 on secondary expenditure (accommodation, meat processing, rifles, etc.). The study also indicated that the recreational hunting industry in South Africa harvests about one million animals per year and that South Africa has about
200,000 recreational hunters. This means that the turnover in this hunting industry is about R 3.1 billion per annum (R 2.3 billion for animals and R 0.8 billion for secondary expenditure).

The same study further indicates that at least 35 different species were hunted; the most popular being springbok (Antidorcas marsupialis) – 29% of all animals hunted; impala (Aepyceros melampus) – 19%; blesbok (Damaliscus dorcas) – 13%; kudu (Tragelaphus strepsiceros) – 8%, and warthog (Phacochoerus africanus) – 8%. This sub-sector is not united in the sense that it is served by two non-governmental institutions. The first is the South African Hunters and Conservation Association (SAHCA), which is the oldest and largest hunting association in South Africa, with a membership of approximately 22,000 recreational hunters. The second is the Confederation of Hunting Associations of South Africa (CHASA), which represents 13 hunting associations with a collective membership of approximately 15,000 hunters. Together, these two bodies represent at least 37,000 hunters. If one adds to this the local hunters, not belonging to any hunting association, the number of recreational hunters in South Africa approaches 200,000 (1). The government does not contribute to the hunting industry, since SA law does not permit hunting in National Parks. There is limited hunting allowed in certain Provincial Conservation Areas.

Wildlife capture and translocation industry

The Wildlife Translocation Association (WTA) is a voluntary association of professional wildlife capturers and associated stakeholders in South Africa that was established in the early 1990s. It currently has 53 registered members and represents more than two-thirds of the active wildlife capture units in SA. Its members are drawn from both the private sector and government service, and it is the only organisation in SA that represents these wildlife capture units. The association is recognised at both national and provincial levels by conservation authorities, and anyone who wishes to tender for government contracts must be a member of the WTA.

Wildlife translocation occurs locally and internationally. Local stakeholders, such as the private-sector capture units, SA National Parks, provincial capture units, zoos, private wildlife veterinarians and wildlife ranchers are all involved in the movement of live wild animals, both locally and internationally. South Africa exports wildlife to the rest of the world and imports indigenous and exotic wild animals from other countries. There are no official figures available, but it is estimated that about 70,000 animals are captured and translocated annually in South Africa. The estimated turnover generated by capture operations varies between R 750 million to R 900 million. These figures, however, include the value of the captured wildlife because capture operators become the owners of the animals while they are in transit (1).

Trophy-hunting industry

The Professional Hunters’ Association of South Africa (PHASA) was established in 1978. It is currently the official mouthpiece of the professional hunting industry in South Africa and is the largest professional hunting association, not only in Africa, but also in the world. At present, PHASA has over 1,100 registered members and in reality represents the commercial hunting industry. When 1,100 professional hunters generate R 500 million and 37,000 cultural hunters generate R 2.3 billion of the monetary value of the game industry in SA, it is clear that the trophy-hunting industry is a successful commercial enterprise (1).

Indeed, PHASA states that SA has become one of the hunting world’s greatest destinations, and attracted about 7,500 foreign hunters in 2005, mainly from Europe and the United States. South Africa offers the greatest variety of animal species that can be hunted in one country, including Africa’s ‘Big Five’ – the lion, leopard, African buffalo, African elephant and white/black rhinoceroses. The value of animals harvested by trophy hunters (overseas hunters) is approximately R 410 million
per annum. Together with secondary expenditures (e.g. accommodation and travel) of approximately R 100 million, the value of the trophy-hunting industry is estimated at over R 500 million per annum. In 2005, professional hunters hunted about 40,000 animals in SA (1).

**Taxidermy industry**

The SA taxidermy industry is serviced by two bodies; namely, the Taxidermy Association of Southern Africa (TASA) and the Commercial Taxidermists and Game Skin Tanners of SA (CTGSTSA). The Taxidermy Association of Southern Africa was established in 1980 and currently has 70 members. The CTGSTSA was established in 1994 (when it broke away from TASA) and has 20 members. While TASA represents the so-called ‘small-scale’ taxidermists, CTGSTSA represents the larger taxidermist establishments. Each of these organisations has approximately 50% of the market share. The contribution of the taxidermy industry towards the SA wildlife economy is estimated at R 200 million. Some wildlife hunted elsewhere in Africa is also processed in SA, but the extent of this is unknown (1).

**Game auctions**

Table IV shows that, despite the recent increase in the number of game ranches, National Parks and Provincial Reserves provided about 23% of all the wildlife on auction in SA. In monetary terms, wildlife sales from the private sector were responsible for 60% of the turnover at game auctions and produced 77% of the animals sold (1). During 2010 there were 56 game auctions held in SA and a total of 15,000 animals were sold, with a turnover of R 316 million (2).

<table>
<thead>
<tr>
<th>Sector</th>
<th>Animals sold</th>
<th>(%)</th>
<th>Turnover (South African rand)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>4,117</td>
<td>23.43%</td>
<td>36,980,333</td>
<td>39.53%</td>
</tr>
<tr>
<td>Private ranchers</td>
<td>13,452</td>
<td>76.57%</td>
<td>56,568,967</td>
<td>60.47%</td>
</tr>
</tbody>
</table>

**Game meat industry**

Some forms of game ranching in SA that concentrate on certain preferred table species are ideally suited for the production of game meat, provided that the correct slaughtering techniques are followed and cooling facilities are available. However, the extensive nature of game ranching makes the harvesting of wildlife much more difficult than that of domestic livestock. More mobile abattoirs, passive capturing techniques, and improved carcass handling, product descriptions and meat-processing facilities are needed. Red meat abattoirs are also not allowed to slaughter wildlife at the same facility as domestic livestock. The general opinion within the game-ranching industry is that the requirements for local abattoirs are too strict. South Africa has five export abattoirs for game-meat; namely: Camdeboo in Graaff-Reinet, Swartland in Malmesbury, Mosstrich in Mosselbaai, Krugersdorp and Westville in Port Elizabeth. Approximately 450 metric tons of game meat is exported per annum, mainly to Europe. The value of these exports is approximately R 15 million (R 33/kg). About 1,350 tons of game meat (three times the amount exported) is consumed locally (1). For the export market, it is important for SA to brand its game meat and distinguish it from products originating in other countries. The quality of game meat and the environment in which it is produced makes it an ideal product to market as being organic.
Summary of the monetary value of the game-ranch industry

The monetary value of the game-ranch industry is summarised in Table V below. The tourist industry (non-consumptive) is not reflected in this summary.

Table V
Monetary value in rand of the wildlife industry in South Africa

<table>
<thead>
<tr>
<th>Sector</th>
<th>Value (South African rand)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreational hunting industry</td>
<td>3,100,000,000</td>
<td>66%</td>
</tr>
<tr>
<td>Translocation (capture)</td>
<td>750,000,000</td>
<td>16%</td>
</tr>
<tr>
<td>Trophy-hunting industry</td>
<td>510,000,000</td>
<td>11%</td>
</tr>
<tr>
<td>Taxidermy</td>
<td>200,000,000</td>
<td>4%</td>
</tr>
<tr>
<td>Live animal sales (auctions)</td>
<td>94,000,000</td>
<td>2%</td>
</tr>
<tr>
<td>Meat production</td>
<td>42,000,000</td>
<td>1%</td>
</tr>
<tr>
<td>Total</td>
<td>4,696,000,000</td>
<td>100%</td>
</tr>
</tbody>
</table>

Problem statement

Information about the wildlife industry is principally derived from *ad hoc* studies and/or projects. Furthermore, the wildlife industry is fragmented into a production sector (agriculture) and a conservation sector (environmental), with no consolidated information management tool in the nine SA provincial governments to serve the industry as a whole. In each of these governments, both environmental (nature conservation) and agricultural (with a separate section for veterinary control) departments control the wildlife industry, thus, no fewer than 27 bodies must communicate with the private sector and coordinate the regulation of the industry.

Proposed and recommended solution

A solution to this maze of regulatory controls would be to create an independent trust to maintain all data related to the wildlife industry on behalf of all the stakeholders.

The purpose of a central wildlife information management system would be to:
- gather sound statistical information to enhance decision-making
- identify and support research topics that are relevant to the well-being of the industry
- provide readily available denominator data to quantify disease risk and spread and hence improve the ability to control disease outbreaks in or from wildlife.

The SA Breweries agreed during 2010 to establish a sponsorship programme of R 1 million, in partnership with the SA Veterinary Foundation, to implement a central database for wildlife in SA.

Recognition by government of a central wildlife information management system

The SA Department of Agriculture published a policy on game farming for public comment in 2006 (3). This included a statement on a national game-farm and animal database: ‘Accurate information and statistics (human resources, skills, budget and equipment) are essential for effective long- and short-term planning and management. This will require effective liaison and linkages between institutions collecting information and statistics, such as Statistics SA, Agricultural Statistics,
Customs and Excise, and other organisations within the industry, and would best be coordinated by the lead Department. This should include a detailed geo-referenced database of all game farms.’ No mention is made on how this idea should be implemented, but the most important thing is that it has been recognised by the Government.

The National Environmental Biodiversity Act instructs the SA National Biodiversity Institute (SANBI) to: ‘collect, generate, process, coordinate and disseminate information about biodiversity and the sustainable use of indigenous biological resources, and establish and maintain databases in this regard’.

A central wildlife information management system (CWIMS) involving all stakeholders will only work under the following conditions:

– the CWIMS must be controlled by a neutral body
– data ownership should remain with the relevant stakeholder and always be treated as confidential
– information releases should only contain aggregated data, so that anonymity is ensured for individual contributors
– there must be no political affiliations attached to the CWIMS
– participation in the CWIMS must have incentives for farmers/game owners
– the SA government must also submit its data to the CWIMS, to obtain a complete perspective of the industry. Farmers must have a choice whether to submit their information to the Department of Agriculture or the Department of Environmental Affairs.

**Implementation of a central database**

A proposal is currently being drafted for the Minister of Agriculture to implement such a CWIMS under the Animal Health Act (Act No. 7 of 2002) as an Animal Health Scheme under:

Article 16: (1) The Minister may by notice in the Gazette establish a scheme in respect of any controlled purpose or for the improvement of animal health.

(2) The Minister may under subsection (1) establish different schemes in respect of different kinds of animals, different animal diseases or parasites, different classes of persons and different areas.

**Opportunities created by a central wildlife information management system**

Such a system offers the opportunity to:

– create a neutral instrument, representing both government and the private sector, through the formation of a trust
– provide data through an integrated system that is available to all stakeholders
– provide standardised data that can be used for research purposes
– avoid duplication and save money through the innovative use of technology and self- administration
– aid forensic analysis through a genetic identification database
– horn from rhino that are registered on the genetic identification database can be genetically matched and verified as legal, and hence pave the way for a controlled trade mechanism
– such a CWIMS can be expanded to include domestic animals and identify important wildlife-livestock interfaces for risk mitigation.
Conclusion

The wildlife industry in SA has evolved considerably during the last century, becoming a full-blown commercial industry, with very strong links to conservation. It has, however, proven to be a very difficult industry to regulate, due to its various roots in conservation, commercial agriculture and trade. This could be alleviated by creating a support structure for the industry to enhance communication and exchange between these diverse domains. Such a framework would not only improve its regulation, but also greatly enhance its efficiency and ability to contribute even further to the national economy, as well as providing much-needed information on this natural asset of the continent.

References

The unregulated and informal trade in wildlife: implications for biodiversity and health

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Summary

The global trade in wildlife provides disease transmission mechanisms that not only cause outbreaks of human disease but also threaten livestock, international trade, rural livelihoods, native wildlife populations and the health of ecosystems. In addition to providing a direct route for the threat of disease introduction, over-exploitation of wildlife for trade is the greatest threat to biodiversity after degradation and loss of habitat. The illegal wildlife trade is considered the second-largest black market after narcotics, valued at US$ 20 billion per year, and includes more than 13 million mammals, birds and reptiles extracted from ecosystems globally. At the local population level, this causes a mean decline of 60% to 70% in wild populations and facilitates the introduction of alien invasive species. Eighty-seven percent of countries have officially reported the illegal trade of wildlife or wildlife products. Notable disease outbreaks resulting from wildlife trade have resulted in hundreds of billions of dollars’ worth of economic damage globally. Detailed assessments of the impact of the far more insidious disease transmissions that are slowly devastating wildlife populations in many parts of the world have yet to be made. Rather than attempting to eradicate pathogens or the wild species that may harbour them, a practical approach would include decreasing the contact rate among species, including humans, at the interface created by wildlife trade. Wild animals are captured, transported and sold either live or dead, and co-mingled throughout this process, which functions as a system with major hubs rather than evenly distributed supply systems among countries, suppliers and consumers. These focal points for distribution and sales provide control opportunities to maximise regulatory efforts, as has been demonstrated with domestic animal trading systems (processing plants, wholesale and retail markets, for example). Focusing efforts at markets to regulate, reduce or, in some cases, eliminate the illegal trade in wildlife could provide a cost-effective approach to decreasing disease risks for humans, domestic animals, wildlife and ecosystems.

Keywords

Introduction

The global trade in wildlife is the greatest threat to biodiversity after degradation and loss of habitat (13, 15), and has additional impacts on human livelihoods, food security and the overall health of ecosystems. The illegal wildlife trade is currently considered one of the largest black markets globally, estimated to be between US$ 5 and 20 billion per year (19). The global scope of the illegal trade is far-reaching, with 93% of signatory countries to the Convention on International Trade in Endangered Species (CITES) having officially reported an illegal trade in wildlife or wildlife products, with North America the world’s foremost importer in terms of the number of reports of illegal shipments (Fig. 1) (1).

Red lines: exporting countries and blue lines = importing countries
CITES: Convention on International Trade in Endangered Species
CA: Canada; CN: China; DK: Denmark; ES: Spain; GB: United Kingdom; HK: Hong Kong; ID: Indonesia; IT: Italy; MT: Malta; MX: Mexico; NG: Nigeria; NL: Netherlands; NZ: New Zealand; PH: the Philippines; PT: Portugal; TH: Thailand; US: United States; ZA: South Africa; XX: Unknown

Fig. 1
The distribution of the number of reports on the illegal wildlife trade submitted by signatory countries to the Convention on International Trade in Endangered Species between 1975 and 2010

With growing evidence of the importance of biodiversity in contributing to the health of animals and people, the effects of poorly managed wildlife trade include not only the translocation of infectious diseases, but also loss of natural resources and ecological resilience. In addition to human and animal disease outbreaks, the previous emergence of disease from wildlife exchange has destabilised trade and caused hundreds of billions of dollars of economic damage globally (5).

Scope of the trade

At the international scale, the legal wildlife trade is a lucrative and common business that generates billions of dollars in revenues. According to CITES, for international trade in only species of conservation concern, the average annual figures include more than 1.5 million live birds, 640,000 live reptiles, 300,000 crocodilian skins, 1.6 million lizard skins, 1.1 million snake skins, 150,000 furs, almost 300 metric tons of caviar, more than one million coral pieces and 21,000 hunting trophies. However, the full scope of the illegal wildlife trade is currently unknown, and institutions such as TRAFFIC, IUCN, INTERPOL and the World Wildlife Fund (WWF) have tried for years to better define the scope of this illegal trade through confiscation databases.
Recent studies have evaluated the global magnitude of the illegal wildlife trade through a systematic review, combining the databases of CITES and TRAFFIC (the international illegal trade), as well as the scientific literature (the domestic illegal trade), to assess general patterns of illegal trade for birds, mammals and reptiles. The results show that more than 1,687 species of birds, mammals and reptiles are traded illegally worldwide, with an estimate of 29 million individuals per year (1). This alarmingly high estimate is composed mostly of reptiles at 69%, followed by birds at 23% and mammals at 8%. The domestic illegal wildlife trade is at least equally as important as the international trade, but goes largely unreported in CITES databases since the mandate of CITES is focused on international trade (1). In addition, these estimates could be an order of magnitude larger if we consider that only one of ten animals extracted for illegal trade is finally sold (2).

At the regional scale, the United States (USA) serves as an interesting example of a large participant in both the legal and illegal wildlife trade. Based on US Fish and Wildlife Service import registry data from 1994 to 2006 on imports from South America to the US, the countries exporting the largest number of animals illegally are the same as those exporting legally: Argentina, Peru, Colombia, Brazil and Guyana. Based on the same data set, the most heavily represented taxonomic classes in the legal trade were fish (88%), reptiles (6%) and amphibians (2%), but for the illegal trade, the distribution was biased towards reptiles (60%), fish (21%) and insects (16%). As a result, these four taxonomic classes are the most exploited by wildlife trade in the western hemisphere, based on numbers of animals. Yet species traded in large numbers have less market value than species such as rare birds and mammals that are sold in smaller numbers. This may indicate that the illegal wildlife trade also targets threatened species for their higher economic value. The high value of rare species serves to maintain trade pressure on those species and explains why the illegal trade, even at low volumes, has been identified as a major threat to such a large percentage of threatened and endangered species. When combined, the data show that all taxonomic classes are under pressure from the illegal wildlife trade (2).

The European Union (EU) ranks as the top global importer, by economic value, of many wild animals, including caviar harvested by killing wild female sturgeon, reptile skins and live reptiles. In 2005, the legal trade in wildlife products in the EU had an estimated total declared import value of €93 billion (€2.5 billion with fisheries excluded). As EU membership has expanded, the size of the EU market for wildlife and wildlife products has also increased. There is a huge and escalating demand in Member States for exotic pets and other wildlife products. While the majority of this wildlife trade into and within the EU is conducted legally, continued demand for some rare and protected species means that illegal wildlife trade still occurs. From 2003 to 2004, enforcement authorities in the EU made over 7,000 seizures, involving more than 3.5 million CITES-listed specimens; from 2000 to 2005, almost 12 metric tons of caviar were seized. The effects of this on wild populations of rare and endangered species can be devastating; the last four years of seizures in the EU of the critically endangered Egyptian tortoise (Testudo kleinmanni) represented around 13% of the total estimated population remaining in the wild (4).

Finally, one must consider the national or domestic scale of trade. Analyses of the illegal trade in Venezuela found an estimated one to ten million individuals, including 390 different species of birds, mammals and reptiles, were traded each year, with an approximate market value of more than US$321 million (2). This illegal trade, which escapes any regulation that would contribute to the management of natural resources or taxation that could provide direct economic benefits to the country, has total estimated revenues exceeding that of both international tourism and aquaculture production for the entire country. Figures for the number of individuals traded further show that illegal trade at the national level is as problematic as trade at the international level. Given that this single country analysis is finding trade volumes similar to the totals reported for global illegal trade, this type of detailed examination suggests that the information currently available for international trade significantly underestimates the scope of the illegal wildlife trade worldwide.
Threats to biodiversity

One hundred and seventy-five countries have signed the CITES agreement, which is the most comprehensive international treaty on wildlife trade and provides a legal framework to regulate the trade of roughly 5,000 species of animals and 28,000 species of plants. Many countries have enacted additional regulations for wildlife trade with the purpose of reducing biodiversity loss, preventing the introduction of alien invasive species, and controlling the spread of diseases. However, illegal wildlife trade is still widespread.

In Africa, some wild populations of kob antelope (*Kobus kob kob*) have declined over 90% in the last 20 years, due to poaching (6), and more than 10,000 African elephants (*Loxodonta africana* and *L. cyclotis*) die each year to supply the black market for ivory in Europe and Asia, resulting in a population decrease of 60% to 70% (16). Consistent with these specific examples, broad-ranging analyses of the wildlife trade's impact on local wildlife populations have found that this activity produces an average decrease in the size of source populations of 60% to 70% and facilitates the introduction of alien invasive species (1).

In addition to these direct threats to individual species, poorly managed harvesting of wildlife can disrupt ecosystems by changing species dominance and their functional roles in the system, putting other species and linked ecosystems at risk. For example, bats are a crucial component of their native ecosystems for pollination, seed dispersal and insect population control. Moreover, for a variety of innate factors, such as longevity, low reproductive rate and roosting behaviour, the conservation of many bat populations is threatened by their inability to sustain current harvests for the wildlife trade (9).

Pimentel *et al.* reported that the approximately 50,000 invasive species in the USA cost the country environmental damages and losses of nearly US$ 120 billion per year. In addition, they noted that 42% of the threatened or endangered species in the country were primarily at risk due to the impacts of these alien species (12). Additional information on alien invasive species and spread of diseases is provided in the two-volume issue of the World Organisation for Animal Health (OIE) *Scientific and Technical Review* (10, 11).

Wildlife trade and infectious disease

The 2004 joint World Health Organization (WHO), Food and Agriculture Organization (FAO) and OIE report on drivers of zoonotic disease emergence reflects upon the anthropogenic movement and manipulation of domestic and wild animals, including globalised trade, as the next big trigger point for emerging disease since the advent of agriculture. During the process of wildlife trade, animals are extracted from deep within their habitats, placed in stressful captive situations, and exposed to other species of wildlife from distant locations; domestic animals used for hunting, transport or sale, and hunters, traders, sellers, preparers and consumers along the trade chain and in markets. These conditions present unique opportunities for pathogens to meet naive hosts, infect them, and potentially evolve and adapt in their new hosts to something more dangerous than before. The risk for disease exchange across species and geographic borders is higher than it was previously with mere local or regional consumption and movement. The practice of wildlife trade is advancing through the establishment of major trade routes across the globe, and the increased sophistication of crime networks (19). In turn, the demand for wild animals for use as companion animals/pets has been responsible for the majority of the live animal trade in the western hemisphere. This market involves billions of individual live animals, ranging from corals to non-human primates, originating from all over the globe, and it appears to be increasing (14).
Nearly 75% of emerging infectious diseases in humans are zoonotic (pathogens transmissible from animals to humans), the majority of which originate in wildlife (18). Therefore, infectious diseases acquired from contact with wildlife, such as the contact that occurs through wildlife trade, are increasingly of concern to global public health. Yet health risks to the public posed by wildlife trade have been largely unquantified, due to minimal health surveillance of the live wildlife and wildlife products traded regionally and internationally (7).

In December 2003, a legal shipment of 800 small mammals, including rodents from Ghana, entered Texas, USA, for the pet trade. Animals from this shipment were housed near rodents native to the USA, prairie dogs (*Cynomys* sp.), also destined to be pets. New owners of these native rodents subsequently developed fever, respiratory disease and skin lesions, resulting in more than 70 human cases of monkeypox across six states, 24% of which required hospitalisation. Investigation by the US Centers for Disease Control and Prevention (CDC) identified the imported West African rodents as the source of the outbreak. These findings emphasise that a single shipment of infected animals can result in a serious impact on public health.

The outbreak of severe acute respiratory syndrome- (SARS-) associated coronavirus, that started with several hundred cases of respiratory disease in Guangdong Province, China, and, within a short time, led to 8,098 known cases and 774 deaths (a case-fatality rate of 9.6%) in 29 countries, originated in the wildlife trade markets of China. The masked palm civet (*Paguma larvata*), common in the wildlife markets of China, was the source of human infection, having probably contracted a related form of the virus from its natural host, the horseshoe bat (*Rhinolophus* spp.), also commonly traded in the markets (8). These findings were supported by a study showing 0% prevalence of antibodies against the virus in civets on breeding farms, compared to an 80% prevalence of antibodies in civets exposed to the wildlife markets (17). In addition, bats have been shown to host a variety of zoonoses, such as rabies, henipaviruses, filoviruses and Menangle virus. Despite this, bats remain common in the wildlife trade for a range of purposes, from food to display items.

The harvest and consumption of non-human primates has resulted in multiple transmissions of the filovirus or filoviruses causing Ebola haemorrhagic fever and in the transfer of retroviruses to humans, including the simian immunodeficiency virus (SIV) precursors of the human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS) viruses (7). Surveillance for antibodies has shown a prevalence for SIV of over 30% in free-ranging chimpanzees, sooty mangabeys and green monkeys. Serological evidence exists for numerous SIV strains and more than 35 other lentiviruses in a large number of additional species (3). Yet, non-human primate species continue to be hunted for human consumption, facilitating the risk of human infection posed by such pathogens. Transmission of disease agents in the other direction, from humans to non-human primates kept in captivity or in the wild, is not uncommon.

The hunting and trade of wildlife can be an ideal mechanism not only for the emergence of novel pathogens, but also for the spread of well-known zoonotic agents, such as Salmonella, hantaviruses, leptospirosis, psittacosis, lymphocytic choriomeningitis, rabies, yellow fever, herpes B, Nipah virus and Lassa fever. Beyond the threat to humans, there are innumerable examples of animal diseases and pests that, through the trade of wild species, have had detrimental impacts on native populations of wildlife as well as on agricultural industries. *Batrachochytrium dendrobatidis* (also known as chytridiomycosis or chytrid fungus) has played a large role in significant reductions and local extinctions of amphibian populations worldwide. The global spread of this disease has been attributed to the international trade in African frogs, decades ago, for laboratory use; the trade in frog species for food and companion animals, and even from a trade in some species of amphibians used as bait for freshwater sports fishing. The international spread of reportable diseases, such as spring vireaemia of carp and koi herpesvirus, has been facilitated by the lack of quarantine requirements for fish importation by many nations and has threatened both food fish and ornamental fish industries. The
source of many novel disease introductions remains a mystery, such as in the case of the introduction of West Nile virus into North America in 1999.

**Recommendations**

The illegal trade in wildlife and wildlife products has been shown to significantly threaten wildlife populations, both directly, through population depletion (1), and indirectly, through the disruption of species compositions needed for ecosystem and habitat stability, as well as by facilitating the introduction of invasive species and invasive pathogens to new areas. In many or most countries of the world, legal frameworks for regulating trade are adequate, but law enforcement and monitoring are often hampered by limited resources, lack of motivation or awareness, and inadequate training. The growing demand for wildlife and wildlife products in both developed and developing countries must also be addressed through better public education efforts, directed at reducing demand and encouraging support for compliance and the enforcement of regulations.

Governments should support capacity-building and the interdisciplinary professional collaboration necessary for effective wildlife trade regulation and health surveillance, through staff education and providing mechanisms for public health authorities, agricultural health authorities and natural resource management authorities to work together. The large disparity between reported international trade and actual international trade needs to be addressed. As trade is more effectively and uniformly monitored and reported, the opportunity to reduce the risk of adverse impacts and to increase economic benefits will be greatly increased. Improvements in monitoring illegal trade and in law enforcement will also contribute to the economic value of the legal, legitimate and sustainable trade in wildlife that is currently being undermined by the illegal trade.

Wild animal species can harbour many of the same diseases or pathogens that threaten other animal species and humans without showing evidence of disease. A health certificate is only as good as the scope, type and timeliness of the disease tests completed. Advances in testing methods allow additional tools for disease diagnosis beyond visual inspection and should be implemented where practical and cost effective. Animals are imported at the risk of the importing country. The cost of implementing disease surveillance for such high-risk activities as the wildlife trade, and instituting key preventive measures, may be much less than the price of responsive damage control.

Reasons for the lack of thorough health investigations may include cost, limited resources (e.g. diagnostic capacity, qualified staff, etc.), or fear of repercussions from the international community (i.e. the impact on disease-free status of the importing country, the effect on international relations in regard to the disease-free status of the exporting country, or misguided trade sanctions). However, countries should be empowered to conduct pathogen surveillance of confiscated animals and animal products at their designated quarantine facilities, to protect their valuable resources and disease-free status. For this reason, and to avoid disincentives for border port surveillance activities in which Veterinary Service authorities test illegally imported animals or animal products for evidence of pathogens, Chapter 5.6. of the OIE *Terrestrial Animal Health Code* states that disease agents discovered in animals and animal products sampled and incinerated at border port quarantine stations do not affect the disease-free status of the importing country.

In summary, rather than attempting to eradicate pathogens or the wild species that may harbour them, a practical and cost-effective approach to mitigating health risks from trade involves decreasing the contact between wild animals, livestock and humans created by the wildlife trade and improving practices to reduce the risk of disease transmission. As has been demonstrated with domestic animal trading systems, focal points for collection, distribution (markets) and consumption (national ports) provide monitoring and control opportunities to maximise regulatory efforts and decrease disease risks for humans and animals, as well as to provide better protection for ecosystems and natural resources.
References


From forecasting to control of emerging infectious diseases of zoonotic origin: linking animal and human health systems

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Summary

Emerging infectious disease (EID) outbreaks, such as severe acute respiratory syndrome, Ebola and H5N1 often cause serious problems for public health services. Since about 75% of EIDs are of animal origin, humans are threatened not only by pathogens spreading across countries and regions but also by diseases crossing borders between people, domestic animals and wildlife. Lack of timely laboratory diagnosis and functional epidemiological surveillance, poor infection control practices at health-care facilities, inappropriate control measures and inadequate dialogue with the affected population, and weak vector control programmes often result in prolonged outbreaks, increased suffering and disease spread.

To respond to the threat of emerging zoonotic diseases, the World Health Organization and its national and international partners have developed a global strategy that coordinates animal and human health systems through a process of forecasting, epidemic intelligence and coordinated response, as follows.

– Forecasting and readiness programme aims to mitigate disease emergence. Forecasting systems based on risk mapping, satellite images, disease climatology, disease forecasting models, vector-monitoring data and animal disease surveillance help affected countries to prepare themselves before EIDs emerge in human populations and allows authorities to implement measures to avert impending epidemics.

– Hazard detection, verification and risk assessment: the timely detection and verification of EIDs internationally is based on a systematic identification of signals of events that may be of public health importance and the rapid verification and risk assessment of these events. Surveillance and early detection of EIDs rely on competent local, national and international surveillance systems, supported by diagnostic and reference laboratories, in close collaboration with wildlife and domestic animal health authorities.

– A coordinated response: a rapid response to control outbreaks is based on a multi-sectoral and multidisciplinary approach to ensure that appropriate control measures are taken and that advances are made in understanding new diseases to aid global preparedness.
Today’s technologies can help to detect, manage and contain the international spread of emerging zoonotic diseases more effectively but a high level of government commitment and international collaboration remain the fundamental principles of disease control.

**Keywords**


**Introduction**

Human populations have been shaped by continuous interactions with the world of microbes. Over the last 30 years, emerging infectious diseases (EIDs) have been on the increase (5). The sources and transmission methods of these novel pathogens are often poorly understood. Many have the potential to cause large outbreaks. Human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS) is the most recent example of a pathogen which has emerged in the recent past and is now causing a major epidemic that threatens the economic future of many nations. Other examples include severe acute respiratory syndrome (SARS), avian influenza (H5N1), Lassa, Ebola and, most recently, Nipah virus.

**Emerging infectious disease outbreaks at the human/animal interface**

Zoonoses present the greatest risk for disease emergence (6). About 75% of the new and emerging diseases that have affected humans over the past 30 years have been caused by pathogens originating from animals or from products of animal origin. The frequency of all EID events has significantly increased since 1940, reaching a peak between 1980 and 1990. Sixty-one percent of EID events are caused by transmission from animals (zoonoses) and 74% of these come from wildlife. In addition, zoonotic EIDs from wildlife have reached their highest proportion over recent decades. With emerging zoonotic diseases, we are not only dealing with pathogens spreading across countries and regions but also diseases that cross the barriers between humans, domestic animals and wildlife.

Figure 1 illustrates the different transmission events that occur during an EID outbreak originating from wildlife. Emerging infectious disease pathogens infect wildlife populations with a prevalence (the percentage of animals carrying the pathogen) which varies, according to the season and susceptibility of the population (for example, the proportion of non-immune juveniles likely to be infected by chronic infected adults). Infected wild animals then come into direct or indirect contact with domestic animals which may lead to epizootics of great magnitude in livestock. Humans become infected either through direct contact with infected wildlife, or through contact with domestic animals. Successful transmission to humans – through human-to-human, vector-borne, foodborne or water-borne transmissions – can then result in large outbreaks, causing human suffering and death, with the potential to disrupt a country’s economic activity and long-term development.

For example, the cost of the 1999 Nipah outbreak in Malaysia was estimated at US$ 625 million nationally, while the estimated costs due to SARS were US$ 30 billion globally. Equally devastating, although more difficult to quantify, are the social and cultural costs associated with such outbreaks. In many societies, the livelihoods and social standing of families are intimately linked to their animals, and epidemics that affect both animals and humans increase the vulnerability of individuals, families and communities to poverty, discrimination and stigma. Many developing countries continue to be affected by epidemics of zoonotic diseases in domestic livestock (e.g. avian influenza, Nipah, Rift Valley fever and brucellosis) and wildlife (e.g. Ebola, Marburg and yellow fever), in addition to an already heavy disease burden caused by non-zoonotic epidemics such as cholera, malaria, meningitis and measles.
**Fig. 1**
Outbreak of emerging infectious disease at the human/animal interface

**From outbreaks to epidemics and pandemic**

Figure 2 illustrates the progression of EIDs from localised outbreaks to epidemics and even pandemics. Such outbreaks tend to emerge at the human/animal interface, in remote rural areas, in vulnerable populations that are often marginalised and underserved, who have limited or no access to medical services (e.g. in the case of Ebola and Nipah). Once emerging pathogens have been successfully transmitted between humans or through adequate vectors, they tend to amplify in large metropolitan areas (e.g. SARS, influenza, dengue fever, chikungunya). Lack of timely laboratory diagnosis, limited functional epidemiological surveillance, inappropriate control measures, poor infection control practices at health-care facilities, inadequate dialogue with affected populations, and weak vector control programmes often fail to contain such outbreaks in time and space and may lead to international, even global, spread.

The emergence of new EIDs is an inevitable consequence of the combination of a range of factors that are unlikely to change in the foreseeable future. These include ecological changes, human demographics and behaviour, the increase in international travel, more intensive agricultural practices, technology and industry, microbial adaptation and change, and the breakdown in public health infrastructures and services (3). Emerging infectious diseases pose a global health security challenge that must be addressed by building sufficient global capability to detect, contain and control these diseases promptly in both the developed and developing world.

In May 2001, the World Health Assembly resolution on ‘Global health security: epidemic alert and response’ formally recognised that emergence and re-emergence of new infectious diseases can only be addressed by finding global solutions that are supported by strong national public health systems. In May 2005, the revised International Health Regulations (2005) were adopted and provide the global legal framework to address these needs through a collective approach to the prevention, detection and timely response to any public health emergency of international concern. The International Health Regulations (2005) (7) came into effect in June 2007 and established new and explicit obligations for WHO and its Member States.
Fig. 2
Drivers of epidemics and pandemics

**Globalisation**
- Global travel: people, animals, vectors
- Global trade: animals and their products, vaccines, medical products, etc.

**Amplification**
- Urbanisation
- Population density
- Agricultural intensification
- Technology and industry
- Vector distribution and densities
- Transmission associated with health care
- Accelerated transmission to humans (human-to-human, vector-borne, food-borne or water-borne transmissions)

**Emergence**
- Human encroachment, ex-situ contact,
- Successful animal to human transmission
- At-risk behaviour
- Ecological pressure
- Exploitation
- Translocation of wildlife
- Climate variability and vector ecology
The Global Alert and Response Department at WHO, in collaboration with other WHO departments, through WHO regional and country offices, is tasked with supporting countries to prepare for, and respond to, public health threats caused by EIDs and major epidemic-prone diseases. Its day-to-day activities are focused on supporting Member States and operational partners in strengthening national and institutional capacities for epidemic preparedness and response, in line with countries’ commitments under the International Health Regulations (7).

**Four phases: from forecasting to outbreak control, a comprehensive strategy**

The public health imperative during an outbreak is to control the event as quickly as possible and to minimise morbidity, mortality and other negative disease impacts. The opportunity for rapid control of EID outbreaks is highest if the outbreak is detected early and an appropriate response is initiated quickly. There are four distinct phases for action (Fig. 3):

- pre-event phase (preparedness, readiness)
- alert phase (detection and risk assessment)
- response phase (outbreak control)
- post-event phase (evaluation and recovery).

A variety of strategies are used to address these four phases. During each phase, close collaboration and cooperation between human and animal health sectors are crucial.

