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Importance of wildlife disease surveillance

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Disease management has been a vital part of society since the plagues of biblical times, but only recently have we begun to understand the importance of wildlife as vectors and reservoirs of many human diseases (Daszak et al. 2000, Zinsstag et al. 2007). An integral component to identification and management of wildlife diseases is surveillance. We describe the primary threats of wildlife diseases to humans and the environment, the role of surveillance in wildlife disease management, and proposed actions to enhance surveillance.

Threats to human health and safety

One of the most important concerns of wildlife diseases is their threat to human health and safety. Sixty-one percent of infectious diseases in humans are zoonotic (Taylor et al. 2001), and 75% of new and emerging infectious diseases are zoonotic (Merianos 2007). The latter cause >14 million human deaths annually worldwide (Taylor et al. 2001). Numerous wildlife species serve as vectors of zoonotic diseases. Feral hogs (*Sus scrofa*), for example, are susceptible to brucellosis, plague, and influenza A viruses, all of which have the potential to cause human illness (Witmer et al. 2003). The ability of these pathogens to infect multiple species, including humans, is of extreme importance to public health surveillance. Knowledge and awareness of zoonotic diseases is obviously critical in situations where direct contact with an animal leads to human illness.

Historically, pathogens have been used to create panic and fear among human populations. Recently, concern over bioterrorism, or the use of biological agents as weapons against humans, has intensified (Pavlin et al. 2003). In the last decade, memorable incidents occurred when anthrax was sent through the U.S. Postal Service (Hsu et al. 2002). National and international agencies have since been created or expanded to strengthen emergency preparedness for rapid detection and response to disease outbreaks and reduce the likelihood of bioterrorism through proactive efforts at international borders (Buehler et al. 2003, Pavlin et al. 2003, U.S. Department of Agriculture 2005).

Threats to wildlife conservation

Pathogens can impact environmental health. If the effect of a pathogen on a wildlife population or species is substantial, loss of biodiversity can occur (Daszak et al. 2000). While an individual death within a population would unlikely be catastrophic, the loss of an entire population would be. We are only now beginning to recognize fully the potential and magnitude of these threats. There are 2 fatal diseases currently impacting insectivorous wildlife populations in North America: the chytrid fungus (*Batrachochytrium dendrobatidis*) and white-nose syndrome fungus (*Geomyces destructans*). The chytrid fungus has been attributed as the cause for rapid declines of numerous amphibian species worldwide (Stuart et al. 2004), and the recent white-nose syndrome is creating massive declines in bat populations throughout the northeastern United States (Blehert et al. 2009, Buchen 2010).

Impacts to wildlife conservation can be even more detrimental when threatened or endangered species are concerned. As a result of chytrid fungus infestations, populations of endangered amphibian species are disappearing around the world (Bosch et al. 2001, Lafferty and Gerber 2002, Wheldon et al. 2004). Similarly, the Tasmanian devil (*Sarcophilus harrisii*) population has declined >60% since the 1990s, largely as a consequence of devil facial tumor disease, a nonviral transmissible parasitic cancer (Hawkins et al. 2006, McCallum et al. 2007). Consequently, the International Union for Conservation of Nature (IUCN) has changed the global conservation of Tasmanian devils from lower-risk–least-concern in 1996 to endangered in 2008 (Hawkins et al. 2008).

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Economic threats

Wildlife diseases result in economic losses because of their adverse effects both on human health and safety as well as wildlife and domestic species. For example, the annual estimated cost of canine rabies in Africa and Asia is $583 million (Knobel et al. 2005). The economic impact of chronic wasting disease in white-tailed deer (*Odocoileus virginianus*) from a 4-county area in Wisconsin was $15 million annually (Bishop 2004). The Hong Kong government spent $32 million in 2001 to cull 1.3 million poultry in an unsuccessful effort to contain the spread of H5N1 avian flu virus (Cyranoski 2001).

Wildlife diseases can also impact economic stability (Cleaveland et al. 2001). Certain diseases carried by wildlife have the potential to cause high mortality in livestock and poultry. As agricultural production expands, direct contact between wildlife and livestock will increase, leading to problems not only for farmers and producers, but for consumers, as well. For example, the foot-and-mouth disease outbreak in the United Kingdom during 2001 resulted in the destruction of approximately 4 million sheep and cattle, costing the agriculture and food industry >$4.5 billion (Thompson et al. 2002).

Ecology and natural history of pathogens

We can improve our knowledge of wildlife diseases through understanding pathogen transmission within and among species. Knowing pathogen entry into the host and transmission rates among hosts can help us to assess the significance of a particular pathogen to an individual or population. One example of a functional surveillance program involves *Baylisascaris procyonis*, a parasitic roundworm known to cause death in children (Sorvillo et al. 2002). Studies of the natural history of that pathogen suggest that it is spread primarily by raccoons and that transmission occurs commonly through ingestion (Sorvillo et al. 2002, Murray and Kazacos 2004). These types of information can lead to advances toward treating the infection and eliminating the source before more humans or animals are infected (Murray 2002, Murray and Kazacos 2004). Although *Baylisascaris procyonis* is resistant to many decontamination methods (Wise et al. 2005), preventative measures effective in reducing risk from this pathogen are now available (Brown 2007).

