★ ★ ★ SPECIAL EDITION: WILDLIFE DISEASES ★ ★ ★

USAHA

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A Closer Look at Diseases in Wildlife

Wildlife-Livestock Disease Interactions

by Victor F. Nettles
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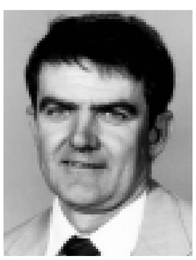
Animal health is an important issue for agricultural industries and wildlife conservationists. Both groups have concerns as to how various diseases may impact their animals, and each group has apprehension about possible disease introduction from the other's animals. From the livestock/poultry producer's perspective, there are multiple concerns about the perceived or actual presence of diseases in wildlife. A recent USAHA news release gave the cost of disease to producers at $1 billion annually, so there is much to be feared. When a disease moves from wildlife to domestic animals, there is the direct threat due to morbidity and mortality, and the accompanying economic losses. Additional financial losses occur through quarantines, special husbandry practices (fencing, closed housing) required to segregate wildlife from domestic animals, surveillance programs, vaccination, etc. Also, there may be loss of export markets due to endemic infections in wildlife, even when domestic animals are not infected. A reverse economic threat also can occur when public grazing is denied to livestock owners because of a real or perceived disease threat to wildlife from domestic stock.


Vic Nettles

Challenges and Opportunities

Wildlife conservationists, in-

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Articles

by John Fischer, Special Edition Editor
Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, The University of Georgia, Athens, GA

Diseases in free-ranging wildlife command increasing attention each year from animal and public health authorities, wildlife managers, livestock producers, and the general public. This subject is no stranger to the USAHA newsletter. Wildlife-related topics appearing in recent newsletter issues include brucellosis in the Greater Yellowstone Area, wildlife aspects of animal disease emergency management, and regulatory authority over wild animals harboring significant pathogens. In fact, it is nearly impossible to pick up a copy of the newsletter that does not contain at least one mention of diseases in wild animals. More often, wildlife disease topics come up in the President's Corner, regional reports, and other regular columns, as well as in individual articles.


John Fischer

This special issue of the newsletter is devoted entirely to diseases in wildlife. The author list rep-

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President's Corner

OVER the past 14 months, the United States Animal Health Association has undertaken the development and publication of special editions of our newsletter to address, in depth, issues of great importance to USAHA membership and to our nation.

Bob Hillman
President, USAHA

The first special edition, published in June of this year, focused on foreign animal diseases and the urgent facility needs of our national laboratories in Ames, Iowa. This special edition is focused on diseases in wildlife.

As we work to complete our national disease control programs in brucellosis, tuberculosis and pseudorabies, it has become evident to all that the presence of these diseases in wild and feral animals will have a dramatic impact upon our ability to eradicate the diseases from the United States.

In addition to the above diseases, there are many other avian and animal diseases that are transmissible among domestic and wild or feral species. The potential for importation of exotic or foreign diseases or agents in imported wildlife is a vital concern to animal health officials, industries and wildlife managers.

Some USAHA committees have discussed and deliberated on the wildlife/domestic livestock disease interface issues for a number of years. Last year at our annual meeting, wildlife diseases and the livestock/wildlife interface were topics for one of our general sessions.

This special edition will focus on many of the issues that confront us as we work to find ways to address diseases in wildlife. We hope it will also serve to illustrate that we must all work together if we are to successfully address the wildlife disease and wildlife/livestock interface issues that confront us if we are to be able to control, then eliminate important diseases from wildlife.

I want to thank Dr. John Fischer for his hard work in identifying authors, organizing and developing the content of this special edition and Dr. Dick McCapes for digitally creating this edition for printing and posting on our webpage.

Strategies to Address Diseases in Wildlife

by E. Tom Thorne
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Although the same basic methods are used to study, diagnose, and manage diseases of domestic animals and wild animals, managers of diseases in wildlife face difficulties that are relatively unimportant to domestic animal disease managers. Some of these difficulties are inherent in the wild nature of free-ranging animals, while others relate to a lack of knowledge and/or tools to effectively manage diseases of concern. These problems are compounded by varying perceptions of ownership and management jurisdiction. Public involvement is another potential factor because wild animals capture the interest of diverse constituencies, including some advocacy groups that have little concern for the health of domestic animals.

Tom Thorne

Detecting and treating disease in wildlife can be very difficult.

Surveillance by serologic tests is feasible, but may be expensive and time-consuming due to difficulties in obtaining sera from hunter-killed animals, and retesting of "suspect" animals usually is impossible. Sensitivity and specificity of serologic tests developed for domestic animals often are unknown when used on wild animals. Few wild animals are individually marked for re-identification, and recapture is problematic. Many wild animals are migratory and they never respect jurisdictional boundaries or property lines. Carcasses of wild animals frequently are recycled back into the environment before they are located and examined; consequently, a disease outbreak might not be detected until quite advanced. Compared to most domestic animals, live wild animals are intractable, and restraint may induce a spectrum of perturbations, such as capture myopathy; physiologic stress may confound diagnostic and disease management procedures. Moreover, it is rarely possible to capture all, or even a majority, of all the individuals in a free-ranging population.

