

Int. Zoo Yb. (2007) **41**: 3–11

DOI:10.1111/j.1748-1090.2007.00020.x

Role of the zoo veterinarian in the conservation of captive and free-ranging wildlife

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The challenges to execute wildlife conservation projects successfully have become more complex as anthropogenic changes continue to stress the planet, changing wild lands. As the wild becomes less so, more species are placed in captivity to improve their chances of long-term survival, while concurrently management (and medicine) for free-ranging wildlife has become increasingly important. A variety of disciplines, including veterinary medicine, is now recognized as key to wildlife conservation. Although veterinarians have been involved in conservation for decades, it is only recently that their role has become more appreciated in the larger conservation community. This realization of the contributions of veterinarians has occurred at a time when disease has been recognized as significantly impacting species' conservation both *in situ* and *ex situ*. Today, veterinarians work with captive and free-ranging animals to prevent and/or treat diseases that threaten species' survival. Most of these diseases are associated with the increasing human footprint. In this paper, I present wildlife health in today's world and the zoo veterinarian's role in wildlife conservation.

Key-words: conservation; disease; health; species; wildlife; zoo veterinarian.

INTRODUCTION

Veterinarians have played a key role in conservation efforts carried out by zoological parks (zoos) for many decades. For the purpose of this paper, 'zoos' refers to accredited zoos, such as the more than 200 zoological facilities in North America accredited by the Association of Zoos and Aquariums (AZA) and the 300 member facilities in the European Association of Zoos and Aquaria. Traditionally, the zoo veterinarian's role focused on *ex situ* populations, ensuring animal health and welfare for captive animals by applying therapeutic medicine for individuals and, more recently, preventive and therapeutic medicine

for populations. Now, as zoos expand their role in conservation efforts and move conservation outside their 'walls' with an increasing number of projects directed at the conservation of populations *in situ*, the zoo veterinarian's role has also expanded. In addition to the health care provided to captive animals, zoo veterinarians today have a number of roles within *in situ* conservation projects that ensure the maintenance of healthy and viable free-ranging populations of wildlife.

The commitment of zoos to conservation efforts and the development of the discipline of conservation biology are primarily responses to the current conservation crisis. Unlike past extinctions, this 'sixth extinction' (Leakey & Lewin, 1996), in which we are losing species at a rate 100 to 1000 times above the 'normal' level (Pimm *et al.*, 1995), is related to human activities that have resulted in habitat fragmentation and degradation, isolation of species and an increased contact between wild animals, domestic animals and humans. Zoo personnel have responded to this extinction crisis. Many of the activities performed by zoos today are devoted to ensuring the long-term survival of wildlife. Within this directive, the role of the zoo veterinarian has also expanded to address the health needs of wildlife populations, both in captivity and in the wild.

In conjunction with the current extinction crisis, wild places containing 'wild' animals, untouched by humans and/or human activities, are now hard to find. In fact, it has been noted that few species exist today that have not been influenced by some form of human

intervention (Redford & Richter, 1999). Additionally, in the last few decades it has become increasingly clear that the impact, and potential impact, of disease on conservation efforts must be factored into the conservation equation (Dobson & Hudson, 1986; May, 1988; Scott, 1988; Thorne & Williams, 1988; Daszak *et al.*, 2000; Deem *et al.*, 2001; Cleaveland *et al.*, 2002). Examples of diseases with known significant conservation implications include canine distemper virus in a number of carnivore species (Deem *et al.*, 2000), fibropapillomatosis in sea turtles (Herbst, 1994), worldwide amphibian declines associated with a fungal agent (Daszak *et al.*, 1999), Ebola in great apes (Walsh *et al.*, 2003) and West Nile virus in free-ranging and captive wild birds (Ludwig *et al.*, 2002).

As reviewed by Woodroffe (1999), there are several species that have experienced near extinctions associated with disease, including the Black-footed ferret *Mustela nigripes*, Bighorn sheep *Ovis canadensis*, African wild dog *Lycaon pictus* and the Ethiopian wolf *Canis simensis*, probably because small populations are particularly vulnerable to external factors, including infectious diseases. Additionally, the first report of an infectious disease causing the extinction of a species, the Land snail *Partula turgida*, has been confirmed (Cunningham & Daszak, 1998), and there is now strong evidence of disease being the proximate and ultimate cause of extinction in a species in the wild (Sharp-snouted day frog *Taudactylus acutirostris*: Schloegel *et al.*, 2006).