![Fig. 3](image.png)

**Fig. 3**

*Four phases at the human/animal interface*
Pre-event phase: preparedness and readiness

Amplification of EID pathogens in wild and domestic animals often precedes outbreaks in humans. The opportunity for protecting human health against zoonoses such as Rift Valley fever (RVF), Nipah or Ebola comes from strengthening animal and wildlife surveillance to detect the first cases in animals: for example, by recognising a higher incidence of wild animal die-offs than usual or outbreaks in livestock. Close collaboration between the animal and human health sectors will quickly alert public health authorities, thus using animal surveillance as a trigger for implementing preventive programmes whose main objective will be to reduce the risk of human infections at source. Examples include the identification and education of at-risk groups (e.g. individuals, communities, healthcare providers, policy-makers) so that they are ready and able to adopt and sustain risk reduction and protective measures that have been identified through formative research and community dialogue and participation. In central Africa, great ape mortality has been monitored for Ebola by non-governmental organisations (NGOs) working in conservation (e.g. the Wildlife Conservation Society and the African Conservation Foundation programme, ECOFAC) and this serves as an early warning system to alert human populations to Ebola outbreaks. A similar system exists for yellow fever in monkeys in South America.

Preparedness strategies of permanent, continuing, infection prevention and control (IPC) programmes, both at national and hospital levels, are fundamental for a successful outbreak response. Implementing appropriate IPC measures during the pre-event phase will strengthen healthcare facilities’ capacity to put them into practice in outbreak situations. A set of essential core components has been defined by WHO (9) to help plan, organise and implement the IPC programmes. One of the essential components of IPC in healthcare is the Standard Precautions (8), which are meant to reduce the risk of infection transmission from both recognised and unrecognised sources. They are the basic set of infection control precautions which are to be used, as a minimum, in the care of all patients. Additional infection control measures may be needed to address particular threats in the outbreak control phase, but the lack of the Standard Precautions at any phase would virtually guarantee amplification of the outbreak through the provision of health care. Another component of the ‘base-line’ IPC programme, which is very important, both for the alert and outbreak control phases, is a hospital-based surveillance system with early warning capacity and functional links with the public health surveillance system.

The pre-event phase is also the time to generate risk maps (2) and use predictive climatology. Forecasting models based on satellite images and weather/climate forecasting data have been developed for RVF and are being developed for other vector-borne diseases (Crimean-Congo haemorrhagic fever, West Nile fever, Ebola). Forecasting alerts help with early detection and allow implementation of health education, risk communication and social mobilisation programmes to prevent human infection or mitigate the impact of the outbreak. When countries are informed of a high probability of disease emergence, they can intensify RVF surveillance in humans and animals, prepare outbreak response teams and plan for vector control (mass animal vaccination, social mobilisation, coordination with the Ministry of Livestock, etc.). On two occasions, the National Aeronautics and Space Administration (NASA) monthly RVF-emergence-risk-mapping tool was able to predict RVF emergence one month before the start of the outbreak (1). Work needs to continue to refine the models but the use of predictive climatology for insect-borne EIDs has been very encouraging.

Forecasting and early detection of epidemics are necessary and essential tools for risk assessment and the implementation of timely and effective control measures.
Alert phase

Early detection of EIDs relies on competent national and regional surveillance systems, a global system of alert and response and on close collaboration and cooperation with wildlife and domestic animal health authorities.

The global alert and response activities of WHO represent a major pillar of global health security, aimed at the detection, verification, assessment and containment of epidemics. The International Health Regulations (7) introduced new operational concepts, including specific procedures for disease surveillance, notification and reporting of public health events and risks to WHO by countries; requests by WHO for verification of public health events occurring within countries; rapid collaborative risk assessment with, and assistance to, countries and determinations as to whether an event constitutes a public health emergency of international concern.

Thus, WHO systematically gathers official reports and rumours of suspected outbreaks from a wide range of formal and informal sources. Formal reports of suspected outbreaks are received from Ministries of Health, National Institutes of Public Health, WHO regional and country offices, WHO collaborating centres, civilian and military laboratories, academic institutes and NGOs. It also gathers epidemic intelligence from informal sources. With the advent of modern communication technologies, many initial outbreak reports now originate in the electronic media and electronic discussion groups. Media aggregators such as the Global Public Health Intelligence Network, developed by Health Canada (now the Public Health Agency of Canada), in collaboration with WHO, enable continuous searches of global media sources, such as news wires and websites, to identify information about disease outbreaks and other events of potential international public health concern.

At WHO, raw intelligence from all formal and informal sources is converted into meaningful intelligence seven days a week. Each weekday morning, a team meets to review incoming reports and rumours, assess their epidemiological significance and decide on the actions needed. A similar process is conducted in each of WHO’s regional offices. Information on any of these events is stored in an electronic ‘event-management system’ (EMS), which records key information, decisions and actions by WHO and its partners. The EMS helps to manage critical information about outbreaks and ensures accurate and timely communications between key international public health professionals, including WHO regional and country offices, collaborating centres and partners in the Global Outbreak Alert and Response Network (GOARN: www.who.int/csr/outbreaknetwork/en/index.html).

Keeping close contact with animal health partners is an essential task to enable quick dissemination on reports of animal outbreaks that cause zoonoses in humans. To ensure global health security, WHO, together with the World Organisation for Animal Health (OIE), Food and Agriculture Organization of the United Nations (FAO) and their partners, has developed a system to gather in real-time information on wildlife disease outbreaks before they reach domestic animals or humans.

The Global Early Warning System for animal diseases, including major zoonoses (GLEWS: www.glews.net.), is a joint mechanism that builds on the added value of linking the alert mechanisms of the FAO, OIE and WHO and triangulating the expertise and disciplines from the three organisations to provide a unique opportunity for joint risk assessment of potential health threats. The FAO, OIE and WHO use their organisational systems to detect threats and verify information through national authorities, other representatives of the country and relevant networks. The GLEWS Task Force in the FAO, OIE and WHO regularly tracks disease events, conducts epidemiological analyses and maintains a web platform to facilitate information exchange on disease threats at the animal-human interface. The WHO’s alert and response team actively cooperates with GLEWS during the investigation and risk assessment of EID events originating from wildlife or livestock.
Considering the long-term threat that the international trade in wildlife represents, international surveillance and regulation of wildlife markets should be initiated in collaboration with the International Union for Conservation of Nature, FAO, OIE and NGOs working in the conservation area (4).

Outbreak control

When an EID outbreak is detected, the WHO team assesses its epidemiological significance and, if an event poses a potential risk to health security, offers technical assistance to the affected country. If requested, WHO will launch a coordinated international investigation, drawing on technical and logistics resources within the WHO system and from GOARN.

The Global Outbreak Alert and Response Network is a collaboration of over 300 technical institutions, NGOs and networks. This network was created in April 2000 to improve the coordination of international responses to disease outbreaks and to provide an operational framework to effectively deliver support to countries. The GOARN network’s primary objectives are: to assist countries with their disease control efforts by ensuring rapid and appropriate technical support to affected populations, to investigate and characterise events and assess the risks of rapidly emerging epidemic disease threats, and to support national outbreak preparedness by ensuring that responses contribute to the sustained containment of epidemic threats. Since 2000, WHO and GOARN have responded to over 150 events worldwide, with more than 1,200 experts providing field support to some 75 countries.

Over more than a decade, GOARN has helped to build consensus on guiding principles for international outbreak alerts and responses, to establish operational protocols to standardise field logistics, security and communications, and to streamline administrative processes to ensure rapid mobilisation of field teams. The World Health Organization has also developed its capacity at all levels, with regional and sub-regional response teams initiating field operations with GOARN partners. New strategic areas will be developed over the next two years to increase GOARN's effectiveness, by:

– strengthening the network's composition and regional focus to rapidly adapt and draw upon multidisciplinary support
– developing further specific capabilities in outbreak response team leadership, integrated data management, logistics and communications and field-based administrative procedures and protocols
– refining WHO/GOARN's expert collaboration and virtual networking for international technical collaboration.

The World Health Organization has developed a multi-sectoral and multidisciplinary approach to EID outbreak control, to ensure that countries adopt a strategic approach to outbreak management and that appropriate and effective control measures are identified and adopted by affected or at-risk populations and groups. It is also important that we advance our understanding of new diseases through such approaches, and share new insights in a timely manner to improve global preparedness. Strategies for controlling emerging zoonotic disease outbreaks must consider the nature of the disease (the method of virus transmission and possible treatment or vaccine), its epidemiology (the potential for family or nosocomial transmission, exposure to arthropod vectors or direct contact with virus-infected animals) and human behaviour (social and cultural practices and their underlying beliefs that may prevent or aid exposure, transmission and amplification).

Since the Ebola outbreak in Kikwit in the Democratic Republic of Congo in 1995, WHO has regularly participated in and coordinated responses to several outbreaks of viral haemorrhagic fevers and other severe emerging zoonotic diseases. These outbreaks were investigated and controlled by the local authorities, assisted by national and international multidisciplinary teams. During these operations, coherent control strategies were developed.
These strategies are based on the following principles (Fig. 4): coherent coordination mechanisms, recognised by all participating organisations; rapid anthropological assessments to determine existing practices, beliefs and understandings of communities; health-care staff and rapid response teams that may influence and/or undermine outbreak control operations.

Fig. 4
Multidisciplinary strategy used during EID outbreak control field operations
- an intense social mobilisation and health education programme that secures community support and adherence to measures that prevent exposure to sources of infection and stop transmission, which may include restricting existing practices;

- the establishment of isolation wards at the outbreak site where safe and humane case management of patients can be ensured, the organisation of safe funerals that allow the process of mourning, together with a programme offering psycho-social support to patients, families and health-care workers;

- outside the outbreak site, the implementation or reinforcement of infection control precautions, both in health care and in the community, to avoid dissemination and amplification of the disease beyond the outbreak site. In addition to the standard precautions, additional sanitary procedures may need to be introduced;

- the establishment of a sensitive and timely active surveillance system that allows:
  
i) the identification of any new cases and follow-up of their contacts within 21 days (isolate if ill) with the aim of stopping transmission chains at the source of infection

- linking and coordinating with animal surveillance in order to:
  
i) monitor wildlife die-offs, outbreaks in domestic animals, test samples and alert public health authorities

  
ii) control wildlife and domestic animal slaughter – both at home, and in facilities

- organising logistical support which guarantees a secure environment for field workers and health-care workers.

Bringing in experts from disciplines central to effective outbreak management is also valuable, in terms of applying and sharing experiences, adapting practice and consequently shaping understanding, knowledge and the development of robust strategies and policies. For example, during an outbreak, the challenge is to rapidly research, plan, manage and monitor a range of communication approaches and activities targeting the behavioural and social aspects of outbreak control. These approaches encourage dialogue between the affected communities and response agencies to find appropriate and effective control and prevention measures at the household and community level. This is often complex and time-consuming and may challenge assumptions about what people do and why they do it. The Global Alert and Response department at WHO has adopted a WHO strategic framework called ‘Communication for behavioural impact’ (COMBI) for outbreak response, which can be used by health-promotion, social-mobilisation and communications staff (as well as other response personnel) to integrate behavioural and social communication in outbreak responses.

The EID outbreak responses also illustrate the need for specialised networks in a variety of disciplines: epidemiology, clinical management, infection prevention and control, behavioural and social communication, risk communication, logistics, the aetiological/laboratory network, ecology...

During EID outbreaks, it is necessary to have reliable but rapid laboratory results available to support evidence-based advice and control measures. To this end, the WHO Emerging and Dangerous Pathogens Laboratory Network (EDPLN: www.who.int/csr/bioriskreduction/laboratorynetwork/en/index.html) was established, made up of global and regional EDPLN networks of high-security, public health and veterinary diagnostic laboratories. These centres collaborate to:

- share their knowledge, biological materials and experimental research results to support real-time diagnostic functions during international responses

- facilitate the transfer of safe and appropriate diagnostic technologies, practices and training to regional networks and national laboratories in zones of EID occurrence. This transfer enhances
diagnostic readiness for the earlier diagnosis and management of outbreaks and infections of emerging and acute endemic disease threats. These EDPLN laboratories are also GOARN response partners.

The EDPLN vision is collaborative: national and international laboratory networking within and across the human and animal health sectors to support better understanding of the natural history of emerging zoonotic diseases and to develop evidence-based strategies and tools for faster detection and better containment of outbreaks that affect human and animal health.

Another specialised network closely linked to GOARN is the Global Infection Prevention and Control (GIPC) Network. The GIPC (10) Network supports WHO to ensure the availability of international infection prevention and control expertise to enable a comprehensive response to any outbreak of disease amplified by or related to health care. During the pre-event phase, the GIPC Network also supports WHO in developing and disseminating evidence-based guidance and tools to Member States to promote sustainable infection prevention and control preparedness in health care.

**Conclusion**

Outbreak detection is better than it was in the past but could be improved by strengthening the collaboration between the wildlife, domestic animal and human health sectors and improving forecasting models.

Controlling EID outbreaks requires not only medical expertise but also the willingness of the affected and at-risk populations to adopt recommended control measures. Acceptance of these control measures, essential for an effective operational response, relies upon an understanding of the cultural, economic, political and social contexts in which the outbreak is situated and how these affect outbreak control activities. This is even more significant in the absence of effective therapies or vaccines against most EIDs, which severely limits our attempts at control.

There is a need to provide customisable frameworks to countries to improve public health and people’s livelihoods, so that people are less vulnerable and more prepared for disease epidemics and pandemics arising at the human/animal interface.

Today’s technologies can improve detection, management and containment of the international spread of emerging diseases, but this is not enough. High-level government commitment and international collaboration to support and strengthen local response capacities remain fundamental requirements.

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**References**


Wildlife, wild food, food security and human society

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Summary

From early history, wildlife has played a crucial role in the emergence of Earth’s most successful mammal species, Homo sapiens. Exploitation of wild food, through hunting, was the main evolutionary driver of upright, running human beings and vital to the species’ nutritional health, early expansion and growth. In contrast, the recently growing human population has been sustained through the domestication of species for food and industrialisation of agricultural systems without taking natural capital into account. This paper critically evaluates this strategy and presents evidence that modern systems are not necessarily optimal and are, in fact, undermining long-term food security and the health of the planet and of people. There are disturbing trends: an unprecedented loss of biodiversity, thus reducing ecological resilience; the emergence of new infectious and non-infectious diseases; rising global ambient temperatures and climate change threatening life itself. Human behaviour is at the root of these problems and modern Western culture, seemingly incapable of change. However, with current population growth, there is little choice.

So why has this happened? It is argued here that, for various reasons, people became culturally, physically and mentally disassociated from nature, developing an incredible self-belief in the human right to exploit the environment and in our capacity for technological solutions, ignoring the consequences. Humanity is at a crossroads. The solution to the crisis is in human hands. There is a need for a new politics, philosophy and science. We urgently require a careful analysis of trends and options to determine whether there are technological solutions or whether society needs to turn towards a culture more in tune with nature and more sensitive to ecological limitations. We argue that the latter is the way forward, through the restoration of functional ecosystems and a reappraisal of our place; a return to complex food chains that also includes sustainable agriculture. With our knowledge of physics and biological systems, this should not be impossible but for this there must be a complete paradigm shift and, most probably, a reduction in human population.
Keywords


Introduction

Wildlife and particular natural food sources have been intimately linked to human evolution and global food security.

In this paper we argue that solving the food security crisis in the coming decades requires reflection on the place of agriculture in human history and identifying key events and factors that have led to, and continue to drive, the current challenges. The past is more than prologue, it is the path from which our present circumstances emerge and whose direction we take for granted. It also actively exists, albeit in a modified form, in the structures and processes we find ourselves a part of today. So how far back should an analysis of our food crises extend? Because of the complexity and scope of the present crises, we begin here with our species’ origins, and how this affected, and, in turn, was affected by, the evolution, distribution and human exploitation of the available wild food resources. This includes the basic truth that health and biological diversity have always been and always will be linked.

Our nomadic origins

Humans evolved as nomadic hunters dependent on wild herbivores, vegetables and fruit, and benefiting from a rich and nutritious diet.

The first recognisable humans evolved around 1.8 million years ago as Homo erectus. The period saw a diversification in our lineage, from intelligent, tool-using apes to upright bipedal walking hominins. The archaeological record supports the hypothesis that pre-hominins adapted to an increasingly terrestrial lifestyle, marked by hunting and tool use sophisticated enough to remove meat from bone. The cultural adaptations enabled an ecological generalisation at a time of climatic variability and, along with increased brain size and tooth development, a more varied diet. This in turn was influenced by the availability and abundance of wild food.

In the context of these drivers, Homo sapiens evolved. Grazing herbivores emerged alongside humans, colonising grasslands which evolved in tropical biomes during the late Neogene period, ending 2.6 million years ago and now thought to be related to an extended dry climatic period (19). This emerging animal and plant community provided the substrate on which an upright, agile human being, capable of long-distance running, first evolved. The new mobility selected for long-range nomadism and increased human home ranges, allowing the species to expand into new lands, and distributing hominins across Africa, Asia, and, eventually, the Americas and Oceania (10).

A necessary agriculture

Agriculture was not just a bright idea but rather a necessity for a growing population of humans forced to scavenge for food by overhunting.

A fundamental change in the human species occurred some 10,000 years ago. There was a gradual shift of communities away from nomadic hunting, with its high-quality protein diet and nutritious wild vegetable-like plants, to cultivating a range of plants in which nutritional diversity decreased as other
traits were preferentially selected. This increasing sedentism took place over some 7,000 years and the switch was a result not of some sudden brainwave or upsurge in intrinsic intelligence, nor a passing preference for sedentary lifestyles. Agriculture most likely arose from necessity as overhunted megafauna became relatively scarce. The evidence suggests that the Holocene extinctions were brought about by overhunting (14). One benefit of such a sedentary lifestyle proved to be a more efficient use of space and time, leading to widespread experimentation with plants and, ultimately, the domestication of staple crops and animals (3). These changes inevitably led to profound modifications of the landscape, an intensification of plant and animal management and, at their core, possibly the earliest anthropogenic impact on reduction in biodiversity. They also signalled fundamental change in the evolutionary drivers to which humans were forced again to respond, as evidenced by a shift away from tall, agile physiques to shorter, more muscular bodies, fit for digging and hauling. Cultural change, housing and more diverse livelihoods followed.

It is often assumed that agriculture immediately resulted in improved nutrition and increases in reproduction and growth rates, but there is good evidence, supported by palaeopathology, to suggest that mortality rates increased with more sedentary lifestyles, by way of, among other causes, exposure to new infectious diseases and nutritional deficiencies, especially amongst children and the elderly (13). There was, however, eventually a net increase in the Neolithic human population, albeit small, at about 0.1% per year, ascribed to reduced birthing intervals and increasing fertility (2). As the population slowly grew and expanded, attendant increases in average family sizes were accompanied by an expansion in demand for food and better nutrition. The gradual adoption of a broad-spectrum diet, agriculture, storage, and sedentism mitigated seasonal shortages and gradually, as productivity improved, life expectancy increased (11).

**Modern times**

The Industrial Revolution produced another fundamental shift in the food regime

Once humans learned how to domesticate plants and animals, they achieved a reasonably secure life, in many different settings and climates. A new balance was struck with nature and the resulting post-Neolithic populations remained relatively stable globally for three millennia, despite the odd extirpation, up until the past three centuries.

A considerable diversity of livelihoods, ethnicities and cultures emerged alongside a remnant of hunter-gatherers. Modern rural societies comprised sophisticated livestock-keepers (some nomadic), agricultural communities, crafts and trades people. Most humans just a century ago still moved no more than a few tens of miles from their birthplace during their lives. People were, as a result, probably extremely sensitive to ecological processes and seasons, as their food remained largely locally derived. The relationship between mind and place soon changed.

Finally, towns and cities developed on settlement sites, usually river courses; ironically enough, on some of the richest soils which would soon disappear under rubble and buildings. Driven by urbanisation, goods and people were transported over considerable distances, reducing the risks of local crop failure and food shortages. A market culture emerged.

Science, alongside plant- and animal-breeding, led to massive increases in potential food sources, in both diversity and distance. Along with rapidly improving medical technologies and, eventually, public health, newly emergent globalising cultural complexes led to improving survival rates for some populations. With industrialisation, humanity entered a period of exponential growth, concentrated in cities, and increasingly losing an intuitive grasp of the ecological processes that sustained early food production. The human population took some of its most dramatic turns only 60 to 70 years ago,
although the groundwork had been laid down through the 18th and 19th Centuries. Agricultural and industrial development, tied to capital accumulation, contributed to a rapidly evolving cycle of human population growth and expansion, forcing greater innovation in agricultural and industrial methods and increasing settlement, population concentration and landscape change.

**Ecological tipping points**

Do we suffer the illusion of an inevitable existence?

The precariousness of our situation is apparent in current affairs. Science and human ingenuity have resolved one food security crisis after another – for the most part on the local scale and often by shifting food surpluses. But the crises appear to multiply and the options to resolve them are dwindling in number and scope as ecosystem resilience declines and productivity is threatened by still greater production, rooted in the assumptions of neoclassical economic theory. We have stepped over the green line – an ecological tipping point – and are dipping deeply into all of Earth’s assets. In a blink of a geological eye, habitat destruction, biodiversity loss and ecological dysfunction, with attendant increases in disease emergence (12), resource depletion (e.g. phosphorus), soil degradation, pollution, energy concerns and climate change, have all hit home, coincident with a hubristic celebration of the remarkable scientific achievements of the past few decades.

The collapse of ancient civilisations may well have felt something along these lines. We face, however, a complex of problems that is at least one order of magnitude greater in its difficulty. Globalisation – geological in its scope, leaving us nowhere to run – has so changed the conditions in which humans relate to, or are alienated from, their environment that we are, a single civilisation now, confronted with a make-or-break proposition of our own undoing. The resulting damage may be too complete. History may offer us many collapses that our species has survived, but these, whatever their number, can offer no representative sample sufficient for guaranteeing the security of a future.

On a finer time scale, prospects look dim. The ‘abundance bubble’ is burst. An entrenched global financial crisis, coincidental with dramatic spikes in food prices in 2008 and again this year (5), is pushing us towards another fundamental shift in our food regime that may, in due course, produce the conditions that lead to its demise. While previously we could stutter-step from one food regime to another, we are now reaching an absolute global carrying capacity that precludes merely expanding capacity, which, until now, via land grabs and export economies, came at the cost of deflating the carrying capacity for those in the global South with little access to the markets they supplied.

The majority of the human population now lives in cities, seeing the natural world through television screens and computers. Nature and wild food are treated as a thing of the past and modern food as a commodity whose origins reach no further back than the supermarket shelf. A terrific world in some minds, perhaps, but a fragile one since empty shelves, as they more frequently appear, are more likely to inspire political revolution than a return to the plough. History is littered with examples. Before the French revolution it was famously suggested that the masses should ‘eat cake’. The uprising against Mengistu’s regime in Ethiopia took place when bread and beer became unavailable. Mubarak’s downfall in Egypt this year took place after massive rises in food prices.

Given these social and ecological trends, with sharply detrimental turns over the past decade, it would appear to be high time that we question the fundamental tenets of technologically driven economies and a consumption-based economy that both produces and depends on cheap labour pressed up against ecological limits. As our species’ history shows, paradigm shifts in both concept and practice, when needed, are essential to our survival.
**Scavenging again?**

*Rich and poor are struggling over a declining resource base*

In its ‘State of Food and Agriculture’ report (8), the Food and Agriculture Organization (FAO) estimates that the number of those suffering from chronic hunger in the world reached 1.2 billion in 2009. The report states that the challenge that lies ahead is ‘to secure the food security of these one billion hungry people and also to double food production in order to feed a population projected to reach nine billion by 2050’. This is a noble statement, dependent on extraordinary faith in science and a perhaps myopic belief in technological solutions, one ignoring basic ecological constraints, whereby natural resources are made finite and will ultimately limit production, consumption and population growth. The FAO claims to recognise some of the issues, including: ‘demographic and dietary changes, climate change, threats to agriculture from bioenergy development and natural-resource constraints’ but continues planning under the heroic assumption that science and enterprise will find a way.

The ‘State of Food and Agriculture’ report outlines the extraordinary changes in the livestock sector over the past few decades, under the rubric of the ‘livestock revolution’, in which the breeding, processing and distribution of fast-growth livestock are vertically integrated under a few large operations. The ‘revolution’ appears to both service and drive demand for meat protein from growing urban populations, particularly now in so-called developing countries. The new food commodity chains are, however, doing little good for poor rural communities or traditional livestock-keepers, who rarely benefit from these markets. The poor and food-insecure stay poor and food-insecure, whilst increasing pressure is exerted on ecosystems and biodiversity, and natural resources, soils and fresh water needed to feed the urban masses are put in decline. Science and agribusiness instead focus on commercial food development, while subsistence agriculture and livestock-keeping suffer contractions in the few services that they receive (15). Comparatively little is being done to sustain their livelihoods, which are vital to the resilience of agricultural systems in the longer term, when energy reserves are finally depleted and reliance on machines can no longer be assured.

**Diet and disease**

*With the decline of wild food, the majority of humans are increasingly restricted in their choice of diet to a few staples*

Poor societies have always been food-challenged. Much of the Indian population survived over the 20th Century on an average of two acres of cultivated land per family, but they tilled the land without machines and understood much of its ecological basis. There was, and is, little waste. Improved crop production and pest management have helped considerably to buffer these communities from starvation, but seasonal failure of rains and reductions in the volume of melt from the Himalayan water tower, Earth’s ‘third pole’, brought about by climate change, remain significant threats to over 500 million people on the northern Indian plain. Here, *per capita* availability of fresh water in India is expected to drop by nearly 50% by 2025 in response to climate change and population growth (4). Agriculture accounts for approximately 70% of the available water globally (20), so the choice is stark. As water becomes scarcer and more costly, it will be a crucial factor on which we base our food choices. On average, one egg requires 135 litres of water; one kg of chicken: 6,000 litres, and 1 kg of beef: 15,000 litres (6).

Meanwhile, pathogen evolution and spread has become part of the risk frame of the industrialised food system. The science of food safety is daily called upon to quell outbreaks throughout a global system connected through daily shipments of breeding or neonatal stock, and the wide dissemination of potentially contaminated food products, including this year’s extraordinary *Escherichia coli* outbreak.
across Europe, attributed to contaminated seed stock. In turn, wildlife, increasingly squeezed by encroaching livestock and human populations, is spilling its potential pathogen community into wet markets, bushmeat butcheries, farmland and urban environments, producing risky natural experiments in disease transmission and pathogen evolution across species.

Pathogens evolve at increasing speed in industrialised, genetically limited, domestic animal and crop communities. Agriculture is increasingly managed in sterile but still pathogen-friendly conditions, requiring repeated applications of pharmaceuticals and vaccines in livestock chemicals and to reduce now-endemic diarrhoeas and respiratory diseases, and applications of pesticides on crops, engineered to withstand still greater chemical application. The resulting waste run-off carries highly evolved cassettes of bacteria and other pathogens with drug-resistance genes, and increasing concentrations of oestrogen-like chemicals and other ecotoxins are poured into water bodies and river systems, or even recycled as fertiliser. Even pharmaceuticals are becoming detectable in biologically active concentrations in the environment, with increasing evidence of ecological, physiological and even pathological impacts, as illustrated by the virtual extinction of the Gyps vulture, which ingested deadly residual diclofenac, a pharmaceutical, in the carcasses they scavenged.

Solutions, big picture

Before us lie two options for resolving the present food crises

So, serious problems abound. What can we do to solve them? There are basically two schools of thought for resolving this dangerous situation. One promotes more of the same: increased industrialisation; more mass production, processing and marketing of food; increasing gene modification for purposes of improving agricultural production and pest and disease resistance; and raising yields, year on year, with large inputs of artificial fertilisers, pesticides and herbicides. The objective appears to be to sustain the human population and even, alarmingly, sustained growth, whatever the cost to the environment.

The other school seeks an alternate path, a future based on a respect for and engagement with the historical present; a system depending on low artificial inputs, sustainable natural resource use and conservation agriculture, requiring the restoration of natural ecological processes and cycles; and a return to more complex food webs (based around more wild-type, resilient, naturally disease-resistant and biodiverse plant and animal foods). The present production system – antibiotic-fed livestock monocultures in huge confined animal feedlots – removes many of nature's cheap and self-renewing ecological services. Ecological resilience, natural selection and a probiotic ecology represent three important services in an epizootiological context that could be reintroduced under a new food regime.

The path of conservation agriculture

A conservation agriculture approach proposes lower input costs (minimising ecological subsidies to be provided by governments and consumers), using organic, naturally renewable production methods and conservation agricultures. Pretty (18) summarises a number of practices that are already inputs and outputs of more sustainable agro-ecosystems, including ‘sustainable intensification’ which, in some cases, is producing as much food per acre as clear-cut, chemical agribusiness:

1. integrated pest management, which uses prevention through developing ecosystem resilience and biological diversity for pest, disease and weed control, and only uses pesticides when other options are ineffective;

2. integrated nutrient management, which seeks both to balance the need to fix nitrogen within farm systems with the need to import inorganic and organic sources of nutrients, and to reduce nutrient losses through control of run-off and erosion;
3. conservation tillage, which reduces the amount of tillage, sometimes to zero, so that soil can be conserved through reduced erosion, and available moisture is used more efficiently;

4. cover crops, which grow in the off-season or along with main crops, and help to protect soil from erosion, manage nutrients and pests, maintain healthy soil and enhance water infiltration and storage in soil;

5. agroforestry, which incorporates multifunctional trees into agricultural systems, and collectively manages nearby forest resources;

6. aquaculture, which incorporates fish, shrimp and other aquatic resources into farm systems, such as irrigated rice fields and fish ponds, and so leads to increases in protein production;

7. water harvesting in dryland areas, which can mean that formerly abandoned and degraded lands can be cultivated, and additional crops can be grown on small patches of irrigated land, due to better rainfall retention;

8. livestock re-integration into farming systems, for example, raising dairy cattle, pigs and poultry, using both grazing and zero-grazing cut-and-carry systems. Mixed crop-livestock systems provide many synergies that enhance production and allow for better nutrient cycling on farms.

Complex and diverse wild-type food webs appear more resilient to stochastic events, animal losses and crop failures, and the whims of centralised governance systems. Restoration of ecological processes and systems, conserved biodiversity, and complex agro-ecologies should restore resilience to food communities, which, among other benefits, should help to slow down or stop the drivers for rapid pathogen evolution and spread, thus preventing the emergence of new strains of diseases.

The benefits are more than ecological, however. Contrary to the underlying assumptions of the first model, food is not just about calorific content. Wild or organic food and a diversity of livestock breeds and plant types provide a better quality of nutrition over all, if only by reducing chemical residues and toxins and, in many cases, increasing levels of micronutrients. Comparisons of disease incidence in developed countries – in particular, of allergies, diabetes and obesity – are establishing links between diet from the industrialised food system, the immune system and disease (16).

Agro-ecologies must be deeply social in character, of course, if humanity is to bother with them. As much of agriculture was ecological in character before industrialisation, examples abound, particularly in the less-industrialised world. The village chicken, selected over thousands of years for local climates and production outlets, offers an excellent example of the way that food diversity, nutrition, health and indigenous ownership are integrated. Mixed agricultural systems that involve cropping and village poultry production provide an excellent example of synergy, where crop wastes provide scavengable feed for poultry; poultry provide manure and pest control for the crops; and the crops and poultry products provide a source of nutritious food for farmers and their families (4).

Farid Hosny (9) writes of the bird’s role in the face of an Egypt increasingly pressured into a foreign-capitalised livestock revolution:

‘Poultry production can provide meat and eggs for the family, be a source for a small and fairly regular cash flow and avoid waste by using kitchen leftovers and broken seeds as feed. Poultry manure can be used as a fertilizer for crop production and poultry also help in pest control. Importantly, unlike in the case of larger livestock, poultry production is not restricted by land ownership. This is important as only 24.5 percent of rural households own land, which is very unequally distributed. Poultry is also important for festivals and traditional ceremonies and for [a variety of] other socio-economic reasons…’
Outfoxing our own fallacies

The very assumptions under which the present food system is viewed as advantageous may be spurring on its destruction. But, as in the past, humanity can think its way out of its present conundrum

A good first step towards resolving our present fix is to explicitly confront the assumptions underlying ‘business as usual’.

As we look to the future, lessons learned about sustainable agriculture on other continents can help to inform alternative approaches to food security. Despite heavy investment in conventional agriculture, domestic livestock production has not succeeded in meeting the protein demands in Africa, for instance; a situation compounded by the increasing pressure of the human population. As a consequence, people in rural Africa today are exploiting most of the wild resources traditionally known to be edible. To solve this growing food insecurity problem, more holistic and innovative strategies are required. The wildlife resources of Africa hold much promise in contributing to food security there and can contribute most effectively if adequate investments are made into production, marketing and technical support (17). If well-managed, the strategy may allow ecosystems and biodiversity to recover from overzealous exploitation. While such efforts are already under way, research is needed to develop the tools for the kinds of ecosystem assessment that can best determine the type of agriculture or wildlife systems most appropriate for meeting the food security needs of rural and urban populations from one locale to another.

A key to this revolution – and there can be no other word for it – will be the governance of change. To give credit to global institutions, there has been a shift in policy thinking around food security, towards more sustainable and equitable solutions, but these will all still be highly dependent on improved global governance systems. To date, the progress is in the rhetoric and not in the field (7, 20). The need to adapt is accepted during the ‘good’ times but is soon submerged in a political panic as economies fail by way of the very models used to justify continuing production practices. Contradictory approaches by international agencies and the failure to ‘grasp the nettle’ on the food security issue reflect weak governance. Alternatively, as the uprisings across North Africa and the Middle East exemplify, the political will may be supplied by a popular movement outside the present political infrastructure.

The problems of food security, biodiversity conservation and access to resources appear inordinate. But the human species is resilient and our current generation, and those soon to follow, have an opportunity, indeed an obligation, to apply the full force of our intellect and will to shifting the dominant paradigm to a sustainable, just and healthy way of being and sharing with other species. This shift is not only a good idea but a necessity, as our species’ history has repeatedly shown.

References


Illustrating contributions to public health


Policy opportunities for linking animal and human health

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Summary

Emerging and re-emerging zoonotic and animal diseases, as well as so-called ‘neglected’ diseases, have, in the past, had a severe impact on both human and animal (including wildlife) health and community socio-economics. Factors predisposing to an increased risk of disease include more liberal and widespread global movements of people, wildlife and trade; increasing population with rapid urbanisation and increased demand for meat; intensification of livestock production; environmental damage and ecosystem changes; and climate changes with increased variability. The effectiveness of predicting, identifying, responding to, and managing diseases has been hampered by the general structural separation of veterinary and human medical science disciplines in the 20th Century and a lack of attention to the role of wildlife in disease evolution and spread. International policy support for a ‘One Health’ approach, a concept that has existed for several thousand years and involves an integrated approach to human, animal and ecosystems health, should improve prediction, prevention, recognition and response systems to disease if implemented in a sensible and coherent manner. Some key factors mitigating against the adoption of ‘One Health’ approaches include financial constraints, other national or sub-national priorities, a lack of understanding of the ‘One Health’ concept and its potential benefits, and conservatism. Opportunities for policies to support ‘One Health’ may arise following demonstration of the cost benefit and efficiencies such an approach may bring. The key factors to the success of the ‘One Health’ approach lie not in the structural combination of human and animal health services, but rather in functional coordination and cooperation across a wide range of interested parties. Linking animal and human health supports key policy imperatives, including the Millennium Development Goals and food security. Case examples are discussed to demonstrate the policy value of ‘One Health’ approaches.

Keywords

Illustrating contributions to public health

Introduction

In recent years, emerging and re-emerging zoonotic and animal diseases, including highly pathogenic influenza A (H5N1), pandemic 2009 H1N1, severe acute respiratory syndrome (SARS), foot and mouth disease (FMD), bovine spongiform encephalopathy, human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) and porcine reproductive and respiratory syndrome (PRRS), as well as so-called ‘neglected’ diseases, such as rabies, have had a significant impact on public and animal health (including wildlife), with serious adverse socio-economic consequences. The prevention and/or limitation of the adverse effects of such disease events that transcend the human/animal interface, together with other policy considerations such as food security, are key factors that foster the need to enhance links between humans and animals.