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Epizootic Hemorrhagic Disease of Deer

by David Stallknecht
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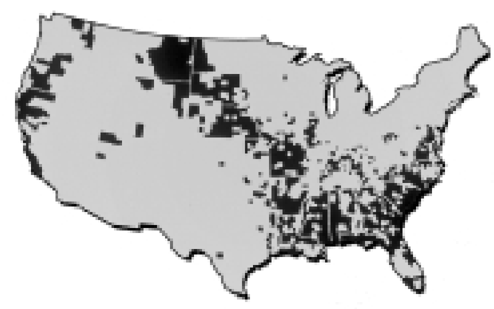
Hemorrhagic disease (HD) is the most significant infectious disease of white-tailed deer in North America. The closely related epizootic hemorrhagic disease (EHD) and bluetongue (BT) viruses are the etiologic agents of HD. The EHD serogroup in the genus Orbivirus and the family Reoviridae includes 10 serologically distinct vector-borne viruses. Two of these, EHD virus serotype 1 (EHDV-1) and serotype 2 (EHDV-2) are present in North America. Clinical disease associated with EHD viral infections also has been reported in other native ungulates including mule deer, pronghorn, and bighorn sheep. Like the BT viruses, the EHD viruses are transmitted by biting midges including *Culidoides sonorensis, C. insignus,* and other *Culicoides species.*

Dave Stallknecht

Through the continued support of state wildlife agencies, the U.S Fish and Wildlife Service, and the United States Department of Agriculture, significant progress has been made in understanding the epidemiology of the EHD viruses. It is known that clinical disease is seasonal, occurring in late summer through the fall. The response of white-tailed deer to EHD viruses is highly variable, ranging from subclinical infection to acute death and this variation is regionally predictable. In areas where these viruses are enzootic, such as the coastal plain from South Carolina to Texas, antibody prevalence is high and reports of deer mortality are generally low. In contrast, significant mortality often occurs when deer are infected in epizootic areas in the midwest, Appalachian, and mid-Atlantic states where antibody prevalence generally is low. In enzootic areas, HD may occur an-



Hemorrhagic disease distribution in the U.S.

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Chronic Wasting Disease of Deer and Elk

by
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and
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Although many animal health and media professionals regard it as a new or emerging disease, “chronic wasting disease" (CWD) was first recognized by biologists in the 1960s as a disease syndrome of captive deer held in several wildlife research facilities in Ft. Collins, CO. Originally believed to be a nutritional malady, CWD was not recognized as a transmissible spongiform encephalopathy (TSE) until a decade later. CWD soon was identified in captive deer and elk from wildlife research facilities near Ft. Collins, Kremmling, and Meeker, CO, and Wheatland, WY, as well as in at least two zoological collections. By the 1980s, CWD had been documented in free-ranging deer and elk in northeastern Colorado/ southeastern Wyoming. In the 1990s, CWD was diagnosed in privately owned elk on game ranches in five western states and Saskatchewan. By 2000, free-ranging mule deer with CWD had been detected in Nebraska and Saskatchewan.

Beth Williams

The true origin of CWD remains a mystery. Although CWD was first diagnosed in captive research cervids, the original source (or sources) of CWD in either captive cervids or free-ranging cervids is unknown. Whether CWD in research animals really preceded CWD in the wild, or vice versa, is equally uncertain and probably never will be determined.

Chronic wasting disease is relatively rare in wild cervids, and its geographic distribution is quite limited. Fewer than 250 naturally occurring cases of clinical disease, mostly in captive research and free-ranging mule deer, have been documented in 10 contiguous counties in northeastern Colorado and southeastern Wyoming. The CWD-positive mule deer recently found in Nebraska and Saskatchewan did not show clinical signs of CWD. Although clinical disease doesn’t appear to be common, the number of cases detected has increased in recent years. This trend may be explained by increased vigilance by wildlife and animal health officials, the wildlife farming industry, and the public in reporting cases, but

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Mycoplasmal Conjunctivitis in Wild House Finches

by Barry K. Hartup
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An epidemic of conjunctivitis with associated mortality in house finches (*Carpodacus mexicanus*) was first described in February 1994 from northern Virginia and Maryland. House finches are canary-sized songbirds native to the western U.S. that were introduced on Long Island, NY, in 1940 and since have expanded their eastern range throughout the eastern and midwestern United States and Canada. By 1996, the conjunctivitis epidemic had spread from suburban Washington, DC, throughout the entire eastern range of house finches, from Florida to Quebec and as far west as Missouri. The clinical signs and behavior in affected finches include swollen or crusted eyelids, debilitation and a propensity to remain on or around bird feeders. The causative agent of the conjunctivitis, *Mycoplasma gallisepticum* (MG), was later isolated from affected house finches across the eastern United States.

Barry Hartup

In house finches, conjunctivitis and upper respiratory disease develop within 10-14 days of infection, and are accompanied by weight loss and debilitation despite access to abundant food sources. Resolution of clinical disease has been documented in wild individuals, but often takes several weeks. The prolonged clinical course of the disease is believed to result in significant mortality from secondary causes such as predation or accidental death (window strikes). The disease has had a profound impact on the population dynamics of house finches. Within 5 years, the eastern house finch population has decreased by as much as 60 percent in many areas, a loss of 100 to 200 million individuals.

Host specificity is a hallmark of mycoplasma-host relationships and house finches are apparently the primary host of this previously unrecognized MG strain of wild songbirds. MG isolates obtained from finches across the disease range are genetically indistinguishable, but they differ from vaccine or disease strains of MG in domestic poultry. Occasionally, spillover of MG from house finches to other common species occurs at bird feeders. Since its discovery, the house finch strain of MG has been isolated from wild American goldfinches (*Carduelis tristis*), a purple finch (*Carpodacus purpureus*), evening grosbeaks (*Coccothraustes vespertinus*), pine grosbeaks (*Pinicola enucleator*), and a blue jay (*Cyanocitta cristata*) that was reared at a rehabilitation facility where infected house finches were maintained. Domestic chickens exposed to the house finch strain produced antibodies to MG, but clinical disease was mild and rare.

