MANAGEMENT STRATEGIES FOR ADDRESSING WILDLIFE DISEASE TRANSMISSION: THE CASE FOR FERTILITY CONTROL

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Abstract: Transmissible diseases among wildlife species, and between wildlife and domestic livestock, are a matter of increasing concern. A combination of approaches should be considered for controlling disease transmission. If a vaccine is available or can economically be developed for the disease, it should be used as the primary component of the disease management strategy. For example, development of an oral rabies vaccine has led to programs where baits are dispersed on a large scale in a barrier zone to prevent the spread of rabies. However, there are no vaccines available for many diseases and incentives are frequently not present for their development. Because disease transmission is often a function of population density, culling is sometimes used to slow or prevent the spread of a disease. This technique also has disadvantages, because it can lead to an influx of new diseased animals, and because populations generally rebound quickly. Fertility control has been suggested as a management option for slowing disease transmission. Reproductive technology which lowers the population but which also reduces or eliminates reproductive behavior could be used to minimize contact among animals. Physical contact during mating may increase disease transmission by traditional oral, pulmonary and nasal routes. For some wildlife diseases, such as brucellosis and pseudorabies, there is evidence that transmission in also venereal. For these wildlife diseases, fertility control could potentially reduce disease transmission and be a very effective tool for preventing disease transmission.

Key words: Brucellosis, disease transmission, fertility control, pseudorabies, wildlife disease

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THE PROBLEMS AND CONCERNS

Transmissible diseases among wildlife species, and between wildlife and domestic livestock, are a matter of increasing concern. Density of wildlife populations have increased as a consequence of a reduction in natural predators, loss of wildlife habitat, and increases in suburban development and agricultural land. While many species have adapted to the changes in their environment, these conditions have resulted in increased opportunities for contact and disease transmission among wildlife, humans, and domestic livestock.

There are many current examples of wildlife diseases that have garnered the attention of wildlife managers and policy makers, primarily because of the potential threat posed to humans or domestic livestock. Bovine tuberculosis in brush-tailed possum (Ramsey 2007), European badgers (Tuyttens and MacDonald 1998), and white-tailed deer (O'Brian et al 2006), pseudorabies and brucellosis in feral swine (Cogner et al. 1999, Wheeler 1999), swine fever in wild boars (Ruiz-Fons et al 2007), foot and mouth disease in feral swine and deer (Ward et al. 2007) brucellosis in bison and elk in the Greater Yellowstone Area (Kreeger 2002) and rabies in foxes (Smith and Wilkinson 2003) and feral dogs in developing countries (Rupprecht et al. 2006) are but a few of numerous examples worldwide (Anon. 2002). Less publicized, but no less a concern is the threat wildlife diseases pose to biodiversity, especially when considering endangered species (Daszak et al. 2000).

While it is clear that diseases like tuberculosis, brucellosis and rabies occurring in wildlife have their recent origin from domestic animals, emerging infectious diseases for which wildlife serve as a reservoir are another source of concern (Cunningham 2005, Daszak et al. 2000). Indeed, several relatively recent examples of transmission from wildlife to domestic species or man include Lyme disease, avian influenza and hantavirus (Cook 2005, Daszak et al. 2000). Concern over emerging wildlife diseases also stems from the fact that microorganisms and pathogens occurring in wildlife are incompletely defined, and it is estimated that up to 75% of these diseases may be zoonotic (Cunningham 2005).

APPROACHES FOR DEALING WITH DISEASE TRANSMISSION

Vaccination of wildlife for the pathogen of concern is clearly a desirable direct approach to address disease transmission. Vaccination may help to reduce symptoms or transmission from chronically infected animals and prevent uninfected animals from acquiring the disease. Development of a rabies vaccine that could be dispersed on a large scale in bait has led to programs to prevent the spread of rabies in raccoons and skunks east of the Mississippi River to the western states (Slate et al. 2005).