Emerging infectious diseases and risk

Humanity is currently facing many challenges that require global solutions. One of these is the threat of emerging infectious diseases (EIDs) of animals and/or humans (5). These EIDs are defined as diseases that have recently increased in severity, incidence or geographic range, moved into new populations, or are caused by newly evolved pathogens (11). Changes in human demographics, behaviour or societal structure (7) are seen as significant drivers for the change in the host–pathogen ecology supporting the emergence of most EIDs. These changes may enhance transmission between individual hosts; increase contact with new host populations or species; and create selection pressure leading to the dominance of pathogen strains adapted to these new environmental conditions (14).

It has been estimated that somewhere in the order of 60% of infectious diseases of humans are of animal origin (including wildlife). Over the last 30 years, 75% of new infectious diseases of humans have originated in animals (15, 16). What is even more alarming is that, according to the World Organisation for Animal Health (OIE), 80% of the pathogens identified as having potential for use in bioterrorism come from domestic or wild animals. These zoonotic diseases, together with a range of animal-specific diseases of a highly infectious nature, such as FMD and PRRS, have resulted in significant adverse socio-economic impacts with disproportionate effects on developing countries. On average, the past three decades have also hosted the emergence of one new disease a year, with an overall rise in the incidence of new events. These statistics are not just an outcome of increased awareness or reporting but of a combination of factors, affecting both the likelihood of a new disease emerging, and the opportunity for diseases to spread to new populations (1).

Factors contributing to the emergence, spread and amplification of EIDs include increased population growth and demand for animal protein; trade, and the faster and more widespread movement of people and goods throughout the world; intensified livestock production, urbanisation, environmental degradation and political and social disruption. The continued convergence of animals, humans and wildlife provides a figurative nidus for disease agents.

The role that wildlife plays in the epidemiology of EIDs has been well demonstrated; however, human-driven changes at the human-wildlife interface also play a significant role. For example, the human population increase leading to encroachment into wildlife habitats is seen as a key factor in the global emergence of Marburg and Ebola viruses and HIV (10). The 1998 to 1999 outbreak of Nipah virus infection in Malaysia, which caused 265 human cases of viral encephalitis with a 38% mortality rate, was attributed to the expansion of intensively managed pig farms and the retention and planting of fruit-bearing trees beside the piggeries, which led to increased contact between flying foxes and pigs (3). The emergence of bat-related viral infections transmissible to humans and animals has also been attributed to the loss of natural habitats of bats. In the case of Hendra virus infection in Australia, it is suggested that, as the flying fox habitat and source of food is destroyed by human activity, their immune system gets weaker, leading to an increased virus load and shedding in the urine and saliva.
Since the emergence of this disease in 2004, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia has listed seven people who were confirmed to be infected with Hendra virus, four of whom died as a result of the disease.

Consumption of wildlife has also led to the emergence of infectious diseases in several parts of the world. Studies show that handling both live non-human primates and bushmeat risks the exposure of populations to simian immunodeficiency viruses (SIV), as well as other serious pathogens. Blood taken from nearly 800 monkeys hunted in the rainforests of Cameroon, and either sold within markets as bushmeat or kept as pets, revealed serological cross-reactivity with HIV antibodies in over 16% of cases, indicating infection by an SIV. In fact, SIV infection was identified in 13 of the 16 primate species examined; this was the first time that the virus had been reported in four of these species (9). Moreover, several outbreaks of Ebola virus infection in western Africa have been associated with consumption of bushmeat; in many cases, this involved the scavenging of dead chimpanzees (8). Similarly, SARS has been linked to the trade of live, wild carnivores, especially the civet, in the People’s Republic of China (4); however, recent study suggests that the masked palm civet may be the source of the SARS outbreak but indicates bats as the natural reservoir of the virus. Bats are often found in traditional medicine markets (12). The list of diseases associated with the consumption of exotic food has also been linked with various zoonotic pathogens or parasites (2).

The nature of EID risks can vary with climate change and variability in weather patterns, which can affect the eco-biology of microbiological agents. The recent economic downturn has, in many instances, resulted in reduced investments in agriculture, including animal health, impacting adversely on the poor. Emerging infectious diseases are more likely to originate where there are fewer resources allocated to identify their emergence and prevent subsequent spread. By the year 2050, it is forecast that the global population will increase by 50%, with much of the increase expected in Southeast Asia. It is estimated that there will be a 2% to 3% per annum increase in the demand for animal protein over the next ten years. The growing demand for animal protein drives increases in production and trade, factors which will exacerbate risk for the spread of EIDs.

These EIDs have had, and will continue to have, serious economic and social consequences. For example, avian influenza due to the H5N1 virus resulted in losses of approximately US$ 20 billion, with significant impacts on small farmers and trade. The estimated economic cost of an H5N1 pandemic is US$ 2 trillion (5). Foot and mouth disease poses continuing threats to the gross domestic product of countries and to developmental and trade opportunities. It is estimated, for example, that the 1995 FMD outbreaks in the Philippines cost, in Philippine pesos, 2.1 billion. The cost of the current FMD outbreaks in South Korea (starting in 2010) is estimated by the Food and Agriculture Organization of the United Nations (FAO) at over US$ 2 billion, with the culling of 3.37 million animals, including pigs, cattle, goats and deer. This cost relates to both direct expenses as well as compensation to farmers. Studies indicate that the global production of food animals is reduced by more than 20%, due to disease. Consequently, this reduction may lead to public health problems caused by food shortages, nutritional deficiencies and reduced cash flow. A logical conclusion derived from this presentation on the multitude of risk factors is that the risks of EIDs are increasing; however, the nature of such diseases – their agents and severity for example – is very difficult, if not impossible, to predict.

**Constraints**

The effectiveness of predicting, identifying, responding to, and managing diseases has been hampered by the general structural separation of veterinary and human medical science disciplines in the 20th Century. For example, research on zoonotic disease is often duplicated in separate animal health and human health research institutes, with different funding allocations, educational and
Some fragmentation of Veterinary and medical Services has been observed, with a lack of collaboration and even, in some instances, competition (13).

Improvement in the prevention and management of a number of human infectious diseases, through measures such as vaccination and antibiotic use, has possibly led to a degree of complacency in this area of disease control. In fact, in the year 1967, United States Surgeon General William H. Stewart stated that it was: ‘time to close the books on infectious diseases’ and shift resources towards non-infectious diseases, such as cancer and heart disease.

In more recent times, separate, and often less than adequate, animal and human disease reporting mechanisms have limited the effectiveness of working relationships. The adoption of the new World Health Organization (WHO) International Health Regulations (IHR) in 2005 for the notification of communicable diseases will help strengthen human health disease reporting and provide improved capacity to link with animal health information systems, in particular those of the OIE. In terms of EID management, actions have commonly been more directed to response rather than preparedness and the development of sustainable and coordinated approaches to health.

Many of the zoonotic diseases that have appeared during recent decades have originated from wildlife; however, there has still been a lack of attention to the role of ecology and wildlife in disease evolution and spread. More research is required into the potential effects of wildlife diseases, whether they infect domestic animals or humans or both, as well as on biodiversity. A significant issue in terms of disease risk is the legal and illegal trade in wildlife: a rapidly growing global market estimated by the International Criminal Police Organization (Interpol) to be worth at least US$ 6 billion, with the potential for global dissemination of disease agents and new pathogens.

These constraints are progressively being overcome as we recognise that cross-sectoral and interdisciplinary collaboration is essential to prevent, manage and minimise the impacts of EIDs through a ‘One Health’ approach.

‘One Health’ and emerging infectious diseases

The ‘One Health’ approach recognises the intimate connection between humans, animals and ecosystems, and proposes an international, interdisciplinary, cross-sectoral approach to the identification, management and control of infectious diseases, as well as environmental conservation (5). ‘One Health’ is not a new concept and has been around for many years. However, recent EID events, such as H5N1, reinforce the importance of adopting and improving well-coordinated interdisciplinary approaches to prevent, manage and control disease.

The global experience with H5N1 highly pathogenic avian influenza (HPAI) and pandemic H1N1 in 2009 has also highlighted the importance of international and regional cooperation, national political commitment, inter-sectoral collaboration, timely and transparent communication, and capacity building as essential components of health systems capable of addressing emerging threats and ensuring effective pandemic response mechanisms are in place across the various sectors of the economy. These issues were raised at the International Ministerial Conference on Animal and Pandemic Influenza (IMCAPI) in Hanoi, Vietnam, in 2010, where emphasis was placed on the need for sustained and well-coordinated, multi-sector, multi-disciplinary, community-based actions to address high-impact disease threats that arise at the animal-human-environment interface.

Approaches to ‘One Health’ can be varied and range from sharing information to engaging in joint projects, research and the management of emergency situations. The key emphasis is on meeting the functional needs of ‘One Health’ through a cooperative, collaborative and consultative approach and
customising arrangements to suit the particular needs of key participants and stakeholders at national, regional and global levels.

The structural institutionalisation of ‘One Health’ is opposed by numerous organisations, such as the OIE, WHO, FAO, European Union and a range of countries. This approach requires overcoming bureaucracies which are involved with a wide and complex range of existing institutional systems, organisational forms, funding allocations, governance arrangements and priorities, and it is highly unlikely that this method will achieve the goals of ‘One Health’. Rather, a functional and collaborative approach, as described in the FAO-OIE-WHO Tripartite Concept Note, reflects arrangements that are most likely to achieve success (6).

The policy agenda

There are a range of opportunities to modify policy to support, directly or indirectly, ‘One Health’. These include:

The Millennium Development Goals

The Millennium Development Goals (MDGs) describe eight international development goals that the United Nations (UN) Member States and a number of international organisations have agreed to achieve by the year 2015, to encourage development in the world’s poorest countries. The MDGs promote advancement on human needs and basic rights that everyone should enjoy – freedom from extreme poverty and hunger; quality education; productive and decent employment; good health and shelter; the right of women to give birth without risking their lives; and a world where environmental sustainability is a priority and where women and men live in equality. Goals number one (eradicate extreme poverty and hunger), six (combat HIV/AIDS, malaria and other diseases), seven (ensure environmental sustainability) and eight (develop a global partnership for development) are particularly relevant to public and animal health and fall within the remit of ‘One Health’.

The Paris Declaration and Accra Agenda for Action

For over a decade there has been an increasing recognition that aid flowing to governments has been, at times, ineffective. As a result, the donor aid community has committed itself to improving aid effectiveness and ensuring that the MDGs are achieved through better coordination mechanisms. At the High Level Forum on Harmonization, convened by the Organisation for Economic Co-operation and Development (OECD) in February 2003, donor agencies committed themselves to work with developing countries to better coordinate and streamline their activities at the country level.

In February 2005, at the Paris High Level Forum on Aid Effectiveness, more than 100 signatories – from donor and developing country governments to multilateral donor agencies, from regional development banks to international agencies – endorsed the Paris Declaration on Aid Effectiveness. The Paris Declaration represents consensus among the international community on improved effectiveness, with the commitment to help developing-country governments formulate and implement their own national development plans, according to their own national priorities, using, wherever possible, their own planning and implementation systems.

At the Third High Level Forum on Aid Effectiveness, held in Accra, Ghana in 2008, Ministers endorsed the Accra Agenda for Action (AAA), an agenda to accelerate progress, strengthen country ownership and promote capacity development of all stakeholders. There was a strong focus on helping developing countries to better monitor and evaluate aid impacts. The Ministers’ endorsement of the AAA provides a political commitment to pave the way for better partnerships between donor agencies and recipient countries.
Illustrating contributions to public health

‘One Health’ approaches will gain considerably from improved aid effectiveness, if properly implemented, since this will provide greater opportunities for capacity building in the health area, supported by monitoring and evaluation programmes. It is important that countries include ‘One Health’ in their national plans.

Food security, biodiversity and climate change

There is a clear link between climate change, biodiversity and food security, given the imbalance between global population (demand) and food production (supply). The world is facing a decline in biodiversity, due to factors such as degradation of habitats, pollution and disease, leading to loss of species and unsustainable food supply systems. The Addis Ababa principles and guidelines for the sustainable use of biodiversity provide a framework to aid governments and other stakeholders to conserve biodiversity, address poverty alleviation and support food security. Article 6 of the UN Convention reaffirms the need to develop national biological diversity strategies and action plans. The UN Framework for Climate Change calls for the launching of national strategies to address greenhouse gas emissions and the provision of financial and technological support to developing countries.

Association of South-East Asian Nations and Inter-Ministerial Commission on Avian and Pandemic Influenza

Clear policy support has been provided by the Inter-Ministerial Commission on Avian and Pandemic Influenza (IMCAPI), with global ministerial agreement and support for ‘One Health’ at the regional, sub-regional and national levels. The Commission reaffirms the importance of international and regional cooperation, national political commitment, inter-sectoral collaboration, timely and transparent communication and capacity building as essential to developing a health system capable of addressing emerging threats, such as animal and human influenza, in a sustainable manner.

Particular attention was given to improving in-country animal and public health capacities; engaging communities and the private sector through ‘partnership’ arrangements; reinforcing the need to maintain and improve emergency management and contingency planning; cooperation and coordination at the regional and global levels on prevention, management and information systems; and progressively adopting and improving ‘One Health’ approaches through multi-disciplinary and interdisciplinary collaboration. The Hanoi IMCAPI outcomes support and extend agreements reached at a previous meeting of Ministers at Sharm el-Sheikh, Egypt, in October 2008. The IMCAPI process has focused on the zoonotic disease aspects of ‘One Health’ but has not engaged stakeholders from the environmental sector, nor addressed issues related to environmental impacts linked to disease control and animal production to the extent that is needed.

In Southeast Asia, policy support for improved animal health is being driven by the Association of South-East Asian Nations (ASEAN). One of ASEAN’s objectives is to support sustainable animal health improvements and enhance multi-sectoral cooperation. Southeast Asia encountered its first HPAI outbreaks in 2003 and, since then, more than 140 million birds have died or been destroyed, with losses to the poultry industry estimated at more than US$ 10 billion. Human cases and deaths have also been comparatively high compared to other sub-regions. Since 2003, ASEAN has been in the front line of the battle against HPAI, facilitating partnerships among various sectors under the principle of ‘One Health’ to ensure synergies and complementarities. The 32nd Meeting of the ASEAN Ministers of Agriculture and Forestry declared its commitment to advancing the ‘One Health’ approach and supporting existing collaborative frameworks on animal and public health governance to address vulnerabilities associated with zoonotic diseases. In particular, it encouraged the implementation of the ‘ASEAN Plus Three Joint Recommendations and Work Plan on Animal and Human Health
Collaboration’, and the ‘Call for Action towards the Elimination of Rabies in the ASEAN Member States (AMSs) and Plus Three Countries’.

Thus, ASEAN has developed a roadmap to eradicate HPAI by 2020, using the South East Asia Foot and Mouth Disease (SEAFMD) 2020 Roadmap as one of its main references, and is working to establish a regional coordination mechanism (RCM) on animal health and zoonoses. The RCM’s goal is to establish a unified and broader mechanism for regional coordination to address current priority diseases, as well as provide for effective responses to new, emerging or re-emerging transboundary animal diseases (TADs) and zoonotic disease threats in ASEAN. A number of Member States have put in place national zoonotic committees or collaboration mechanisms between the animal and human health sectors.

The World Organisation for Animal Health and capacity building

Capacity building aimed at enabling Members to strengthen the quality of their national Veterinary Services is one of the five objectives of the Fifth OIE Strategic Plan (2011–2015). The Fifth OIE Strategic Plan applies ‘One Health’ concepts at the human/animal/ecosystems interface and aims to support poverty alleviation and food security by addressing animal and aquatic animal health issues. It also aims to understand and manage the effects of environmental and climate change on animal health and production. Stronger collaboration has been forged between WHO, FAO and the OIE in terms of sharing responsibilities and coordinating global activities to address health risks at the points where animals, humans and ecosystems interact. The key global animal health capacity building activity is the OIE Performance of Veterinary Services (PVS) Pathway, which enables countries, on the basis of national evaluations and gap analyses by trained personnel, to develop strategic plans to support the allocation of resources for Veterinary Services from national budgets or donor organisations. Technical professional matters are examined, as well as governance issues, including legislation and education. Thus far, 99 countries have been evaluated by the OIE PVS system and 34 have undergone an OIE PVS gap analysis. These numbers continue to grow rapidly. Effective and sustainable Veterinary Services are critical to the prevention and management of EIDs.

Although there is not yet an equivalent system for public health systems, application of the PVS can, among its many benefits, enable recommendations to be made on ways of improving cooperation between a country’s Veterinary Services and public health services. Recent events have shown just how important this cooperation can be in dealing with zoonotic diseases such as rabies and HPAI, and indeed with certain types of foodborne diseases. In all these cases, controlling the pathogen at its source in animals can help avoid subsequent public health problems. The importance of adequate budgetary allocations for disease prevention and control, and the usefulness of national joint committees with the participation of both Veterinary Services and Medical Services, aimed at establishing permanent consultation and cooperation, should not be underestimated. Such arrangements unfortunately do not operate in many countries.

Macro-policy opportunities exist, as do technical policy opportunities, based on factors such as networking, information technology (IT), sharing new technologies, surveillance, prediction, laboratory diagnostics, and social/economic issues, including capacity development, the role of communities, gender, etc.

Some examples of ‘One Health’ developments

A number of practical activities are in place or are being developed to support the Ministerial Declarations and ‘One Health’. The following examples demonstrate the policy value of ‘One Health’ approaches.
Meetings and consultations

In 2010, numerous events were held on this topic, including the United Nations System Influenza Coordination pandemic preparedness meetings (Thailand, various dates); the Asia-Pacific Economic Cooperation ‘One Health’ meeting (the Philippines, 8 to 10 February); the 16th Federation of Asian Veterinary Associations Congress (the Philippines, 15 to 18 February); the First International One Health Congress (Australia, 14 to 16 February); and the OIE Global Conference on Wildlife (France, 23 to 25 February). More activities are in the pipeline, aiming to better understand and implement ‘One Health’.

Countries promoting ‘One Health’

Slowly, interest in adopting ‘One Health’ is growing. In Asia, Thailand, Indonesia, Vietnam, India, Bangladesh, and the Philippines are promoting the ‘One Health’ approach by way of conferences, symposiums and other activities.

The Philippines Inter-Agency Committee on Zoonoses

One example of a national joint committee structure is the proposed Philippines Inter-Agency Committee on Zoonoses (PhICZ), which aims to institutionalise collaboration between the animal, human and ecosystem sectors. This is in recognition of the need to ensure early detection of diseases and react rapidly and effectively to such events. This Committee will seek to harness the strengths of each organisation, synergise actions and use resources efficiently and effectively. Existing collaborative mechanisms will be strengthened to control and eventually eliminate, where possible, existing zoonoses.

A technical working group, composed of members from the Departments of Health; Agriculture; and the Environment and Natural Resources, is currently developing the release of Executive and Administrative Orders to formally establish PhICZ. It is intended that WHO, the OIE and FAO will act as advisers to PhICZ.

Australian Animal Health Laboratory

The Australian Animal Health Laboratory’s (AAHL) mission is to protect Australia’s livestock and aquaculture industries, and the general public, from emergency and zoonotic disease threats. In essence, AAHL is a national, high-security, bio-containment laboratory working on pathogens that affect both animals and people. It is also an OIE Collaborating Centre for New and Emerging Diseases and functions as a reference laboratory for several animal diseases. In addition, it is an OIE Collaborating Laboratory for Capacity Building and WHO Collaborating Centre for SARS.

As part of its responsibility as an OIE Collaborating Laboratory for Capacity Building and its reference laboratory roles, AAHL has a large number of projects in Southeast Asia related to capacity building and research with the major TADs, including avian influenza, FMD and classical swine fever. The AAHL’s projects are focused on improving disease diagnosis in the region and also at the AAHL itself.

Conclusion

Many animal and human diseases, some of which are zoonotic, have emerged or re-emerged over recent decades. The socio-economic impacts of some of these diseases have ranged from serious to catastrophic, and have adversely affected biodiversity. Responding to the multitude of issues raised in this paper and involved in managing such diseases presents major challenges. ‘One Health’
Illustrating contributions to public health

approaches provide an excellent opportunity to improve the prevention and management of high-impact diseases in a sustainable way, and it is pleasing to note that the global health community is supportive of this approach and is implementing change in a progressive manner. Sustained, well-coordinated, multi-sectoral, multi-disciplinary and community-based coordination and cooperative actions that address threats arising at the animal-human-environment interface will also support the wide range of related policy agendas agreed at the international level. In this regard, it is important that greater attention be given to wildlife and ecosystem health so that it becomes more of a mainstream concern.

References


Domestic animal health programmes to protect wildlife

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Summary

The transmission of infectious diseases between domestic animals and wildlife populations has many implications for wildlife conservation and the management of protected wildlife areas. Here, the authors discuss these issues with reference to large rangeland ecosystems in Africa, exploring the role that domestic animal health programmes may play in the development of integrated conservation strategies. Specifically, the authors examine how domestic animal health programmes can influence and mitigate disease-related impacts on wildlife populations and natural resources, considering, as examples: domestic animal diseases that are a direct cause of population declines in endangered species (e.g. rabies, canine distemper); livestock diseases that have been a major factor in shaping ecosystem dynamics (e.g. rinderpest); and wildlife infections transmitted to livestock that affect rural livelihoods and land-use policy (e.g. malignant catarrhal fever, trypanosomosis, foot and mouth disease). The authors use these examples to explore key interactions affecting wildlife conservation and rural development, and the complex interface between domestic and wildlife health, delivery of ecosystem services, and human well-being.

Keywords


Domestic animal diseases can pose a threat to wildlife and areas in which wildlife are protected as a result of both direct and indirect mechanisms. These threats arise in several different contexts:

– where transmission of infectious diseases from domestic animals poses a direct extinction threat to endangered populations

– where transmission of infectious diseases from domestic animals has important ecological consequences as a result of impacts on key wildlife species, and

– where transmission of infectious diseases from wildlife threatens livestock production and livestock economies, with consequences for land-use policy and protected-area management (Fig. 1).
As a consequence of these relationships, disease control programmes targeting domestic animals can result in benefits to the health of both wild and domestic animals and, in certain circumstances, the ecosystem itself.

![Diagram illustrating relationships of wildlife, domestic animal health and production](image)

**CDV**: canine distemper virus  
**FMD**: foot and mouth disease  
**FeLV**: feline leukaemia virus  
**MCF**: malignant catarrhal fever

**Fig. 1**
Direct and indirect impacts of disease transmission on wildlife

**Transmission of infectious diseases from domestic animals to wildlife**

The greatest extinction threat to endangered wildlife populations arises from spill-over transmission from domestic animal reservoirs, which has been documented in several systems (Table I). The vast majority of wild mammal species threatened by diseases (88%) are from the orders Carnivora or Artiodactyla, within families that also include the most common livestock and companion animal species (13). Exacerbated by the abundance and global distribution of domestic mammals, the close phylogenetic relationship with these endangered wildlife species heightens the risk of cross-species transmission. Given that over 80% of livestock and domestic carnivore pathogens can also infect wildlife, it is not surprising that wildlife species in these lineages are at greatest risk from domestic animal diseases (13).

**Table I**
Endangered wildlife populations threatened by transmission of infectious diseases from domestic animals

<table>
<thead>
<tr>
<th>Threatened host</th>
<th>Pathogen/disease</th>
<th>Suggested source population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopian wolf (<em>Canis simensis</em>)</td>
<td>Rabies</td>
<td>Domestic dogs</td>
</tr>
<tr>
<td>Ethiopian wolf</td>
<td>Canine distemper</td>
<td>Domestic dogs</td>
</tr>
<tr>
<td>African wild dog (<em>Lycaon pictus</em>)</td>
<td>Rabies</td>
<td>Domestic dogs</td>
</tr>
<tr>
<td>African wild dogs</td>
<td>Canine distemper</td>
<td>Domestic dogs</td>
</tr>
<tr>
<td>African lions (<em>Panthera leo</em>)</td>
<td>Canine distemper</td>
<td>Domestic dogs</td>
</tr>
</tbody>
</table>

Compendium of the OIE Global Conference on Wildlife
Table I (cont.)

<table>
<thead>
<tr>
<th>Threatened host</th>
<th>Pathogen/disease</th>
<th>Suggested source population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baikal seal (Phoca sibirica)</td>
<td>Canine distemper</td>
<td>Domestic dogs</td>
</tr>
<tr>
<td>Channel Island fox (Urocyon littoralis)</td>
<td>Canine distemper</td>
<td>Domestic dogs</td>
</tr>
<tr>
<td>Crab-eater seals (Phoca vitulina)</td>
<td>Canine distemper</td>
<td>Domestic dogs</td>
</tr>
<tr>
<td>Iberian lynx (Lynx pardinus)</td>
<td>FeLV</td>
<td>Domestic cats</td>
</tr>
<tr>
<td>Florida panther (Puma concolor coryi)</td>
<td>FeLV</td>
<td>Domestic cats</td>
</tr>
<tr>
<td>Arctic foxes (Alopex lagopus semenovi)</td>
<td>Otodectic mange</td>
<td>Domestic dogs</td>
</tr>
<tr>
<td>White-nosed coati (Nasua narica)</td>
<td>Notoedric mange</td>
<td>Domestic cats</td>
</tr>
<tr>
<td>Sea otters (Enhydra lutris nereis)</td>
<td>Toxoplasmosis</td>
<td>Domestic cats</td>
</tr>
<tr>
<td>Bighorn sheep (Ovis canadensis)</td>
<td>Pasteurella</td>
<td>Domestic livestock</td>
</tr>
<tr>
<td>Chamois (Rupicapra rupicapra)</td>
<td>Infectious keratoconjunctivitis</td>
<td>Domestic sheep</td>
</tr>
<tr>
<td>Hirola antelope (Beatragus hunteri)</td>
<td>Rinderpest</td>
<td>Cattle</td>
</tr>
</tbody>
</table>

FeLV: feline leukemia virus

Strategies to control transmission of infectious diseases from domestic animals to wildlife

Control of domestic animal diseases to reduce risks to endangered species clearly has a role in conservation management. However, a strategy focusing on domestic animals represents only one of several options, which are not mutually exclusive. Additional approaches include direct protection of the endangered population (e.g. through vaccination/treatment) and ‘blocking strategies’ to prevent contact and transmission between domestic and wild animals. For example, direct vaccination of wildlife has been carried out to protect Ethiopian wolves (Canis simensis) against domestic dog rabies (7) and to protect Iberian lynx (Lynx pardinus) against feline leukaemia virus (FeLV) (10). The removal of feeding stations was also implemented as part of a multi-pronged disease control strategy to reduce contact and transmission of FeLV from domestic cats to the Iberian lynx (10).

Several factors need to be considered in assessing whether domestic animal disease control is likely to be a feasible, appropriate and cost-effective strategy for protecting wildlife.

Is intervention necessary?

At the outset, the threat to wildlife needs to be evaluated to decide whether intervention is necessary or not. While infection and outbreaks of disease associated with domestic animals have often been documented in wildlife, the consequences for long-term population declines and extinction have only rarely been quantified. Wildlife populations can, and do, recover from infectious disease outbreaks. However, it is also clear that virulent pathogens that cause high adult mortality in small populations, particularly in social species, have the potential to cause extinction. This has been demonstrated empirically by the local extinction of African wild dogs (Lycaon pictus) following outbreaks of rabies in the Serengeti National Park (20), and through population viability analyses quantifying extinction risks associated with disease in Ethiopian wolves (6).
Understanding infection dynamics in multi-host populations

When considering whether disease control programmes aimed at the domestic animal level will be feasible and effective, it is important to understand the role that the specific domestic species plays in the epidemiology of multi-host pathogens. Where domestic animals act as the only maintenance hosts (as in the case of cattle with rinderpest), disease control measures not only reduce spill-over transmission, but have the potential to eliminate infection entirely. Conversely, where infection is maintained in other wildlife species, domestic animal control programmes will only have limited success in protecting wildlife, reducing transmission only in the proportion of hosts that act as a direct source of infection (i.e. as ‘liaison’ hosts). Rabies illustrates these examples well. Where domestic dogs are the sole maintenance hosts for rabies, as has been demonstrated in the Serengeti (8), rabies has been eliminated in large parts of the ecosystem through domestic dog vaccination alone (9). Where rabies is maintained in other species, e.g. vampire bats in South America, raccoons (*Procyon lotor*) and skunk spp. in North America, and yellow mongooses (*Cynictis penicillata*) in South Africa, domestic dog vaccination will serve only to prevent occasional transmission events (i.e. from dogs that are acting as a link in the transmission chain), with no impact on the long-term persistence of the virus.

The benefits of eliminating rabies through dog vaccination are substantial. From a conservation perspective, African wild dog populations have re-established themselves in rabies-free areas of the Serengeti, and the population is showing a dramatic recovery, with growth rates estimated at 17% per annum (A. Dobson, personal communication). Canine rabies is now almost entirely absent from the Serengeti National Park, whereas recurrent outbreaks, particularly in bat-eared foxes (*Otocyon megalotis*), were documented throughout the 1990s (8). Public health impacts have also been important, with a dramatic decline in people’s exposure to rabies and demand for costly post-exposure vaccines (9). These tangible benefits ensure the continuing popularity of dog vaccination campaigns in local communities, which, combined with greatly reduced risks for wildlife, suggests that domestic dog rabies vaccination, as a veterinary intervention, can provide a genuine ‘win-win’ scenario for both parks and people.

While domestic dog rabies vaccination campaigns have clear benefits, the situation regarding canine distemper virus (CDV) differs in key aspects, and our understanding of its epidemiology is less clear (Table II). Despite evidence that domestic dogs were the source of the 1994 CDV outbreak that caused dramatic mortality in lions (*Panthera leo*), hyaenas (*Crocuta crocuta*) and other wild carnivores in the Serengeti (14), a clear understanding of CDV circulation and maintenance patterns has since been difficult to unravel, largely because analyses have relied on serological data, which provide only rather coarse insights into temporal patterns of infection and transmission pathways, in comparison with detailed transmission histories and sequence data analyses available for the interpretation of rabies epidemiology (reviewed in 9). Immunisation against CDV is included in the mass dog vaccination campaigns around the Serengeti. However, the same levels of vaccination coverage that achieved the elimination of rabies have not resulted in the elimination of CDV, with evidence that the virus continues to circulate, albeit at low levels, in both domestic dogs and wildlife populations.

A further complication is that CDV appears to have highly variable outcomes in wild carnivore populations. Although 30% of lions died during the 1994 epidemic, age-seroprevalence data demonstrate clearly that lions have been infected with CDV on several other occasions, with no associated morbidity or mortality (11). Similarly, in some African wild dog packs, high CDV seroprevalence levels indicate widespread recovery from infection, whereas in other packs, mortality in CDV outbreaks can exceed 90% of individuals (1). It is likely that co-factors are important contributory causes in determining CDV pathogenicity. For example, lions in Serengeti and...
Ngorongoro have only shown signs of disease when infected with CDV during periods of drought and when experiencing a high intensity of Babesia infection (11).

**Table II**

**A comparison of rabies and canine distemper virus epidemiology and control in the Serengeti**

<table>
<thead>
<tr>
<th>Feature of disease</th>
<th>Rabies</th>
<th>Canine distemper virus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance hosts/reservoirs</td>
<td>Domestic dogs identified as sole maintenance hosts; wildlife sustain only short chains of transmission</td>
<td>Role of wildlife hosts uncertain</td>
</tr>
<tr>
<td>Clinical disease</td>
<td>Invariably fatal, once clinical signs appear</td>
<td>Recovery possible with long-lived immunity</td>
</tr>
<tr>
<td>Pathogenicity</td>
<td>~50% domestic dogs exposed to rabies succumb to fatal infection</td>
<td>Highly variable; case-fatality rates likely to depend on co-factors</td>
</tr>
<tr>
<td>R₀ in domestic dogs</td>
<td>Values of R₀ consistently low (&lt;2), irrespective of dog population density</td>
<td>Few estimates, values likely to be higher than for rabies</td>
</tr>
<tr>
<td>Vaccine availability</td>
<td>Inactivated vaccines; oral vaccines available. Vaccines relatively cheap</td>
<td>Live, attenuated vaccines; oral vaccines not widely available. Commercial vaccines relatively expensive</td>
</tr>
<tr>
<td>Other benefits</td>
<td>Public health benefits include reduced human mortality and reduced expenditure on post-exposure vaccines; benefits in terms of reduced livestock losses; improved life expectancy of domestic dogs and possible decreased turn-over of dog population</td>
<td>Improved life expectancy of domestic dogs; possible decreased turn-over of dog population</td>
</tr>
<tr>
<td>Cost-effectiveness</td>
<td>Likely to be cost-effective when integrated within a public health programme</td>
<td>Cost-effectiveness uncertain</td>
</tr>
</tbody>
</table>

R₀: Basic Reproduction Number

In terms of population impact, the lion populations recovered very rapidly from the 1994 outbreak, with numbers currently at an all-time high, despite the presence of CDV in the ecosystem. In contrast, although African wild dog numbers have been increasing, and despite domestic dog vaccination campaigns, CDV has affected the recovering populations, with deaths recorded in 23 out of 38 individuals in 2007, in one pack near the north-eastern boundary of the Serengeti National Park (4). Although CDV continues to circulate at low levels in domestic dogs in the vaccination zone adjacent to the Serengeti National Park, this outbreak may have been linked with a CDV outbreak in domestic dogs close to the Maasai Mara National Reserve, in the Kenyan part of the Serengeti ecosystem, in early 2007. This highlights a potential problem of vaccinating in only a limited cordon sanitaire, which may be insufficient to protect wide-ranging African wild dogs. The recovery of both lion and African wild dog populations, even in the face of persistent CDV infection, raises questions as to whether CDV control in domestic dogs is essential for conservation management in the Serengeti, particularly given the high costs of CDV vaccines in comparison with rabies vaccines.

**Additional benefits**

From the perspective of conservation management, the primary motivation for domestic animal control programmes is to protect endangered wildlife, and not to achieve more widespread disease control outcomes. Nonetheless, secondary benefits for public health, livestock production or domestic dog health can be extremely important factors in enhancing the acceptability and feasibility of interventions involving local communities. Many generalist pathogens that threaten wildlife species are also
zoonoses (e.g. rabies, bovine tuberculosis, anthrax, toxoplasmosis) or diseases of importance to the livestock sector (e.g. rinderpest, peste des petits ruminants, bovine tuberculosis), creating opportunities for sharing benefits and costs across the public health, livestock and wildlife sectors. Although the practical and political difficulties of integrating programmes across sectors means that, in reality, shared programmes have rarely occurred, the widespread promotion of ‘One Health’ approaches may act as a catalyst for new cross-sectoral initiatives, in which the priorities of wildlife conservation, public health and livestock economies are managed within a more inclusive framework.

Where transmission from domestic animals has important ecological consequences as a result of impacts on key wildlife species

Transmission of infectious disease from domestic animals to wildlife species can have profound ecological consequences beyond the species primarily infected. In such circumstances, control measures, designed with the aim of enhancing livestock production or companion animal health, can also have major conservation benefits. For example, vaccination of cattle against rinderpest, while primarily conducted as part of a pan-African rinderpest eradication campaign, has had major impacts on wildlife in the Serengeti ecosystem. Following the introduction of cattle vaccination campaigns in the 1950s and 1960s, the size of the wildebeest (Connochaetes taurinus) population increased five-fold to current levels of about 1.3 million animals, as a result of removing rinderpest-induced mortality, principally in yearlings. The impact of increasing wildebeest numbers has resulted in a suite of trophic cascades, mediated through changes in vegetation, fire and predator-prey dynamics (16). A veterinary intervention in cattle thus represents one of the most profound ecological perturbations experienced by the Serengeti ecosystem. It is no exaggeration to say that domestic animal disease control is largely responsible for the spectacle that we witness today of the world’s largest surviving migration of wild mammals.

Transmission of infectious diseases from wildlife to domestic animals

In addition to posing a direct threat to endangered species, domestic animal diseases have conservation relevance as a cause of livestock production losses, which directly affect land-use policy, attitudes to wildlife and patterns of wildlife use. In conservation terms, these impacts are most acute in livestock-keeping communities that live in and around protected wildlife areas, and conflicts invariably arise in situations where diseases in livestock are caused by the transmission of pathogens from wildlife. As a result, control of domestic animal diseases can play an important role in mitigating livestock-wildlife conflicts that often result in people taking actions that are harmful to wildlife, and can help support land-use policies that allow for a more sustainable co-existence.