Mycoplasmal conjunctivitis in a house finch

In poultry, MG is transmitted primarily through direct contact

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Bovine Tuberculosis in Michigan's Deer

by Stephen M. Schmitt
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Since 1994, Michigan has recognized a problem with bovine tuberculosis (TB) in wild white-tailed deer in 12 counties in northeastern lower Michigan. Through June 2001, more than 67,000 free-ranging deer have been examined and 340 have been positive for *Mycobacterium bovis*. The bacterium has been found in other free-ranging wildlife including 13 coyotes, 4 black bears, 2 raccoons, 2 opossums, 2 bobcats, and 2 red foxes. In 2000, bovine TB was found for the first time in a wild elk in the affected area of northeastern Michigan. The disease also was detected in 1997 in captive deer in a hunting enclosure that subsequently was depopulated. Since 1998, bovine TB has been found in 16 cattle herds, resulting in reclassification of Michigan's TB status.

Steve Schmitt

Recognizing the potential economic and public health consequences of bovine TB to Michigan, the governor issued orders to eradicate *M. bovis* from the state. Unfortunately, the situation is unique because bovine TB never has been self-sustaining in a free-ranging cervid population in North America. Control programs for bovine TB in wild deer do not exist, and there is much about bovine TB in deer that is unknown.

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Wildlife Rabies Control

Problems and possibilities

by Dennis Slate
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Rabies control in the U.S. became more complex 40 years ago when wildlife surpassed domestic dogs as the principal reservoir of rabies virus. Several wild carnivore and insectivorous bat species currently account for 90 percent or more of the 7,000-9,000 rabid animals reported annually. Rabies occurs in wild reservoirs as distinct variants adapted to individual species, although spillover to other species occurs. There are three skunk variants that occur in the upper Midwest, the southern plains, and in California; two gray fox variants that occur in Texas and Arizona; and an arctic fox variant that occurs in red foxes in the northeastern United States (and in arctic foxes in Alaska). A single raccoon strain now occurs from Alabama to northern Maine and has spread as far west as northeast Ohio, and a canine variant has spilled over into coyotes in south Texas. In addition to these terrestrial variants, there are several strains of bat rabies.

Parenteral vaccination strategies that greatly reduced dog rabies obviously are not directly applicable to the wild species that currently comprise the major rabies reservoirs in the United States. The varying ecological, behavioral and biological attributes of several wild rabies vectors have introduced new challenges that underscore the need for veterinary medical, wildlife, and public health professionals to collaborate in rabies control efforts. Programs targeting wildlife require input and approval from state wildlife agencies with regulatory and management responsibility for most wildlife rabies vector species. Furthermore, management decisions affecting wildlife, a public resource, are shaped in large part by public attitudes.

In spite of these complexities, considerable advances have been made in wildlife rabies control technology with oral rabies vaccination (ORV) showing the most promise. The ORV concept originated at the Centers for Disease Control and Prevention in the 1960's. ORV field trials were conducted to control fox rabies in Switzerland, France, and Belgium in the late-1970's to the mid-1980's. As a result of these trials, ORV programs have been implemented in several European countries. In North America, Ontario has enjoyed success toward elimination of the arctic fox rabies variant in red foxes since ORV began in the late 1980's. Although ORV in the Unites States has lagged behind European and Canadian programs, steady progress has been made since initial field trials with V-RG (recombinant vaccinia-rabies glycoprotein vaccine) were conducted in Virginia and Pennsylvania in the early 1990's.

Currently, Raboral V-RG® is the only oral rabies vaccine approved for field use in the United States. Although progress has been made with ORV in some species, Raboral V-RG® is not immunogenic in skunks, and there is no practical system for vaccinating wild bats. Nevertheless, Raboral V-RG® has been used since 1995 in south Texas to successfully suppress canine rabies in coyotes; the vaccination zone now has been compressed to a 30-mile wide maintenance corridor. ORV also is being applied to control a gray fox rabies outbreak in west central Texas. To prevent the further spread of raccoon rabies in the northeastern United States, there are vaccination zones that interface with large bodies of water or mountains extending from Vermont along the Canadian Border through northern New York to Lake Ontario, on the Niagara

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Wildlife Rabies Control
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frontier between New York and Ontario, and in northeast Ohio from Lake Erie south to the Ohio River. Portions of these vaccination zones began in the mid-1990's; most have been in place since 1998. Additionally, there are smaller ORV projects designed to determine if vaccination barriers can prevent rabies from entering specific areas (Cape Cod, MA) or if rabies case frequency can be greatly reduced or eliminated from areas where rabies is enzootic (Cape May, NJ; Anne Arundel County, MD; Fairfax County, VA; and Pinellas County, FL).

Meetings have been held in several northeastern U.S cities to discuss plans to potentially expand ORV programs to prevent the spread of raccoon rabies beyond the barrier in Ohio and on into populated regions of Quebec and Ontario, Canada. Representatives attended these meetings from states and provinces actively involved in ORV projects. Participants recognized the following needs: 1) expand vaccination zones along the Canadian border with New York and Vermont and initiate ORV in the upper Connecticut Valley to contain the northward spread of raccoon rabies; 2) extend the current Ohio vaccination zone into West Virginia to prevent raccoon rabies from spreading west; and 3) provide additional cooperative federal funding to assist Texas in restoring the ORV gray fox project to its previous scope.