As part of the team to address these disease-related challenges, veterinarians have unique skills, training and experience that contribute to conservation programmes, both *ex situ* and *in situ*. In addition to their basic training in veterinary medicine, most zoo veterinarians have a degree in animal husbandry, biology, conservation biology or zoology, and advanced training in a subspecialty of the medical profession. Wildlife-health-related subspecialties include anaesthesiology, clinical medicine, epidemiology, nutrition, pathology, theriogenology and toxicology.

In this paper, I present the historical and current roles of zoo veterinarians in conservation, and offer suggestions of how to integrate the health sciences into conservation initiatives. Although the focus of this paper is on the role of zoo veterinarians in wildlife conservation, the distinction between the 'zoo' and 'wildlife' veterinarian has become increasingly less clear and many veterinarians can be viewed as 'zoo and wildlife' veterinarians. Additionally, many 'non-zoo or wildlife' veterinarians employed in private practice, at universities, in non-profit organizations and within Governments play significant roles in conservation.

THE CHANGING REALITY OF THE WILD

In today's world, it is hard to define the word 'wild' as it pertains to wildlife. Is the recently confiscated Jaguar *Panthera onca* now held at a zoo in Latin America wild? Is the African elephant *Loxodonta africana* just immobilized for telemetry collar placement in Kruger National Park, South Africa, wild? Is the third-generation Western lowland gorilla *Gorilla gorilla gorilla* held at a zoo in North America wild? Or, is the Black-footed ferret captive bred and identified for release to nature, wild? If one considers the role of veterinarians in wildlife conservation, it is important to also consider the changing realities of the wildlife for which they provide care.

The above questions exemplify the grey zone that exists for veterinary care of an animal we call wild and one we call captive. As conservation projects include the maintenance of some species, on the brink of extinction, with captive propagation for intended release to the wild (e.g., Black-footed ferrets and Bali mynah *Leucopsar rothschildi*), the captive and wild populations effectively become one regarding health status. Similarly, with the growing support of ecotourism projects, bringing humans in closer contact with free-ranging animals, as exemplified by species such as the Mountain gorilla *Gorilla beringei beringei* (Cranfield *et al.*, 2002), the

possibility of infectious-disease transmission and impacts on the conservation of the species increase.

Pressures on wildlife health from proximity to domestic animals have also led to recent epidemics among threatened species. Some of the best-documented cases are studies on African carnivores and include rabies in the Ethiopian wolf (Laurenson *et al.*, 1998), rabies and canine distemper in the African wild dog (Alexander & Appel, 1994; Kat *et al.*, 1996), and canine distemper in Lions *Panthera leo* (Roelke-Parker *et al.*, 1996). Conversely, zoo animals are often exposed to pathogens carried by feral domestic animals and/or free-ranging wildlife including the agents that cause leptospirosis, rabies and canine distemper, which often result in morbidity and mortality within the zoological setting (Rupprecht, 1999; Deem *et al.*, 2000; Bolin, 2003).

With much of the Earth's wild lands now little more than very, very large zoos, zoos too have changed. Zoos today often have multi-species exhibits, enclosures with more natural habitats and with more possible connections between captive and wild animals as a result of strategies such as captive reproduction and reintroduction programmes. Animals living in both these situations (captive and wild) have been influenced by humans and may in fact now require veterinary intervention for their survival.

THE EXPANDING ROLE OF THE ZOO VETERINARIAN

Historical

As a conservation tool, healthy captive animals in zoos have been the ambassadors for their species, educating and inspiring people to care about wildlife conservation. Historically, the zoo veterinarian's role in conservation focused on the health care of these individual captive animals. The success of maintaining wild animals in captivity has been largely a function of our ability to provide adequate nutrition and health care for these captive animals living in artificial

environments. Zoo veterinarians applied (as they continue to do today) diagnostics and therapeutics to captive animals as a means of ensuring good health and long lives. Additionally, veterinarians historically (as they continue to do today) were instrumental in animal-welfare issues being properly addressed within zoos (Miller, 1992).