Efforts to develop and test other vaccines for wildlife diseases are underway and some results are promising. Among the most notable undertakings are the efforts to develop and test vaccines for brucellosis in bison and elk in the Greater Yellowstone Area (Kreeger 2002). The RB51 form of this vaccine has shown the most promise to date for use in bison. However, the RB51 vaccine has been found ineffective in elk, apparently due to the inability of the immune system to respond appropriately (Kreeger et al. 2002). Another disadvantage of these vaccines is that they are currently delivered by injection, which requires direct contact with the target individuals. Assuming the injectable vaccine delivery method could be modified to an oral method to enable greater distribution to the target species, this approach still has some limitations. Each disease requires that a specific vaccine be available for the causative agent. While some vaccines may be readily available to use in wildlife from those developed for human or domestic animals, there are likely many other wildlife diseases for which no vaccines currently exist. Part of the problem is that wildlife can be a reservoir for unknown or emerging diseases, or for diseases that do not pose an apparent or significant concern for humans or domestic livestock. In these circumstances, the economic incentives for pharmaceutical companies to develop and produce a vaccine are lacking. In addition, even if the economic incentives were present, new vaccine development and testing could take years before a product were available.

Current strategies for management of wildlife diseases recognize the impact of population density on the potential for disease transmission (Gotazar et al. 2006, Lloyd-Smith et al. 2005). Culling is an approach which has been used to reduce population density. Selective removal of diseased animals is ideal, but this requires easy access to and identification of diseased or infected individuals, which is not often possible in the field. Consequently, the practical approach is to cull as many individuals as possible in an area known to have high incidence of the disease. In Michigan's lower peninsula where bovine tuberculosis is endemic in white-tailed deer, the management strategy includes depopulation and reduction of supplemental feeding to minimize aggregation of animals (O'Brian et al. 2006). In the case of chronic wasting disease (CWD) in free ranging white tailed deer, many states have implemented monitoring programs to define areas where incidence has occurred. For CWD in Wisconsin (Joly et al. 2003), large scale euthanasia programs have been undertaken to significantly reduce deer populations in counties where incidence of CWD was high. While these efforts may result in a short term reduction in disease prevalence and transmission, the benefits will be temporary unless measures are taken to sustain populations at lower density.

While culling is a contemporary tool used to manage the transmission of wildlife diseases, potential disadvantages of this approach have been recognized (Tuyttens and MacDonald 1998, Tuyttens et al. 2000, Donnelly et al. 2006, Woodroffe et al. 2007). Depopulation by lethal means may result in a "vacuum" effect where territorial boundaries are no longer defended allowing for influx of new diseased and non diseased animals to the area. Moreover, populations greatly reduced by culling are likely to rebound quickly, providing young animals to serve as disease hosts. And, as territorial boundaries are defined by the new population, interactions will likely increase among individuals in the population that may increase disease transmission.

Historically there are examples where culling has been used to manage disease transmission in wildlife. Among the most studied is the use of culling to eradicate bovine tuberculosis in badgers in South West England (Krebs 1997, Tuyttens and MacDonald 1998, Donnelly et al. 2006, Woodroffe et al. 2007). A culling program was initiated in 1975 to remove badgers from areas where their potential contact with cattle was high. After some apparent success in reducing the number of badgers testing TB positive and farm infections of cattle during the first 10 years of the program, the trend reversed in subsequent years. By 1996, incidences of TB in badgers and cattle were as great as when the study began. Scientists evaluating the results suggested that the program may have failed as a consequence of the social disruption which occurred within the resident badger population as a result of culling (Tuyttens and MacDonald 1998, Tuyttens et al. 2000, Delahay et al. 2006, Vicente et al. 2007). They argued that social disruption led to more migration of badgers into the area that was culled, and increased contact and conflict between resident badgers and immigrants. These findings clearly indicate that knowledge of the social structure and behavior of the target species is important for developing a disease management strategy (Vicente et al. 2007). Whether culling alone could be used effectively to control disease transmission in species with less defined social structures than the badger is an open question.

Because high population density is believed to be a factor that facilitates disease transmission in wildlife, fertility control has also been suggested as a management option (Tuyttens and MacDonald 1998, Smith and Wilkinson 2003). Fertility control by itself could take years to impact population density, especially in long-lived species. On the benefit side, however, there is evidence for some species that fertility control approaches are less disruptive to social structure and behavior. For brush-tailed possums in New Zealand it has been reported that fertility control by interfering with fertilization or the control of endocrine mechanisms directed at gonadotropin releasing hormones would have minimal affect on behavior or social structure (Ramsey 2007).

Fertility control offers some other advantages for slowing disease transmission in a wildlife population. If the fertility control approach suppresses reproductive behavior, physical contact between individuals associated with estrous behavior, courtship or competing males would be reduced. If fertility control were successful, vertical disease transmission between parent and offspring would also be eliminated.