Strong support to address these needs led to increased Wildlife Services federal appropriation for rabies control in FY 2001, as well as the release of $4.2 million in Commodity Credit Corporation funds for specific ORV rabies control in 2001. Wildlife Services and its state, federal and university cooperators are working to ensure that ORV efforts go forward with an adequate program evaluation component. The long-term goals are to prevent raccoon rabies from infecting broader regions of the United States and Canada and contain the gray fox outbreak in Texas. If successful, collaborators plan to explore elimination strategies for these rabies variants.

ORV aimed at raccoons, gray foxes and coyotes will not solve all existing rabies problems. Vaccination currently is not an option to control skunk or bat rabies in the United States. Therefore, ORV must be considered as an adjunct to more conventional rabies control strategies including education, pre-exposure vaccination for groups at occupational risk, post-exposure treatment, pet vaccinations, case investigations, diagnostic support and site-specific wildlife management to minimize contact between vector species and people and their pets. However, ORV does offer promise in reducing risk and the cost of living with raccoon, gray fox and coyote (canine) rabies over broader geographic areas. Continued success with ORV will hinge, as it currently does, on public support and effective cooperation and coordination among multiple disciplines. Elimination of selected rabies variants may be practical in the future, but likely will require improved understanding of rabies dynamics in wildlife, accurate surveillance, and the technical ability to implement optimized ORV strategies.

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With respect to disease control, vaccines and delivery systems developed for domestic animals may not be safe, effective, or suitable for wild animals.

There is a unique human factor relative to disease management with wild animals. While there is strong personal or economic incentive to control diseases of domestic animals, wild animals often are regarded as belonging to everyone or belonging to no one. Some people believe wild animals are capable of overcoming diseases on their own if we simply restore the balance of nature or remove domestic animals and they question the desirability of management of disease in wildlife. This philosophical obstacle to disease management is seldom encountered regarding domestic animals. Desirability of wildlife disease management is complicated further in western states with large public land holdings. These factors and others make disease management considerably more difficult with wild animals. If such factors are taken into consideration, however, attempts to manage important wildlife diseases may be more effective.

There are three major reasons to control diseases in wild animals: Diseases have deleterious effects on wild species considered important to man; pasteurellosis in bighorn sheep and hemorrhagic disease in white-tailed deer are examples. Diseases can constitute threats to human health; brucellosis in elk and bison and bovine TB in white-tailed deer are examples. Diseases can threaten health of domestic animals; again brucellosis and bovine TB are examples.

Wildlife disease management

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Strategies

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strategies are based upon manipulation of the host, the agent, the environment, and/or human activities. Controlling the causative agent of a disease or its vector is the most direct strategy. A disease eradication program has an ultimate objective of time- and place-specific elimination of a causative agent. The screwworm program eliminated the fly in the southern United States and Mexico. Although this highly successful program was intended primarily to benefit domestic animals, it also greatly reduced screwworm-induced losses of deer, especially fawns.

Manipulation of host populations for disease management can occur through restrictions on distribution, selective removal (i.e., culling) of infected animals, and reduction of population density. Disease- and host-specific factors may influence the potential efficacy of respective strategies. Population manipulation is generally intended to reduce or prevent disease transmission; but at its extreme, which is depopulation, it may eliminate a disease. Disease management through treatment or immunization may have application under certain circumstances. Treatment of wild animals is rarely attempted, but has occasionally been used with individuals or small populations of species at risk or of critical concern. Immunization of wild animals may have greater utility under appropriate conditions, but requires safe and effective vaccines and delivery systems that will reach a sufficiently large portion of the population to protect exposed individuals and/or reduce transmission. Vaccination of free-ranging elk to control brucellosis in Wyoming is an example as is oral rabies vaccination of wild carnivores at selected locations.

Environmental and habitat modifications are strategies that may be used to manage diseases in wild animals. Objectives generally are to reduce survival of specific disease agents or vectors, or lower population densities and reduce transmission rates. Habitat modifications usually do not produce rapid results, but the effects generally are long lasting. Habitat enhancements to disperse bighorn sheep in winter serve to reduce disease transmission.

Finally, diseases of wild animals may be managed by influencing human activities. The best example is taking measures to prevent movement or introduction of diseases through translocation and reintroduction of free-ranging, captive, or domestic animals. Specifically, some western states have restrictions on translocation of white-tailed deer from the east to prevent introduction of meningeal worm (*Parelaphostrongylus tenuis*) to the west. Other human practices, such as extensive supplemental feeding or baiting of deer, have been associated with disease problems such as bovine tuberculosis of wild deer in Michigan, and management strategies include bans on these activities. Of greater long-term importance may be modifying public opinion through education and information programs to improve acceptance of disease management in wild animals.

In summary, many important wildlife disease problems may be successfully managed for the benefit of both wildlife and livestock interests. Success will depend on sharing both responsibility and support for such management among a broad range of agencies and constituencies, on setting realistic goals and timetables for disease management in free-ranging populations, and on recognizing and overcoming technical challenges unique to managing the health and viability of valuable wildlife resources.

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Epizootic Hemorrhagic Disease of Deer

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nually or in 2- to 3-year cycles that are somewhat predictable. In epizootic areas, HD occurs sporadically in 8- to 10plus-year intervals. It is apparent from serologic data and viral isolates from clinically affected animals that most of the recent HD outbreaks in the eastern United States were due to EHD rather than BT viruses. In addition, the EHD viruses appear to have a wider distribution than the BT viruses that are primarily associated with deer populations of the coastal plains. Investigations of recent HD outbreaks and improvements in our diagnostic capabilities to detect BT and EHD viruses from infected wildlife have provided a wealth of EHDV-1 and EHDV-2 isolates for analysis, and studies are underway to elucidate the molecular epidemiology of the viruses.