In the past, the division between the zoo veterinarian caring for the individual animal in captivity and the wildlife veterinarian, focusing on free-ranging wildlife populations, was often very clear. These veterinarians, working in zoos *or* on free-ranging wildlife issues, would rarely overlap in their efforts directed at species' conservation. Zoo veterinarians provided veterinary treatments for individual sick animals in cages while wildlife veterinarians focused on diseases of wildlife as they related to the health of domestic species (e.g. cows, pigs, chickens) in contact with wildlife, game animals (e.g. deer, ducks) and/or zoonotic diseases (diseases transmissible from animals to humans), such as rabies, brucellosis and tuberculosis (Friend, 1976). Additionally, the primary role of wildlife veterinarians was often only put into action for the management (conservation) of populations experiencing disease epidemics associated with high mortality. In the more recent past, we find zoo veterinarians providing care for animals in multi-species exhibits in captivity and directing much of their efforts towards preventive medicine on populations both in captivity and in the wild, while wildlife veterinarians may be called upon to care for an individual of a highly threatened species.

Present

Zoological parks have become increasingly important players in the conservation effort. No longer menageries for wild animals and centres strictly for public entertainment, zoos are now conservation centres. Many of the activities of the 'new' zoo (conservation centre) are to ensure both *in situ* (e.g., species' viability and protection) and *ex situ* (e.g., captive-reproduction programmes)

conservation efforts globally. Along with this changing philosophy of zoos, has come an expanding role for zoo veterinarians within conservation efforts. In fact, advances in veterinary medicine (e.g., anaesthesia, diagnostics and medical management) have been key for zoos to develop into the conservation centres they are today. Veterinarians are one component of the conservation team that remains instrumental for providing preventive and therapeutic medicine, and inspector functions that help ensure the proper psychological well-being, husbandry, nutrition and health care of the animals maintained in zoos (Miller, 1992). However, veterinarians have moved beyond these traditional (and vital) roles to include a number of other essential functions for wildlife conservation *in situ* and *ex situ*.

Captive wildlife Veterinarians, who are integral members of staff at many zoos, provide preventive and therapeutic medicine for captive animals. Ensuring that captive zoo animals have proper health is essential if their educational value and use as reproductive stock for species' conservation is to be maintained. Moving beyond the individual animal, zoo veterinarians now direct much of their efforts at preventive medicine for captive populations, thus minimizing the need for treatment of an individual animal by decreasing the transmission of infectious and parasitic agents. Preventive medicine has also allowed species maintained at more than one zoo to be managed as 'one' population. By providing preventive medicine for species that undergo an increasing number of inter-zoo loans and movements, the zoo veterinarian helps to ensure the successful propagation of these populations on a scale greater than any one zoo can provide.

A prime example of the 'one population' approach in zoos today is the establishment since the early 1980s of zoo-based Species Survival Plans (SSP) and Taxon Advisory Groups (TAG) for wildlife conservation. These programmes were designed to provide cooperative population management of a number of the most highly threatened species. Of the currently more than 100 SSPs and 46

TAGs within the AZA in North America, a veterinary advisor is a member of approximately three-quarters of these programmes, providing expert opinion and input on health issues (www.aza.org). Additionally, several SSPs also have veterinary-pathologist advisors and other health professionals (e.g., nutritionists, reproductive physiologists) who contribute to the health care of these species.

It is beyond the scope of this paper to provide a complete review of all the specific diseases of captive wildlife and the role of zoo veterinarians in the management of these diseases. To gain an appreciation of these issues, readers are directed to have a look at the many volumes of the *Zoo and Wild Animal Medicine* textbook (e.g., Fowler & Miller, 2003) and the *Journal of Zoo and Wildlife Medicine*, which has been published for 38 years (<http://www.aazv.org/>). A few examples of major diseases that have hindered captive wildlife propagation for which zoo veterinarians have directed much research include elephant endotheliotropic herpesviruses (Richman *et al.*, 2000), toxoplasmosis in Pallas' cats *Otocolobus manul* (Basso *et al.*, 2005), iron overload in a number of birds and mammals (Lowenstine & Munson, 1999) and chytridiomycosis in amphibians (Nichols *et al.*, 1998; Daszak *et al.*, 1999).

As the role (to manage diseases of captive animals) of zoo veterinarians expands, so too does the contribution of zoo veterinarians to the significant advances in diagnostic capabilities, anaesthesia, vaccination options, reproductive technologies and improved nutrition and therapeutics of these captive animals.

