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Role of Zoos in One Health

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Drs. Deem and Emmons assess the health of a maned wolf as part of a zoo-led study in Noel Kempff Mercado National Park, Bolivia. Photo credit: Sharon Deem.

Biodiversity, which encompasses all the ecosystems, species, and genetic material on earth, is the ultimate source of the resources on which humans depend. The food we eat, material we use for building shelter, medicines for healing, and ecosystem services which include purification of water and cleansing of air, are only possible because of the Earth's biodiversity. At the very time that the importance of biodiversity for human survival has become

better appreciated, we are witnessing an unprecedented loss of species. Recent analyses demonstrate rates of species extinctions that are currently 100-1,000 times pre-human levels, with these rates increasing steadily. These extinctions are concurrent with human-driven (anthropogenic) changes resulting in what many contend is the new Anthropocene epoch.

It is estimated that since 1970 global population sizes of wildlife species have decreased by 30%. Wildlife taxa threatened with extinction include 12% of birds, 21% of mammals, 32% of amphibians, and 27% of reef-building corals. In response to this dramatic decline, the 1990s welcomed the field of conservation medicine. In this transdisciplinary field, we strive to understand the relationship between human, animal, and ecosystem health to ensure the conservation of all biodiversity. More recently, One Health, which is an initiative that aims to merge animal and human health science to benefit both, has become widely accepted within the human and animal medical professions with the focus of ensuring public health and the conservation of species. Although often branded as new approaches, these initiatives are built on decades (and some might argue centuries) of previous work that operated with the same guiding principles. This may have been most eloquently phrased in the 1800s by Rudolf Virchow with his statement "between animal and human medicine there is no dividing line – nor should there be." More recently, Calvin Schwabe first coined the term One Medicine in the 1984 third edition of his book entitled *Veterinary Medicine and Human Health*.

The One Health Initiative has gained wide support due to recent global changes that include the rise in emerging infectious diseases, many of which are

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Gayle Albers and Dr. Pam Dennis (right) completing stream habitat assessment as part of a zoo-led study examining the effect of water quality on an Ohio state endangered fish, the big mouth shiner (*Notropis dorsalis*).

Photo credit: Sharon Deem.

zoonotic and diseases of conservation concern that challenge species survival. For example, of 335 emerging disease events in humans, 60% were zoonotic and 72% of these originated in wildlife. Additionally, disease in wildlife species have been increasingly documented to impact on species survival with both population extirpations and even species extinctions.

In this article we review five roles that zoos have in the emerging field of One Health, and the benefits that zoos offer to both biodiversity conservation and human health. These roles include: 1) providing healthcare of zoo wildlife, thus ensuring the sustainability of biodiversity; 2) conducting studies on diseases of conservation concern; 3) understanding diseases in zoo wildlife as sentinels for emerging diseases of humans and animals in urban areas; 4) surveillance of disease in wild animals at the interface of wildlife, domestic animals and humans; and 5) contributing to the field of comparative medicine and the discovery of life.

1) Providing healthcare for zoo wildlife, thus ensuring the sustainability of biodiversity.

Zoological institutions are recognized as organizations dedicated to the conservation of animal species. Of the 68 species whose IUCN threat level has been reduced, 17 (25%) had captive breeding at zoological institutions play a role in the threat level reductions. Advances in veterinary care were essential for the propagation of these species. Additionally, a number of species that were once on the brink of extinction are no longer so due to reintroduction efforts, many of which were zoo led. These biodiversity conservation efforts provide preventive disease control associated with the “dilution effect” in which a larger assembly of species, each with different disease susceptibilities, may minimize the emergence of infectious diseases in human and other animals.

2) Conducting studies on diseases of conservation concern

Health professionals in zoos are leading research efforts to understand many of the infectious diseases that threaten the long-term survival of wildlife species, such as chytridiomycosis in amphibians. Disease-related conservation challenges are not solely linked to infectious diseases, as evident from the near extinction of three *Gyps spp.* in India associated with the use of an anti-inflammatory drug in livestock. These diseases can have impacts that occur on multiple scales, affecting individuals (fitness costs), populations (population size and connection), communities (changes in species composition), and ecosystems (structure, function, and resilience). The epidemiology, pathology, and clinical implications of many of these significant wildlife diseases are studied by zoo health professionals, both *in situ* and *ex situ*.