These conflicts are not unique to Africa; the transmission of bovine tuberculosis from badgers (Meles meles) to cattle in England, and of brucellosis from bison (Bison bison) in the Yellowstone ecosystem have led to divisions between the livestock sector and wildlife conservationists. In sub-Saharan Africa, threats to livestock production from wildlife are commonly associated with malignant catarrhal fever (MCF), trypanosomosis, foot and mouth disease (FMD), and African swine fever.

Wildebeest-associated malignant catarrhal fever

Wildebeest-associated MCF is a gammaherpes virus that is transmitted by asymptomatic infected wildebeest and causes fatal disease in cattle. The disease is a major source of land-use conflict across eastern and southern Africa and, for pastoralists reliant on livestock production for food security and income, MCF contributes substantially to widespread poverty and malnutrition. For example, Maasai pastoralists in the Ngorongoro district, living in communities on the eastern Serengeti plains, consistently record losses of around 5% of cattle per annum to MCF, with mortality occurring mainly in adults (2). As the disease is primarily transmitted by wildebeest calves, Maasai are
effectively forced to avoid the prime grazing lands of the short grass plains during the wildebeest calving season. The increase in wildebeest numbers and expansion of the migration over the past 30 years has led to Maasai cattle becoming increasingly confined to non-productive highland and woodland pastures each wet season. The consequences are profound. First, cattle production is decreased through reduced access to salt and to high-quality forage. Secondly, because cattle must be confined in highland areas at relatively high densities, they acquire an increased burden of vector-borne and directly transmitted diseases. Thirdly, the increased concentration of cattle in the fragile highland ecosystems contributes to over-grazing, deforestation, uncontrolled burning and soil erosion (17). Poor livestock production has resulted in families becoming trapped in a cycle of poverty, with insufficient animals to meet food and subsistence demands and a growing dependence on grain. Inexorably, families are forced to sell their animals to raise cash, which further reduces their livestock resources and drives them further into destitution.

Although the decline in pastoralist livelihoods may not appear to be a factor of immediate concern for wildlife conservation, the implications may be serious. Concern about food security has been a major factor behind the recent expansion in crop cultivation in critical buffer zones and wildlife corridors adjacent to the Serengeti and Tarangire National Parks in northern Tanzania. While small-scale cultivation may arguably have few impacts on wildlife, the replacement of traditional pastoralism with large-scale cultivation is of great concern, with major declines in wild ungulate populations being recorded in areas adjacent to the Maasai Mara, as a result of conversion of rangelands to mechanised agriculture (15).

Recent advances in the development of immunisation strategies against MCF (5) suggest that cattle vaccination may provide a solution to some of these land-use conflicts, supporting traditional practices of livestock-keeping and slowing the conversion of rangelands. Nonetheless, uncertainties still remain as to the consequences of increased wildlife-livestock co-existence; for example, the additional levels of grazing that can be tolerated without compromising biodiversity, the potential for exacerbating human-wildlife conflict (e.g. through increasing livestock predation), and the ecological impacts from increased human activity in these areas.

Trypanosomosis

One of the earliest instigators of conflict between livestock-owners and those protecting wildlife areas was the tsetse fly and the trypanosomes that it carries, illustrated by the large-scale culls of wildlife in the early 20th Century, in an attempt to clear areas of trypanosomosis for cattle production. Wildlife represent the natural hosts for \textit{Trypanosoma congolense}, \textit{T. vivax} and \textit{T. simiae}, all important livestock pathogens. These trypanosomes can be maintained in sylvatic cycles and transmitted by the tsetse vector to the domestic livestock with which they come into contact. This has resulted in large tracts of land across sub-Saharan Africa being unusable for livestock production, and has historically helped to preserve areas which have become today’s wildlife reserves.

However, with increasing human populations and increasing demand for land, people and livestock are moving into areas where tsetse and trypanosomosis are prevalent. For example, the introduction of cattle into tsetse areas of the Rift Valley in Ethiopia from the tsetse-free highlands, which have suffered from over-grazing, has led to trypanosomosis epidemics (3). Interface areas where livestock-keeping communities border protected wildlife areas present the biggest challenge. Protected areas with suitable vegetation can sustain large tsetse populations and high wildlife densities which can maintain trypanosome circulation, providing a source of infection which puts surrounding livestock at risk. In addition, trypanosomes maintained predominantly by wildlife appear to cause more severe disease in cattle: \textit{T. congolense} strains from sylvatic cycles have higher virulence in susceptible hosts than those that circulate in livestock-only areas (18).
Although trypanosomosis control has progressed from the days when wildlife eradication and bush clearance were widely practised, control programmes that balance livestock and wildlife priorities can be difficult to achieve. Successful control can bring about increased production, both directly, as livestock disease decreases, and indirectly, for example through increased availability of traction, and the ability to mix small-scale arable and pastoral agriculture. However, even small-scale increases in agricultural production after tsetse control operations lead to changes in vegetation, which have been associated, for example, with altered bird species composition (19). Disease control programmes focused on the tsetse vector are often unsuccessful; small-scale community programmes are difficult to sustain, and national or regional programmes require long-term investment, whether they are aimed at human or livestock trypanosomosis. Incorporating animal health programmes, which engage farmers by improving diagnosis, enabling access to trypanocides and insecticides, and enlarging their knowledge in how to use these substances cost-effectively, may be more effective at improving livestock health whilst maintaining biodiversity. However, this requires investment in Veterinary Services and coordination between wildlife and livestock health sectors.

Foot and mouth disease

In southern Africa, veterinary fences have traditionally been used to separate livestock and wildlife, primarily to prevent the transmission of FMD virus, which poses a threat to livestock economies based on lucrative meat export markets. These fences allow the establishment of strictly enforced disease protection zones, which act as buffers for the ‘disease-free’ commercial sector. However, these fences come at a high ecological cost, disrupting wildlife migration patterns and fragmenting landscapes. Furthermore, as the economic benefits of wildlife-based tourism become recognised, and new trade options develop for meat exports, a reappraisal of land-use policy is under way, with growing political and conservation momentum for the creation of unfenced transfrontier conservation areas (12).

While the removal of veterinary cordon fences is likely to be beneficial for wildlife conservation, challenges remain, particularly with respect to minimising risks from wildlife-transmitted diseases. In these future scenarios, developing effective domestic animal disease control programmes will be crucial to foster sustainable co-existence between wildlife and livestock, and research efforts need to address these specific issues, focusing on the development of effective vaccination strategies against MCF, FMD, bovine tuberculosis and brucellosis, and of effective treatments for trypanosomosis.

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References


Land-use paradigms, wildlife and livestock: southern African challenges, choices and potential ways forward

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Summary

One of the most ambitious and potentially significant conservation developments taking place in southern Africa today is the formation of transfrontier conservation areas (TFCAs), which may incorporate national parks, game and forest reserves, hunting areas and conservancies embedded within a matrix of land under traditional communal tenure. The TFCAs provide extraordinary biodiversity conservation and sustainable development opportunities, and are a top priority for the Southern African Development Community. Nature-based tourism (photographic safaris, trophy hunting, etc.), the primary economic driver of TFCA development, now contributes about as much to the gross domestic product of southern Africa as agriculture, forestry and fisheries combined – a remarkable and relatively recent development, documented by the Millennium Ecosystem Assessment. However, the management of wildlife and livestock diseases (including zoonoses) within proposed TFCAs presents a range of emerging policy issues of major concern to livestock production, associated access to export markets, public health and rural development in the region. The authors outline the context in which current development issues and land-use dilemmas have arisen, and note that southern Africa’s global comparative advantage lies in its unique wildlife resources. The ecological constraints inherent in southern Africa’s rangelands place it at a disadvantage in competing with South America, for example, in beef export markets to Europe. The authors examine mitigating strategies and potential ways forward for both livestock- and wildlife-based land uses in TFCAs. These include the management of multi-species systems that match ecological spatial scales, the development of new approaches to trade and marketing, such as commodity-based trade, and the need for policies that allow rural communities within TFCAs to realise the full value of wildlife- and nature-based tourism. Over the past eight years, the Wildlife Conservation Society and its partners in the Animal and Human Health for the Environment and Development programme have learned a range of lessons on the programmatic and animal health policy challenges facing TFCA initiatives. Among these is the need for better information across a range of disciplines, on which to base sound policies. The authors conclude that TFCAs have the potential to offer effective regional risk
diversification of land-use options and livelihood opportunities that will serve to enhance resilience in the face of climate change and food security challenges.

Keywords


Introduction

How should southern Africa’s mostly arid-to-semi-arid rangelands be used to generate wealth to support its largely agriculturally based rural population, the greater proportion of which comprises small-scale subsistence farmers? The prevailing approach during the 20th Century was to promote commercial livestock development with an emphasis on producing beef for high-value export markets in Europe and North America. Small-scale farmers were encouraged, with limited success, to participate in commercial livestock production. Those farming in areas where foot and mouth disease (FMD) was prevalent were excluded from export zones. Large wild herbivores were seen to be competing with domestic stock for grazing and as the primary reservoir of livestock diseases. The result was that wildlife areas were separated, usually by fences, from those designated for livestock production. Game reserves and larger national parks were therefore mostly relegated to peripheral, low-lying, disease-ridden areas of southern African states. Today, a very high proportion of the region’s larger conservation areas lie on international boundaries and are well placed to participate in transfrontier conservation initiatives (2).

During the 1960s, very largely as a result of Julian Huxley’s writings (9), there was a brief period when Africa’s wildlife was seen as a means of meeting the protein needs of the continent’s burgeoning human population. Game ranching and cropping schemes for commercial meat production were promoted. However, the harvesting and marketing of meat were soon curtailed in the face of constraining veterinary and public health regulations and the unexpected negative responses of some species to cropping (15).

By the 1980s, the value of southern Africa’s wildlife as a pillar of nature-based tourism (photographic safaris, trophy hunting, etc.) was being realised. By the turn of the century, it was contributing about as much to the gross domestic product (GDP) of southern Africa as agriculture, forestry and fisheries combined – a remarkable development, documented by the Millennium Ecosystem Assessment (19). Associated with this development was the realisation that linking peripheral conservation areas into transboundary national parks promised to meet the demands of a growing tourism market and achieve the region’s wider conservation and rural development objectives. ‘Peace Parks’ and the transfrontier conservation area (TFCA) movement were effectively initiated in southern Africa with the creation of the Kgalagadi Transfrontier Park in May 2000 and the signing of the treaty to establish the Great Limpopo Transfrontier Park in November 2002. Some 14 terrestrial TFCAs, most of which include state-protected areas and an intervening matrix of traditional communal lands, are presently under development in southern Africa (Fig. 1). They vary in size from 2,000 km² to 400,000 km² (Table I) and cover a combined area of more than 1,200,000 km². These TFCAs include within their borders many of sub-Saharan Africa’s highest priority biodiversity conservation areas.

However, the management of wildlife and livestock diseases (including zoonoses) within existing and proposed TFCAs (Fig. 1) (Table I) presents an emerging policy issue of major concern to livestock...
production, associated access to export markets and other sectors, including public health, in the region (14). It is also of major concern to conservation initiatives in the region, since disease control methods may entail the erection of fences, the maintenance of existing fences, the elimination of certain valuable large mammal species (such as buffalo) and constraints on the re-introduction of valuable species to areas where they previously occurred.

![Map of southern Africa and transfrontier conservation areas](image)

**Fig.1.**
*Map of southern Africa and transfrontier conservation areas, showing the major protected areas and the locations of 14 transfrontier conservation areas in southern Africa*

Southern Africa is defined here as including Angola (Ang), Zambia (Zm), Tanzania (Tz) and the countries lying to the south of these countries; namely: Botswana (Bw), Lesotho (Le), Malawi (Mw), Mozambique (Mz), Namibia (Na), South Africa (SA), Swaziland (Sw) and Zimbabwe (Zw).

The numbers adjacent to each transfrontier conservation area are provided, together with their names, in Table I.

Here, the authors examine the major disease management challenges, choices and potential solutions that come into play in meeting the nature-based tourism and conservation objectives of TFCAs and the rural development objectives of improving livestock production and market access for small-scale farmers living within TFCAs. Nature-based tourism also seeks to contribute to development objectives and improving the livelihoods of the rural poor but it is constrained in much of the region by existing policy frameworks and inappropriate scales, which TFCAs seek to correct (21).
## Table I
Important diseases of wildlife, domestic animals and humans and their distribution in the Transfrontier Conservation Areas being developed in southern Africa (adapted from 2)

<table>
<thead>
<tr>
<th>TFCA</th>
<th>Area km²</th>
<th>Foot and mouth disease</th>
<th>Bovine tuberculosis</th>
<th>Brucellosis</th>
<th>Canine distemper virus</th>
<th>Contagious bovine pleuropneumonia</th>
<th>African Trypanosomiasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Kavango-Zambezi</td>
<td>400,000</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2. Niassa-Selous</td>
<td>96,200</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>3. Great Limpopo</td>
<td>87,000</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>4. Kgalagadi TFP</td>
<td>37,256</td>
<td>?</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>5. Iona-Skeleton Coast</td>
<td>32,000</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>6. Lower Zambezi-Mana Pools</td>
<td>25,000</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>7. Drakensberg-Maloti</td>
<td>13,000</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>8. Liwue Plain-Musumba</td>
<td>10,000?</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>9. IAI-Ais-Richtersveld</td>
<td>6,681</td>
<td>?</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>10. Greater Mapungubwe</td>
<td>4,872</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>11. Lubombo</td>
<td>4,195</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

W: may infect wildlife
D: may infect domestic animals
H: may infect humans
TFP: Transfrontier Park

*: reported from one or more countries involved in the TFCA and likely to be present in the TFCA
?: status uncertain
+: in southern Africa, two Trypanosoma sub-species are involved, one of which causes nagana of domestic stock and the other causes human sleeping sickness


**Context, issues and dilemmas**

Historical contingency and several present-day contextual issues have an important bearing on the dilemmas presently facing policy-makers and the development of TFCAs in southern Africa (Fig. 1). Human populations in the region have grown twenty-fold over the last century and are continuing to increase at a rate of 2% to 3% per annum. The rural population of the region comprises more than 50% of the total population, compared with less than 10% in developed nations. Combined with high levels of poverty and unemployment, these factors place increasing strain on natural resources, such as grazing, woodlands and non-timber forest products, and on wildlife. They also provide a strong constituency urging improved rural development and access to markets for livestock products. However, ecological constraints to improved animal production in extensive rangelands are severe in more than 60% of the region, where rainfall is low and uncertain. Where rainfall is higher and more predictable, soils tend to be leached and nutrient poor, a factor that also limits the range of animal production (Fig. 2). The combination of ecological constraints and human population growth in the region has resulted in a continuing decline in *per capita* production of protein and cereals since 1960 (2). The region has thus become a net importer of foods.

**Fig. 2**

*Relationship between mean annual rainfall (mm) and biomass (kg.km⁻²) of large herbivores (livestock + wildlife) in southern African countries*

The dashed line, inserted by hand, indicates the link between rainfall and large herbivore biomass in countries with eutrophic soils, while the cluster of countries with low biomass in relation to rainfall (Ang, Mw, Mz, Zm) are characterised by predominantly dystrophic soils and large areas with tsetse fly. Botswana also has large areas of dystrophic soils. Countries are Angola (Ang), Botswana (Bw), Lesotho (Le), Malawi (Mw), Mozambique (Mz), South Africa (Za), Tanzania (Tz), Zambia (Zm) and Zimbabwe (Zw)

Source: (5) and Food and Agriculture Organization of the United Nations

With regard to livestock production and disease management, particularly in relation to FMD, the countries of southern Africa have been locked into an outmoded colonial paradigm focused on exporting beef to Europe (20). This focus began in the early 1900s and was stimulated by an increasing demand for beef in Britain and Europe (16). However, despite continuing state subsidies, it has largely failed on both economic and production grounds. South American countries and those in...
Europe are able to produce up to 20 times more meat or milk, per person and per animal, than southern Africa (2). Production levels for commercial herds, let alone communal herds, are very low compared with those of Argentina, Brazil and Europe (Table II). Small-scale communal farmers use their livestock as they would a bank and seldom actively participate for long in commercial livestock production schemes. Livestock, of course, also provide agro-pastoral households with many additional and valuable services, such as draught power, milk, manure, hides and meeting traditional obligations (1).

**Table II**

A comparison of human population density, proportion of the population engaged in agriculture, number of cattle per person and levels of meat production for four southern African countries and three South American countries that form the primary competitors in exporting beef to Europe and North America

<table>
<thead>
<tr>
<th>Country</th>
<th>Human population (people/km²)</th>
<th>Agricultural population (%)</th>
<th>Cattle/person of total population</th>
<th>Meat per person (kg)</th>
<th>Meat per cow (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botswana</td>
<td>3.15</td>
<td>43</td>
<td>1.3</td>
<td>18.5</td>
<td>14.6</td>
</tr>
<tr>
<td>Namibia</td>
<td>2.48</td>
<td>44</td>
<td>1.2</td>
<td>20.5</td>
<td>16.8</td>
</tr>
<tr>
<td>South Africa</td>
<td>40.27</td>
<td>11</td>
<td>0.3</td>
<td>16.4</td>
<td>57.5</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>31.90</td>
<td>58</td>
<td>0.4</td>
<td>7.8</td>
<td>18.0</td>
</tr>
<tr>
<td>Mean</td>
<td>19.15</td>
<td>39</td>
<td>0.8</td>
<td>15.8</td>
<td>26.7</td>
</tr>
<tr>
<td>Argentina</td>
<td>14.22</td>
<td>8</td>
<td>1.3</td>
<td>71.7</td>
<td>55.8</td>
</tr>
<tr>
<td>Brazil</td>
<td>22.47</td>
<td>12</td>
<td>1.1</td>
<td>37.1</td>
<td>35.1</td>
</tr>
<tr>
<td>Uruguay</td>
<td>18.95</td>
<td>10</td>
<td>3.7</td>
<td>167.7</td>
<td>45.3</td>
</tr>
<tr>
<td>Mean</td>
<td>18.54</td>
<td>10</td>
<td>2.0</td>
<td>92.1</td>
<td>45.4</td>
</tr>
</tbody>
</table>

Set against southern Africa's globally uncompetitive use of rangelands for meat production from domestic livestock is the enormous gain being realised by nature-based tourism. Southern (and eastern) Africa's competitive advantage in generating wealth from its savannahs and rangelands lies in its incomparable, charismatic large mammals, which form a major attraction for tourists from all over the world, as well as locally. It is therefore not surprising that the contribution of nature-based tourism to the economy of southern Africa is growing rapidly, at 5% to 15% per annum. Furthermore, it is expected to continue to do so, in contrast to a growth in domestic animal production at 1% to 3% per annum (19). In Namibia, the growth of community involvement in natural resource management through the establishment of community conservancies is impressive. Direct benefits to communities have increased from about US$ 23,000 in 1995 to more than US$ 6.5 million in 2009 (11). The value of game ranching on private land in South Africa is considered to exceed that of the country's dairy industry, with typical game ranches generating US$ 30 per ha compared with US$ 11.4 per ha from conventional livestock farming (7). Recent analyses of the economic advantages of controlling FMD in Zimbabwe and elsewhere in Africa (e.g. 16, 18) do not consider the adverse effects that current approaches to FMD control (such as fencing and game elimination) may have on other land uses. This is particularly true for the dry lands of Africa, where land uses based on biodiversity (e.g. 1, 11, 21) may be more appropriate. The dangers of ‘single resource decisions that result in multiple resource consequences’ in relation to disease management and control have been noted by Cumming (3).

Despite the growth and promise of nature-based tourism in generating wealth, its performance in terms of improving rural livelihoods in the region’s communal lands and within TFCAs has, other than in Namibia, mostly not been realised. In general, rural communities have not been able to access the
full range of benefits from wildlife because of constraining government policies and exorbitant ‘taxes’ on returns from wildlife by state agencies (e.g. 10). Increasing wildlife populations are also resulting in increasing human-wildlife conflict. The existing elephant population within the Kavango-Zambezi TFCA probably exceeds 250,000 and is still growing. The result is increasing conflict with farmers, particularly in the Caprivi Strip where, during 2010, a dusk-to-dawn curfew for villagers was advised to minimise the risk of being injured by elephants. In many areas, predation on livestock is a highly emotive issue.

The issues and policy dilemmas outlined above are further compounded by those associated with diseases at the interface between wildlife, livestock and people. These problems are likely to be particularly acute in the larger TFCA, such as the Kavango-Zambezi and the Great Limpopo (Table I), which harbour a larger range of diseases and include more than two participating countries. Similar concerns also apply to the smaller Greater Mapungubwe TFCA, which includes three countries (Fig. 1) (Table I). Fences have been erected across the length and breadth of southern Africa to control the movement of large wild mammals and livestock. In many instances, e.g. in Botswana, these fences have had enormous impacts on wildlife resources and pre-empted the potential future development of economically competitive and viable nature-based tourism ventures in many areas. These single resource decisions with multiple resource consequences have tended to dominate disease management and control strategies in the region (3, 8). Despite the adverse effects of using fences to create disease-free zones, several countries (e.g. Kenya, Mozambique, Namibia and Zambia) are presently contemplating introducing or extending their use to create FMD-disease-free zones to meet European market requirements. The full environmental, social and economic consequences of such projects are seldom fully examined. If they were, fences might be aligned, or re-aligned, to minimise impacts on biodiversity while still functioning as disease-mitigating factors. The potential of developing ‘immune barriers’ using improved regionally appropriate vaccines instead of physical barriers has yet to be fully explored. (See Bengis and de Klerk-Lorist in this publication for more discussion and recommendations on disease issues.)

As if these issues were not enough, much of the region is likely to face increasing aridity over the next few decades as a result of changing climate. The development of adaptive strategies at several scales will be vitally important, as will the need to deal with present and ensuing scale mismatches between ecological, social and economic systems (6).

The management of wildlife and livestock diseases (including zoonoses) within many TFCA (e.g. Kavango-Zambezi and Great Limpopo) remains unresolved and is an emerging policy issue of major concern to livestock production, its associated access to export markets, and other sectors, including the public health sector (14).

As Osofsky (12) has noted:

‘The TFCA concept promotes free movement of wildlife over large geographic areas, whereas the present approach to the control of transboundary animal diseases (TADs) is to prevent movement of susceptible animals between areas where TADs occur and areas where they do not, and to similarly restrict trade in commodities derived from animals on the same basis. The TFCA concept and current internationally accepted approaches to the management of TADs are therefore largely incompatible and present a key threat to transboundary conservation success, to diversification of land-use options, and to livelihood opportunities in the face of climate change in the region.’

The issues and interconnections between diseases, disease management and the primary sectors involved in TFCA are complex (Fig. 3) and their resolution will require new approaches, if not a paradigm shift, to land-use and disease management strategies within and between countries in southern Africa.
The Animal and Human Health for Environment and Development (AHEAD) programme, launched in 2003, aims to help resolve these issues and contribute to the conservation of biodiversity and the enhancement of livelihoods of the rural poor in TFCAs, such as the Great Limpopo and the Kavango-Zambezi. This is to be accomplished by:

- helping to create an enabling environment for enhanced cooperation among conservation, agriculture and human health experts and authorities, within and between Member Countries
- identifying mechanisms for controlling transboundary animal diseases (TADs) without complete reliance on current fencing approaches, and
- informing and influencing cross-sectoral and transboundary policy responses that support both TFCAs and control of TADs (13).

![Diagram](image)

*Fig. 3 Conceptual diagram of the linkages between wildlife, livestock and human diseases and the potential implications of disease control strategies for livelihoods and conservation (5)*

**Mitigating strategies and potential ways forward**

Livestock and wildlife have existed together in southern Africa for at least 2,000 years. Traditional societies developed herding practices that reduced contact between wild and domestic animals at critical times of the year to minimise disease transmission, e.g. the transmission of malignant catarrhal fever (MCF) from wildebeest to cattle by avoiding contact between them during the calving season. Seasonal ungulate movements and migrations result in higher carrying capacities and standing crop biomasses, and migrations may also serve to reduce parasite burdens and the prevalence of diseases. However, traditional seasonal movements of livestock between winter and summer grazing areas in southern Africa have been curtailed over much of the region by increasing sedentarisation of pastoralists and agro-pastoralists, as well as by national boundaries, which are often fenced. The resulting present scale mismatch between the spatial distribution of rangeland resources and current sedentary grazing practices dictated by current institutions (i.e. social, policy
and legal norms) may thus serve to reduce both rangeland and livestock production, as well as wildlife populations, in much of the region. The development of multi-species animal production systems, comprising mixed herds of domestic stock and a range of large, wild herbivores, offers a promising potential option that would meet both livestock production and nature-based tourism goals in generating wealth in extensive rangelands (1). The example of the Ol Pejeta Conservancy in Laikipia, Kenya, provides an illuminating example. This conservancy successfully runs a pedigree herd of 6,000 Boran cattle with the full range of wildlife, including the ‘big five’. Predation by lions is minimised with two herders to 100 head of cattle and the use of moveable circular bomas, in which animals are not able to stampede and are effectively protected at night. Dipping, when necessary, controls tick-borne diseases. This model is being extended northwards and the system is being incorporated into traditional pastoral areas in northern Kenya.

Rural communities in Namibia are successfully engaging in wildlife-based nature tourism alongside their domestic livestock in community conservancies (11). In the Caprivi Strip, these conservancies fall within a designated ‘FMD-infected’ zone and so cannot participate in beef export markets at the present time. A potential solution lies in the development of commodity-based trade (CBT), in which animal products, such as properly deboned, de-glanded and aged beef, can be exported under conditions that pose a minimal risk of disease transmission. This option is currently being explored as part of a beef export pilot study being conducted in Namibia. While the CBT option may mitigate the effects of FMD on export options, it will have little impact on the management of diseases such as trypanosomosis, bovine tuberculosis, and others listed in Table I. The control of rabies and canine distemper, which carry high risks for endangered species such as the wild dog, require management of domestic and feral carnivore populations and continuing vaccination campaigns.

There are, however, important policy issues besides those dealing directly with disease management that adversely affect rural development options within TFCAs. Perhaps the most important are those dealing with resource access rights and benefit streams to rural communities from wildlife-based land uses and nature-based tourism. With the exception of Namibia, the policy frameworks in most countries in southern Africa result in the State or district authorities, or both, taking a high percentage of the financial returns from wildlife. These taxes or rents are extracted in the form of trophy and lease fees, and controls on quotas and harvesting, on the basis that wildlife belongs to the State and not to the landholders or occupiers of the land. In Botswana, the extent of resource management devolution to community-based organisations is severely constrained by centralised State and district controls (10). These constraints, which are not faced by cattle farmers, include such measures as having to obtain a 15-year lease, submit management plans, pay annual land rentals and royalties, pay 65% of the income from wildlife to a national environmental fund, provide reports on the expenditure of the remaining 35% of income, and so on. As Martin (10) cogently asked – what cattle farmer would accept these conditions and can wildlife managers (whether individuals or communities) seriously be expected to accept these impositions?

As with disease issues, those relating to human-wildlife conflict are also not readily resolved and are closely linked to questions of incentives and returns from wildlife. The underlying dichotomy in the individual ownership of livestock, as opposed to the community or national ‘ownership’ of wildlife, remains to be resolved. A potential solution lies in providing rural households with increased access to banks, finance and communication to reduce their direct dependence on livestock holdings and to provide ready access to returns from wildlife and earnings from nature-based tourism. In part, this argument is based on the observation that households tend to invest their returns or dividends from wildlife into community projects, or into increasing their livestock holdings, because they lack ready access to alternative means of securing their earnings.

Climate-change scenarios predict increasing aridity over much of southern Africa in the next few decades. Given the relationships between rainfall, primary production and large herbivore biomass
Illustrating relationships of wildlife, domestic animal health and production

(e.g. Fig. 2), we can expect declining levels of livestock production and thus of financial returns from livestock as a land use. The same is not necessarily true for nature-based conservation because economic returns are based very largely on services and are partially decoupled from primary and secondary production. Adaptation to climate change will almost certainly have to rely heavily on a diversification of livelihood strategies and the current prevailing paradigm of ‘livestock or wildlife’ will need to shift to considering both (1) as necessary components of a land-use portfolio for extensive rangelands.

Concluding comment

The need for interdisciplinary, trans-disciplinary and innovative approaches to the management and conservation of natural resources in southern Africa has never been greater. It is also clear that, in the development of TFCAs and the associated management of TADs, there is a dearth of temporal and spatial information, not only on diseases of humans and wild and domestic animals in these areas, but also on their ecology and socio-economic systems. These gaps need to be filled if sound, acceptable and sustainable disease management and alternative land-use strategies, grounded in science-based, economically rational policies, are to be implemented. There is a need to take account of the full costs and benefits of alternative development options, to avoid option foreclosure and to enhance resilience in the social-ecological systems within TFCAs.

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References


Assuring transparency

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Summary

Transparency of the world animal health situation, a major goal of the World Organisation for Animal Health (OIE), is becoming increasingly important, given the growing risk of pathogens being spread through the international movement of animals and animal products. Yet many problems stand in the way of full transparency, particularly when it comes to diseases in wildlife. The OIE has therefore stepped up its efforts to improve disease notification. Major improvements include networking with OIE Members, establishment of a single list of diseases notifiable to the OIE, the introduction of an online disease notification system called the World Animal Health Information System (WAHIS), ongoing development of WAHIS-2 and WAHIS-Wild, the introduction of National Wildlife Focal Points, reporting of positive laboratory findings by OIE Reference Laboratories and Collaborating Centres, and an active search procedure for unofficial information. Changes are also being made to the Terrestrial Animal Health Code to distinguish between diseases that have implications for trade when they occur in wildlife and those that do not. Furthermore, the outbreak maps in the World Animal Health Information Database (WAHID) now clearly distinguish between outbreaks in domestic animals and those in wildlife. These and other changes introduced by the OIE have helped to enhance the level of transparency in animal disease reporting worldwide. Yet much work remains to be done. It should be remembered that 80% of emerging diseases in humans are of animal origin and 70% of the pathogens involved originate in wildlife. Thus, the OIE’s Wildlife Disease Notification System has an important role to play in fulfilling one of the OIE’s main goals: namely, to ensure transparency, safe trade of animals and their products and a better knowledge of the worldwide animal health situation in both domestic and wild animals, for the benefit of animal health and human health.

Keywords

Introduction

Achieving transparency and knowledge of the world animal health situation is no easy task. Considerable efforts are still required on the part of the World Organisation for Animal Health (OIE) and its Members to reach this major goal, which in fact lay behind the creation of the OIE in 1924. Globalisation, increasing trade in food products, including those of animal origin, rising incomes for certain sectors of the population in some emerging countries and increasing human populations have led to the increased movement of a wide variety of food products, including those of animal origin, carrying with it the risk of the movement and spread of pathogens (2, 4). This trend is set to increase in the coming years.

For obvious economic reasons, countries with an interest in exporting animals and animal products have always found it difficult to notify diseases, especially when they occur in backyard animals and wildlife. The national Veterinary Services, which participate in the development and adoption of
Illustrating strategies for efficient surveillance and management of animal diseases

international standards, are in the front line when it comes to taking the measures needed to protect animal and human health within their borders. However, the measures taken to ban imports of animal commodities are sometimes inappropriate and not truly science-based. This can result from inadequate knowledge of risk analysis or incorrect interpretation of information. Nevertheless, some countries use a ban simply as a protectionist measure, creating an unjustified trade barrier to protect their domestic market from other countries. Unjustified barriers often go unchallenged because the countries affected consider the procedure too expensive and time-consuming. This situation must change, otherwise all efforts to assure transparency will be in vain. It is clear that the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) gives countries the right to protect the health of their human and animal populations by implementing international standards and, if their standards of protection are higher than those of the relevant international standards, they can then justify their import requirements on the basis of a risk analysis.

While the right of countries to protect themselves is clearly stated in the SPS Agreement, many countries, especially the least developed, either do not apply science-based import requirements or have requirements that are insufficient, given the animal health status in the exporting countries, to protect their animal and human populations from the introduction of pathogens via imported commodities. Concerning their notifications to the OIE, these importing countries, as well as countries with traditional production systems and no access to international markets because of the animal health status of their livestock, used to be reluctant to send regular information to the OIE because they could see no obvious benefit from doing so. This situation has changed over the past few years and it is now in the interests of all countries to provide the OIE with information and fully respect their notification obligations.

Since the establishment of the OIE Animal Health Information Department in January 2002, the OIE has gradually been improving its networking with Members, rather than simply being a ‘mailbox’. This process began by involving all countries, regardless of whether they were engaged in trade in animals and animal products, and sought to ensure that all Members participated in animal health notification and other OIE-related activities. The OIE started by issuing regular updates on the reporting records of Member Countries and raising awareness among those that were not submitting regular reports to the OIE on their animal health status. This was done at OIE General Sessions, Conferences of OIE Regional Commissions, etc. Countries are frequently sent reminders to emphasise the importance of submitting regular reports, including, in the case of exceptional events, regular follow-up reports to enable the monitoring of further developments.

Since 2002, the OIE has operated an active search and analysis procedure for unofficial information from a variety of sources and networks, verifying it where appropriate with the countries concerned. This has allowed us to detect a number of exceptional events needing to be notified and has helped to improve transparency. Another strategy consists of raising awareness among the OIE’s network of Reference Laboratories and Collaborating Centres and ensuring that they comply with one of their key mandates; namely, to inform the appropriate OIE Delegate and the OIE of positive laboratory findings of disease. This strategy will certainly help to improve transparency.

The establishment of a single list of diseases and the new notification procedures that started in 2005, coupled with the launch of the online notification application, the World Animal Health Information System (WAHIS), have enabled countries to notify monthly information on all priority diseases present in their territory rather than solely on the previous List A diseases. The effect has been to give an excellent picture of the situation regarding priority diseases by sub-region or region of the world. This has, in turn, improved the quality of information used to define common strategies for designing targeted control programmes.
To further improve transparency, a communication strategy is used, based on discriminating, where relevant, between a disease event that might necessitate measures to avoid the pathogen being spread by commodities though trade, following an immediate notification of an exceptional event, and events that are notified but have no impact on trade. For example, a display system for the disease outbreak maps in the World Animal Health Information Database (WAHID), enabling outbreaks in domestic animals to be clearly distinguished from outbreaks in wild animals, was introduced in 2007. In the OIE Terrestrial Animal Health Code (the Terrestrial Code), the avian influenza chapter differentiates between reporting notifiable avian influenza in poultry, including hobby birds, and notifying it in wild birds, a situation that should not affect trade of poultry. Similar work needs to be done for all Terrestrial Code chapters in order to identify diseases that may be present in wildlife and indicate what effect, if any, their presence may have on trade in the relevant animal commodities.

In 2009, disease occurrence codes that differentiated between domestic and wild species were introduced for relevant diseases. The main objective was to give decision-makers a clearer picture of the animal health status of domestic animals and of wildlife, to avoid the introduction of unjustified trade barriers when only wild animals are affected by disease. This change was also intended to raise the awareness of all countries of the need to include disease surveillance of wildlife species in their animal surveillance systems and so provide better coverage of the animal health situation in their various animal populations.

In addition to the efforts to improve transparency mentioned above, changes are being made to the OIE notification system to better address the disease situation in wildlife. For example, a new version of WAHIS (WAHIS-2) will be launched in 2012, which will bring significant improvements in the field of disease notification in wildlife. These improvements include the identification of affected species by their Latin names and the integration of National Wildlife Focal Points. These focal points will help to improve our knowledge of the animal health situation in wildlife through a newly developed on-line notification application, named WAHIS-Wild. This new online system will replace the annual questionnaire on wildlife diseases which covered both OIE-listed diseases and non-listed diseases that were specifically relevant for wildlife. The OIE is convinced that these improvements will contribute to transparency by offering a better understanding of the animal health situation through improving our knowledge of the global wildlife disease situation and by increasing disease surveillance in wildlife species in OIE Members.

Since some diseases present in wildlife have the potential to be transmitted through trade in animals and their products, these risks should be taken into account in the different chapters of the Terrestrial Code. Conversely, when the presence of a disease is limited to wild animals only, and should not affect trade in domestic animals and their products, this should also be clearly stated in the Terrestrial Code chapters. All these changes will encourage countries to improve transparency and knowledge of their animal health situation. This is vitally important, given that 80% of emerging diseases in humans are of animal origin and 70% of the pathogens involved originate in wildlife (1, 3). The OIE’s Wildlife Disease Notification System also has the aim of protecting wildlife, and consequently biodiversity, and, where appropriate, serves as an early warning system to protect livestock health and public health. A new website will be developed to make the collected information available to a wider public.