There are few management options for HD in deer. However, understanding regional population impacts and the predictability of HD outbreaks may be useful to wildlife managers. With this information, HD mortality can be factored into deer management plans to adjust annual deer harvests or to insert HD-related mortality estimates into the population models used in long-term deer population management.

EHD viruses can be associated with two additional problems relating to wild ungulate species. The first potential problem involves endangered ungulate management; the second real problem involves the movement of captive white-tailed deer. In both cases, the movement of susceptible animals from epizootic or EHD virus-free regions to enzootic HD regions can result in severe disease or death. There is circumstantial evidence that either BT or EHD viruses were partially responsible for disappearance of

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Epizootic Hemorrhagic Disease of Deer
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desert bighorn sheep in Texas. This scenario is much clearer in the case of captive white-tailed deer. Each year, privately owned deer from northern states are moved to southern states and many of these deer die during their first exposure to an EHD or BT virus. Native animals in the same area generally are mildly affected or totally unaffected. This variation in susceptibility may be the result acquired immunity, innate immunity, or both.

Past and current studies have been designed to examine the immunity of white-tailed deer to the HD viruses. Investigations were conducted to understand the potential role of acquired immunity, and results suggest that there is some cross protection when EHD virus-infected animals are challenged with a different EHD serotype. However, there appears to be no protection associated with previous exposure to an EHD virus and subsequent challenge with a BT virus. The possibility of innate immunity currently is being investigated in EHDV-1 and EHDV-2 challenged deer from Texas (an endemic area) and Pennsylvania (an area that generally is free of the EHD viruses). Deer are extremely susceptible to infection with both EHDV-1 and EHDV-2 and it is reasonable to assume that over time these viruses have provided a strong selective force in the evolution of this species.

Disease in livestock is a growing concern associated with the EHD viruses. Unlike the BT viruses, EHD viruses are not associated with disease in sheep; however, it has long been suspected that EHD viruses may cause a bluetongue-like disease in cattle. Most recently, EHDV-2 was detected in clinically affected cattle in Indiana during 1996 and in Missouri and Iowa during 1998. However, overt disease never has been reproduced in cattle experimentally, and although serologic surveys indicate significant exposure of cattle to EHD viruses in the United States, there are few reports of clinical disease. In clinically affected herds, a small proportion of infected animals typically show signs suggesting great variation in individual response to the virus. It is obvious from these results that the pathology, epidemiology, and significance of EHD viral infection in cattle is very poorly understood and that additional research is needed to identify the actual risk factors associated with disease.

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it may also reflect increased disease occurrence.

Based on random, preclinical testing of brain tissues from animals harvested in specific management units, it appears that CWD probably infects about 5 to 15 percent of the deer in a small core endemic area within north-central Colorado/southeastern Wyoming, and 2 percent or fewer of the deer in other surrounding mountain and plains areas. Testing of harvested animals indicates that probably less than 1 percent of the elk in endemic areas are infected.

Prior to the 2000 hunting season, no evidence of CWD had been detected in more than 7,500 wild deer and elk tested outside the endemic area in Colorado and Wyoming, or from other states and Canadian provinces where surveys have been conducted in recent years. However, a hunter-killed wild mule deer from a Nebraska county adjacent to the Colorado/Wyoming endemic focus tested positive for CWD, and subsequent active surveillance revealed an additional infected mule deer in early 2001 within the same immediate area. The scenario in Saskatchewan was similar: surveillance revealed CWD in a hunter-killed mule deer from the Manito Sandhills region of western Saskatchewan and a second positive animal was detected within 5 kilometers during follow-up surveillance. The difference in the Saskatchewan situation is that CWD never had been found in free-ranging cervids prior to 2000, although the disease has been diagnosed on several captive elk ranches in the province. Consequently, the challenge of developing programs to manage CWD in free-ranging cervids now is being faced by wildlife management agencies in Colorado, Nebraska, Wyoming, and Saskatchewan.

In addition to cases in captive research and free-ranging deer and elk, CWD has been diagnosed in privately owned elk on game farms in Colorado (2), Montana (1), Nebraska (2), Oklahoma (1), South Dakota (7), and Saskatchewan (25) since 1996. Infection has been particularly severe in a group of interconnected facilities near Rapid City, SD, that appear to be the original source of infection for other South Dakota game farms. In contrast, infected elk in Nebraska originated in Colorado, infected elk in Oklahoma apparently originated in Montana, and CWD has been confirmed in the Montana and Colorado source herds. The overall distribution and occurrence of CWD among farmed-elk operations should become clearer as industry-wide surveillance programs are developed. There are no apparent epidemiological connections between the Colorado-Nebraska, South Dakota-Saskatchewan, and Montana-Oklahoma foci; moreover, there are no apparent epidemiological connections between any of the cases in farmed elk and cases in free-ranging or captive research deer and elk in the United States. Currently, it is unknown whether CWD recently detected in wild mule deer in Saskatchewan represents a previously unrecognized endemic area or spillover from privately owned elk. National programs for managing CWD in farmed cervids in both the United States and Canada currently are under development.