The captive and free-ranging wildlife

interface As noted above, the line separating captive and wild (free-ranging) populations is no longer distinct. Programmes such as wildlife rehabilitation, reintroduction and translocation all highlight the fact that the health of captive and wild populations is often intimately linked.

Providing rehabilitation and medical care to confiscated and injured free-ranging wildlife is a controversial conservation tool. However, many zoos offer this service at their hospitals. If one considers that the majority of the free-ranging animals admitted to zoo veterinary hospitals are there as a result of human activities, such as confiscation from the illegal animal trade, intoxication from pesticide application or vehicle-related injuries, many members of zoo staff feel a responsibility to care for these injured individuals. Beyond the individual animal, an important benefit of animals cared for in these programmes is their role as sentinels of ecosystem health (Sleeman & Clark, 2003), often alerting zoo veterinarians to disease issues in the free-ranging wildlife around their zoo.

Many conservation efforts have focused on captive propagation for subsequent release (e.g., reintroduction) and translocation schemes to move animals to 'safer' havens. Zoo veterinarians are instrumental in such efforts. There are many examples of past animal movements that have resulted in serious wildlife disease problems owing to a lack of health concerns addressed before project implementation (e.g. see Meltzer, 1993; Woodford & Rossiter, 1993; Cleveland *et al.*, 2002). The ability to move animals from captive-breeding programmes to the wild and between various sites is one conservation tool that demands that health concerns be addressed to minimize the disease threats associated with these programmes (Woodford, 2001).

Zoo-based programmes, such as the SSP and TAG programmes mentioned above, focus efforts on *in situ*, as well as *ex situ*, conservation of wildlife. A number of veterinarians within these programmes work on health issues of both captive and wild populations of the species for which they are responsible. One example of this dual role of a SSP veterinarian is the Jaguar SSP in which the veterinary advisor has incorporated health care for both the AZA captive population and Jaguars living *in situ* through training, hands-on research and publications (Deem & Karesh, 2002; Hope & Deem, 2006).

Free-ranging wildlife Many conservation efforts are now directed at maintaining the population viability of wildlife *in situ*. This should remain a primary goal of conservation. As we move forward with *in situ* conservation initiatives, it has also become increasingly evident that disease and health concerns are a significant threat to successful conservation (Scott, 1988; Daszak *et al.*, 2000; Deem *et al.*, 2001). While zoos expand their *in situ* conservation efforts, and disease becomes more of an issue for wild populations, the role of zoo veterinarians as integral members of these *in situ* conservation projects has also expanded. Decisions about the level of veterinary involvement in any *in situ* project should be based on: (1) the status of the species or population affected or at risk; (2) the nature of the cause of the health problem, which requires veterinary investigation; (3) the spatial distribution of the species; (4) the cost and practicality of necessary preventive and treatment measures; (5) specific disease issues of concern; (6) implications of intervention or lack thereof on the health of other species, including humans and domestic animals (Deem *et al.*, 2001). Above all else, veterinarians in wildlife conservation should 'do no harm'.

In some cases, it may be appropriate to apply therapeutic measures to an individual animal within its natural environment. Examples of direct *in situ* veterinary intervention for the individual animal have primarily involved highly Endangered species (e.g. rabies vaccination of African wild dogs and snare removal of Mountain gorillas) (Gascoyne *et al.*, 1993; Cranfield *et al.*, 2002; IUCN, 2006). These interventions are in response to human-induced situations, such as rabies transmitted by domestic dogs to African wild dogs and snare hunting within Mountain gorilla home ranges. In such cases, direct individual animal care in the wild is warranted as the conditions are human induced, few individuals of the species exist today and the extinction of the species is highly probable without intervention.

The fragmentation of landscapes with the associated isolation of species onto 'artificial islands' is another land-use change that often requires wildlife management (and medicine). As our continents becoming increasingly divided by development, threatened species find themselves confined to small areas (artificial islands) with no routes for emigration. Challenges for the long-term conservation of these species are evident when one considers the historical records of species' extinctions, many of which were associated with disease, on geographical islands (Quammen, 1996). For example, although the biological diversity of islands is a small percentage of the world's total, of the recorded number of invertebrate and vertebrate extinctions that have occurred since the 1600s, 367 have been island species and only 124 have been continental species (Smith *et al.*, 1993). The most well known of these extinctions is the loss of multiple Hawaiian land birds associated with avian diseases (Van Riper *et al.*, 1986).