All these changes, coupled with a change in the attitude of certain stakeholders who apply unjustified trade barriers, will certainly help the OIE to fulfil one of its main missions: to ensure transparency, safe trade of domestic animals and their products and a fuller knowledge of the worldwide animal health situation in both domestic and wild animals, for the benefit of animal health and, where zoonoses are concerned, human health.
References


Managing disease outbreaks

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Summary

The rapid global spread of animal diseases during the last 2 decades has placed a new dimension on the role played by wildlife in the occurrence of diseases in livestock and on the ability of the Veterinary Services of countries to manage the livestock-wildlife interface. Disease control methods that in the past proved successful to cope with disease threats and disease outbreaks in livestock do not necessarily apply to disease control in wildlife. International standards to facilitate the safe trade in livestock and livestock products also does not necessarily apply or give the same risk mitigation assurances for the trade in wildlife and wildlife products.

The paper will describe some of the difficulties posed when managing outbreaks of trade-sensitive diseases in livestock where wildlife are incriminated as the primary source of the outbreak, and the challenge posed to the setting of international animal health standards in addressing these difficulties. Some of the most common animal diseases where wildlife plays a role in the epidemiology of the disease will be used to illustrate some of the difficulties faced by the Veterinary Services of countries in harmonising disease control methods in wildlife and livestock.

Keywords


Introduction

Outbreaks of diseases listed by the World Organisation for Animal Health (OIE), in which wildlife are involved, often call for a different approach to the application of disease control strategies to contain the outbreak, in comparison with disease outbreaks where the disease is limited to domesticated species with no wildlife involvement. The competent veterinary authority of the country concerned, which is responsible for containing the disease, must not only consider the risk to the health of the livestock population, as well as possible trade restrictions, but also the role of wildlife in the epidemiology of the outbreak and any measures that may be necessary to manage the disease. Cooperation with wildlife resource agencies and other organisations may be necessary to increase the chances for success in the outbreak response. In addition, the veterinary authority may have to consider wildlife conservation interests and make difficult decisions to meet the needs, priorities and very often conflicting demands of livestock producers, the wildlife industry and other interest groups. Classical control measures, such as isolation, vaccination and culling of infected stock, are seldom questioned when applied during disease outbreaks in livestock. However, when similar methods are proposed for wildlife, in the event of threatening outbreaks, objections may be raised, such as the need for wildlife conservation and the guarantees required for certification of freedom from disease in the domestic population when the disease is also present in the wildlife population.
The OIE standards for diseases where wildlife are implicated as a primary source have a two-pronged approach. For those diseases where controlling the wildlife vector is accepted as impossible (such as wild birds, in the case of highly pathogenic avian influenza), proof of absence of the disease in the domestic population is accepted for international trade. However, the presence of the disease in wildlife, where the wildlife vector can be controlled through such methods as isolation or separation from susceptible livestock (e.g. foot and mouth disease in free-roaming buffalo), requires a different set of guarantees for international trade.

**Generic approaches to animal disease control and management**

In veterinary faculties all over the world, students are taught that the most effective way to detect and manage an animal disease outbreak is to establish an effective surveillance system; to aim for early detection and diagnosis; to isolate the infection or disease when detected; to contain the disease and to prevent escape of the pathogen; to vaccinate where indicated; and to cull animals to minimise spread of the disease or pathogen. It is then advisable to wait for a (safe) time, to confirm no further re-introduction or new cases, to confirm the absence of any further clinical cases or circulating pathogen, and eventually to lift the restrictions that were initially imposed on detection of the disease.

Such a generic approach aims at restoring normality in the livestock population as quickly as possible. For obvious reasons, such an approach might not necessarily be equally applicable in an outbreak of disease in a wildlife population. The main emphasis in the generic approach taken to livestock populations is to prevent economic losses and to restore the food production chain; to minimise possible negative trade concerns and to provide sanitary guarantees of safe trade to potential trade partners.

Outbreaks of livestock diseases generally occur in an unstable but controllable environment, where classical disease control measures can usually be applied effectively to contain the outbreak. In addition, further measures are usually available, which can be applied with a varying degree of success, such as vaccination, serological surveillance, movement control and restrictions, identification of affected animals or animals at risk, where indicated, and isolation of affected populations.

**What are the challenges in managing outbreaks of diseases with wildlife involvement?**

A disease outbreak in wildlife more often occurs in a permanent but unstable environment which offers a variety of scenarios and challenges. In some instances, wildlife and/or livestock can be separated but not effectively isolated; sometimes contact between wildlife and livestock can effectively be avoided or prevented, while in other circumstances this ideal cannot be achieved. In some instances, mechanical separation methods, such as game fencing, are made challenging by wildlife; natural events, including floods, drought or seasonal animal migrations; or human activities, such as intentional or accidental breaches of the fencing.

Generic or classical disease outbreak management strategies are thus subject to failure or might not be feasible where wildlife are involved. Vaccines are not usually available to control diseases in wildlife; options to create an immune buffer in the domestic animal population or a buffer between the wildlife population and humans are subject to challenge; and diagnostic tests in wildlife are not always validated or of doubtful sensitivity and specificity. Sampling and surveillance strategies in wildlife offer their own challenges in terms of availability, access, cost implications, absence of clinical cases and the best sampling methods, as well as choosing the most appropriate samples to be taken. The target species for sampling to confirm the source of a disease outbreak is often subject to dispute – is the primary source generated in wildlife or transmitted from livestock to wildlife? However, it is important to
remember that disease transmission is a two-way exchange between wild and domestic animals, and that once a disease is present in both wild and domestic populations, the source of the outbreak assumes less importance than mounting an effective response.

The potential value of involving wildlife conservation agencies and organisations in a disease outbreak response involving wildlife should not be overlooked. These agencies/organisations may provide a plethora of resources for the response, ranging from knowledge of the local distribution and density of susceptible wildlife species, as well as their natural history, to personnel, vehicles, laboratory space and other infrastructure that may facilitate the response. And the more complicated an outbreak situation becomes, the less likely it is that the local veterinary authority can single-handedly achieve a successful disease response.

Culling wildlife for disease control purposes is seldom an option and always subject to public debate (1, 3). There is often a thin line between harvesting wildlife to control their numbers and allegedly to preserve the environment or maintain biodiversity and outright culling to control disease. In South Africa, where black-backed jackals (Canis mesomelas) were culled on a massive scale by poisonous baits to control a rabies epidemic in cattle, it was found that, within three to four months, other jackals moved in and re-occupied the space left by their unfortunate predecessors (2). The debates around the culling of badgers (Meles meles) in the United Kingdom (UK) to control outbreaks of bovine tuberculosis more or less came up with the same conclusion (1) and raised questions about the feasibility of creating a threshold value with culling — i.e. to cull ‘just enough’ to contain the disease — but what is enough? Based on present models, some within the wildlife conservation profession believe that harvesting can actually increase wildlife disease epidemics (3).

**Provisions within the OIE Terrestrial Animal Health Code to facilitate the managing or mitigation of disease outbreaks**

The OIE Terrestrial Animal Health Code (Terrestrial Code) applies a risk-based approach for OIE-listed diseases with potential or proven wildlife involvement in the epidemiology of the disease. The emphasis is on ensuring sanitary guarantees to prove freedom from disease in the domestic population.

In support of such sanitary guarantees, risk-based mitigating measures are suggested to either prevent transmission of the pathogen from wildlife to the domestic population or to provide surveillance guidelines to demonstrate the absence of the pathogen in the domestic population, while it might remain circulating in the wildlife population. The approach varies from either accepting freedom from disease in the domestic population without compulsory separation from wildlife, but requiring proven absence of the pathogen in domestic stock (e.g. highly pathogenic avian influenza with the accepted presence of the virus in wild birds), to an approach that does not accept freedom from disease in the domestic population if they cannot be effectively separated from wildlife (e.g. foot and mouth disease in cattle where the virus circulates in African buffalo) (6).

While the emphasis in the Terrestrial Code is thus on providing standards for safe trade in domestic animals and their products, risk mitigation measures to manage the interface between domestic animals and wildlife are provided for in a number of trade-facilitating measures, such as zoning, the establishment of protection zones and, more recently, the recognition of disease-free compartments. The latter makes it possible to continue trade in domestic stock and their products even if disease is present in wildlife. Examples include African swine fever and classical swine fever. A further facilitating measure in the Terrestrial Code is the identification of commodities that are safe for trade, even if the disease in question has been demonstrated in the country, i.e. those commodities which do not pose a risk for disease transmission despite the presence of disease.
Illustrating strategies for efficient surveillance and management of animal diseases

The *Terrestrial Code* also provides specific surveillance guidelines for some diseases where wildlife play a role, to ensure that this role is recognised in the epidemiology of the disease and taken into account in the presentation of surveillance data, for example, for foot and mouth disease and classical swine fever (6).

**Examples of disease management options for a few selected diseases**

Although there might be some generic aspects to controlling animal diseases when wildlife are involved, no blueprint exists that fits all diseases. Control measures vary, depending on what measures can and cannot be taken to contain a disease in a variety of circumstances. This might be best illustrated through some familiar examples.

**African swine fever**

The complexity of the disease cycle has been well described, involving an arthropod vector, persistent infection in some instances and both a sylvatic and a domestic cycle. Separation of domestic pigs from wild pigs has proven to be effective, through the application of compartments, and in some countries the disease could also be zoned out i.e. by establishing a domestic population not subject to risk from wildlife transmission. In some countries, especially where the domestic cycle has become established, people ‘live’ with the disease. Culling affected domestic stock, mainly because there is no effective vaccine, is often the preferred choice to quickly contain outbreaks. Recent experiences in Eastern Europe have shown that the disease can invade a naïve wildlife population and then become endemic.

**Rabies**

Attempts to break the sylvatic cycle have only been successful in those instances where governments have launched an almost total onslaught to stop the disease in its tracks, such as in Europe and North America, through the use of bait vaccines. However, attempts to contain the disease through culling, such as gassing *viverridiae* or poisoning jackal populations, have mostly been unsuccessful (2). The most effective preventive control measure is still to create an immune buffer between the wildlife vector, humans and the domestic (*canid*) population through vaccinating the domestic canine population. It has been well documented that the establishment of an immune threshold value of at least 70% to 75% in the domestic canine population would usually be sufficient to protect the human population and to prevent rabies epidemics in the domestic population (4).

**African horse sickness**

This vector-borne disease, with the additional involvement of wild *equidae* (zebra), offers in itself several challenges – especially in respect of the establishment of disease-free zones. In countries where the disease is endemic, the ideal scenario is absence of the *Culicoides* vector, as well as of wild *equidae* that act as reservoirs of the disease. Other risk mitigation options would include vaccination and separation of the species and the application of seasonal freedom from disease. The presence of nine antigenically distinct serotypes and the fact that only selected inactivated vaccines are available further complicate outbreak management options.

**Foot and mouth disease**

With seven immunological distinct serotypes and a wide range of susceptible cloven-hoofed species, foot and mouth disease (FMD) remains not only one of the most contagious animal diseases but also one of the most challenging to control. Although only the African buffalo (*Syncerus caffer*) have been shown to maintain FMD viruses, a wide range of wildlife species are susceptible (5), offering often
unique challenges for disease control management options. This was the case with the most recent outbreak of FMD in wild boar in Bulgaria. Traditional attempts to separate infected wildlife from domestic stock through fencing have proven to be successful in countries such as Botswana, Namibia and South Africa. However, this risk-mitigating system is continuously under challenge through natural disasters such as floods and droughts, and also through political interventions, such as the establishment of transfrontier conservation areas and pressure from environmentalists to abandon forced fencing-in of game and to allow free migration of species across national boundaries. Culling wildlife to contain FMD outbreaks is not an option; nor is it an option for eradicating the disease. In some countries, such as those in southern Africa, where buffalo are in abundance and spread throughout the region, the total eradication of FMD is not possible.

Highly pathogenic avian influenza

Ever since the late 2000s, when the H5N1 virus epidemic began and overshadowed the agendas of almost every Veterinary Service in the world, the role that wild birds play or do not play in the epidemiology of this disease has dominated the debate on highly pathogenic avian influenza (HPAI). The OIE recognises that this is a sensitive issue for international trade and has come out strongly in favour of non-discrimination against countries for trade purposes where the disease has been diagnosed in migratory wild birds. The result is that managing outbreaks is aimed at safeguarding the domestic poultry population and not at eradicating the disease from the wild bird population, i.e. controlling HPAI at its source within the domestic population. The presence of the virus in wild birds is thus accepted without discriminating against the domestic population, while the objective is to safeguard the domestic population through vaccination and other disease risk management strategies, including physical separation of wild and domestic birds.

Bovine malignant catarrhal fever

Attempts to legislate for stringent control measures to prevent this disease from being transmitted from blue or black wildebeest to cattle have met with variable success. Separation by fencing has also had a varying degree of success because the high-risk periods for disease transmission (i.e. during the first trimester after calving in wildebeest) have not always been taken into consideration. There are indications of vaccine developments for bovine malignant catarrhal fever (BMCF) but, until then, it has been demonstrated that contact between wildebeest and cattle should be avoided during high-risk periods.

Conclusion

The interface between wildlife and domestic animals poses various options but also a number of challenges for applying mitigating measures to facilitate disease outbreak management. It must be accepted that some diseases cannot be eradicated in wildlife, such as FMD, HPAI, BMCF and African swine fever. There are some risk mitigation options available, such as vaccination to create an immune buffer between wildlife and domestic animals; physical separation through fencing, as in the case of FMD and BMCF; farming in harmony with wildlife, as for FMD, and breeding disease-free wildlife (such as FMD-free buffalo). It is also important to remain sensitive to the spatial and temporal variables that so often dictate disease outbreaks within the wildlife-domestic animal cycle, and to remain committed to cooperation with wildlife conservation agencies and other organisations, not only to increase the chances of a successful disease response, but also to facilitate the co-existence of both animal groups, in order to maintain biodiversity and respect mutual trade concerns. The application of disease management options where wildlife are involved will remain a sensitive issue but one which should not necessarily stand in the way of harmonising the interests of both animal agriculture and wildlife conservation.
References


Capacity-building: issues and opportunities

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Summary

National capacity to manage wild animal health issues requires active engagement by the country seeking such capacity, through the establishment and maintenance of supportive policies that facilitate all essential functions of the national programme, including inter-ministerial alliances, collaborative programme management, positive incentives for programme personnel, and engagement with non-government groups. Within this enabling environment, integrated activities aimed at disease prevention, surveillance, response and recovery must be established that are supported by capacities for scientific research in wildlife health and disease, and for training essential programme personnel. Wildlife health management programmes contribute considerably to the informed management of natural environments and biodiversity, to human economies, health and well-being, and to the safety and security of the food supply.

Keywords


Introduction

A great challenge to humankind today is to develop sufficient global capacity to manage new and potentially problematic diseases: to detect them quickly, to understand their causes, transmission and ecology, and to take steps, if necessary and if possible, to reduce their negative impacts on animals, environments and people, and to speed recovery. Many global disease issues involve wild animals and wild animal pathogens. This paper considers what it means to build or develop ‘capacity’ to manage wildlife health and disease issues, and what range of capacities is required in low and middle-income countries (LMIC).

Building ‘capacity’

During the decade from about 1995 to 2005, the terms ‘capacity-building’ and ‘capacity development’ were redefined. While previously these terms were broadly used as synonymous with any kind of international development, they are now used to refer to a specific form of such development. This change in the use of these terms also represents a major change in thinking by many international development agencies, following major reviews of the general failure of decades of development programmes to make a lasting difference in the major indicators of human well-being in LMIC, such as poverty, primary education and child survival. The conclusion of these assessments was that lasting success is seldom achieved when external investment is used directly to finance development objectives, such as grain-production targets or vaccination rates. Instead, success is associated with programmes that empower LMIC to achieve these development goals for themselves, through the step-by-step creation of enabling political environments, stable organisational
infrastructures and processes, and access to and mastery of the knowledge and technologies required to achieve such development goals. Subsequently, many development agencies have advocated that the terms ‘capacity-building’ and ‘capacity development’ should be used specifically for this approach to development (5, 8, 9, 10, 16).

The essence of capacity development is, then, that a country with adequate capacity in any particular domain is empowered to meet its own needs in that domain autonomously.

Such empowerment is required on at least three different levels if there is to be lasting capacity at any level. There must be an enabling environment within the country, such that the country wants the capacity, makes it a national priority and takes ownership of the development process. There must also be organisational capacity to implement and manage the new or enhanced activities being developed, and there must be a cadre of motivated individuals in a structure that offers them incentives to engage with the process and its intended outcomes (9).

In the past, much international development has focused heavily on knowledge transfer, training and technology, without considering the political environment and organisational skills and infrastructures required to harness that knowledge and technology effectively. But to speak of ‘capacity’ development, as currently proposed, is to speak of engagement with a whole system and not just a few selected components. It is the whole system that is the objective of capacity development and, through this capacity, the development goals themselves can then be achieved.

A key aspect of capacity development is autonomy. The objective of developing national capacity is that a country becomes capable of looking after its own needs, capable of establishing its own priorities and carrying out its own programmes, with its own resources, on a long-term basis. In this sense, capacity development becomes the responsibility of the recipient country, with donors assuming a supporting role which is respectful of the national context and priorities of the recipient country (9).

**Capacity in wildlife health management**

Wildlife health management refers to a range of activities aimed at reducing the potentially harmful effects of pathogens and diseases found in wild animals. The effects of concern may be social, economic or ecological, and may have their impacts on wild animal populations, domestic animals or people, in many different combinations. Many pathogens and diseases affecting wild animals normally play significant ecological roles and do not require management through human intervention. However, active management is sometimes necessary to reduce important risks and impacts, and the basic components of wildlife health management are the same as those involved in managing veterinary or public health: prevention, surveillance and response (15, 19).

In the context of wildlife health management, preventive programmes include avoiding the importation of pathogens which might result in new disease problems. This requires gathering and analysing global information about human and animal disease occurrences, and implementing various forms of border controls and sanitary standards to reduce the likelihood that new pathogens will arrive in a country. Preventive programmes also include the evaluation of events and circumstances within the country that might create or enhance human or animal health risks from wild animal sources, such as changes in land-use policies, settlement patterns, agricultural practices and environmental changes, which are increasingly recognised as key factors in the emergence of new disease problems (11).
Illustrating strategies for efficient surveillance and management of animal diseases

Health risk assessment to identify substantial risks and policies to reduce the probability of disease emergence can then be pursued.

Surveillance for diseases in wild animals is required in order to establish baseline data on the presence of pathogens and patterns of disease occurrence, and then to detect the occurrence of new pathogens or new occurrence patterns as early as possible. Surveillance requires an integrated system of many different players, including field personnel to detect disease events in the field and collect and transport specimens, capable diagnostic laboratories, information technology to manage the data over time and epidemiological expertise to analyse data and communicate the results to policy- and decision-makers.

The capacity to respond appropriately to potential disease issues revealed by prevention and surveillance programmes requires, in the first instance, an established mechanism to make and implement decisions: to evaluate wildlife disease information and decide whether or not a response is required and, if so, who will respond and who will pay the cost. Furthermore, there must be some advance planning on how responses to wildlife disease events will be carried out in various plausible future scenarios, and there must be trained personnel, equipment and funds available for such responses.

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Fig. 1
Essential components of national capacity in wildlife health management
These three key elements – prevention, surveillance and response – when appropriately coordinated into a unified programme, form the core of a national programme of wildlife health management, but they are not sufficient to constitute a complete programme. As indicated in Figure 1, wildlife health management also requires capacity in education and in scientific research. Education and training at all levels, specifically about wildlife diseases, wildlife biology and wildlife management techniques, must be a continuous component of wildlife health management programmes. Without this, knowledge and expertise are lost over time, and programmes cease to function. Autonomy requires that a country be able to acquire and transmit the knowledge and skills it needs, and to produce its own highly trained personnel.

Some capacity to undertake wildlife disease research is also an essential component of wildlife health management. There are large gaps in knowledge about wild animal diseases in all parts of the world. Information about the range of vertebrate hosts, modes of transmission, vectors, reservoirs, prevalence and geographic distribution is often incompletely known or unknown. Yet any management actions that might be taken to limit or control wild animal pathogens and diseases must be based on such information, and very often research must be done immediately to obtain it. Thus, a country must have sufficient capacity in wildlife disease research to fill its own most urgent and important knowledge gaps if it is to have capacity in wildlife health management.

A wildlife health management programme also requires a supportive legal framework that enables it to function and provides it with a governance structure and financial resources to do its work. No wildlife health management programme can be sustained unless it is supported by government policy, a functional governance structure and sufficient resources to achieve national objectives. Most countries do not have policies in place specifically for managing health and disease in wild animals. In most countries, legal responsibilities for wildlife management, and for health and disease management, are separate and are spread across several different Ministries and departments. Seldom does any single Ministry or department have overall responsibility for wildlife health management. This lack of well-defined legal responsibility makes the governance of wildlife health management substantially different from health management programmes for humans and domestic animals. Effective wildlife health management almost always requires a large amount of collaboration among government Ministries and among other institutions and organisations, which often significantly contribute to aspects of wildlife health management. Thus, national capacity to manage wildlife health issues must include government policies that enable and facilitate inter-ministerial collaboration, and which endorse both collaborative governance for the programme among several government Ministries and departments, and stable partnerships with a range of non-government groups who may also participate in the programme.

Thus, to achieve national capacity in wildlife health management that is autonomous and sustained over time is to achieve some version of this entire system (Fig. 1), on a scale appropriate to meet national objectives and priorities. It is this system, with its several diverse components, that is the broad objective when developing capacity in wildlife health management.

**Challenges and difficulties**

Low and middle-income countries face many challenges when seeking to build capacity in wildlife health management. Perhaps the greatest challenge is that all such countries are trying to improve their capacity in multiple domains. For many, the eight Millennium Development Goals (MDG), established in 2000 by the United Nations, represent a set of imperative objectives that are interdependent and must be achieved simultaneously (12, 13).
Illustrating strategies for efficient surveillance and management of animal diseases

Capacity to manage wildlife health and disease issues can contribute to achieving several of the MDG: environmental sustainability, certainly, but also – directly and indirectly – child health, maternal health and prevention of major infectious diseases like human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS), which itself originated in wild animals. However, until recently, wildlife health management has not been given high priority relative to other components of MDG achievement.

Another challenge can be the expectations and demands of donors and sponsors of development projects. Donors of funds for international development may not be interested primarily in developing capacity in the recipient country. Many are concerned with achieving particular wildlife health outcomes or objectives, rather than with empowering the recipient country to manage wildlife health issues autonomously and set its own priorities. Donors may be interested in acquiring specific information, or specimens for disease studies, or meeting particular conservation objectives. These objectives of donors may have considerable scientific or other merit, but, nonetheless, they can pose problems to host countries. For example, such programmes can generate information affecting trade or other international relationships, sensitive information that any sovereign nation would itself want to control. They may also focus on, and require investment by the host country in, issues that are not of the highest priority for the host nation itself (8).

Thus, there can be, and often are, mis-matches between the objectives of the donors, who can provide resources to LMIC for wildlife health management programmes, and the needs and priorities of the LMIC to develop the capacities needed to carry out these management programmes themselves, as full partners and decision-makers.

A third challenge in developing capacity in wildlife health management is the loss, through emigration, of highly trained personnel who are essential components of that capacity. The training of such people is often a key component of capacity development programmes. Yet emigration of these people can quickly erode the gains made through training. This is not a trivial problem, as shown in Figure 2. Wildlife health management is dependent on a cadre of highly trained veterinarians, biologists, physicians, epidemiologists, laboratory diagnosticians and disease ecologists; without them, no wildlife health management programme can function. Potential loss of highly trained people can only be countered effectively by including an enabling national environment in the capacity development programme: organisational incentives, such as salary and opportunities for advancement, that make participation in the national programme attractive to highly trained personnel in the long term, and sufficient investment in training to keep up with emigration rates (2).

Capacity-building also always takes place in a particular cultural and political context that must be understood, accepted and accommodated within the capacity-building programme. This is not easy to do, and requires planning, time and effort, which are often not factored into the time-frame and cost of externally funded development projects. However, lasting capacity cannot be developed unless it is done in a way that is compatible with the prevailing cultural and political milieu where it is to function autonomously (9, 17).

Figure 2 shows the fraction of all physicians from the listed African countries who were working and living abroad as of 2000. Estimates were based on the census data of the following countries: France (1999); the United States of America (2000); Australia, Belgium, Canada, Portugal, South Africa, Spain and the United Kingdom (2001). From Clemens & Pettersson (2), used with permission.
Fig. 2
Emigration rates of health professionals in Africa

Opportunities

Despite all the very real challenges that confront programmes to develop wildlife health management capacity in LMIC, there are reasons to be optimistic about opportunities for doing so successfully in the second decade of the 21st Century. Recent global experience with emerging infectious diseases transmitted from wild animals to people or to domestic animals has focused attention on the inter-
relatedness of human, animal and ecological health. This is the essence of the ‘One World, One Health’ concept, and is the motivation behind a growing awareness of pathogens in wild animals as sources of emerging diseases that have important effects on people, livestock and ecosystems (14).

This new and well-reasoned interest in wild animal pathogens has two important implications for LMIC with respect to building capacity to manage wild animal health issues. First, many of these countries now consider wildlife health management a high priority, and are seeking ways to improve their capacity in this area. Secondly, international development agencies and other potential donors increasingly view emerging diseases, and wildlife health management as a component of their control, as high priorities for investment. Thus, programmes to develop capacity in wildlife health management are now being proposed by LMIC and receiving donor support, while only a few years ago this was not the case.

Furthermore, the objective of developing national capacity, of empowering LMIC to manage their own affairs autonomously, to set their own priorities, and to engage with other nations as true partners in the management of global health issues, has come to be viewed as perhaps the most effective approach to achieving lasting improvements and meeting the Millennium Development Goals with some permanency. Thus, many donor organisations have now made capacity development a primary objective of their international development investments (9, 16).

The World Organisation for Animal Health (OIE) is an international standard-setting organisation which has also developed capacity-building activities to enable Member Countries to implement the OIE standards. Capacity-building in wildlife health management is included in these programmes. At the level of governance, enabling environments and organisational capacity, the OIE assists Member Countries to evaluate their national Veterinary Services and animal health management capacity, including wildlife health management, to identify gaps or weaknesses, and to find ways to fill those gaps (18). The OIE also supports institutional twinning programmes, in which OIE Reference Laboratories and Collaborating Centres form close relationships with equivalent institutions in LMIC, through which organisational and technical models, competencies and skills are transferred and fostered.

The OIE provides direct training of Member Country personnel (OIE National Focal Points nominated by the Delegate of each Member Country) in six different areas of animal health and welfare, one of which is wildlife health management. A series of training workshops for the Wildlife Focal Points in all OIE Member Countries were provided in 2009 to 2010; the Training Manual used for these workshops is now available on the OIE website (19). A second series of wildlife health training workshops began in 2011. In addition, the OIE provides a wide range of technical and surveillance information through its website, its World Animal Health Information System and its many publications.

Science and experience

National programmes of wildlife health management are relatively new. Even now, the base of scientific knowledge upon which to erect wildlife health management programmes is thin and has many gaps. Nevertheless, over the past two to three decades, this knowledge has increased markedly, and there is now a significant body of supporting science. There is also now a small but valuable body of practical experience with wildlife health management. A number of countries have developed formal national wildlife health management programmes and policies, and many more have ad hoc programmes that nonetheless are operational (4, 6). There is a growing store of lessons learned from these programmes, successes and failures, which can be shared with other countries who wish to develop similar capacity. Similarly, there is a small but growing collection of scientific literature concerning methods and successes in national capacity development that can be shared and adapted to new settings (1, 3, 7).
Illustrating strategies for efficient surveillance and management of animal diseases

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References


National wildlife disease surveillance systems

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Summary

Interest in wildlife health surveillance is growing in the veterinary public health sector. It is a primary tool for the management and mitigation of zoonotic diseases as well as for the control of livestock and poultry diseases. Moreover, as Veterinary Services become more involved in the field of wildlife conservation, more and more efforts are being invested into the surveillance of pathogens that can affect the health of wild animal populations.

The primary stage of surveillance is the collection of samples for diagnostic testing. This important aspect will not be addressed in this paper, which focuses on data collection, information management and communication. In a national surveillance scheme, these steps most often come under the responsibility of Veterinary Services, at least for listed and regulated diseases.

The challenge frequently posed by surveillance is that of making good decisions with poor data. Wildlife populations are usually remote, difficult to assess, and their pathogens are not always similar to those of domestic species. Consequently, surveillance data are frequently sparse, biased or inaccurate. However, when properly stored and analysed, they have the capacity to detect relevant health events in natural animal populations. Rabies in Europe and North America is a good example of the appropriate use of surveillance data to monitor the spread of a disease and evaluate the efficiency of control measures. A range of epidemiological approaches, such as targeted surveillance in sentinel species, risk-based surveillance and syndromic surveillance will, in the future, improve the usefulness and efficiency of wildlife health surveillance. For Veterinary Officers, the challenges in this field are numerous. One is the need to collaborate with organisations and government departments that have access to wildlife, and to understand the distribution and ecology of wildlife populations. For the purpose of transparency, the need to regularly report on important pathogens detected in wildlife is crucial. To encourage Veterinary Services to undertake this, international trade rules must take into account that infection in wild animals is not usually a threat for domestic species, provided that appropriate biosecurity measures are applied.

Keywords

**Introduction**

This article examines free-ranging wildlife and veterinary public health. The aim is to describe the general organisation of wildlife disease surveillance systems and to discuss the management of information emanating from these systems in order to protect the health of both humans and domestic and wild animals.

In this article, wildlife refers to free-ranging animals of non-domestic species that do not live under human supervision or control and do not have their phenotype selected by humans (18). While captive wild animals can play a major role in veterinary public health, they are not the focus of this article.

Wildlife populations can be reservoirs or victims of pathogens shared with humans or domestic animals. They may also point to health problems caused by pollution or changes in the natural or human environment and are hence sentinels for potential threats to human and animal health (3, 14, 16).

For these reasons, the World Organisation for Animal Health (OIE) considers it crucial for national Veterinary Services to be able to ascertain their respective country’s wildlife disease status and to demonstrate the capacity to report the presence of diseases that are liable to pose a health risk, where required, in an emergency, if not on a regular basis.

The term ‘surveillance’ is confusing because its official definition is much narrower than the meaning in common parlance, which is to watch or guard a person or thing, especially one under suspicion, or supervision for the purpose of direction or control. While the notion of threat and prevention is present in the customary usage of the term, the notion of disease is not. Artois et al. (1) propose the following definition for a wildlife disease surveillance system: ‘a system for continuously collecting and analysing information on the health of wild species and associated risk factors, in order to meet the objectives of controlling or potentially eradicating diseases in a population or community of wild animals’.

According to the OIE *Terrestrial Animal Health Code* (18), the term ‘animal health surveillance’ means: ‘the systematic ongoing collection, collation, and analysis of information related to animal health and the timely dissemination of information to those who need to know so that action can be taken’.

**Specific characteristics of wildlife surveillance**

There are specific features of wildlife disease surveillance that are sometimes viewed as problems. However, these difficulties can be overcome, and we suggest ways of doing so. These difficulties can be summarised in four points:

- Wild animals are often secretive and difficult to locate, observe and handle, at least when compared with farm or companion animals. In addition, their numbers and demographics are often unknown. However, many aspects of wildlife surveillance concern a small number of game species from which samples can be obtained, at least at certain times of the year. Other aspects concern human commensal species or companion animals, which many groups of people care for or observe. Other animal populations are monitored for scientific or conservation purposes and the assistance of biologists and ecologists can be enlisted to obtain information or samples;

- Wildlife surveillance is sometimes undertaken specifically to permit early detection of a new or unexpected pathogen of major consequence. Early detection requires detection of a rare disease event and detection of rare events is a challenge. For example, in a theoretical modelling exercise, Hone & Pech (8) estimate that if foot and mouth disease were to occur among wild pigs in Australia, for example, there would be virtually no chance of detecting it early. However, not all diseases are rare, and some requirements (in particular, to control disease transmission between
Illustrating strategies for efficient surveillance and management of animal diseases

domestic and wild animals) relate to infections that are widespread among wild populations, whose presence can at least be pinpointed on maps (e.g. rabies in foxes, raccoons or skunks or epizootics of H5N1 highly pathogenic avian influenza, mycoplasmosis or trichomonosis in garden birds);

– a third difficulty is the wide taxonomic diversity of wildlife, which, given the level of zoological training among animal health professionals, frequently leads either to a failure to identify or to misnaming animal species involved in an outbreak (12), or else to lack of detail in describing a case in a wild animal (points shown on a map with only the term ‘wildlife’ indicated in the key). Under such circumstances, it is necessary to call upon the assistance of zoologists or naturalists who are able to recognise species and name them correctly;

– a fourth difficulty is that many biologists are not familiar with wildlife pathogens and health disorders. Again, this problem can be overcome through collaboration among specialists.

Objectives of surveillance

In this section we consider the targets and objectives of wildlife disease surveillance.

Surveillance programmes may focus on different categories of animals, depending on the objective of the programme. If the objective is to detect actual ‘disease’, then the programme will focus on sick or dead animals. If the objective is to detect the presence of a particular pathogen, whether or not the infected or exposed animal is sick, then the programme may focus instead on populations of wild animals which are in apparent good health.

Surveillance for ‘disease’ in animals is often called ‘clinical surveillance’. It is usually organised to detect dead or visibly sick animals, with the aid of people on the ground who are able to discover and identify them and take them to a laboratory to investigate the cause of their condition. Clinical surveillance is based on the examination of subjects that have attracted the attention of the general public or wildlife professionals. Clinical surveillance can therefore be practised in a fairly ‘passive’ way, based on the often opportunistic collection of dead or diseased individuals.

Clinical surveillance detects disease events in which wild animals are the victims of a pathogen. In some cases, the disease can undermine the demographics of a natural population or even threaten it with extinction. Some recent examples include chronic wasting disease of cervids and white nose syndrome of bats in North America, or chytridiomycosis of amphibians worldwide, infections which have seriously affected the health of wild populations. These diseases were first detected by clinical surveillance.

When the objective of surveillance is to detect the presence of a particular pathogen, the usual approach is screening a sufficient number of individuals to detect the pathogen or to estimate its prevalence (by use of laboratory tests to identify individuals carrying the pathogen or which have been exposed to the agent and thus carry antibodies against the pathogen). Where the pathogen being sought is relatively rare, it will be more difficult to detect, so the surveillance will need to cover a larger population sample. This form of surveillance will therefore require a more ‘active’ approach, in which sample collection must be planned to meet statistical requirements.

In cases where Veterinary Services are interested in wildlife surveillance, very often in practice the aim is to establish the absence or presence of pathogens transmissible to humans or domestic animals. If these pathogens cause a ‘visible’ disease in wildlife (such as rabies or myxomatosis), clinical surveillance may be useful. However, it is common for wildlife pathogens to be largely invisible; wild animals ensure the pathogen’s survival in the environment but they themselves are not visibly affected by the pathogen (for example, strains of foot and mouth disease in southern Africa to which domestic livestock are susceptible but with which the African buffalo \([\text{Syncerus caffer}]\) is infected.
without apparent disease). To be effective, surveillance must therefore mobilise resources to allow a sufficient number of wild animals to be analysed to detect the pathogen (or determine the absence of the pathogen).

Veterinary Services may therefore wish to set up a wildlife disease surveillance system that meets a variety of objectives, which, in turn, will guide the organisation of the surveillance, traditionally employing ‘passive’ surveillance (clinical, general or syndromic surveillance), as well as ‘active’ or targeted surveillance (see below).

Wildlife surveillance is undertaken to limit the harmful consequences of pathogens or diseases to human health, to livestock health, to the interests of the agrifood industry, and also to safeguard the health of wildlife or related natural resources and to preserve wildlife populations. Surveillance programmes are implemented to achieve two main objectives. The first is to determine the predominant diseases in the wildlife of a country and their causes (infectious, toxicological, etc.). The second relates to epidemiological vigilance to detect new animal health events. Each national government must set its own priorities in these two areas in accordance with the importance it places upon them and the resources that the government can allocate to such research.