Neither the agent causing CWD

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Chronic Wasting Disease
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nor its mode of transmission have been definitively identified, but clinical disease is associated with the accumulation of protease-resistant prion protein (PrPres) in brain tissue (as in other transmissible spongiform encephalopathies). Experimental and circumstantial evidence suggests infected deer and elk probably transmit the disease laterally through animal-to-animal contact and/or contamination of feed or water sources with saliva, urine, and/or feces. Chronic wasting disease seems more likely to occur in areas where deer or elk are crowded or where they congregate at man-made feed and water stations. Although CWD does not appear to be transmitted via contaminated feed, artificial feeding of deer and elk may compound the problem. This may in part explain the intensity of infection in some cervid populations housed in farm or research settings.

According to public health (Centers for Disease Control, World Health Organization) and animal health officials, information available to date indicates that CWD is not likely to be naturally transmitted to humans, or to animals other than deer and elk. As a general precaution, public health officials recommend that people avoid contact with deer, elk, or any other wild animal that appears sick. Although there's no evidence that CWD can be naturally transmitted to domestic livestock, the disease is similar in some respects to two livestock TSE's: scrapie, which affects domestic sheep and goats worldwide and has been recognized for over 200 years, and bovine spongiform encephalopathy (BSE), which is a more recent disease of cattle in the United Kingdom and Europe. Despite some similarities, there is no evidence suggesting either scrapie or BSE are caused by contact with wild deer or elk, or that wild deer or elk can contract either scrapie or BSE in countries where these diseases occur. Two recent studies show that the CWD agent is even less likely to cause disease in cattle than scrapie under experimental conditions and, consequently, natural transmission of CWD to cattle is highly unlikely.

Deer and elk affected with CWD show subtle but progressive loss of body condition accompanied by behavioral changes. In the later stages of disease, emaciation, excessive salivation, increased drinking and urination, stumbling, trembling, and depression may precede death. As with other TSE's, the clinical course of CWD appears to be progressive and irreversible, ultimately leading to the death of affected animals. Because the clinical signs of CWD are relatively nonspecific, laboratory examination of clinical suspects is essential for confirming this diagnosis.

At present, the diagnosis of CWD is based on microscopic examination of brain tissues (specifically, the medulla oblongata at the obex) from suspected cases. Both histopathologic examination and immunohistochemistry (IHC) are used in routine diagnosis of clinical cases, and may also be used to detect preclinical cases in surveillance and monitoring programs; of these, IHC appears to offer greater sensitivity in detecting early preclinical cases. In deer, IHC on tonsil and retropharyngeal lymph node tissues offers an additional tool for reliable preclinical diagnosis, similar to scrapie in sheep. Western blots and negative-stain electron microscopy also have been used to further confirm diagnoses. There are currently no validated live-animal tests for diagnosing either clinical or preclinical CWD in either deer or elk; however, research is underway to evaluate several promising avenues for antemortem diagnosis.

The wiseth mind hath something yet to learn.
George Santayana

Mycoplasmal Conjunctivitis
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between infected and susceptible individuals or by contact with contaminated surfaces, airborne droplets, dust or feathers. The flocking behavior of house finches, as well as social and foraging behavior at bird feeders, probably enhances the transmission of MG. We have documented contaminated bird feeder surfaces that may act as a source of MG infection for other house finches and songbirds. MG also is transmitted vertically through the egg in poultry, and may be responsible for the persistence of outbreaks. To date, egg transmission has not been documented in house finches; however, MG infection has been confirmed in nestlings, suggesting pseudo-vertical transmission of disease from parents to their dependent young.

We have studied several aspects of the epidemiology of this emergent disease by combining traditional field investigation techniques with a unique public survey known as the House Finch Disease Survey (HFDS) of the Cornell Laboratory of Ornithology (www.birds.cornell.edu/hofi). The survey has facilitated investigation of disease trends across large geographic areas that would have been impractical by traditional means. For example, HFDS data revealed the proportion of northeastern U.S. monitoring sites with at least one diseased house finch present each month ranged from a peak of 59 percent (August 1995) to a minimum of 12 percent (July 1999). Two aspects of these data are noteworthy. First, the long-term trend of the data suggests that mycoplasmal conjunctivitis is declining in northeastern house finches and may have disappeared or become endemic in some areas. Secondly, subsequent to the epidemic peak of disease in 1995, a series of recurring cycles occurred, with elevations of disease activity in late fall and winter when house

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Mycoplasmal Conjunctivitis
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finches form large flocks and are more dependent on bird feeders, and lower disease activity during the breeding season when birds are more dispersed. The recurring seasonal cycles have been confirmed by field studies in New Jersey, although the long-term decline has not been observed there due to high host population density.

The HFDS also has established a network of concerned professionals and individuals who are monitoring the health of native western house finches. Mycoplasmal conjunctivitis has not been confirmed in western house finches to date. However, eastern and western house finches intermingle in the west-central U.S., and MG infections have been confirmed in house finches in Texas, Kansas and Nebraska. Dispersal, particularly of infected juvenile house finches, may enhance spread of the disease further westward.

Unfortunately, treatment of this disease in wild populations is impractical due to difficulties in treatment of wild populations, the enormous scale of the problem, and the social and mobile nature of the house finches. No direct control measures are readily available; proper sanitation at backyard feeding stations may decrease transmission of the disease agent.

The dynamics of this emerging infectious disease are only beginning to be understood, yet provide a unique opportunity to study a novel pathogen in an abundant wild bird. Our research team recently has received funding from the National Institutes of Health and the National Science Foundation to continue this investigation over the next several years as a model of infectious disease ecology in natural populations. In addition, mycoplasmal conjunctivitis of house finches demonstrates the need to be vigilant for the appearance of novel infectious agents in species that historically have been unaffected by such pathogens. These issues are critical for safeguarding wild and domestic bird health.