Artificial islands are being developed by human activity (e.g., fencing, development and roads) that divide and separate species into smaller, isolated populations with similar geographic and biologic constraints of populations on 'real' islands. Modern examples of the threat of disease associated with land fragmentation can be found in many species living in National Parks throughout North America (Gillin *et al.*, 2002), in Buffalo *Syncerus caffer* in Kruger National Park, South Africa (Keet *et al.*, 1996), as well as for a number of the most threatened species on the brink of extinction today, partially owing to disease (as reviewed by Woodroffe, 1999; Cleaveland *et al.*, 2002).

A growing number of conservation projects now focus on 'buffer zones' around national parks and on ecotourism projects within parks. Buffer zones often allow domestic animal grazing, and in some cases ensure sustainable hunting of wildlife, while protecting wildlife within park boundaries. Ecotourism projects bring people into 'pristine' areas, allowing close association of people and wildlife. Unfortunately, both of

these conservation strategies may facilitate the transmission of diseases between humans, domestic animals and wildlife by an increased direct, and indirect, contact between these groups. Veterinary interventions to minimize disease transmission to wildlife associated with these strategies may include implementing preventive medicine programmes, including vaccination of humans (e.g., for non-human primate conservation) and domestic carnivores (e.g., for rabies, canine distemper and other canid pathogens) in these regions (Wallis & Lee, 1999; Fiorello *et al.*, 2006). Zoo veterinarians, with their knowledge of animal diseases, zoonoses and species susceptibility, are instrumental in such projects.

There are a number of reviews and papers on the diverse contributions of zoo veterinarians, and veterinary medicine in general, for *in situ* wildlife conservation. Among these contributions are the acquisition of much-needed baseline health data, animal immobilization and handling for ecologic studies, management of wildlife diseases within park borders, veterinary integration within the policy arena to ensure that health issues are addressed in park planning and conservation programmes, rapid response to epidemics within threatened species' populations, studies on domestic-animal reservoirs, the proper research and management approaches to zoonotic pathogens associated with possible wildlife reservoirs and control efforts for confiscated, rehabilitated and nuisance animals (for select reviews, see Hutchins *et al.*, 1991; Porter, 1992; Karesh & Cook, 1995; Deem *et al.*, 2001; Cranfield *et al.*, 2002; Gillin *et al.*, 2002; Deem, 2004).

CONCLUSIONS

Zoo veterinarians have played a vital role in wildlife conservation for many decades, with this role fully accepted for the health care of captive wildlife and increasingly accepted within *in situ* wildlife conservation projects. As the veterinarians' roles in *ex situ* and *in situ* health care are being realized, the distinction between captive and wild animals has also become less clear.

Wild places, containing 'wild' animals unaffected by human activities, are now hard to find. In fact, few species exist today that have not been influenced by some form of human intervention. Today, there is a place for using wildlife health skills for the prevention and treatment of disease in wild animals *in situ*. Wildlife health is crucial for wildlife conservation, and the skills and knowledge that veterinarians have, ranging from anaesthesia and clinical skills to knowledge on disease ecology and epidemiology, allow them to play a vital role in conservation initiatives.

With the current trends of human population growth, land fragmentation and degradation, and increased contact between wildlife, domestic species and humans, veterinarians are necessary members of any multidisciplinary approach to conservation. The efficiency and effectiveness of conservation efforts are significantly enhanced by incorporating animal health considerations into the planning, implementation and evaluation phases of all programmes (captive and wild) involved in conserving wildlife. One tenet of medicine that should be considered in the conservation equation is that prevention is always better than the cure. Maintaining healthy, viable populations as opposed to treating (saving) the last individual of a species makes the most sense.

It is nearly impossible to predict all the future roles of zoo veterinarians (and other conservationists) in tomorrow's world, just as it would have been hard to predict 50 years ago the world we find ourselves in today. The world is changing too quickly and the stresses on wildlife are too great. One thing is clear. It will take all the conservation disciplines, including veterinary medicine, to handle the current and future challenges.

ACKNOWLEDGEMENTS

The author thanks Ellen Bronson, R. Eric Miller, Nicole Savageau, Patti Young and three anonymous reviewers for their helpful comments on this manuscript.

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- Manuscript submitted 21 August 2006; revised 27 February 2007; accepted 18 April 2007