In all situations, wildlife disease surveillance requires the cooperation of agencies, services and departments from different branches of government (Veterinary Services, environmental services and/or natural resource services, such as water and forests, hunting, fisheries and wildlife, public health services, universities and research institutes and many more). In many cases, private organisations, associations or non-governmental organisations can, and often must, take part in surveillance. In practice, for some specific wildlife health issues, it sometimes occurs that no government agency or service has been assigned responsibility to collect information and manage wildlife health and diseases. A national wildlife disease surveillance system must therefore be established by coordinating the activities of these various entities and endowing the system with specific resources, in keeping with the importance attached to the various priorities.

**Target populations, sampling and diagnosis**

Countries should be encouraged to set up a minimum surveillance system for the predominant diseases of its wildlife. To do this, they will need to set up cooperation among a range of government and non-government groups that can share information on the disease status of indigenous wildlife. The main purpose of the surveillance system will therefore be to share knowledge with the various decision-makers.

Wildlife surveillance may also have to meet the quality standards of an epidemiological surveillance programme (5). In particular, sampling should be done in compliance with the OIE *Terrestrial Animal Health Code* (and, if applicable, the *Aquatic Animal Health Code*). Several published papers describe how to organise sample collection for wildlife disease surveillance (2, 4, 10, 11). This collection should take into account the country’s historical and cultural context and seek to obtain data from existing or new organisations. In practice, plans for general wildlife surveillance are often limited to opportunistic sampling of animals, using whatever means are available to collect specimens for necropsy and for laboratory tests. Where wildlife populations are not counted precisely, the size and composition of target populations are often estimated by wildlife, hunting or fisheries services, by scientists, naturalists, hunters, birdwatchers, etc.

Where surveillance data are collected from a particular area (a national park) or over a relatively long period (monitoring lasting several years), it is useful to analyse trends to ascertain, for example, whether disease distribution is focalised (a persistent outbreak in a natural habitat or particular area), whether a seasonal trend exists, whether the incidence is growing or whether a control programme is proving effective. Epidemiological studies may therefore supplement and enhance surveillance data.
In this case, interpretation of the analysis must take into account the constancy and uniformity of surveillance pressure, in order to limit the influence of recruitment bias.

Another aspect of wildlife disease surveillance requiring special skills is the approach to and quality of pathogen diagnosis (or screening). Although an increasing number of tests that can be used to diagnose a disease in wildlife species have been validated for wildlife (6, 7), this must be checked on a case-by-case basis. The OIE Working Group on Wildlife Diseases and the relevant OIE Reference Laboratories and Collaborating Centres are involved in the OIE work on diagnostic tests that are valid for wildlife.

Because of the wide diversity of host animal species and pathogens potentially encountered in wildlife disease surveillance, such programmes should include people with specific expertise in wild animal diseases and their diagnosis.

**Three types of surveillance: general, syndromic and targeted**

Typically a distinction is made between ‘passive’ and ‘active’ surveillance but these terms are inappropriate, since surveillance is never a passive process. Also, a new form of surveillance based on monitoring syndromes has grown in importance in recent years and become applicable to wildlife (16). Three categories of surveillance are considered here.

**General surveillance**

This is surveillance of mortality and sometimes of morbidity. It is based on various methods of collecting carcasses or tissues from dead wild animals. It involves carrying out necropsies in one or more specialist laboratories (in this case, organised into networks). The system can include all animal species and all causes of mortality/morbidity. As interest in general surveillance increases among public administrations, organisations and the general public, and the subjects of study are expanded, so the range of species widens. Diagnostic methods also tend to become more sophisticated as more searching questions are asked and investment in the programme is increased.

**Syndromic surveillance**

Disease data collected on an ongoing basis can be used for syndromic surveillance, which adopts lesion-based or clinical criteria to define syndromes and tracks the number of cases with such syndromes in space or time. Syndromic surveillance has grown significantly in human medicine, due to the ease with which systematic codified medical information can be recorded electronically and to the expansion of computer connections between departments. The classification of syndrome-based records makes it possible to measure a trend and distribution in space or time and to issue an alert whenever the reporting rate exceeds a critical threshold.

Although syndromic surveillance in the area of animal health is still in its infancy (15), it holds promise for wildlife diseases (17). It offers a major advantage over surveillance targeting specific diseases or pathogens in that it can detect potentially invasive or emerging diseases of unknown aetiology. Another advantage is that it can be used when screening tests either do not exist, are difficult to implement, slow to give a result, prohibitively expensive or inappropriate for wildlife.

**Targeted surveillance**

Targeted surveillance for wildlife pathogens meets some of the criteria for ‘planned surveillance’ (18) of domestic animal health. Surveillance data can raise the alarm on health threats or environmental threats (epizootics or even toxic build-up), and wildlife can be used as sentinels to
provide early warning when critical risk levels are reached. Targeted surveillance is usually directed at a particular disease and/or species. In practice, many wildlife sampling plans are for game species that are monitored during hunting, from which one or more organs are removed for analysis. Targeted surveillance can also be conducted on animals captured live for inventory purposes (bird-banding programmes) or for scientific programmes, enabling trained personnel to collect the samples of blood and other biological materials. Targeted surveillance can be used to target a particular risk (e.g. transmission to livestock, anticipation of a foreseeable hazard such as H5N1 avian influenza or mapping a zoonotic risk, such as rabies or multilocular echinococcosis).

**Database organisation**

Database software now enables huge amounts of information to be stored for surveillance purposes. The problem is no longer how to store such information but how to use it. The objectives of the surveillance programme should guide the construction of such databases. The amount and complexity of data to be recorded will depend on a balance between the resources available to store and analyse the data, surveillance requirements in the strict sense and the subsequent use of the data for retrospective epidemiological studies. The volume of data is less important than regular and accurate entries.

For wildlife surveillance data to be useful in analysing trends over time and space, the data must indicate the precise place and date when the animals were discovered or sampled. The species must be recorded by its binomial scientific name (e.g. Genus species, using a drop-down menu to avoid entry errors), so that the epidemiological role of animals found with a pathogen or disease can be determined.

To conduct surveillance based on necropsy descriptions, the necropsy data must be entered in two different fields: a field describing the organ(s) involved (topography [T]) and a field describing the pathological changes in these organs (morphology [M]). A predetermined nomenclature can be used to group the ‘organs/changes’ pairs (TM), the combination of which can be used to define syndromes *a priori* or *a posteriori*.

A separate field should be reserved for aetiology (E), defined as the pathogen that caused the lesion recorded as TM. Standardised lists of pathogens can be used to reduce the risk of entry errors by using drop-down menus.

The exploitable disease information will thus be coded in the form TME, which allows for statistical analysis of the number of recorded events.

Lastly, pathologists may be asked to complete a free text field with their final conclusions concerning the cause of death or disease. This information, which is very important to the submitter of the case to the laboratory, can also be exploited later by using search queries of keywords (a thesaurus of pathology terms will facilitate this analysis).

**International reporting data**

This box contains the minimum data to be entered to meet reporting requirements, in particular for the OIE World Animal Health Information Service (WAHIS) Wild database.

The geographic coverage of this type of database should be global. At this scale, multispecies surveillance should be based on a small number of entries limited to the minimum required to meet the transparency objectives of each country’s disease status. The aim of the OIE is to acquire knowledge of the major wildlife diseases that may harm the health of humans and animals, including wildlife, and damage international trade in animals and animal products.
Illustrating strategies for efficient surveillance and management of animal diseases

Factual and precise data on the nature of the case (and/or outbreak):
- place (based on the most accurate administrative unit)
- date (of discovery)
- animal species(s) (genus and species)
- number of affected individuals of each species
- pathogen that caused the wild animal’s disease
- responsibility for diagnosis (probability that the diagnosis is correct)
- where possible: confirmation by means of a laboratory test in compliance with the OIE Manual.

**Discussion: decriminalising the reporting of regulated diseases**

For wildlife health surveillance to become widespread, the official declaration of regulated diseases in wildlife must be facilitated and encouraged. It is therefore important to ensure that the interests of countries or zones who report the presence of a major disease in wildlife are not damaged disproportionately.

Epidemiological surveys and scientific investigations should be facilitated in order to describe and analyse the origin, persistence and spread of pathogens among wildlife and their transmission to affected populations (9).

Where a threat emerges, but current scientific knowledge does not enable us to accurately characterise its risk, use of the precautionary principle should be avoided in favour of a graduated and coordinated response.

The obligation to immediately report a pathogen detected in a wild animal or population should be limited to cases in which the risk of direct transmission to humans or domestic animals is well documented, particularly if the pathogen has been released and is liable to spread rapidly (e.g. foot and mouth disease).

National governments should also be encouraged to share their knowledge gained through wildlife disease surveillance and also to commit themselves not to close their borders to trade on the basis of such reports by other countries, as long as no infection of domestic animals or humans has occurred.

For wildlife species, which are of special importance due to their sentinel role, early detection systems that include such approaches as syndromic surveillance, as described above, should also be organised, based on the concept of vigilance (13). A new standard for epidemiological surveillance of wildlife could be developed; for example, through the establishment of production systems governed by biosecurity standards.

This approach, which takes wildlife into account, would permit wise management of the consequences of any new health event in wildlife that potentially threatens another sector.

**Conclusions**

A country wishing to build a network for wildlife disease surveillance must rely on collaboration between Veterinary Services and public health and other services responsible for wildlife. Together they must set up a system for studying animals in the wild and for sample analysis in specialist veterinary laboratories by well-trained staff. Reporting wildlife diseases is a key task of Veterinary Services in discharging their public service mission. However, if no risk of transmission to
domestic animals and animal products is demonstrated, such reporting should not incur inappropriate sanctions from trading partners.

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Transfrontier conservation areas – compatibility with animal and human health: a southern African perspective

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Summary

In the Southern African Development Community (SADC), there are currently 14 Transfrontier Conservation Area (TFCA) projects, involving land from two or more participating countries. Of these projects, four have treaties signed, six have Memoranda of Understanding (MOUs) negotiated, two have MOU’s pending and two are still in the conceptual phase. These initiatives are strongly supported by conservationists, ecotourism enterprises and the urbanised population at large. However, the management of wildlife, livestock and zoonotic disease within larger transboundary landscapes remains unresolved, and is of major concern.

Keywords
Ecotourism – Land-use practices – Transboundary animal diseases – Transfrontier conservation areas.

Introduction

As Africa’s conservation areas come under increasing pressure from expanding human resource needs, commercial agriculture, water extraction and impoundment, as well as logging and oil exploration, the development of transfrontier conservation areas (TFCAs) are a welcome breath of ‘fresh air’ for biodiversity conservation. They are seen to be the first tangible moves that may reverse the current human encroachment being experienced by existing and established conservation areas, as expanding local communities struggle to survive the onslaughts of nature’s climatic fluctuations and plagues which threaten their food security.

The concept of TFCAs, also known as peace parks, involves the opening of transboundary landscapes to allow for protection of habitats and dispersal of wildlife. The TFCA vision and initiative explores the possibility that changing land-use practices from subsistence farming on marginal land to community participation in nature-based ecotourism may have sustainable economic and ecological benefits for all.

In addition, the integration of land across international borders, as well as the consolidation of State, privately owned and communal land in joint ecotourism ventures, may have positive economic ‘spin-offs’ for specific regions.

The various ecozones and habitats present in the TFCA will determine the animal species mixes that occur, which may include some important wildlife disease maintenance hosts or disease vectors that pose an animal or zoonotic health risk.
The challenge is how to achieve compatibility between the TFCA concept and local animal and human disease issues at the interface, as well as finding solutions to address incompatibilities between international standards for managing transboundary animal diseases (TADs), and the removal of barriers that may result in expansion of the interfaces between wildlife and livestock (see Cummings and Atkinson in this issue for further discussion).

![Map of African countries with TFCA boundaries]

Fig. 1
Transfrontier conservation areas. Courtesy of Peace Parks Foundation

It is definitely not the intention of this paper to portray these environmental conservation initiatives in a negative light. However, all parties entering these initiatives should do so with their eyes 'wide open', aware and forewarned of the potential animal and human health implications and challenges that may be expected when increasing the current geographic range of certain animal and zoonotic pathogens, or disease vectors. Without barriers on international boundaries, and with biological bridges being formed by contiguous wildlife populations, any contagious/infectious agent or vector present in any one of the participating countries or areas may eventually spread throughout the entire TFCA (3). Animal disease and zoonotic issues may also be compounded as a result of the enlarging wildlife/livestock interface, and this may have negative consequences for adjoining communities (5). Therefore, the presence of potentially problematic pathogens should be identified at an early stage, through scanning and targeted surveillance programmes, and pro-active joint containment or control measures, as well as contingency plans, should be established when and where necessary. This paper is a review of potential sanitary issues for animal and human health and describes some of the risk factors, related to pathogens and disease vectors, that may become problematic in certain African TFCAs. The paper also suggests possible mitigating procedures and future technological needs to prevent or reduce disease transmission at the interface.
**Important disease risk factors**

Several important animal/zoonotic disease risk factors have been identified with regards to the development of TFCAs. These risk factors are related to the presence of disease maintenance or amplifying hosts, the transmission patterns and modes of certain diseases, and the presence of patent disease vectors for vector-borne diseases. These, in turn, are related to certain environmental variables associated with geographic location and climate, such as mean temperatures, rainfall and altitude, and the resultant habitat and landscape types.

It is probably the savannah ecosystems, with their amazing ungulate (especially ruminant) biodiversity, that support the greatest variety of agriculturally important macro- and micro-parasites and vectors. In contrast, in very arid (desert) ecosystems, with relatively low densities of specialised mammalian species, many contagious or vector-borne infections are unlikely to be maintained. Similarly, high-altitude Afro-montane habitats, which are regularly subjected to freezing temperatures, are at most only seasonally suitable for the circulation of certain vector-borne infections.

In intermediate terms, the African tropical rainforests, with their high rainfall, reduced sunlight and canopy-bound nutrients, mainly support certain specialised niche-adapted primates, rodents and bats, together with low densities of wild ungulates on the forest floor.

In addition, the hydrology of the area, the drainage, and the presence of permanent surface water or seasonal pans may support the life cycles of important insect disease vectors, such as mosquitoes and midges.

All these factors will dictate the animal species mix that occurs in the participating land areas of the TFCA, which may also give some insight into the animal disease risk. In sub-Saharan Africa, certain key mammalian species have been identified as maintenance hosts or reservoirs of certain endemic infectious agents and are therefore of epidemiological importance. For example, the role of the African buffalo in the maintenance of foot and mouth disease (9) and theileriosis has been well documented. The association of wildebeest with alcelaphine malignant catarrhal fever (16), and the epidemiological links between wild porcines and argasid ticks in the maintenance of African swine fever (17), are also well established. Zebras and certain water- and dung-breeding midges are linked to the seasonal cycling of African horse sickness (2), while bushbuck, together with certain ixodid ticks, are linked to the epidemiology of bovine petechial fever.

Although these infections are generally 'silent' in their traditional hosts, these traditional hosts should be considered high-disease-risk species under certain interface conditions with livestock (4). It is also important to note that these key species are predominantly denizens of African savannah systems (arid, temperate or tropical).

Some wildlife species may also fill the role of amplifier hosts of infection, resulting in environmental contamination (e.g. anthrax in species with high terminal bacteraemias), or providing viraemic animals for pathogen uptake by insect vectors (e.g. orbivirus infections in wild ruminants and equids, and Rift Valley fever in ruminants).

Similarly, certain wildlife species are preferred hosts for disease vectors, e.g. the spiral horned antelopes (tragelaphids), wild porcines, buffalo, black rhino and elephant are preferred hosts for certain savannah and riverine tsetse flies (14). In addition, African buffalo, giraffes, and black and white rhinoceros are preferred hosts for the adult stages of many important ixodid ticks that are proven vectors of livestock diseases.
The disease status of domestic animals adjacent to the TFCA is also a major risk factor for wildlife within the area. For example, the presence of foreign animal diseases such as bovine tuberculosis (8, 18) or rinderpest (in the past – now eradicated globally) (12, 13) in adjacent cattle populations places the wildlife in the TFCA at risk. Similarly, the presence of canine distemper or rabies in domestic or feral dogs at the interface may threaten wild carnivorous species in the TFCA, especially the social carnivores (1, 19).

The extent and type of the interface with adjoining domestic livestock herds is also an important animal disease risk factor. The interface may be linear, as along a fenceline, or patchy – reflecting habitat preferences of the disease host. It may be focal, at a shared water point, or diffuse, where range and resources are shared, as in savannah pastoral societies. More often than not, it may be a complex combination of several of these various states. A diffuse interface holds the greatest challenge for animal disease control. In the African context, focal interfaces at water points in water-scarce systems are particularly high-risk situations for aerosol or waterborne disease transmission (7). However, infection transmission has complex dynamics and is frequently a function of the relative host population densities and their abilities to maintain infection (NT), and the inherent basic reproductive rate of the pathogen (R$_0$) in those populations.

Animal disease transmission at these interfaces may be bi-directional, with traditional ‘livestock diseases’ entering wildlife populations, or indigenous wildlife infections crossing over into livestock. Both scenarios have potentially serious implications from a conservation, disease control and economic perspective. Innovative approaches are needed if we are to achieve compatibility between the TFCA concept and traditional livestock-based agriculture.

The whole issue of disease transmission across the wildlife/livestock interface has several potentially negative outcomes:

- local losses of livestock to indigenous wildlife infections;
- losses of wildlife from non-native infections originating in livestock;
- the endemic presence of, or outbreaks of, transboundary animal diseases (TADs), with serious epidemic potential (21), may result in trade barriers being instituted that deny local communities access to lucrative markets for livestock and animal-derived agricultural products. Buffalo-associated foot and mouth disease, Rift Valley fever and African swine fever are three very important listed diseases in this context.

**The Great Limpopo Transfrontier Conservation Area – a potential case study**

The Great Limpopo Transfrontier Conservation Area currently incorporates the Greater Kruger National Park Complex (KNP) in the Republic of South Africa, the Limpopo National Park (LNP) in Mozambique, and is linked to the Gonarezhou National Park in Zimbabwe via the Sengwe Corridor (Fig. 2). A ratified treaty has been signed by the three participating countries, and a Joint Management Plan has been developed. A Joint Management Board with supporting committees in the fields of safety and security, finances and human resources, tourism and conservation (plus a veterinary sub-committee) are in place. The long-term vision is to expand the Great Limpopo Transfrontier Conservation Area (GLTFCA) eastwards to include the Banhine and Zinave National Parks in Mozambique, with these conservation components embedded within a matrix (hatched area of map, Fig. 2) of land with multiple-use options.
At this point in time, 48 km of fencing has already been taken down between the KNP and LNP. Over 4,000 head of plains game (including zebra, wildebeest, impala, waterbuck, giraffe), as well as 110 elephants and two white rhinos, were initially translocated to a fenced 30,000 ha core sanctuary area near Massingiri Dam in the Limpopo National Park. This core sanctuary has subsequently been opened. In addition, between 500 and 1,000 elephants move seasonally across the now opened border, from the KNP into LNP.

**Fig. 2**

**Gonarezhou Transfrontier Park**

Source: an information pamphlet, entitled ‘Gaza–Kruger’, issued by the Joint Management Board of this transfrontier conservation area
Animal disease risks in this TFCA are moderate-to-high, for the following reasons:

- the TFCA lies in a low-lying sub-tropical savannah ecosystem;
- the TFCA has a species mix that includes all the traditional endemic disease maintenance host and reservoir species, such as buffalo, wildebeest, zebra, wild porcines and tamps. All the indigenous diseases, including foot and mouth disease, thilerios, malignant catarrhal fever, African swine fever, anthrax, Rift Valley fever and African horse sickness, have been detected in one or more of the contributing parks;
- there are currently 20,000 people and 10,000 cattle still living in Limpopo National Park;
- the eastern side of the Mozambique component of this TFCA is unfenced and thus there will be a diffuse interface between wildlife and domestic livestock. In addition, the fences of the Gonarezhou National Park in Zimbabwe are fairly porous. The western side of the KNP section of the TFCA is fenced, creating a linear interface, but a burgeoning elephant population is increasing the porosity of this fence.

In addition:

- certain buffalo, kudu and warthog populations within the KNP component are infected with bovine tuberculosis (TB) – a foreign animal disease (6, 8, 10). These three species are all potential maintenance hosts of this contagious bacterial infection, and spill-over has already occurred into at least nine additional incidental hosts (10, 11). Bovine TB has also spread throughout the length and breadth of the KNP during the period of 1990 to 2006 (unpublished data), and has now crossed the Limpopo river and been detected in buffalo in Gonarezhou National Park in Zimbabwe in 2008 (unpublished data, C Foggin Pers. Com.). Zimbabwe previously claimed freedom from of bovine TB in cattle, based on abattoir surveillance. The TB status of cattle and wildlife in Mozambique is unknown, although limited sampling of buffalo in LNP has yielded negative results. Bovine TB has significant zoonotic potential;
- a tsetse fly incursion was detected in the northern part of the Gonarezhou National Park in Zimbabwe in 2002 (C. Foggin, personal communication). Tsetse flies also occur north of the Savé river in Mozambique. The KNP has been free of tsetse flies for over a century, and the LNP appears to be currently free of these disease vectors. There is a strong possibility that, as the numbers of preferred hosts increase in the TFCA, tsetse flies may find conditions optimal to expand their range southwards into the KNP and LNP;
- during the past decade, buffalo were introduced from Hwange National Park in western Zimbabwe into Gonarezhou National Park in the east, to address a possible genetic bottleneck. These buffalo carry different topotypes of FMD virus from those of the local resident buffalo (C. Foggin, personal communication). New topotypes may require the use of different vaccine strains for protective coverage of livestock in vaccinated protection zones;
- the northern section of the Kruger National Park and the south-eastern lowveldt of Zimbabwe are endemic anthrax areas, with annual sporadic cases, punctuated by 10- to 20-year cyclical epidemics in livestock and wildlife (7). This constitutes an important zoonotic risk;
- rabies outbreaks have been detected in domestic dogs in the Pafuri area of Mozambique (20), and rabies in Zimbabwe is currently poorly controlled. In addition, two significant rabies outbreaks occurred in domestic dogs in Limpopo Province (2008), and Mpumalanga Province (2009/2010 and ongoing) of South Africa, adjacent to the Kruger National Park. Although rabies has never been able to establish itself in free-ranging wildlife within the KNP, this disease remains a serious threat to wildlife, especially social predators, and has serious zoonotic potential;
- canine distemper is currently still circulating in domestic dogs belonging to communities adjacent to all three of the GLTFCA component national parks. This disease also poses a major threat to susceptible predator populations in the TFCA.
Conclusion

The formation of TFCAs has positive potential benefits for biodiversity conservation and ecotourism, with associated regional economic ‘spin-offs’. This land-use practice may have sustainable ecological and economic benefits for participants and the region. Participating nations should, however, be aware of the potential animal and zoonotic health challenges which may arise from these initiatives. To address these health challenges, one or more of the following mitigating measures could be instituted. A Joint Management Plan should be developed for each TFCA and should include a detailed animal health component, which spells out policy on disease surveillance and monitoring, animal translocations and introductions, disease research, movement of animal products and the keeping of domestic animals, including pets, within the protected area. High priority must be given to the development of appropriate and robust scanning and targeted disease surveillance measures, which are essential for the development of an inventory of endemic infections and for detecting emerging or newly introduced infections. In addition, appropriate contingency and response planning for significant disease events also needs to be included in the Joint Management Plan, and should cover disease managementcontainment strategies for both the TFCA and adjoining farming areas, in cooperation with local communities. Another powerful disease management and containment tool to be explored in collaboration with neighbouring communities is the sensible alignment or re-alignment of disease barrier fences, where appropriate. A further important strategy would be the development and deployment of regionally appropriate vaccines which could create immune barriers by vaccinating livestock at risk. Co-operative support offered to neighbouring communities to ensure regular dipping or spraying of livestock to control disease vectors would also go a long way towards fostering animal health, good will and cooperation. In addition, if the TFCA is located in an area that has endemic trade-sensitive diseases circulating in wildlife, the possibility of minimal risk, commodity-based trade for livestock products should be explored.

The challenges of how to achieve compatibility between TFCAs and adjoining traditional, livestock-based livelihoods are highly complex and need to be thoroughly thought through, analysed and discussed with all stakeholders, before political ratification and signing of international treaties.

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Building competence and confidence – the Performance of Veterinary Services (PVS) Pathway
(PVS evaluation and PVS gap analysis, legislation)

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Summary

The initial evaluation of the Performance of Veterinary Services (PVS) in a country, using the World Organisation for Animal Health (OIE) PVS Tool, sets the baseline, founded on democratically adopted OIE international standards on the quality of Veterinary Services.

A PVS Gap Analysis mission helps a country to define its Veterinary Services’ objectives in terms of compliance with OIE quality standards, suitably adapted to national constraints and priorities.

The country’s PVS Gap Analysis report includes a suggested annual budget and one exceptional budget (for exceptional investment), when relevant, consolidated to make up a proposed five-year budget for the country’s Veterinary Services.

In practice, this means:

– defining, together with the Veterinary Services, and in accordance with national priorities and constraints, the expected result (i.e. the level of advancement defined in the OIE PVS tool) at the end of the five-year period for the critical competencies of the OIE PVS tool which are relevant to the national context

– determining the activities to be carried out in order to achieve the expected results for the critical competencies of the OIE PVS Tool which are relevant to the national context of the country

– determining, with the help of information, data or interviews, the tasks and human, physical and financial resources required to implement these activities to enable the Veterinary Services to function appropriately.

The country PVS Gap Analysis priority objectives focus primarily on the national context of the country and its priorities. How and what to finance is a sovereign decision of the country. The country’s Government decides if this is kept for internal use (government funding) or shared with donors and relevant international organisations to prepare investment programmes.

Periodic use of the OIE PVS Tool (an initial PVS evaluation and subsequent PVS Pathway follow-up missions) provides a way of measuring in absolute terms the progress that countries have made in sustainably improving their compliance with the OIE quality standards set out in the OIE Terrestrial Animal Health Code (the Code).
Regular country PVS Pathway Follow-up missions (every two to five years) are useful to assess, monitor and accompany the progress made (changes in legislation, structure, the impact of national and international investments, improved technical capacities, etc.).

The OIE is aware that, in many developing countries, veterinary legislation is inadequate to address the challenges of today and of the future. At the request of Members, the OIE has developed guidelines on all the essential elements to be covered in veterinary legislation. Any Member that has participated in an OIE PVS Evaluation may request a follow-up mission dedicated to the provision of advice and assistance in modernising the national veterinary legislation. The OIE guidelines on veterinary legislation will be used to update the national legislation where gaps are identified in the course of an OIE PVS Evaluation.

Keywords


Introduction

Competence and confidence cannot be imposed. They are fragile assets which must be fostered progressively and which can easily be lost in the early stages of development. The Members of the World Organisation for Animal Health (OIE) have adopted international standards on the quality of Veterinary Services (8) and of aquatic animal health services (6). Within this legal framework, the OIE has developed a tool for the evaluation of Veterinary Services (the OIE PVS Tool) (5). This constitutes the cornerstone of the PVS Pathway for good governance of animal health systems, for the strengthening of Veterinary Services, and for building competence and confidence among relevant national authorities.

OIE mandate and standards

International standard-setting activities referred to in the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) are the responsibility of the ‘three sister’ international standard-setting organisations; namely, the Codex Alimentarius Commission (CAC), the World Organisation for Animal Health (OIE, formerly the ‘Office International des Epizooties’ or International Office of Epizootics), and the relevant international and regional organisations operating within the framework of the International Plant Protection Convention (IPPC).

The international standards, guidelines and recommendations developed under the auspices of the OIE for animal health and zoonoses are essential reference tools for improving animal health and welfare worldwide, through the application of science-based, democratically adopted global standards on animal diseases, including zoonoses.

The work of the OIE on standards can be divided into two broad categories:

– standards contained in the Terrestrial Animal Health Code and the Aquatic Animal Health Code, dealing with animal diseases, including zoonoses; animal welfare, and sanitary safety (including animal production food safety);

– biological standards contained in the Manual of Diagnostic Tests and Vaccines for Terrestrial Animals (the Terrestrial Manual) and Manual of Diagnostic Tests for Aquatic Animals (the Aquatic
Manual), which provide a harmonised approach to disease diagnosis by describing internationally agreed laboratory diagnostic techniques. The Terrestrial Manual also includes requirements for the production and control of biological products (mainly vaccines).

The guidelines and recommendations are given in specific documents separate from the Codes and Manuals. OIE standards integrate the outcome of a risk assessment and thus make additional risk assessments redundant. A majority of OIE standards are now used for national disease control measures.

The WTO recognises that the OIE Codes set international standards on animal disease diagnosis, surveillance and notification, risk analysis, and the quality and governance of Veterinary Services. They also include recommendations on disease prevention and control methods, trade measures, import/export procedures and veterinary certification, veterinary public health and animal welfare. The OIE Codes also aim to ensure the sanitary safety of international trade in terrestrial animals (mammals, birds and bees) and aquatic animals (amphibians, fish, crustaceans and molluscs) and their products.

In brief, the main objectives of the OIE are:

- to ensure transparency in the global animal disease and zoonosis situation
- to collect, analyse and disseminate scientific veterinary information
- to provide expertise and encourage international solidarity in the control of animal diseases
- within its mandate under the WTO SPS Agreement, to safeguard world trade by publishing health standards for international trade in animals and animal products
- to provide a better guarantee of the safety of food of animal origin and to promote animal welfare through a science-based approach
- to improve the legal framework and resources of national Veterinary Services.

In regard to the final objective, which is at the core of the PVS Pathway, one should note that animal health systems are not a commercial nor a strictly agricultural good. They are fully eligible for national and global public resources. Failure of one country may endanger the entire planet.

The concept of public goods has acquired a global dimension. Kaul et al. (2) define global public goods as those which: ‘tend towards universality in the sense that they benefit all countries, population groups and generations’.

The contribution of animal health and veterinary public health to the improvement of food security and food safety is an underlying priority. The importance of non-zoonotic diseases that affect food security (and indirectly contribute to public health issues) will not be forgotten. In relation to the control and eradication of infectious diseases, the benefits are international and intergenerational in scope. Countries depend on each other.

Good governance of Veterinary Services

In the context of the International Ministerial Conferences on Avian and Pandemic Influenza (IMCAPI), which took place in Washington (October 2005), Geneva (November 2005), Beijing (January 2006), Vienna (June 2006), Bamako (December 2006), New Delhi (December 2007), Sharm El-Sheikh (October 2008) and Hanoi (April 2010), the OIE and Food and Agriculture Organization of the United Nations (FAO) published in November 2005 a first advocacy document on the good governance of Veterinary Services: ‘Ensuring good governance to address emerging and re-emerging animal disease threats – supporting the Veterinary Services of developing countries to meet OIE international standards on quality’. This was last updated in September 2007.
The World Health Organization (WHO), OIE and FAO have worked with their partner organisations – the United Nations Children’s Fund (UNICEF), the World Bank and the United Nations System Influenza Coordinator (UNSIC) – to clarify requirements for all countries and to establish an international institutional framework that addresses emerging infectious diseases by reducing the risks of these diseases at the animal–human–ecosystems interface and strengthening capacities in a number of key areas.

There is a crucial need for appropriate legislation in the animal health field and its strict implementation through appropriate animal health systems, allowing, in principle, for:

- surveillance systems, to strengthen the health capacity of international wildlife and ecosystems
- Member incentives for early detection of disease incursions, transparency and notification, in particular for animal diseases under the relevant OIE standards
- rapid response capacity to animal disease outbreaks and implementation of biosecurity and bio-containment measures
- compensation strategies to indemnify animal owners
- vaccination strategies, as appropriate.

The use of the concept and standards of ‘Quality of Services’ (6) and (8), democratically adopted by all the OIE Members, is encouraged. An operational national chain of command is critical. Initial and continuing veterinary education and research may also need to be addressed. Deregulation can be a source of biological disasters

Building and maintaining efficient epidemiological surveillance networks and territorial meshing throughout the national territory, for all potential terrestrial and aquatic animal diseases, is a responsibility of all governments. Alliances between the public and private sectors are necessary to achieve this, given national physical, human and financial competition for resources.

The OIE considers that the key tripod for good surveillance, early warning and rapid response is based on the three following groups:

- farmers/stakeholders/hunters/rangers (wildlife officers): they are ‘the first to know’
- official veterinarians (including laboratories), and
- private veterinarians.

These concepts were encapsulated in the so-called ‘One World, One Health’ concept paper published in October 2008: ‘Contributing to One World, One Health – a strategic framework for reducing risks of infectious diseases at the animal–human–ecosystems interface’. This strategic framework has been jointly developed by four specialised agencies: the FAO, OIE, WHO and UNICEF, and endorsed by the World Bank and UNSIC, in response to the New Delhi IMCAPI recommendation.

While the integration of control systems across animal, food and human sectors has been attempted in some countries and regions (notably after the 1990s bovine spongiform encephalopathy crisis, initially in Europe), in most countries control systems are generally non-integrated with only a few collaborative projects. However, the recent efforts to control highly pathogenic avian influenza and to prepare for a pandemic have re-emphasised the need for enhanced concentration on reducing risks associated with zoonotic pathogens and diseases of animal origin through cross-sectoral collaboration, and have resulted in increased functional collaborations in many countries and at the international level.
To sum it up: more cooperation between veterinarians and medical doctors is encouraged (and 'integration' is not a recommended option). This message has been reaffirmed in the recent WHO–OIE–FAO Tripartite Concept Note – Sharing responsibilities and coordinating global activities to address health risks at the animal-human-ecosystems interfaces – the FAO–OIE–WHO Collaboration (1), published in April 2010 at the Hanoi IMCAPI conference.

Notification of animal and human diseases is an important part of this approach (4). To ensure a timely response, diseases must be immediately notified in a transparent manner.

It is under the mandate of the two global organisations responsible for the dissemination of disease information, WHO for human diseases and the OIE for animal diseases, including zoonoses.

Communicating timely and accurate animal disease information, including information on zoonoses, remains one of the core functions of the OIE and it is one in which the OIE is the world leader. Providing such information requires timely access by the OIE to all relevant data sources, both conventional and non-conventional (using, in this case, non-official information tracking systems), followed by professional analysis, evaluation and interpretation of data, including the views of the Member Country affected, before an official communication is made. The World Animal Health Information System (WAHIS), with the World Animal Health Information Database (WAHID) web-based interface, forms the nucleus of the OIE’s information system. This is an Internet-based computer system which incorporates 178 Member Countries on-line and also allows for non-OIE Members to notify their animal health status.

**The Performance of Veterinary Services Pathway**

The OIE has progressively developed the PVS Pathway, which is a global programme for the sustainable improvement of a country’s Veterinary Services’ compliance with OIE standards. The PVS Pathway encompasses the individual OIE PVS Evaluation (5), PVS Gap Analysis (7), and PVS Pathway Follow-up missions as first steps and integrates them into a comprehensive, staged approach, providing targeted support for the systematic strengthening of Veterinary Services.

- The first step: the country OIE PVS evaluation (5) is a qualitative assessment of the performance and compliance of Veterinary Services in accordance with OIE international standards on the quality and evaluation of Veterinary Services (8).

- The second step: the country PVS Gap Analysis (7) is a quantification of needs and the corresponding indicative budget addresses compliance with priority critical competencies, discussed with the country concerned and based on the PVS report of the PVS evaluation of the country. A PVS Gap Analysis mission helps to define the objectives and priorities of a country’s Veterinary Services, in terms of compliance with OIE quality standards, suitably adapted to national constraints and priorities.

- In addition, periodic PVS Pathway Follow-up missions provide a way of measuring the progress that countries have made in sustainably improving their compliance with the OIE quality standards set out in the OIE *Terrestrial Code*. The initial country PVS evaluation is the baseline, founded on democratically adopted OIE international standards on the quality of Veterinary Services.

Regular country PVS Pathway Follow-up missions (every two to five years) are useful to assess, monitor and amplify the progress made (changes in legislation, structure, the impact of national and international investments, improved technical capacities, etc.).
Figure 1, recently updated, is now the visual representation of the OIE strategy for the use of OIE standards on the quality of Veterinary Services.