Bovine Tuberculosis in Michigan's Deer
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Scientists, wildlife biologists, epidemiologists, and veterinarians studying this situation have concluded that the most logical theory is that high deer densities and the focal concentration caused by baiting (the practice of hunting deer over feed) and wildlife feeding are the factors most likely responsible for the establishment of self-sustaining bovine TB in free-ranging Michigan deer. By unnaturally and repeatedly congregating deer, baiting and feeding provide ideal conditions for the transmission of bovine TB via inhalation of infectious aerosols and ingestion of bovine TB-contaminated feed.

The elimination of bovine TB from free-ranging deer will be a difficult goal to accomplish and will require the cooperation and collaboration of numerous state and federal animal health and wildlife resource agencies. Animal health agencies do not have sufficient expertise in wildlife biology and management techniques to address the situation independently, while wildlife agencies lack the expertise to deal with infectious disease problems in animals. Therefore, multiple agencies must rely on each other and work collaboratively to control disease, such as TB, in wildlife; unilateral efforts cannot be expected to succeed. Although conflicts between wildlife and agricultural interests could arise, it should be understood that natural resource agencies want their wildlife populations to be healthy as much as animal health agencies want domestic animals to be free of disease.

A multi-agency committee was formed to develop a control program for bovine TB in Michigan. Management strategies included testing livestock, educating the public about bovine TB, eliminating feeding and baiting of deer, reducing deer population densities through legal hunting in areas where bovine TB has been found, and banning the transport of free-ranging deer from the infected area.

A statewide surveillance program for free-ranging deer was initiated to identify areas that need intensified management practices, and to monitor the progress of control efforts. The long-term evaluation of the prevalence of bovine TB in deer allows the Michigan Department of Natural Resources (MDNR) to define geographic areas of infection and assess trends in disease occurrence. The surveillance plan focuses on areas where deer are most likely to have bovine TB and it is science based, utilizing past and present livestock infection rates and locations, areas of high deer density, and appropriate sample sizes for statistical analysis. The wildlife program is coordinated with surveillance in livestock conducted by the Michigan Department of Agriculture (MDA), and it is practical in terms of manpower, money, and laboratory capacities.

A strong education program is necessary to encourage public support and participation in the TB eradication project. Improved communications, at the grass roots level and through statewide marketing, is vital to the success of the education program. Continued and enhanced contact with key au-

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Bovine Tuberculosis in Michigan's Deer
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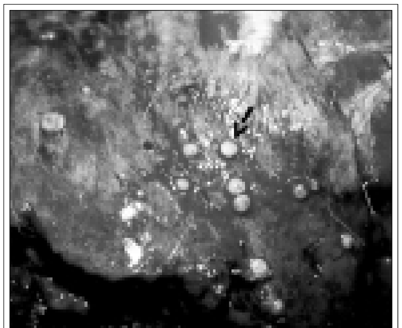
diences (i.e., livestock producers, industry representatives, the media, hunters, and recreational wildlife viewers) will lead to an understanding of the recommended strategies for *M. bovis* eradication in deer and livestock populations. Ongoing educational efforts include MDNR/MDA/Michigan State University extension training sessions, bovine TB brochures and newsletters, the annual Michigan Bovine TB Conference, bovine TB web site, infomercials, satellite training sessions, and press packets.


Deer lung with tuberculosis lesions

Methods employed for eradicating bovine TB from wild deer should decrease the transmission of the disease agent among the animals. Reduction of transmission can be enhanced in two ways: reduction in the number of infected animals, and reduction in the amount of contact (direct or indirect) between infected and susceptible animals. Increasing the hunter harvest of deer will reduce the overall number of deer as well as reduce the average age of the deer population. Hunting regulations should be liberalized to remove greater numbers of antlerless deer to control deer populations and to remove greater numbers of adult males because a higher TB prevalence has been observed in adult bucks in Michigan. The goal of liberalized hunting regulations is a smaller deer herd with a younger age structure.

Elimination of baiting and supplemental feeding of deer will reduce the deer population as the herd density approaches the natural carrying capacity of the land, as well as decrease contact among deer. Artificial feed supplies increase deer population density beyond the carrying capacity. Even if the deer herd density is not artificially inflated, feeding and baiting encourage unnatural congregation of the animals, thereby enhancing the transmission of infectious agents. Large numbers of animals in close proximity for extended periods of time are more likely to inhale infectious aerosols or consume food contaminated by coughing and exhalation.

In summary, the two main strategies for eradicating bovine TB from free-ranging Michigan deer are to minimize concentrations of deer by eliminating baiting and feeding, and to reduce deer numbers through hunting to the biological carrying capacity. Baiting and feeding have been banned since 1998 in counties where bovine TB has been found. In addition, the deer herd has been reduced by 50 percent in the endemic area with the use of unlimited antlerless permits. Measures of the prevalence of bovine TB in Michigan's wild deer have been decreasing since 1997, providing hopeful preliminary evidence that control strategies are succeeding.