Zoos with diverse species collections may serve as sentinels of emerging diseases.

Zoo-funded and zoo-led in situ conservation projects occur in both biodiversity and pandemic pathogen hotspots.

3) Understanding diseases in zoo wildlife as sentinels for emerging diseases of humans and other animals

Often located in urban settings, zoos with diverse species collections may serve as sentinels of emerging diseases. The species housed at zoological collections vary in susceptibilities to pathogens, are observed daily, and receive regular health examinations; all factors that allow the early detection of emerging or introduced pathogens. The most recent and well-known example of zoo animals serving as sentinels was the detection of West Nile virus at a New York City zoo, alerting human and animal health communities to the new arrival of this vector-borne pathogen. Today, the network of accredited North American zoos has surveillance programs for zoonotic pathogens including avian influenza, tuberculosis and West Nile virus. Additionally, many zoos have local surveillance programs for urban wildlife on and near zoo grounds for zoonotic pathogens such as rabies virus and *Bayliascaris procyonis*.

4. Surveillance of disease in wild animals at the interface of wildlife, domestic animals and humans

In 2001, it was estimated that between all the zoos accredited by the World Association of Zoos and Aquariums (WAZA) there were approximately 1,100 field-based projects in 80 countries. Zoo-funded and zoo-led *in situ* conservation projects occur in both biodiversity and pandemic pathogen hotspots. The often long-term commitment to field conservation and research from these programs allows zoo staff to perform health surveillance studies on wildlife and domestic animals.



People in a village in Bolivia bring their dogs to a mobile clinic as part of a zoo-led health assessment to understand disease risks at the interface of wild carnivores and domestic dogs in the region.

Photo credit: Sharon Deem.

5. Contributing to the field of comparative medicine and the discovery of all life forms

Comparative medicine is a long-established field within the veterinary and medical professions, based on comparison and contrasts of the anatomy, physiology and pathophysiology of diseases between species. For example, advances in human medicine are largely due to comparative studies using animal models. Today, there is growing application of human studies that help with our understanding of diseases in animals (e.g., cancers, arthritis) and the use of sentinel animals and humans for the health of the other.

Zoos may have staff epidemiologists, veterinary clinicians, nutritionists, reproductive physiologists, pathologists, endocrinologists, geneticists, animal behaviorists, and animal care providers, all working to advance the One Health concept.



Dr. Pam Dennis performing an insulin ELISA on black rhinoceros serum, as part of a zoo-led study examining insulin resistance as a risk factor for health problems seen in black rhinoceros.
Photo credit: Pam Dennis.

Until recently, conservation of biodiversity emphasized the discovery of vertebrate species with lesser emphasis on invertebrate and parasite species. The metagenomic nature of individuals, composed of their own gene complements and those of all their associated microbes, is now appreciated for humans and other animals. Each species, in fact each individual, is known to have unique microbiomes. Zoos, with collections of animals and a global footprint of projects working with free-living wildlife populations, offer the discovery of life forms down to the microbial level.



Kenyan nationals and international students work on a zoo-led camel study in Kenya to better understand disease threats at the camel-wildlife-human interface. Photo credit: Sharon Deem.

Conclusion

For decades zoos have played significant roles in One Health, and they will continue to do so for years to come. Annual attendance at zoos accredited by the American Association of Zoos and Aquariums (AZA) is 175,000,000 visitors, including people from a few weeks of age to 100 years old! Zoos will continue to educate people on the importance of healthy animal populations and ecosystems for biodiversity conservation and human health.

In conclusion, zoos accredited by AZA are education, research, and conservation centers and many have multidisciplinary One Health teams. Zoos may staff epidemiologists, veterinary clinicians, nutritionists, reproductive physiologists, pathologists, endocrinologists, geneticists, animal behaviorists, and animal care providers, all working to advance the One Health concept. The collaborative efforts of zoos as they work closely with other organizations that have disciplines not traditionally present on zoo staffs (e.g. human medical personnel, economists, sociologists), strengthen their One Health teams.

References: http://myfloridaeh.com/medicine/One_Health/RoleofZoosReferences.pdf

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