**Performance of Veterinary Services evaluations**

The initial PVS evaluation of a country, using the OIE PVS Tool (5), sets the baseline, founded on democratically adopted OIE international standards on the quality of Veterinary Services (8).

The OIE-PVS Tool (5) is based on four fundamental components:
- human, physical and financial resources
- technical authority and capability
- interaction with stakeholders
- access to markets.

The 2010 (fifth) edition of the OIE PVS Tool includes 46 critical competencies; for each critical competency, five levels can be assessed: from 1 (less advanced) to 5 (more advanced).

A harmonised approach is implemented; the following documents are given to all accredited OIE PVS Assessors:
- the Manual of the Assessor – Volume 1: Guidelines for conducting an OIE PVS Evaluation
- the OIE-PVS Tool with Provisional Indicators (now the fifth edition, published in 2010).
To date (March 2011), a total of 112 official country requests for a PVS evaluation have been received. More than 100 missions have already been completed, as presented in Table I. A worldwide overview of the state of play of PVS evaluations is presented in Figure 2.

**Table I**

**PVS Evaluations. State of play up to 4 March 2011**

<table>
<thead>
<tr>
<th></th>
<th>OIE Members</th>
<th>PVS Evaluations requests received</th>
<th>PVS Evaluations missions implemented</th>
<th>Draft PVS Evaluations reports received</th>
<th>Reports available for (restricted) distribution to Donors and Partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>52</td>
<td>49</td>
<td>43</td>
<td>43</td>
<td>35</td>
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<td>29</td>
<td>21</td>
<td>20</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>Asia, the Far East and Oceania</td>
<td>32</td>
<td>17</td>
<td>14</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Europe</td>
<td>53</td>
<td>13</td>
<td>13</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Middle East</td>
<td>12</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>178</strong></td>
<td><strong>112</strong></td>
<td><strong>101</strong></td>
<td><strong>99</strong></td>
<td><strong>76</strong></td>
</tr>
</tbody>
</table>

PVS evaluation missions have pinpointed the following global diagnosis:

- national and international competition for resources
- the weakness of many national Veterinary Services (legislation, human and financial resources)
- Veterinary Services need to improve their ability to present financial information and cost/benefit arguments to support their objectives, both internally (line Minister, Minister of Finance, national Parliament) and, if needed, externally (donors and international organisations).

**PVS evaluation missions (04/03/2011)**

**Fig. 2**

**Worldwide overview of Performance of Veterinary Services (PVS) evaluation missions**

- Pale yellow: official country request received, PVS evaluation mission not completed yet
- Pale blue: PVS evaluation mission completed, country PVS report not available yet
- Green: country PVS reports available for donors and partners
**Performance of Veterinary Services Gap Analysis**

A PVS Gap Analysis mission (7) helps to define the objectives and priorities of a country’s Veterinary Services, in terms of compliance with OIE quality standards, suitably adapted to national constraints and priorities.

The country PVS Gap Analysis report includes an indicative annual budget and one exceptional budget (for exceptional investments), when relevant, consolidated to propose an indicative five-year budget for the country's Veterinary Services.

In practice, this means:

- defining, together with the Veterinary Services, and in accordance with national priorities and constraints, the expected result (i.e. level of advancement defined in the OIE PVS Tool) at the end of the five-year period for the critical competencies of the OIE PVS Tool which are relevant to the national context
- determining the activities to be carried out in order to achieve the expected results for the critical competencies of the OIE PVS Tool which are relevant to the national context of the country
- determining, with the help of information, data or interviews, the tasks and human, physical and financial resources required to implement these activities to enable the Veterinary Services to function appropriately.

As with the OIE PVS Tool, the PVS Gap Analysis follows a harmonised approach. All PVS Gap Analysis experts are provided with the *PVS Gap Analysis Experts’ Manual*, made up of the following:

- Volume I – Guidelines for conducting a mission
- Volume II – Guidelines for writing a country PVS Gap Analysis Report
- the PVS Gap Analysis Tool and Tool Box.

The country PVS Gap Analysis priority objectives focus primarily on the national context of the country and its priorities. How and what to finance is a sovereign decision of the country. The country’s Government decides if this is kept for internal use (government funding) or shared with donors and relevant international organisations to prepare investment programmes.

To date (March 2011), 65 official country requests for PVS Gap Analyses (more than 50% of countries which have benefited from an initial PVS evaluation) have already been received and 34 PVS Gap Analyses have already been completed; an overview of the situation is presented in Table II.

**Table II**

*PVS Gap Analysis. State of play up to 4 March 2011*

<table>
<thead>
<tr>
<th>OIE Members</th>
<th>PVS Gap Analysis requests received</th>
<th>PVS Gap Analysis missions implemented</th>
<th>PVS Gap Analysis document available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>52</td>
<td>31</td>
<td>18</td>
</tr>
<tr>
<td>Americas</td>
<td>29</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Asia, the Far East and Oceania</td>
<td>32</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Europe</td>
<td>53</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Middle East</td>
<td>12</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>178</strong></td>
<td><strong>65</strong></td>
<td><strong>34</strong></td>
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</tbody>
</table>
The country PVS Gap Analysis report can be used for: in-country discussions with the line Minister, other Ministries, the Ministry of Finance, the Prime Minister’s Office, the Head of State, the National Parliament, depending on the circumstances within the country; for the preparation of the country’s Veterinary Services budget and for national or international investments; and, for round-table discussions, within the country, with donor agencies and international organisations, including FAO. From experience, the preparation of round-table discussions in the country begins with bilateral contacts with donors and the headquarters of international organisations, followed by bilateral contacts at the country level, before a representative round-table discussion with all concerned stakeholders can be organised.

**Veterinary legislation**

The OIE is aware that, in many developing countries, veterinary legislation is inadequate to address the challenges of today and of the future. Veterinary legislation is an essential element of the national infrastructure that enables Veterinary Services to efficiently carry out their key functions.

At the request of Members, the OIE has developed guidelines (3) on all the essential elements to be covered in veterinary legislation. Any Member that has participated in an OIE PVS Evaluation may request a specific PVS Pathway Follow-up mission dedicated to the provision of advice and assistance in modernising the national veterinary legislation. The OIE guidelines on veterinary legislation will be used to amend the gaps in the national legislation identified during the course of the OIE PVS Evaluation.

Any Member that has participated in an OIE PVS Evaluation may request a Veterinary Legislation Support Programme mission as an additional mission, designed to provide advice and assistance in modernising the national veterinary legislation.

In 2010, the OIE published the first edition of the OIE *Veterinary Legislation Manual*. The Manual is composed of the following three components:

- Veterinary Legislation Support Programme Manual, Volume I – OIE procedures

The worldwide situation in terms of official requests for technical assistance in veterinary legislation is presented in Table III.

**Table III**

*PVS Legislation missions. State of play up to 4 March 2011*

<table>
<thead>
<tr>
<th>OIE Members</th>
<th>PVS Legislation missions requests received</th>
<th>PVS Legislation missions implemented</th>
<th>PVS Legislation document available</th>
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<tbody>
<tr>
<td>Africa</td>
<td>52</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>Americas</td>
<td>29</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Asia, the Far East and Oceania</td>
<td>32</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Europe</td>
<td>53</td>
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<td>1</td>
</tr>
<tr>
<td>Middle East</td>
<td>12</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>178</strong></td>
<td><strong>31</strong></td>
<td><strong>19</strong></td>
</tr>
</tbody>
</table>
The OIE vision

A world capable of preventing, detecting, containing, eliminating and responding to animal and public health risks attributable to zoonoses and animal diseases (both domestic and wildlife) with an impact on food security through multi-sectoral cooperation and strong partnerships.

Acknowledgements

The OIE PVS Tool and the PVS Gap Analysis Tool have been developed with the support of several experts and donors. Considerable time has passed since the OIE carried out a pilot project, co-financed by the United States Department of Agriculture (USDA) and the World Bank, aimed at evaluating the performance of Veterinary Services (PVS) in 15 countries in three regions and completed a ‘gap analysis’ mission in ten countries. In March 2011, just four years later, the OIE has received an official request for a PVS evaluation from more than 112 countries, more than 100 PVS evaluation missions have been completed worldwide, and this has already generated 65 official requests from countries for a PVS Gap Analysis, based on the country’s PVS Report.

The PVS Pathway for efficient Veterinary Services was thus born and is now a fully fledged worldwide project, co-financed mainly by the European Union, the World Bank, the USDA, the US Centers for Disease Control and Prevention, the United States Agency for International Development, the United Kingdom Department for International Development and British Foreign & Commonwealth Office, Switzerland (the Federal Veterinary Office), Japan, Italy, France, Canada (the Canadian Food Inspection Agency and Canadian International Development Agency, and Foreign Affairs and International Trade Canada) and Australia (the Australian Government’s overseas aid programme, AusAID, and the Australian Government Department of Agriculture, Fisheries and Forestry), through the OIE World Animal Health and Welfare Fund.

Very helpful and valuable advice and guidance were provided by the OIE ad hoc Group on Evaluation of Veterinary Services, currently chaired by Dr Herbert Schneider; as well as the questions raised and comments and written reviews provided by the numerous participants who attended the four PVS training sessions, the two PVS feedback sessions, the two PVS Gap Analysis training sessions and the first feedback session on the PVS Gap Analysis Tool.

References


Alien invasive species: issues related to wildlife and domestic animal trade

A tribute to Frank Fenner, who passed away in November 2010

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Summary

The definition of an alien invasive species depends on the viewpoint of the observer, who in some cases may be responsible for introducing the species. History has taught us that humans are the species that has invaded the largest surface area of the planet.

It has become increasingly evident that, since the outset, humans have not travelled alone. They have always carried with them their parasites and commensals, their food and ornamental crops and their favourite animals, with the list growing longer and more diverse with each successive millennium.

Gradually, certain species came to be universally labelled as ‘useful’ and began to be introduced anywhere where the environmental conditions were suitable, whereas others became known as ‘harmful’, irrespective of their biological reality.

The consequences of invasions by alien species involve many arenas, including agriculture, animal and public health and biodiversity. It is an issue that affects all regions of the world to a greater or lesser extent. It can have detrimental effects on animal health and biodiversity. For example, the International Union for the Conservation of Nature reports that 625 (51%) known endangered species are threatened because of invasive (alien) species.

Both wild and domestic animals may be invasive, with detrimental effects on local biodiversity; for instance, the introduction of the red fox into Australia for hunting purposes had a disastrous effect on some species of autochthonous marsupials. The introduction of goats onto the Galapagos Islands also had a negative impact on the native fauna, and more recently, the introduction of African sciuridae into the United States as new pets resulted in the importation of monkeypox. All issues of alien invasive species related to wildlife and domestic animal trade will be discussed.

Keywords

Introduction

The problem of invasive species is of interest to researchers in a variety of different fields, including biology, epidemiology, agriculture, public health and even human social sciences. It is an issue that affects all regions of the world, to a greater or lesser extent, and it can have detrimental effects on animal health and biodiversity. If many vulnerable species are threatened by alien invasive species, the situation is also exacerbated by the international trade in endangered animals, plants and their products. It must also be remembered that the most invasive species is our own, human beings. Human beings are, and always have been, the cause of many animal and plant invasions, if not most (6).

By February 2007, the Delivering Alien Invasive Species Inventories for Europe project (the DAISIE project) (2), which was the joint effort of 83 partners and 99 collaborators, had identified 10,771 alien species in the region, shared between fungi, bryophytes and lichens, vascular plants, terrestrial invertebrates, invertebrates and fish in European inland waters, marine biota, birds, amphibians, reptiles and mammals. Of course, not all alien species have the same impact on animal health or biodiversity, but the sheer number of species reported is impressive and worthy of concern.

The success of an invasion depends on the biology of the invasive species and its capacity to adapt to a new environment.

Definitions

An alien species is a species which is not native to a region and which was introduced to that region through human activity. In this context, synonyms for ‘alien’ include: exotic, introduced, non-indigenous, non-native and allochthonous. Invasive species are alien species that reach the final stage of an invasion process and have the capacity to spread. They are considered to have a highly detrimental impact in the regions concerned, not only on local biodiversity, but also on socio-economic parameters, such as animal production, animal health and even public health. The invasion process is a sequence of events and processes during which an introduced species faces, and potentially overcomes, various barriers to its establishment, proliferation and spread in a new region.

Globalisation

The recent acceleration in the volume, speed and intensity of global trade and communication has been accompanied by an unprecedented increase in the frequency of species movements, both intentional and unintentional. This acceleration has an impact on infectious diseases since the duration of transport is shorter than the incubation period of most of the known or previously unknown infectious diseases. Another factor is the widespread use of standardised freight containers, which provide easy and invisible passage, to vectors and vector-borne diseases, in particular, but also to vertebrate species. The environment and we, ourselves, are nowadays facing many challenges, such as climate change, human population growth, livestock population growth, competition for fresh water, competition for sources of energy, rapid urbanisation, changing farming systems, virgin forest encroachment, opening of previously closed ecosystems and, of course, globalisation of trade.

Globalisation can be characterised by the ‘five Ts’: trade, transport, travel (two billion people by air in 2008), tourism and terrorism. If the human population is expected to reach nine billion people by 2050, the increase in livestock population (also called the ‘livestock revolution’) should not be neglected. In 2008, over 21 billion food-producing animals were raised to feed a population of over six billion people. By 2020 this demand is expected to increase by 50%. Even biological and medical research played a role in the history of invasive species. A single example is quite relevant. Individuals belonging to an African amphibian genus, *Xenopus*, which has been used worldwide in human
reproduction programmes since the 1930s, established feral populations in numerous countries and may be linked to the global dissemination of the chytrid fungus *Batrachochytrium dendrobatidis* (8). Finally, the present appeal of new, usually exotic, companion animals, mostly in developed countries, is also a contributing factor to new invasions.

**Biodiversity**

As stated above, the problem of alien invasive species is clearly linked to the issue of biodiversity. There is still much to learn about biodiversity on our planet, but we already know that there are currently 62,275 identified vertebrate species (7), comprising:

- 31,564 fish species
- 6,570 amphibian species
- 9,002 reptile species
- 9,723 bird species
- 5,416 mammal species.

The International Union for the Conservation of Nature (IUCN) (5) reports that 625 (51%) known endangered species are threatened because of invasive (alien) species. It has established lists of species (the IUCN ‘red list’), according to their level of vulnerability, as follows:

- extinct (EX)
- extinct in the wild (EW)
- critically endangered (CR)
- endangered (EN)
- vulnerable (VU)
- lower risk (LR)
- data deficient (DD).

As already mentioned, many of these species are threatened by invasive species, but also by the international trade in endangered animals, plants and their products. In an attempt to protect these animals from the negative impact of this trade, 175 countries have signed the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES), which has been implemented since the 1970s.

**Biodiversity of mammals, birds and domestic animals**

The first complete inventory of mammal species was made in 1982 and included 4,170 species. The last complete inventory was published in 2005 and included 5,416 species (genotypic taxonomic revision) (9). The present estimate is that 99% of living mammal species have already been identified. This increase in number seems to be paradoxical and even contradictory, if one takes into account the extinction of some species during the same period. However, the reason for the increase becomes clear when one considers that each phenotype of a newly discovered species is listed separately and, more importantly, that the advent of molecular technology allows for increasingly detailed comparisons of species limits and evolutionary relationships, and the discrimination of species according to their genotypes.

Among mammals, there are 2,277 rodent species belonging to 481 genera (42% of recognised mammal species) and 1,116 species of chiroptera (bats) belonging to 202 genera (20.6% of recognised mammal species). Bats and rodents are often the source and the reservoir of new
emerging infections. There are at present 9,723 bird species identified, belonging to 2,058 genera, most of which are passerines, and most of these species fly.

The genetic diversity of livestock and companion animals should also be taken into account. Livestock (‘stock of lives’) have always played a crucial role in the subsistence of humankind, through meat, milk, eggs, honey, fibre, leather, fur, transportation, manure and work, and accompanied us during our migrations. Through selection, humans have created a huge number of different breeds of domestic animals. For example, there are approximately 700 recognised breeds of cattle worldwide (3), but many of these are on the verge of extinction and have fewer than 100 breeding cows left. There is thus a swift erosion of genetic variability in cattle that is very worrying, because genetic variability is the key to adapting to a changing world, and, on a wider scale, to evolution.

There are approximately 300 recognised dog breeds (more than enough to meet the needs of human beings for working dogs and companion animals). These breeds show a remarkable phenotypic and genotypic variability. As already mentioned, given that there are so many breeds of dog, it is difficult to understand the present fashion for new exotic animals, which may sometimes impact on the biodiversity of already fragile native species or introduce new emerging pathogens.

**Biodiversity of pathogens**

At the beginning of this century, there were 1,415 species of infectious agents known to be pathogenic to humans (1). These included 217 viruses and prions, 538 bacteria and rickettsia, 307 fungi, 66 protozoa and 287 helminths. Of these, 868 (61%) were classified as zoonotic and 175 pathogenic agents were considered to be associated with emerging diseases. Out of 175 emerging pathogens from this group, 132 (75%) were zoonotic, the vast majority of which came from wildlife. Wildlife constitutes an important potential reservoir of unknown pathogens, both for humans and animals. At present, the number of identified viruses is roughly 5,000; this number is thought to be a considerable underestimate. For instance, eight different herpesviruses infecting humans are already known; five different herpesviruses infect cattle. Moreover, due to the lack of nucleic acid correction mechanisms during replication, RNA viruses produce populations of quasi-species and are constantly evolving. The potential for variation is therefore enormous.

**Impact of invasive alien domestic or wildlife species**

The phenomenon of biological invasion is increasing, principally as a result of human activity. It may have consequences for biodiversity, animal health and production, public health and the environment. As far as domestic animals are concerned, one of the best-documented stories is the introduction of rinderpest into eastern and southern Africa at the end of the 19th Century and its impact on the Maasai population, through the decimation of cattle, and on wildlife.

Another frequently described example is the introduction of goats onto the Galapagos Islands and their impact on the biodiversity of native fauna through the overbrowsing of vegetation.

Last but not least is the well-documented impact of the introduction of cattle with heartwater disease (cowdriosis) onto Caribbean islands, accompanied by the appropriate ticks needed to transmit it.

As already mentioned, according to the IUCN, 625 (51%) endangered species are threatened because of invasive (alien) species. There are numerous examples, such as the introduction of the American grey squirrel into the United Kingdom and the progressive elimination of the native red squirrel; the introduction of the European red fox into Australia for hunting, with a detrimental effect on the native marsupials; the release of the American mink into Europe and the progressive elimination of
the native European mink. One of the best examples of the impact of alien invasive species on the environment is the introduction of the European rabbit into Australia, with highly detrimental effects (4).

Wild alien invasive species may also impact on animal and public health; for instance, the brushtail possum, which was introduced from Australia into New Zealand, is now the major reservoir of bovine tuberculosis in its new country, where it has flourished to a very high population density; the introduction of African horse sickness into Spain through the importation of African zebras; the introduction of monkeypox with imported African squirrels into the United States; and the introduction of highly pathogenic avian influenza H5N1 through smuggling eagles for falconry into Belgium.

References
The health of wildlife: the role and needs of zoological conservation organisations

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Summary

The Wildlife Conservation Society (WCS) manages five zoological parks in the City of New York, including the Central Park, Queens and Prospect Park Zoos, the New York Aquarium and the flagship Bronx Zoo. In total there are some 1,700 species of animals managed through the curatorial and health care programmes. In addition, WCS manages approximately 75 land and seascapes in 60-plus countries, many with field health programmes that provide veterinary services, capacity building, disease surveillance and health monitoring efforts for free-ranging wild populations. The Wildlife Conservation Society is part of the Association of Zoos and Aquariums, a regional professional organisation that inspects and accredits facilities, implements models for maintaining the genetic diversity of collection populations, nationally and internationally, and raises the level of health and husbandry care which often exceeds those required by government. There are similar regional groups in Europe, Africa, Latin America and Australasia, as well as the World Association of Zoos and Aquariums, that strive for many of the same goals.

The programmes of modern zoos and aquariums go well beyond the display of wildlife. Today, zoological organisations are increasingly involved with the conservation of free-ranging wildlife around the globe. The health-care programmes have also increased in size and scope, and provide state-of-the-art veterinary and allied science services and research in a variety of areas. In order to maintain viable populations of genetically diverse species in zoos or in isolated-remnant, free-ranging wild populations, it is necessary to move animals regionally, nationally and internationally. Increasingly, the knowledge gained through the intensive management of zoological collections and animal movement is finding important applications in small populations of critically endangered free-ranging species, as well as providing valuable information that contributes to food security and protects the health of people and domestic animals.

Keywords


Introduction

Today’s leading zoos and aquariums strive to provide the highest quality of health care to wild animals. Zoological veterinarians work closely with Departments of Public Health and Agriculture, as well as domestic animal health organisations, at the local, regional, national and international levels.
Close relationships are essential to comply with regulations governing animal movement and to ensure the health of people, domestic animals and wildlife. As zoological organisations have become more involved with species conservation, their expertise in population management and health provides unique skills to mitigate the threats to species survival.

Fifty years ago, zoos were very different places. Animals were primarily kept for display in austere enclosures with limited breeding programmes. Today, zoos and aquariums are evolving into conservation centres that connect people to wildlife through immersion exhibits, educate the public about the threats to biodiversity, strive to maintain sustainable populations of wildlife, create assurance populations for endangered and threatened species with the goal of re-introduction, and perform field conservation projects that seek to conserve wildlife in their native habitats. The global professional umbrella organisation of zoological institutions is the World Association of Zoos and Aquariums (www.waza.org). Members strive for excellence in conservation, animal management, breeding and animal welfare. Zoos and aquariums around the world are visited by some 700 million people each year. This is roughly equivalent to the entire human population of the planet visiting a zoo or aquarium in the next decade.

Zoological associations and record-keeping

Each region of the world has a zoological association. The Association of Zoos and Aquariums (AZA) (www.aza.org) represents North America. The United States Department of Agriculture (USDA) licenses some 2,400 animal exhibitors; however, only approximately 200, less than 10%, qualify for membership in AZA, due to the strict accreditation programmes which include regular inspections by peer professionals. The accreditation standards cover animal husbandry, veterinary health care, organisational governance, education programmes, facilities’ operations, and research and conservation activities that meet or exceed government standards. (www.aza.org/uploadedFiles/Accreditation/Accreditation%20Standards.pdf). In 1981, AZA established the Species Survival Program, with the goal of maintaining demographically sustainable populations of rare species in Member Institutions for 100 years, with genetic diversity exceeding 90%. This effort requires Member participation and is facilitated by population biologists of the Population Management Center, hosted by the Lincoln Park Zoo, Chicago, Illinois, United States (www.lpzoo.org/conservation-science/science-centers/population-management-center). Modelling software, including the Single Population and Analysis Record Keeping System (SPARKS) and Population Management 2000 (PM2000), has been developed over time to aid in the management process. To maintain successful breeding programmes that strive to fulfil these parameters, it is necessary to move animals between institutions and to some extent between regions.

The American Association of Zoo Veterinarians (AAZV) (www.aazv.org) is composed of health-care specialists in zoological and wildlife medicine from zoos, aquariums, universities and governments, representing many countries. The AAZV establishes guidelines for the health care of captive wildlife (1) that serve as the basis for the AZA standards. The guidelines were last updated in 2009 and include requirements for veterinary care, protocols for medicating animals, preventive medicine, necropsy and post-mortem tissue disposal, nutrition, quarantine, isolation of ill animals, hospital facilities’ guidelines, record-keeping and animal identification. Animal identification has been one of the foundations of quality zoological husbandry and medical care for more than 25 years. In mammals, redundant identification systems are optimum, to be certain to accurately identify each individual. Modalities include radio frequency transponders, tattoos, pattern recognition imaging, banding, ear tagging or ear notching. Similar species-appropriate identification systems are used in birds, reptiles and amphibians. Coinciding with the identification system is a computerised record of each animal that includes: signalment, breeding, husbandry and medical information. The International Species Information System (ISIS) (www.isis.org) comprises approximately 800 Member zoos, aquariums and related organisations in some 80 countries. In addition, ISIS maintains the most widely used
record-keeping systems for zoological collections around the world, entitled Animal Record Keeping System (ARKS) and, Medical Animal Record Keeping System (MedARKS). The ISIS global database for the zoological community holds information on approximately 2.6 million animals comprising some 10,000 species. The pooled physiological data of all Member zoos include health diagnostic test results for thousands of species. The ISIS database is in the process of implementing a new generation of web-based software, entitled the Zoological Information Management System (ZIMS). In 2011, the animal-record-keeping module is being introduced and it is hoped that by 2012 the medical record section will be complete.

Healthcare

The work of the Wildlife Conservation Society's (WCS) health staff is but one example of the direction of many zoo and aquarium health programmes around the globe. We deploy veterinarians and wildlife health professionals at our five New York City zoological parks and at landscape conservation sites around the world. The focus is both on population health at a broader, field-wildlife-management scale and on individuals and small groups at the zoological population scale. The challenge of individual wild animal care is that few medications or biomedical diagnostic modalities are made specifically for wildlife. Therefore, the profession seeks to apply new technologies in novel ways. Examples include the use of diagnostic and therapeutic minimally invasive techniques, special imaging studies, pharmacokinetic trials of new medications and the application of vaccines in novel species under controlled conditions. One of the potential benefits of working with intensively managed species in limited habitats is the ability to closely monitor clinical trials during applied studies. One such example at WCS was the administration of rabies vaccines to African wild dogs (*Lycaon pictus pictus*) maintained at the Bronx Zoo collection, Bronx, New York, followed at regular intervals by blood draws for serological testing to evaluate the immune response. In this way, the staff were able to confirm in the zoo environment, where the animals were more easily handled, that the vaccine did produce protective titres (5). This allowed field researchers working with African wild dogs in their native habitat to administer the vaccine with a high level of confidence that titres would be protective.

Re-introduction of species into the wild

Re-introduction and translocation are recognised as part of a holistic species recovery programme (6). Many zoological organisations are deeply involved in re-introduction efforts with a variety of species. The WCS zoological health staff work closely with curatorial and field staff, along with other disciplines and partners in government and non-governmental organisations and universities, to provide a holistic approach to the challenge of repatriation of species. One example from WCS was the recovery of the Kihansi spray toad (*Nectophrynoides asperginis*). This very small amphibian species was native to the Kihansi Gorge in Tanzania. Ten years ago, when a dam project was being planned, WCS herpetologists were asked to bring animals into captivity to rescue the species. The Kihansi spray toad was declared extinct in the following years. Over the ensuing period, WCS Bronx Zoo herpetologists, clinical veterinarians and veterinary pathologists worked closely with colleagues from the Toledo Zoo, Ohio, and representatives of the government of Tanzania. Methods of care and propagation were developed to stabilise and breed the captive population. New diseases were identified, including ranavirus infection and chytridiomycosis, and methods of treatment and prevention established. Tanzanian specialists were trained in the care of the animals. A propagation facility was designed and construction completed in 2010 in Dar Es Salaam, Tanzania. Later, in 2010, for the first time in ten years, Kihansi spray toads returned to Tanzania, where they are stable and breeding in the propagation centre. Work continues to define and prepare safe re-introduction areas in the wild. It is hoped that, within the coming years, the toad will be repatriated to the wild.
Mitigating the risks of animal movement

Successful propagation programmes in zoological parks require animal movement in order to maintain genetically diverse populations over long horizons. The health group performs pre-shipment examinations and diagnostic testing to minimise the risk that animals will carry diseases to other zoological populations. Testing is also performed to comply with government regulations for interstate or international animal movement. In addition, new animals to the WCS collections are placed in quarantine, examined and tested, prior to introduction into the zoo or aquarium collections.

Wildlife pathology

Quality wildlife veterinary pathology is the foundation of medical care programmes and a vital part of disease surveillance, both within the collections and with wildlife that may live in the region. The WCS is amongst a select number of zoological organisations around the world that support a staff of board-certified wildlife pathologists. Upon their deaths, animals receive a thorough post-mortem examination and histology is performed in a majority of cases. Many additional diagnostic procedures, including microbiological culturing and molecular diagnostics, are performed in an effort to isolate and identify pathogens. Dedicated diagnostic pathology services are essential for defining the normal physiology and anatomy of thousands of wild species, as well as the mechanisms of disease pathology and transmission.

In 1999, when the keepers at the Queens Zoo, New York, sounded the alarm that thousands of wild American crows (Corvus brachyrhynchos) were dying and, at the same time, the human medical community was describing a novel deadly disease syndrome in people in the same region, it was the wildlife pathologist of WCS who played an integral role in determining that both crows and people were dying of what appeared to be a similar pathogen. Working with government animal and public health agencies and other researchers, the diagnosis of West Nile virus was confirmed (4). This disease was known to occur in other parts of the world but its occurrence in New York was a novel emergence of the pathogen in the Western Hemisphere. Thereafter, Lincoln Park Zoo, supported by US government funding, sponsored a national reporting system in which zoological parks reported the deaths of wild birds and worked with government laboratories to diagnose the disease. This occurrence demonstrated that robust surveillance systems could decrease delays in identifying novel pathogens and mitigate negative impacts on people, domestic animals and wildlife.

Projects in the field

The presentations by Drs Uhart, Ondzie and Atkinson of the WCS field health programme were provided earlier in the conference and their work demonstrates the importance of field health studies. There are a broad range of additional field health projects being performed by WCS health scientists in collaboration with multiple partners, including participation in the United States Agency for International Development’s (USAID) Emerging Pandemic Threats PREDICT program (www.usaid.gov/our_work/global_health/home/News/ai_docs/emerging_threats.pdf), which builds on the recently completed USAID Global Avian Influenza Network for Surveillance Program (www.avianarchive.gains.org/). PREDICT engages a group of partner wildlife health organisations, headed by the Wildlife Health Center at the University of California School of Veterinary Medicine, Davis, California. Partners include the WCS, the EcoHealth Alliance, the Global Viral Forecasting Initiative, the Smithsonian Institution and others. These collaborative wildlife disease surveillance programmes promise to expand abilities to more quickly identify emerging wildlife pathogens in a variety of species, especially at control points, such as wildlife markets, and at sovereign borders, where confiscations of illegal wildlife products may be seized and tested. As an international non-governmental organisation focused on biodiversity, WCS has concerns about the illegal and
unregulated trade in wild animals, both for its negative impacts on wild species biodiversity but also for the threat it may pose to the health of wildlife, domestic animals and people. Furthermore, the OIE shares these concerns.

Quarantine regulations

As noted earlier, in order to maintain demographically sound populations of wild animals in ex-situ situations, it is essential to move individuals or groups. One of the major challenges to the safe movement of wildlife for purposes of re-introduction, translocation or zoological breeding programmes is government regulation. Oftentimes, the regulations are promulgated to protect the health of people or livestock and are based on our knowledge of domestic animal and human diagnostic testing. However, since the diagnostic tests were not developed for the variety of wild animals to which they are being applied, the results can often be difficult to interpret (2, 3). A false-positive test can prevent or delay shipment and result in unintended negative impacts on both individuals and species.

For example, primates entering the USA must undergo a quarantine period in which three negative tuberculin skin tests are performed, two weeks apart, along with two blood draws for serum banking to test for titres to Ebola virus. This typically requires at least three immobilisations over a five-week period. The tuberculin skin test was not developed for the plethora of wild primate species and false-positive tests may arise, which will further extend quarantine. At present, no consideration is given to the point of origin, so an animal coming from a zoological park with a quality wildlife health programme is treated in the same manner as an animal that comes from the wild with no medical history. However the Centers for Disease Control and Prevention are re-evaluating these regulations and considering modifications (www.cdc.gov/animalimportation/lawsregulations/nonhuman-primates/nprm/questions-answers-importers.html).

Another example is wild ruminants intended for shipment to the USA. Prior to entering the USA, ruminants and swine to be imported must undergo a minimum 30-day quarantine in a USDA-approved pre-embarkation quarantine facility, where they are tested for taxa-specific diseases of concern to the USDA. In countries with known foot and mouth disease, the quarantine is 60 days. Following negative test results and the appropriate quarantine period, the animals may be transported into the USA and placed in a USDA quarantine facility for an additional 30 days before being released to the zoo. The animals may be immobilised three to four or more times to undergo the required testing and, should there be a response to one of the required tests, then the period of quarantine may be extended with further immobilisations required. As with non-human primates, the tests were not developed for wild species and spurious results that extend quarantine and require additional animal immobilisation and quarantine put the individual animal at increased risk. Developing diagnostics whose interpretation is specific for wildlife is an important next step, as are the OIE’s efforts to create standards for testing wildlife.

Conclusion

In conclusion, it is important for regulators in veterinary and human medicine to learn more about the zoological parks within their regions and to see them as a potential resource for wildlife disease expertise. We who work in the zoo and wildlife health profession are challenged to provide for the quality care of wild animals in zoological and wildlife parks. As species are under threat of extinction, and we seek to preserve biodiversity, we will increasingly be called upon to move animals around the globe to save them. Oftentimes, the regulations written to protect livestock and human health are not promulgated to also ensure the health and well-being of wildlife. If we are to preserve a future for species biodiversity and, by extension, the health of ecosystems and ultimately humanity, we must work together to create better diagnostic tests and better regulations.


References


**Integrative approaches to disease control:**
the value of international collaborations

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**Summary**

‘One Health’ and biodiversity issues are global and complex. As such, they require international collaboration if we hope to achieve the goal of minimising disease impacts on humans and animals, while maintaining biodiversity and ecosystem integrity. This will require motivated teams to overcome barriers to collaboration, by focusing on the proven keys to success and developing networks of biological, physical and social scientists as well as decision-makers and stakeholders. These collaborations will require facilitation by governments and international organisations.

Finally, we must move towards a more holistic, transdisciplinary approach to international collaborations. New forms of knowledge, institutional structure and problem-solving require a new dialogue between science and the humanities. Transdisciplinarity serves to ground the particular biodiversity or emerging disease issue in its ecological, social and health context, and enable decision-makers to reach across agencies and disciplines to strengthen the basis for sustainable ecosystems, health and development policies. We believe that future successes in addressing complex issues such as emerging infectious diseases, loss of biodiversity, and climate change will depend on international collaborations based on transdisciplinarity.

**Keywords**


**Introduction**

The problems of a global society are increasingly complex and interdependent and, consequently, are not isolated to particular groups or disciplines. Many are unpredictable, emergent phenomena with non-linear dynamics whose effects have positive and negative feedbacks. As new problems develop, and strategies to address them are implemented, uncertainties continue to emerge and unexpected results occur, requiring not only a re-evaluation of one’s strategies, but also of the problem itself. Social scientists term such complex issues, ‘wicked problems’ (6). Many of the environmental problems we face today are characterised by such complexity. Issues and phenomena such as climate change, maintenance of biodiversity, pollution and ‘One Health’ are not only biologically complex, but are technically and socially complex on a global scale. Traditional, intra-disciplinary
scientific approaches are incapable of addressing complex environmental and health problems that transcend scientific, social and technological fields of study. A new approach to these complex problems is required.

‘One Health’ problems comprise several sub-problems that fall into the domains of different disciplines and social sectors, introducing a further level of complexity. An excellent example of this is the ecology of *Vibrio cholerae*, which requires elucidation by microbiologists, ichthyologists, entomologists, ecologists, epidemiologists, environmental engineers and sociologists, as well as medical professionals. There are wide variations in the preferences and values that decision-makers and stakeholders assign to the qualitative, quantitative and economic attributes of alternatives in a decision-making process, such as the one needed to address the management of cholera. By their very nature, these complex problems require numerous groups of scientists, decision-makers and stakeholders to collaborate on developing and implementing solutions.

### Barriers and keys to successful collaborations

A number of internal and external factors can create barriers to successful collaboration. These include philosophical differences among individuals, organisations and agencies, as well as government policies, poor facilitation, inadequate leadership and project scope. Duplication of efforts can also be a barrier to collaboration. Many organisations often yield duplicated efforts, projects and expenses because traditional boundaries and biases often lead to views such as, ‘we can do it better our way’, and ‘it will be more efficient if we do it ourselves’. Some of the most important barriers, though, are those that arise from methodological boundaries created by the culture of specific disciplines and organisations, such as poultry *versus* cattle health, or wildlife *versus* domestic animal health, or even human *versus* animal health. All of these barriers hinder transdisciplinary approaches to collaboration and problem-solving.