Surveillance

Surveillance is an integral and critical component of all disease management (Food and Agriculture Organization 1999). Once the presence and extent of the pathogens have been determined, steps can be taken to mange them through prevention, control, and eradication. Prevention is the necessary step to keeping a particular area, species, or population free of disease. Control is the method used to bring an already existent infection and infestation down to tolerable levels. Eradication implies taking measures to ensure that the disease or pathogen is no longer viable in the environment (Henke et al. 2007).

Public perception is important to effective, long-term surveillance (Kronenwetter-Koepel et al. 2005). As wildlife is often considered a shared public resource, conservation efforts are often met with divergent opinions from various interest groups. It is important for biologists and managers in the field of wildlife disease management to understand these varying opinions while conveying the importance of their work to the public.

Surveillance of wildlife is increasingly important due to greater rates of interaction between wildlife and humans. Increased interaction also exposes humans to all pathogens that wildlife may be carrying (Rabinowitz and Gordon 2004, Wolfe et al. 2005). Also, as human populations continue to increase and to modify the environment, wildlife habitat is altered, and the resulting changes may increase wildlife vulnerability to various pathogens (Patz et al. 2000, Daszak et al. 2001).

Many national programs and institutions in the United States study pathways of disease transmission, host range, and pathogenicity. The Centers for Disease Control and Prevention in Atlanta, Georgia, is one of the pioneer research facilities dealing with human health concerns and is a leading authority on infectious diseases. The U.S. Department of Agriculture (USDA) has developed multiple nationwide programs to assist in the detection, prevention, and control of human–wildlife conflict management

(U.S. Department of Agriculture 2008). Two of these programs are focused on wildlife disease management: the National Rabies Management Program (NRMP) and the National Wildlife Disease Program (NWDP). While the NRMP is specific to rabies management, the NWDP encompasses surveillance of various feral swine diseases, avian influenza, plague, tularemia, chronic wasting disease, West Nile virus, and other diseases of concern to human and animal health. The USDA/Wildlife Services' National Wildlife Research Center in Fort Collins, Colorado, and the U.S. Geological Survey's National Wildlife Health Center in Madison, Wisconsin, are two of the many research centers devoted to better understanding wildlife diseases. These nationwide programs, combined with international electronic disease notification systems (e.g., ProMED-Mail; *www.promedmail.org*), make response to and prevention of diseases faster and easier, providing more up-to-date knowledge of the causes, method of transmissions, and potential hosts.

Even in its earliest stages, wildlife disease management in the United States has had numerous successful efforts. For example, the release of sterile male *Cochliomyia hominivorax* was the primary instrument responsible for eradication of screwworm in the United States (Baumhover 2002) and North America (Wyss 2000). Wildlife disease surveillance continues to play a critical role maintaining screwworm eradication (Wyss 2000, Baumhover 2002). Similarly, global control and eradication of foot-and-mouth disease has been maintained only through wildlife disease surveillance (Sutmoller et al. 2003). Although global eradication of classic swine fever or hog cholera has been difficult, the United States essentially has been free of the disease since 1976 (Wise 1986, Edwards et al. 2000). Surveillance is an established approach used to maintain classical swine fever eradication in the United States, Canada, and Central and Eastern Europe (Edwards et al. 2000). Continued suppression and management of these and other diseases in the United States and elsewhere during the previous century have demonstrated that surveillance programs are significantly beneficial to public health, the economy, and wildlife conservation.

Conclusions and recommendations

We recommend the following actions to enhance wildlife disease surveillance efforts: (1) increased training of veterinarian and wildlife heath staff on early recognition stages of wildlife diseases; (2) enhanced reporting rates by farmers and wildlife disease professionals to increase data acquisition; (3) development of valid and comprehensive risk assessments to estimate the magnitude, timing, and location of disease outbreaks; (4) validation of appropriate diagnostic tests; (5) improved preparedness of government agencies, including enhancement of infrastructures within wildlife and public health sectors; and (6) continued basic and applied research to understand the ecology and biology of pathogens, their hosts, and the environment for preparedness planning and for refining surveillance efforts.

Communication is a critical aspect of any wildlife disease management program (Myers 1998, Food and Agriculture Organization 1999). Each of the 3 components of wildlife disease surveillance (i.e., detecting disease presence, characterizing prevalence and spread, and monitoring [Nusser et al. 2008]), requires effective communication. Although many countries have national reporting systems and international reporting systems exist (e.g., World Health Organization), improvements can be made (Food and Agriculture Organization 1999). Continued refinement and expansion of communication at all levels, from the individual (e.g., farmer or biologist) to global (e.g., database coordination and management) levels will likely provide the greatest long-term benefits to improve wildlife disease surveillance and management.

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