In addition to the physical contact during mating that may increase disease transmission by traditional oral, pulmonary and nasal routes, for some wildlife diseases there is evidence that their transmission is also venereal. Transmission of brucellosis and pseudorabies are believed to be venereal in feral swine (Romano et al. 2001, Killian et al. 2006). It has been suggested that fertility control methods which suppress reproductive behavior of feral swine would reduce venereal transmission of these diseases (Killian et al, 2006). In bison, transmission of brucellosis occurs when uninfected animals come in contact with the vaginal discharge and aborted placenta or fetuses of infected cows (Kreeger et al. 2002). Preventing pregnancy would prevent transmission by this means to other bison (Miller et al 2004a) or to scavengers which may consume the placenta.

WHAT ARE THE BEST OPTIONS FOR CONTROLLING DISEASE TRANSMISSION?

The major challenges for controlling disease transmission in wildlife are: 1) having a vaccine or treatment available for the specific disease; 2) having a vaccine dispensing system so a significant percent of the population can be treated; 3) having the means to reduce and sustain lower population density to reduce rates of transmission and; 4) the means to reduce behaviors which lead to increased contact among individuals. To address these challenges, there are three major options currently available for wildlife managers to consider for controlling disease transmission. These are direct vaccination or treatment of the affected populations and reduction of population density by culling or by fertility control. The advantages and disadvantages for each of these strategies are summarized in Table 1. It is clear that no approach is without disadvantages or limitations. Modelers (Smith and Wilkinson 2003) and others (Tuyttens and MacDonald 1998, Wobeser 2002, Miller et al. 2004, Killian et al. 2006, Ramsey 2007) have concluded that a combination of approaches may be warranted to address problems of wildlife disease transmission. Although culling and disease vaccination have been the primary strategies used in the past, we believe that reproductive technologies which limit or prevent reproduction and associated behaviors will play an important role in limiting wildlife disease transmission in the future.

We conclude that a combination of approaches should be considered for controlling wildlife disease transmission. If a vaccine is available or can be developed for the disease, it should be used as a primary component of a disease management strategy. Reduction of population density is an essential component either by culling and or a fertility control method. However, culling requires a knowledge of social structure and reproductive behaviors to avoid its use in species where culling may increase behaviors associated with disease transmission. Reproductive technology which reduces or eliminates reproductive behavior should be used to minimize contact among animals. Sterilization by gonadectomy would eliminate reproductive behavior, but field gonadectomy is problematic. Vaccines directed at gonadotropic hormones or their releasing hormones, or gonadic steroid production would also limit steroid secretion and reproductive behavior. "PZP" vaccines directed toward the zona pellucida of the ovum would not be useful in disease management strategies since they are associated with increased mating and reproductive activity. One vaccine currently available which may prove useful in a wildlife disease management strategy is GonaCon™. This contraceptive vaccine is directed at gonadotropic releasing hormones and has been proven safe and effective in a variety of species for (Miller et al. 2004b). Regulatory approval is expected soon for the injectable form of GonaCon™, and efforts are underway to develop an oral form of this vaccine which would greatly expand its potential usefulness in disease management strategies.

Table 1. Advantages and Disadvantages of various strateges for controlling disease transmission among wildlife.

Strategy	Advantages	Disadvantages
Vaccination/treatment	1. Direct affect on disease to limit transmission among animals	1.Vaccine or treatment may not be available for a specific disease 2. New vaccine development may not be possible or require a long time 3. Delivery system may involve bait development suited for species to reach large segment of population 4. Immune system of some species may not respond adequately to vaccine
Culling	1. Rapid response to reduce population density and opportunities for disease transmission	1. May disrupt social structure, increase contact among individuals and opportunities for disease transmission 2. Populations rebound quickly and provide opportunities to spread disease to new individuals 3. Vacuum effect, new individuals migrate into area, territorial conflicts increase contact and opportunities for disease transmission. 4. Negative public relations surrounding wildlife euthanasia
Fertility Control	1. Methods are currently available for a variety of species 2. Disease transmission reduced by reduction of contact associated with mating. 3. Public view generally more positive than for culling 4. May be less disruptive to social structure 5. Sustains lower population density without social disruption seen with repeated culling	1. Population density reduction a slow process 2. Delivery system may involve bait development suited for species to reach large segment of population

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