Active coordination and collaboration can overcome these barriers and produce results more rapidly and efficiently. Numerous researchers from a broad array of disciplines have analysed both successful and unsuccessful collaborations to identify the keys to success. Two of the most important factors identified from these efforts include: identification of the actual issue on which the group will collaborate and the purpose of the collective (8). This seems simple enough, but all too often committees are formed without clearly defined goals, leaving the group itself to struggle with its ultimate purpose. Regardless, once a collaborating group is formed, the participants must set goals and objectives, and have a clear vision of the desired outcomes.

An environment conducive to establishing beneficial working relationships is an integral component of effective collaboration. The ability to build relationships and create an environment of trust and respect is difficult, but essential for achieving the group’s goals. Effective leadership and adequate support in terms of staff, funds and infrastructure are also essential.

Other keys to success are policy-level support and effective communication among all the collaborators and the stakeholders they represent. Indeed, communication has been linked to effective decision-making and consensus-building. For situations characterised by complexity, interdependence and equivocality, communication allows the pooling of individual knowledge, as well as the collective formulation of effective strategies for addressing issues. Information must be exchanged at many levels, including within the collaborative group, and at the policy and technical levels. However, it is also important that information is packaged and delivered in the right form, so it is usually best if provided sequentially and separately to the various target audiences.

Time is also a crucial factor in successful collaborations. It is not only important that a collaborative effort be given adequate time to complete its goals, but the timing of the effort itself is important. All too often, collaborations are under pressure to produce products quickly as a result of an emerging
issue. While a good team can overcome these time constraints, they can almost certainly produce a better product without the pressure of externally imposed deadlines. In other words, proactive collaboration is more effective than reactive collaboration.

Once the barriers and keys to successful collaborations are identified, the next step is to implement a collaborative process. Symposia are an effective way to jump-start communications and collaborations within and beyond the region. These symposia should identify regional priorities for building skills and projects, and identify intra-regional linkages. Such linkages ensure that a region draws from and builds upon existing resources instead of unnecessarily relying on support from outside the region, which can lead to duplication of resources. International support should foster these linkages, rather than weakening them, by focusing collaborations on building and enhancing government agencies that can address conservation and health issues. Without the support of local and national governments, enduring conservation programmes are difficult to maintain.

Some of the most important activities that governments, universities and international organisations, such as the World Organisation for Animal Health (OIE), Food and Agriculture Organization of the United Nations (FAO), EcoHealth Alliance and Wildlife Conservation Society, can undertake to encourage and enhance collaboration are the development of communication tools and training to close technological gaps. These activities also provide an opportunity to develop interpersonal relationships that are crucial to building trust and breaking down barriers. Another important activity that government agencies and organisations can facilitate is the creation and maintenance of rosters of expertise within regions. These rosters can be invaluable for regional scientists, decision-makers and other stakeholders to draw upon, as well as for the international agencies themselves. For example, last year the United States Department of Agriculture (USDA), the Chinese Academy of Sciences and the Chinese State Forestry Administration developed an Asia–Pacific Conference on Wildlife-Borne Diseases. Thirteen countries and five international organisations participated to promote collaboration in the field of wildlife diseases among countries and districts in the Asia-Pacific region; to share activities related to investigation, surveillance and research on wildlife diseases; and to coordinate the cooperation and communication of specialists across multiple disciplines. One of the outcomes of this conference was the creation of an Asia-Pacific communication network of scientists and decision-makers, interested in the ecology and management of diseases in wildlife.

Collaborations should foster an integrated approach to conservation, social, economic and political factors. These principles are embodied within the ‘One Health’ approach to medicine, encouraging the ‘collaborative efforts of multiple disciplines working locally, nationally, and globally, to attain optimal health for people, animals, and our environment’ (1). This approach recognises that the physical, psychological and social health of people are inextricably linked with animal and ecosystem health. As collaborations develop, they should focus on providing science and tools to make informed decisions, rather than adopting the policy positions of donors. Country and regional policy decisions must incorporate socio-economic, cultural and political considerations. Collaborations should harness the complementarity of different institutional programmes. Too much focus is placed on the negative aspects of institutional differences, when it is these very differences that will be most productive in yielding solutions to complex problems.

Appreciating that the process of collaboration is more important than short-term products is a difficult step for product-oriented scientists and managers to make. These professionals are trained to focus on results and products, such as publications, management plans and changes in parameters, such as disease incidence and prevalence, species richness and demographics. While long-term products and solutions should remain the goal, the process of collaboration itself should be the short-term priority. International collaborations are difficult to implement and, once established, they are fragile. So focusing on collaboration should be the primary short-term goal.
Country and regional interdisciplinary start-up teams are initially the most important component of collaborations. These teams must be composed of key players that have expertise, motivation and the skills to build coalitions. They are vital in identifying other supporters and partners, organising meetings and activities, and developing a common vision. Start-up teams help partners to develop a base of common interests and concerns and to develop a consensus on a vision of a desired future.

**Approaches to collaboration**

When developing collaborations, focus should be placed on creating a network of networks. Global problems are too large and complex to be approached from a centralised perspective. If success is to be achieved, we have to accept that we cannot control the network or even know everything that is happening all the time, within every portion of the network. If we acknowledge that international collaborations are essentially networks, then we can apply network theory to understanding and facilitating them. A number of scientists have studied international collaborations in science (10). These studies suggest that collaborations are emergent, self-organising systems where the selection of a partner and the location of the research within disciplines rely upon choices made by individual scientists and not through specific national or international incentives or constraints. The numerous choices of scientists to collaborate are motivated by reward structures where authorships, citations and other forms of professional recognition lead to additional work and reputation (10). This multidisciplinary approach to collaboration is by far the most ubiquitous. While there may be a common problem or set of problems on which the group is engaged, each discipline works independently, and the results are usually brought together at the end of the effort (7). Much of the international community’s efforts in addressing highly pathogenic avian influenza (HPAI) H5N1 have been from a multidisciplinary approach. While this kind of collaboration is not often conceptually innovative, it can provide insight on different aspects of a particular problem, leading to immediate but usually short-lived solutions. To be sure, the focused and refined multidisciplinary approach to science has been the cornerstone of our long-term evolution of knowledge. However, such specialisation also has the undesirable side-effect of fragmenting knowledge, which has been difficult to apply to realistic, complex problems (9). Multidisciplinary science has been essential in illuminating environmental problems, but has been incapable of integrating and synthesising knowledge of such issues into a larger ecological and social context, or guiding the development of policy to resolve them (2, 5).

Although multidisciplinarity is the most common form of collaboration in science, another approach, interdisciplinarity, is becoming more common in addressing complex problems. In interdisciplinary collaborations, scientists work jointly, using a shared conceptual framework which draws together discipline-specific theories, concepts and approaches (3, 7). This type of collaboration provides a more comprehensive organising principle by coalescing traditional fields of investigation. Interdisciplinary collaborations have been successfully used to address malaria control in Thailand and Brazil, diarrhoeal disease risk factors in Nigeria and, more recently, plague and tularemia in the United States of America. Although interdisciplinary collaborations provide new insights on complex problems, the results are often reported by individual disciplines within their traditional publication outlets.

Multidisciplinary and interdisciplinary methodologies provide the building blocks of knowledge within sub-disciplines and the capacity to understand those building blocks in the context of inter-related systems. However, they are generally incapable of understanding the whole ecosystem, including societal, cultural, economic and political, as well as biological and physical, factors. It is the integration of all these dimensions that is essential for resolving specific biodiversity and emerging infectious disease issues. A transdisciplinary approach is needed to ground complex issues in their ecological and social context, and enable decision-makers to reach across agencies and disciplines to work with
their counterparts in conservation, medicine, agriculture, education, economics and planning, to strengthen the basis for sustainable ecosystems, health and development policies. Transdisciplinarity recognises that complex problems are open and ill-defined, and that the reality being investigated consists of a nexus of phenomena which are not reducible to a single dimension (4, 5, 7). The very nature of complex problems is dependent on context and the relationship among the elements being investigated constitutes a core concept for complexity (6). Common ground and a more comprehensive understanding of such problems are not derived from an ideal model of how system function is a result of its constituent parts. Rather, the understanding emerges from the cross-fertilisation of multiple methods and perspectives that are adapted to the particular problem being investigated.

Also, investigation and problem-solving occur at several scales. At the scientific level, teams must learn to work in interdisciplinary and transdisciplinary settings that include multiple and non-traditional stakeholders. This requires time to learn about other disciplines and their terminology, develop a respect for a variety of perspectives on an issue, and learn to work in teams whose members have varying degrees of knowledge and work ethics. Scientists also need to develop skills in working with teams that are geographically separated; most multidisciplinary teams are composed of scientists within a specific country and institution. Complex biological problems, such as emerging infectious diseases and climate change, are global or regional by nature and require international collaborations where team members will not be able to meet physically on a regular basis. Technologically advanced communication tools, such as internet and video conferencing, in combination with traditional forms of communication (e.g. teleconferencing, conferences, physical meetings), along with other information-sharing technologies (e.g. cloud computing, social networking), can significantly improve communication and data-sharing among geographically dispersed teams and decision-makers.

At the institutional level, the scientific system must begin to transform itself and create appropriate curricula and institutional surroundings conducive to transdisciplinary approaches. Universities and agencies are arranged around scholarly disciplines, which promote individual or collaborative approaches within scientific fields. Scientists and professionals must be trained to think beyond the confines of their disciplines and to seek out expertise across multiple fields of study, as well as to embrace non-traditional sources of knowledge (e.g. cultural knowledge of local resources). Institutions must also remove professional impediments to successful transdisciplinary collaborations. Multidisciplinary approaches succeed because the disciplinary members of a team are encouraged to publish findings in their own journals. While numerous awards and promotions are bestowed on those who publish single-authored papers and books within disciplinary journals, relatively few are available to those who work on inter- and transdisciplinary teams. Environmental problems require transdisciplinary approaches, which the conventional knowledge institutions have been unable or slow to provide. Or, as Brewer (2) wrote, paraphrasing a popular axiom, ‘the world has problems, but universities (institutions, agencies) have departments’.

Finally, investigation and problem-solving occur at the political level. Here, policy transformations have effects on science and management systems. Governments, international organisations and donor agencies must play an active role in facilitating transdisciplinary approaches by providing funding, infrastructure, recognition and incentives to support collaboration networks across disciplines. While an increasing number of institutions are adopting transdisciplinary strategies, progress has been slow because organisations and agencies have long histories of multidisciplinary approaches shaped over periods when sustainability and the integrative demands that it requires were not priorities. Thus, many institutions reflect past problems, understanding and imperatives rather than emerging issues. However, progress is being made. The North American Interior Columbia River Basin Ecosystem Management Project, the National Cancer Institute’s Transdisciplinary Centers Initiatives, the Australian Cooperative Research Centres programme, the Intergovernmental Oceanographic Commission’s Integrated Coastal Area Management Project, the Gund Institute of Environmental
Economics, and the United Nations Environmental Science Programme’s Science Initiative are examples of organisations, universities and governments that are addressing complex biological problems through transdisciplinarity.

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The need for sound and sustainable policy in an interconnected world: science-based guidance from the OIE

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Summary

As we increase our understanding of the relationship between wildlife and domestic animals, and between these animals and the humans co-existing in their ecosystems, we also recognise the complexity of these relationships. Changes in land use related to animal production, including the expansion into new geographic areas and the intensification of production to meet increasing needs for animal-based products, have altered the equilibrium between domestic animals and wildlife – and their interactions have changed both in frequency and in nature. At the same time, the growth and heightened urbanisation of the human population place additional pressure on the biodiversity of wildlife. The importance of the relationship between wildlife and domestic animals has for a long time been recognised by the World Organisation for Animal Health (OIE), and the Working Group on Wildlife Diseases, founded in 1994, is the longest-standing Working Group of the OIE. Perhaps even more so than for any other area of the OIE’s work, issues related to species biodiversity, particularly to wildlife biodiversity, necessitate and benefit from the broadest level of inter-sectoral collaboration. This paper describes the current work and future directions of the OIE in relation to protecting animal health and safeguarding biodiversity.

Keywords


Introduction

The World Organisation for Animal Health (OIE) was created in 1924 by 28 countries who wanted to implement an international agreement that would enable them to work together to try to put an end to the epizootics that were devastating their livestock. In particular, they were seeking transparent communication from other countries facing animal disease, so that, if an important disease event occurred, all countries could be informed and take preventive and protective action. These countries also sought information on the most effective methods of controlling the most dangerous animal diseases. The objective of quality sanitary and scientific information in the veterinary field is still among the priority missions of the OIE, both for diseases solely affecting animals and those that are transmissible to humans. The world animal health situation has evolved since the origin of the OIE and, while these fundamental principles remain in force, the OIE also takes into account modern pressures, such as the globalisation of animal trade and movements. As one component of this, the
recognised role and importance of wildlife – both in captivity and in the wild – have considerably increased over recent decades. As a result, the OIE now regards wildlife disease issues as a fundamental component of the world animal health situation.

**OIE Global Conference on Wildlife, Animal Health and Biodiversity – preparing for the future**

In its role as the international standard-setting organisation for animal health, the OIE develops standards based on scientific knowledge, modifying these standards over time to incorporate the evolution of relevant science. To support these efforts for wildlife diseases, in 1994, the OIE founded the Working Group on Wildlife Diseases (WGWD), asking the participants – comprising worldwide wildlife experts – to inform and advise the OIE on all health problems relating to wild animals, whether in the wild or in captivity. In this role, the WGWD provides the OIE with a global perspective and foresight into important wildlife health and disease issues. This entails, among other responsibilities, assisting the Scientific Commission to incorporate wildlife issues into OIE standards, as appropriate; assisting OIE Members and OIE National Focal Points on Wildlife to enhance their capacity to meet OIE standards and obligations for diseases in wild animals; assisting the OIE to receive, record and interpret information on wildlife disease; and advising the Scientific Commission on risks, surveillance, responses and management associated with wildlife disease. It is with these responsibilities in mind that the WGWD proposed and oversaw the first OIE Global Conference on Wildlife, Animal Health and Biodiversity – Preparing for the Future (‘the Conference’) in February 2011, during which the key challenges and opportunities concerning wildlife were identified.

The Conference provided the opportunity to share up-to-date science from a diverse range of disciplines, all of which had consequences for biodiversity. Other chapters in this Compendium go into detail on specific technical areas. This chapter will focus on the larger issues presented during the Conference: the current activities undertaken by the OIE to promote animal health while protecting biodiversity, and the challenge accepted by the OIE, to continue to develop science-based guidance to support sound and sustainable animal health policy, taking into account the need to safeguard biodiversity.

**OIE support for safeguarding biodiversity**

The main challenges that the OIE currently faces reflect our modern understanding of the role and importance of wildlife and biodiversity in our world. They include the emergence and re-emergence of diseases that are transmissible among wildlife, domestic animals and humans, and a recognition of the societal, economic and ecological value and health benefits of healthy and diverse wildlife populations. As the OIE strives to support the increased need for animal protein for growing populations worldwide, it must also take into account the fact that changes in land use and management may lead to new or modified interfaces between humans, domestic animals and wildlife that could favour disease transmission and loss of biodiversity. Consistent with its main mission, OIE guidance and capacity-building must meet the need to increase the capacity of all countries worldwide to conduct surveillance, detect disease early, and initiate an appropriate response to the outbreak and spread of diseases in wildlife, and must also emphasise the fundamental responsibilities of Veterinary Services and their government partners to protect and improve animal health, including aspects related to wildlife and biodiversity. The OIE has a key role in this through its continuous development and updating of standards and trade- facilitating mechanisms to harmonise national regulations that address the ecosystem interface between wildlife and domestic species. The OIE’s role in this area must also reflect the fact that international and national organisations responsible for the delivery of public health, Veterinary Services, wildlife and the environment are all contributors to
safeguarding biodiversity yet may be accommodated in different institutional units. Thus, the OIE, along with others, should promote a multidisciplinary approach, characterised by cooperation among stakeholders, including public and non-governmental organisations, to achieve mutually beneficial outcomes within the wildlife/domestic animal/human/ ecosystem interface.

To address these challenges the OIE currently incorporates wildlife disease issues into the breadth of OIE guidance and standards and supports them with capacity-building efforts to assist OIE Members to comply with standards. The OIE calls upon its expertise, predominantly within the network of OIE Reference Laboratories and Collaborating Centres, and including those centres providing expertise on wildlife issues, to provide a sound scientific basis for its guidance and standards. In support of safeguarding biodiversity, the OIE is working to conceptually balance the positive effects and human benefits from two areas – domestic animals and wildlife/ecosystems – translating science into sound and sustainable policy that recognises the interconnected nature of these systems. From domestic animals, humans gain an important source of dietary protein and food security. Domestic animals provide individual economic security, and national economic benefits through international trade. Wildlife and healthy ecosystems can also provide economic benefits, through ecotourism, hunting, fishing, or farming activities based on healthy wildlife. These ecosystems (including the wildlife populations) also provide broader benefits to animal and human health through their biodiversity (1), as well as more direct benefits, such as potential medical discoveries. Maximising the benefit from either area, however, can apply negative pressure on the other. It is the balance of these pressures and outcomes that will ultimately lead to sustainable approaches that include safeguarding biodiversity, protecting and promoting animal health, maintaining the availability of high-quality protein for consumption, and supporting international trade. The OIE approach includes aspects of early detection, surveillance and control; transparency (notification) of diseases while avoiding undue trade restrictions; promoting and supporting the role of Veterinary Services in safeguarding biodiversity and promoting wildlife health; extending its reach through communication and collaboration; and expanding and incorporating the scientific basis for biodiversity as a benefit to animal health.

Early detection, surveillance and control

The backbone of understanding the animal health situation is the accurate diagnosis of disease. Consistent with OIE standards, this includes the application of validated diagnostic assays shown to be fit for purpose (4, 5). Ideally, these methods should also be widely available and able to be performed in a variety of situations. The OIE has clearly outlined standards to determine such fitness for purpose, including identifying those species for which the test has been validated. Many validated tests exist for domestic animals. However, when applied to other species, these same tests may have much lower specificity and sensitivity, or may provide completely invalid results. Some tests are relatively unaffected by the species of host animal, but others are valid only for the species for which they were developed and validated. The diversity of animal species that make up the category of ‘wildlife’, and the limited resources for addressing wildlife diseases that are not zoonotic or do not occur in domestic animals, has resulted in a lack of validated diagnostic methods for wildlife, leading to a compromised ability to determine the aetiology of a wildlife disease outbreak, determine disease presence or absence among susceptible wildlife species as a component of a country’s disease control programme, with resulting potential implications for trade, and conduct testing that supports the safe movement of wild species and minimises delays necessary to attain release from quarantine and movement to the final destination.

Extreme care must be taken to ensure that the tests used can be validly applied to the wild animal species under study, for surveillance or in outbreak situations. The OIE has convened an expert ad hoc Group on Validation of Diagnostic Tests for Wildlife to address this issue and, through the
activities of this ad hoc Group, is drafting guidelines on the principles and methods for the validation of diagnostic tests for infectious diseases applicable to wildlife, taking into account the existing OIE validation standards. Such guidelines will have to address the complexities of diagnostics in wildlife, such as the broad range of animal species in which diseases manifest differently and the varying epidemiology of any given disease, taking into account the natural history of the wildlife host and potential vectors.

The availability of validated diagnostic assays for wildlife species provides just one tool for surveillance of wild animal disease. Only through wildlife pathogen surveillance can a country know what pathogens exist within its wild animal populations, detect new or emerging diseases, and estimate the proportion of infected animals in a population. The OIE standards and guidance must also offer disease surveillance and management tools relevant to disease in domestic and wild animals. With a good understanding of the relevant wild animal species, surveillance opportunities for wild animals living in captivity are similar to those for domestic animals. However, the methods for conducting both general and targeted surveillance often vary among animals in the wild. General surveillance for wildlife pathogens and diseases most often begins with the detection of sick or dead wild animals, rather than the more systematic abattoir or herd-based serosurveillance among domestic animals. Targeted pathogen surveillance can be conducted to obtain information about a particular pathogen in a particular host animal population or community, or to establish that a pathogen is not present in a susceptible wild population so that a country can claim that it is free of that particular pathogen. For both general and targeted surveillance in wildlife, obtaining desired samples adequate to support the surveillance objectives is often very challenging and requires both careful planning and adequate resources.

Control of the disease, once it has been identified, either to manage an outbreak or to establish freedom from an OIE-listed disease when wild animal species are implicated in the epidemiology of that disease, is made more complex with the presence of wild animals. The management of wild animals in captivity, especially in a farming situation, may be similar to that of a domestic animal population. The occurrence of an outbreak among wild animals, or the presence of wild animals in a domestic animal outbreak, may not be manageable using the traditional domestic animal disease control measures. Movement restrictions may not be easily feasible for wild populations, due to both the freedom of movement required for migration or feeding and to the lack of existing containment facilities. Culling may not be an option, due to the need or desire to maintain wild animal populations. Additional disease control measures, such as vaccination, are rarely an option, as there are few validated vaccines available, due to scientific and practical economic barriers. Both surveillance and disease control measures are being reviewed in the OIE Animal Health Codes, to address the most critical issues relevant to wildlife.

The need to increase transparency and avoid undue restrictions on trade

Understanding the worldwide animal health situation is dependent upon notification of animal health events, including those occurring in wildlife. Legal trade in wildlife is a component of the increasing global movement of animals and animal products. The occurrence of OIE-listed and other emerging diseases among wildlife is important to the health of the affected wild species and because the presence of disease among wildlife can play a role in the introduction or re-introduction of important diseases into domestic animal populations, with the potential for international spread. Through the development and refinement of international standards and notification systems, the OIE has taken steps to promote transparent reporting of animal diseases, including those in wildlife, and, at the same time, avoid undue restrictions on trade or unjustified or ineffective and harmful actions against wildlife populations to protect trade.
In its international standards, the OIE continues to introduce trade-facilitating mechanisms, such as disease-free zoning, compartmentalisation and safe trade in commodities to harmonise the interface between wildlife and domestic species. The OIE also promotes appropriate wildlife trade by supporting other international multilateral agreements and standards (e.g. the Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES], an international agreement between governments to ensure that international trade in specimens of wild animals and plants does not threaten their survival). The OIE, as a part of continual efforts to update the Terrestrial and Aquatic Animal Health Codes (2, 6), is undertaking the revision of disease-based chapters into pathogen-based chapters. This approach would allow clear guidance on which species (domestic and wildlife) play important epidemiological roles in OIE-listed diseases to clarify their potential role in trade-related issues.

To support increased transparency in notification, the OIE has also improved the ability for the World Animal Health Information System (WAHIS) to receive reports of disease events involving wildlife, to avoid undue restrictions on trade where these would not be appropriate or relevant. Improvements made in WAHIS to support notifications of wildlife disease (e.g. the introduction of expanded animal species lists and other methods of differentiating between reports for wild and domestic species) should also improve the quality of information about wild species. These improvements will culminate in WAHIS-Wild, an online reporting system within WAHIS fully capable of supporting notifications for disease events in wildlife, whether for OIE-listed and emerging diseases or for non-listed diseases. Combined, these improvements should result in a better understanding of the animal health situation in domestic and in wild animals, which in turn should lead to improvements in the OIE’s early warning system. Improved monitoring of additional diseases specific to wild species can be used to protect biodiversity and, at the same time, achieve maximum benefits for domestic animals and human health.

The role of Veterinary Services in safeguarding biodiversity and promoting wildlife health

It is a fundamental responsibility of Veterinary Services to protect and improve animal health, including issues related to wildlife and biodiversity, yet not all countries have the adequate capacity to conduct surveillance, achieve early detection, and initiate the appropriate response to disease outbreaks and spread among wildlife. The OIE approaches capacity-building through multiple avenues, with a major approach being the OIE Performance of Veterinary Services (PVS) Pathway, a global programme for the sustainable improvement of a country’s Veterinary Services’ compliance with OIE quality standards. A specific methodology has been developed, using the OIE Tool for the Evaluation of Performance of Veterinary Services (the OIE PVS Tool) as the basis for evaluating performance against the international standards published in the Terrestrial Animal Health Code (6). A similar tool is available for the evaluation of aquatic animal health services. An evaluation using this tool can assess both compliance with international standards, and the appropriateness of the human and financial resources within the Veterinary Services dedicated to national animal health and welfare. Within this evaluation, activities related to wildlife can also be assessed in the context of international standards, recognising that these are all issues relevant to the activities of Veterinary Services.

Since national Veterinary Services may not have the extensive expertise in, awareness of or responsibility for wildlife in their particular country, the OIE has also instigated national Focal Points for Wildlife as a part of the OIE Focal Point system to enable the Delegate to more efficiently manage his or her OIE Member obligations. These OIE Focal Points for Wildlife, appointed by the OIE Delegate, have the responsibility of establishing a network of wildlife experts within his or her country or of communicating with the existing network; of establishing and maintaining a dialogue with the Competent Authority for wildlife in his or her country, or of facilitating cooperation and communication among several authorities (where the responsibility is shared); of supporting the optimal collection and
submission of wildlife disease information to the OIE through WAHIS (immediate notifications and follow-up reports, six-monthly reports, and annual questionnaires), under the authority of the OIE Delegate. They should also act as a contact point with the OIE Animal Health Information Department and the Scientific and Technical Department on matters related to wildlife, including wildlife diseases; and prepare comments for the Delegate, as necessary, by conducting in-country consultations with recognised wildlife and animal health experts on all relevant OIE documents, to reflect the scientific view and position of the individual OIE Member and/or the region, including comments on proposals for new OIE standards and guidelines related to wildlife. In countries where the primary responsibility for wildlife is placed in a separate organisational unit from the Veterinary Services, the Focal Point can serve as a crucial liaison between the Delegate and the national Wildlife Services. The OIE has conducted training of all appointed Focal Points for Wildlife, addressing the main components of a national wildlife disease programme (3).

**Focus for the future – making strides in safeguarding biodiversity**

Building on these existing efforts, the OIE needs to continue developing science-based standards on disease detection, prevention and control, as well as safe trade measures to harmonise policies on disease risks at the interface between wildlife, domestic animals and humans. This includes developing and updating OIE strategies and policies on wildlife and biodiversity through the work of the Scientific Commission and its Working Group on Wildlife Diseases, as well as through the network of OIE Reference Laboratories and Collaborating Centres. Continued support and updating of the notification mechanisms for wildlife diseases, through the global information systems of OIE WAHIS and WAHIS-Wild, is needed, to take into account the possible effects of such notification by Members on trade in domestic animals and their products, and to further promote data-sharing at the international level. Through scientific guidance and capacity-building efforts, the OIE should support Members’ ability to access and use appropriate sampling and diagnostic expertise, as well as validated tools, for disease surveillance and management in domestic and wild animals. The OIE should also encourage research to expand the scientific basis for the protection of biodiversity and the environment, to promote both animal and public health. This would include encouraging the systematic inclusion of these issues in the curriculum for veterinary education. In addition to its established relationships, the OIE should explore opportunities for communicating and establishing a strong collaboration with the relevant global public and private organisations also working on wildlife and biodiversity, to strengthen existing regulations on the trade in wildlife and wildlife products, and advocate the need to mobilise more resources in this area.

Nations and regions also have responsibilities in this area. OIE Members have been recommended to continue to implement international standards and guidelines on the prevention and control of diseases, including those transmissible among wildlife, domestic animals and humans. They should also continue to implement international standards and guidelines to facilitate the acceptable, legal trade of wildlife animals and wildlife products and to help reduce the illegal wildlife trade. OIE Members should notify diseases in wildlife through WAHIS and WAHIS-Wild, including those in quarantine facilities, while carefully acknowledging when such notifications should not have an unjustified impact on the trade of domestic animals and their products with commercial partners, according to the OIE standards on relevant diseases. Members should ensure that the national Veterinary Services and their partners fulfil their responsibilities on aspects of biodiversity conservation, animal health and animal welfare, as they relate to wildlife and the environment, including appropriate legislation and regulation. Where needed, they should seek assistance through the OIE PVS Pathway to improve their services – this can be most effectively implemented if countries make a commitment to nominate and support their national OIE Focal Points for Wildlife in their tasks and encourage their collaboration with partner agencies and organisations. In compliance with OIE standards, Members should seek and apply appropriate sampling and diagnostic expertise and
validated disease management tools for wildlife diseases, with the participation of a broad diversity of stakeholders. Countries also have a role in supporting relevant research to expand the scientific basis for the protection of biodiversity and the environment to promote animal health as well as public health. In addition, they should support, at the national level, the systematic inclusion in the veterinary education curriculum of the promotion, protection and improvement of animal health and animal welfare, including all aspects related to wildlife and biodiversity.

**Communication and collaboration through new and existing partnerships**

In countries and throughout the world, Veterinary Services and organisations with responsibility for animal health are among the many partners promoting wildlife health and who have invested in the broader issue of safeguarding biodiversity. At all levels, the actions of the Veterinary Services can have substantial implications for achieving positive outcomes in these areas. Developing OIE guidance on how national Veterinary Services can make a positive contribution that is consistent with their mandate and international standards, as well as effectively collaborate with partners, is complicated by the fact that these Veterinary Services might belong to different institutional units from those of the Competent Authorities and other stakeholders. OIE guidance can often support these collaborative efforts, but their ultimate success is dependent on a multidisciplinary approach and commitment among public, private and non-governmental stakeholders. Open communication about guidance policies and procedures can lead to opportunities to harmonise such guidance, and to identify and achieve mutually beneficial goals and outcomes. To be effective, such approaches should take into account not only the need to understand the domestic animal/wildlife/human interface but also the interface between the organisations and bodies that are working in these areas.

**The scientific basis for biodiversity as a benefit for animal health**

The OIE develops international standards and guidance within its mandate, based on scientific evidence. While there is a growing body of literature and scientific expertise outlining the benefits of biodiversity, the ability to incorporate such evidence into its standards, and ultimately into policy, is dependent on the publication and broader dissemination of scientific findings in this field, and the effective communication of these findings to policy-setting organisations. The scientific community conducting research on the benefits of biodiversity could most effectively drive policies to safeguard biodiversity by designing, implementing and disseminating the results from studies that have an a priori objective to be useful in informing policy, and by establishing stronger collaborations between scientists conducting this research and those in policy-making organisations, such as the OIE.

**Conclusions**

As an international standard-setting organisation in animal health, which includes responsibility for wildlife, the OIE is committed to providing science-based guidance and standards to Members that promote animal health, as well as measures to protect biodiversity and wildlife populations. Within Veterinary Services, the ability to achieve this aim is based on systems of good veterinary governance. More broadly, taking into account the many partners working in this area, safeguarding biodiversity will also require all involved parties to commit to a similar conceptual governance process, one that recognises each individual and organisation’s responsibility to participate in the good governance of our planet and its resources.
References


RECOMMENDATIONS

CONSIDERING

1. The emergence and re-emergence of diseases that are transmissible among wildlife, domestic animals and humans,
2. The societal, economic and ecological value of diverse and healthy wildlife populations,
3. The key contribution of biodiversity and ecosystems services to health and the need to encourage research and expand knowledge on its interactions,
4. The need to increase the capacity of all countries worldwide to conduct surveillance, early detection, and initiate appropriate response to outbreaks and spread of diseases in wildlife,
5. The fundamental responsibilities of Veterinary Services and their government partners to protect and improve animal health, including aspects related to wildlife and biodiversity,
6. That the OIE is continuously developing and updating standards and trade facilitating mechanisms such as disease free zoning, compartmentalisation and safe trade in animal origin commodities to harmonise national regulation contributing to address the ecosystem interface between wildlife and domestic species,
7. That organisations internationally and nationally responsible for the delivery of public health, veterinary services, wildlife and the environment may be accommodated in different institutional units,
8. The increased need for animal protein for growing populations worldwide,
9. The changes in land use and management that may lead to new or modified interfaces between humans, domestic animals and wildlife that could favour disease transmission and loss of biodiversity,
10. The need for a multidisciplinary commitment and cooperation by stakeholders including public and non-governmental organisations to achieve mutually beneficial outcomes within the wildlife/domestic animal and human ecosystem interface.

THE PARTICIPANTS OF THE OIE GLOBAL CONFERENCE ON WILDLIFE

RECOMMEND TO THE OIE

1. To continue developing science-based standards on disease detection, prevention, and control as well as safe trade measures to harmonise the policies related to disease risks at the interfaces between wildlife, domestic animals, and humans.
2. To continue supporting and updating the notification mechanisms of wildlife diseases through the global information systems OIE WAHIS and WAHIS-Wild, while carefully considering possible impact of such notification by Members on the trade in domestic animals and their products, and to further promote data sharing at the international level on the GLEWS platform.
3. To assist Members to strengthen their Veterinary Services to protect animal health including aspects related to wildlife and biodiversity using, if needed, the OIE PVS Pathway.
4. To encourage OIE Delegates to utilise their OIE focal points on wildlife to identify needs for national capacity building.

5. To support Members’ ability to access and utilise appropriate sampling and diagnostic expertise, as well as validated tools for disease surveillance and management in domestic and wild animals.

6. To encourage research to expand the scientific basis for the protection of biodiversity and environment to promote animal health and public health.

7. To encourage systematic inclusion, in the curriculum for veterinary education, of the promotion, the protection and the improvement of animal health and animal welfare including aspects related to wildlife and biodiversity.

8. To explore opportunities for communication and establishing strong collaboration with relevant global public and private organisations working on wildlife and biodiversity such as FAO\(^1\), WHO\(^2\), UNEP\(^3\), IUCN\(^4\), CIC\(^5\), CITES\(^6\) and other relevant Multilateral Environmental Agreements and international organisations to strengthen support to existing regulations on trade in wildlife and wildlife products and advocate for the need for mobilisation of resources in this area.

9. To continue to develop and update OIE strategies and policies on wildlife and biodiversity through the work of the Scientific Commission and its Working Group on Wildlife Diseases as well as the network of OIE Reference Laboratories and Collaborating Centres.

**RECOMMEND TO OIE MEMBERS**

10. To continue to implement international standards and guidelines on prevention and control of diseases including those transmissible among wildlife, domestic animals and humans.

11. To continue to implement international standards and guidelines to facilitate the acceptable, legal trade of wildlife animals and wildlife products and to help reducing the illegal trade in wildlife.

12. To notify diseases in wildlife through WAHIS and WAHIS-Wild, including in quarantine facilities, while carefully acknowledging when the notifications should not impact on trade of domestic animals and their products with commercial partners according to the OIE standards on relevant diseases.

13. To ensure that the national Veterinary Services and their partners fulfil their responsibilities on aspects of biodiversity conservation, animal health and animal welfare as they relate to wildlife and the environment, including appropriate legislation and regulation, and, where needed, seek assistance through the OIE PVS Pathway to improve their services.

14. To nominate and support national OIE Focal Points for Wildlife in their tasks and encourage their collaboration with partner agencies and organizations.

15. To seek and apply appropriate sampling and diagnostic expertise and validated disease management tools for wildlife diseases, including with the participation of private veterinarians, medical doctors, community workers, fishermen, hunters, rangers, and other stakeholders.

16. To support relevant research to expand the scientific basis for the protection of biodiversity and environment to promote animal health as well as public health.

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\(^1\) Food and Agriculture Organization of the United Nations

\(^2\) World Health Organization

\(^3\) United Nations Environment Programme

\(^4\) International Union for Conservation of Nature

\(^5\) International Council for Game and Wildlife Conservation

\(^6\) Convention on International Trade in Endangered Species of Wild Fauna and Flora
17. To support systematic inclusion, in the curriculum for veterinary education, of the promotion, the protection and the improvement of animal health and animal welfare including aspects related to wildlife and biodiversity.

18. To encourage public and private components of Veterinary Services to play an active role in promoting biodiversity and protecting wildlife.

19. To foster effective communication and collaboration at the national and regional level between different governmental agencies that share responsibilities for the environment and the health of wildlife, livestock and the public.

20. To explore and promote opportunities for communication, collaboration and partnerships with relevant public and private organisations having an interest in wildlife management and biodiversity including the tourism industry, private veterinarians and medical doctors, natural park and zoo managers, rangers, hunters, fishermen, conservation associations and local indigenous communities and stakeholders.

21. To promote the adoption of legislation to clarify or define ownership of wildlife by people and organisations.