Wildlife-Livestock Interaction
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cluding professional wildlife managers, hunters, many landowners, and the numerous private citizens who enjoy wildlife in a non-consumptive manner, also worry about diseases. As with domestic animals, there is the direct risk to wildlife due to the pathogenicity of the disease agent, and there are a few examples where wild populations were decimated by disease. Perhaps a greater threat is for wildlife to become involved in the epidemiology of a disease of significance to animal agriculture. When a wild species is identified as reservoir host, amplifying host, main or alternate host for the disease vector, or transport mechanism for disseminating a disease, it can lead to trouble and conflict for wildlife conservationists. Preserving our agricultural economy may call for harsh control measures such as the depopulation of thousands of animals, intolerance of wildlife on farms, and destruction of habitat. Even perceived health threats from wildlife have led poultry industries to lobby forcefully against waterfowl refuges in poultry-producing areas. Given these circumstances, it is not unusual for agriculture and wildlife interests to collide over health issues.

One special area of health concern for wildlife conservationists is the private ownership of wildlife species as "alternative livestock." Wildlife managers fear the introduction of diseases or undesirable genetic material into wildlife populations from animals that are being rapidly moved throughout the country. In addition to fence-line contact, escapes are particularly worrisome because recovery of the privately owned animals can be difficult, particularly when indistinguishable wild animals are present.

Before progressing further, it is important to recognize that fish-and-wildlife-associated recreation is big business. Outdoor activities associated with wildlife have a huge public constituency and the economics of wildlife generally are under-recognized. The latest National Survey of Hunting, Fishing and Wildlife-Associated Recreation revealed that 77 million Americans participate in fishing, hunting, or non-consumptive wildlife enjoyment. And, they spend $104 billion annually in the process. Thirty-five million people fish and spend $38.1 billion, and 14 million people hunt and spend $20.6 billion. Non-consumptive wildlife activities (observation, feeding, etc.) are enjoyed by 63 million people

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who spend $25.7 billion. Hunting, which is the smallest of the wildlife industries, is huge. Hunting activities provide for $16.1 billion in household income, $3.1 billion in state and federal tax revenue, 704,000 jobs, and an economic multiplier effect of $61 billion. Many of the economic benefits from hunting and fishing impact rural areas.

One comparative example is the value for the cattle industry provided by the National Cattlemen's Beef Association. The farm gate value of all cattle, calves, and dairy products was $44 billion in 1996. There were approximately 1 million cattle farmers and ranchers, which means for every vote the cattlemen had that year, fish and wildlife enthusiasts had 76. Cattlemen have the largest percentage of private land, some 525 million acres, but they also are dependent upon much of the 516 million acres of public land. Both private and public lands are teeming with wild animals that are held in public trust and, thus, there are multiple scenarios where disease interaction between wildlife and livestock can become contentious issues.

Despite the contrasting perspectives of animal agriculture and wildlife conservation groups on some health issues, it must be stressed that there is substantial common ground. To a great extent, many of the same people are involved in both activities and have understanding from both sides of controversial issues. Animal agriculturalists and wildlife managers understand the concept and value of population health management as opposed to individual animal treatment, and the concern for foreign animal disease introduction is mutual. Additionally, both groups are competing against a "tide of humanity" as human populations increase demand for land and water resources, and there is concern regarding the animal rights movement directed against consumptive use of either wild or domestic animals. Lastly, because the land base for much of wildlife production is private land, and much of private land is used for animal agriculture, saving farming enterprises is beneficial to wildlife.

In closing, it is important for all to view the transmission of diseases between domestic animals and wildlife as a "two-way street" where organisms have the potential to move in either direction. Thus, the goal should be to develop programs and policies that can protect and sustain all interests.

A Closer Look
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resents decades of experience and many of the writers have been prominent in the USAHA. These wildlife veterinarians and biologists are the developers of much of the information available today regarding the significance of diseases in wildlife populations, as well as the disease interrelationships between wildlife, domestic animals, and humans.

Vic Nettles and Tom Thorne provide excellent overviews of disease relationships between wildlife and domestic livestock and the strategies to deal with diseases in wildlife. Their articles are abridged versions of the papers they presented in Birmingham and the full text can be found in the Report of the 104th USAHA Meeting. Dave Stallknecht's article summarizes more than 20 years of national surveillance, field epidemiology, and laboratory research on hemorrhagic disease (HD), the most significant infectious disease of white-tailed deer in the United States. Additional information on HD and other wildlife disease topics may be found at the website of the Southeastern Cooperative Wildlife Disease Study, www.scwds.org. Mike Miller and Beth Williams provide an update on chronic wasting disease (CWD), a topic currently on the minds of many wildlife managers, captive cervid owners, and animal health authorities. A recent account of their work on CWD epidemiology in wild cervids can be found in the Journal of Wildlife Diseases 38: 676-690, 2000.

Barry Hartup documents the emergence of a new disease in wild birds caused by an old pathogen of domestic poultry. First recognized during the winter of 1993-1994 in suburban Washington, DC, mycoplasmal conjunctivitis rapidly spread to affect house finches throughout their entire eastern range and demonstrated how rapidly disease can travel in migratory birds years before West Nile virus came to the United States. The article is excerpted from a recent publication in the ornithological journal The Auk 118:327-333, 2001. Steve Schmitt covers the dramatic re-emergence of bovine tuberculosis in Michigan's wildlife and cattle as well as the management techniques employed to control it. Additional information on the Michigan TB situation can be found at www.bovinetb.com. Dennis Slate's article on oral rabies vaccination demonstrates that innovative techniques can be used to control selected diseases in wildlife under the appropriate circumstances.

Articles on diseases in wildlife will be a regular feature in upcoming issues of the USAHA newsletter. Feedback on this special issue as well as suggestions for topics to be covered in future newsletters is always appreciated.