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Abstract: This paper describes diseases that are transmissable from animals to human beings. In many cases, the diseases are contracted by direct contact with the animals. However, several of the diseases are associated with vectors rather than with direct animal contact. Wildlife damage control agents or other wildlife professionals often cannot avoid situations that put them at risk. However, disease may be prevented by knowledge of the risk, and by following simple procedures to minimize risk. Risk may be minimized in many cases with knowledge of transmission modes, endemic areas, and specific preventative measures such as avoidance of known sources of infection, proper handling of potentially infected animals or materials, control of reservoirs and vectors, hygiene, thorough cooking of food, and treatment of water. Vaccination, when available, may be warranted where there is a high risk of exposure of personnel to infectious agents. The symptoms, distribution, animal reservoirs, modes of transmission, incubation time, prevention, and control methods of these diseases are discussed.

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Diseases of animals that may be transmitted to human beings under natural conditions are known as zoonoses. Exposure to bacterial, viral, protozoal, fungal, or other types of agents that cause zoonoses may occur during domestic, occupational, or leisure activity. Occupational exposure to zoonotic agents has been documented as a cause of some important human diseases, including anthrax and brucellosis. Recognition of the risks associated with exposure to certain animal species, combined with appropriate preventive measures, should reduce the chances of acquiring a zoonotic disease.

The practice of wildlife damage management involves exposure of humans to numerous animal species. Some of these species may serve as sources of human pathogens, whereas other species may simply be involved in the natural history of the disease agents or vectors. In either circumstance, exposure of wildlife damage personnel to the reservoir animal, or to vectors associated with animals, may increase the risk of zoonosis. The following report describes several diseases that could affect wildlife damage control agents. This list is not all-inclusive, nor is it meant to make diagnosticians of readers. It is provided simply to advise readers of some of the potential risks associated with contact with certain animal species.

The diseases listed are those that may be most frequently encountered, or those about which wildlife damage management personnel may frequently receive questions. The descriptions of the disease syndromes are based on the most frequently reported symptoms. Additional symptoms or syndromes may be associated with the disease, but are not listed here because they are less frequently encountered. Consultation with a physician is recommended in any instance in which a person was potentially exposed to a disease agent.

In this report, the diseases are arbitrarily categorized according to the association of the infectious agents with avian or mammalian reservoirs, or the involvement of birds or mammals in the natural history or life cycle of the agent. This categorization is arbitrary because in some cases the disease agents may be associated with both birds and mammals, whereas in other cases, the agent is not actually associated with animals, but rather is found in the environment, such as in rodent burrows or in the excrement of birds or bats. The information in this report is derived largely from the fifteenth edition of the official report of the American Public Health Association, Control of Communicable Diseases in Man (Benenson 1990). This handbook is highly recommended for anyone seeking additional information on zoonoses and other human diseases.

HUMAN DISEASES ASSOCIATED WITH AVIAN SPECIES

Arboviral Encephalitis

Several types of encephalitis in human beings are caused by insect-borne viruses known as arboviruses. Disease is characterized by inflammation of the brain and meninges that may result in headache, fever, stupor, disorientation, coma, convulsions, or paralysis. In the United States, eastern equine encephalitis occurs in eastern and northcentral states, western equine encephalitis occurs in western and central states, Venezuelan equine encephalitis occurs in Florida, and St. Louis encephalitis occurs nationwide. The true reservoirs of these viruses are unknown, but may possibly be birds, horses, rodents, bats (*Myotis* spp., *Eptesicus* spp., *Lasiurus borealis*, *Tadarida* spp.), reptiles, amphibians, or mosquitoes. Transmission to humans is by the bite of infective mosquitoes and the incubation period is 5-15 days. Mosquito control or avoidance

are the best methods for prevention of these diseases.

Cryptococcosis and Histoplasmosis

Systemic fungal infections may be associated with human contact with avian roosts or nests. Cryptococcosis may result in meningitis, skin infection, or generalized infection. It is caused by the saprophytic fungus, *Cryptococcus neoformans*, occurs worldwide, and is consistently found in pigeon (*Columba livia*) droppings and old pigeon nests. Histoplasmosis may be an acute or chronic respiratory or disseminated disease and is caused by *Histoplasma capsulatum*, a fungus found in soil around starling (*Sturnus vulgaris*) and blackbird (*Agelaius* sp., *Euphagus* spp., *Quiscalus* spp., *Xanthocephalus* sp.) roosts, old chicken houses, bat caves, and around houses sheltering brown bats (*Myotis lucifugus*, and *Eptesicus fuscus*). Histoplasmosis is more prevalent in the eastern and central United States. Transmission occurs by inhalation of the fungi. Incubation is 5-18 days for histoplasmosis, but is unknown for cryptococcosis. Prevention measures include avoiding exposure to bird droppings, old nests, and the associated dust (Wolf 1990). Blastomycosis is another systemic mycosis caused by inhalation of spores of the fungus, *Blastomyces dermatiditis*, found in the soil.

Psittacosis

Psittacosis or ornithosis is a bacterial disease of worldwide distribution caused by *Chlamydia psittaci*. Symptoms may include fever, headache, myalgia (muscle pain), chills, and upper or lower respiratory tract disease. Parrots (Psittacidae), parakeets, pigeons, turkeys (*Meleagris gallopavo*), ducks, and other avian species are reservoirs. Transmission occurs by direct contact with birds or by inhalation of the infectious agent from dessicated droppings or secretions. The incubation period ranges from 4-15 days with an average of 10 days. Psittacosis may be prevented by regulation of bird trafficking, testing with treatment or removal of infected birds, and disinfection of premises (Grimes 1990).

HUMAN DISEASES ASSOCIATED WITH MAMMALIAN SPECIES

Anthrax

Anthrax is caused by the bacterium, *Bacillus anthracis*, is of worldwide distribution, and may be characterized by skin lesions with spread to lymph nodes and the bloodstream or by respiratory infection progressing to fever, shock, and death. The spores of the bacteria are resistant to adverse environmental conditions and disinfection and may remain viable in soil for many years following contamination by an infected animal. Cutaneous anthrax occurs after contact with tissues of animals (wild and domestic) dying of the disease; contaminated hair, wool, or hides; soil contaminated by infected animals; or possibly by biting insects after feeding on infected animals. Inhalation of spores results in respiratory anthrax, whereas ingestion of undercooked meat may result in intestinal disease. The incubation period is 2-7 days. Prevention is by avoidance of contact with infected animals or tissues, disinfection of animal products, thorough cleansing of skin following potential contact, and control of dust. Vaccine is available for people handling potentially infected animals or their products (Hunter 1990).

Brucellosis

Brucellosis is caused by several species of the bacteria, *Brucella* spp. This disease occurs worldwide and is also known as undulant fever or Bang's disease. Infection may result in fever, headache, sweating, chills, epididymitis, or orchitis (testicular inflammation). *Brucella abortus* is found in cattle, *B. suis* in feral and domestic swine (*Sus scrofa*), *B. melitensis* in sheep and goats, and *B. canis* in dogs. Transmission is by contact with infected tissues, blood, urine, vaginal discharges, and aborted fetuses and placentas; ingestion of raw dairy products, particularly goat cheese; and by inhalation in abattoirs and laboratories. Incubation is usually from 5-30 days, but may range to several months. Prevention methods include elimination of infected animals, proper disposal of tissues, pasteurization of dairy products, and education of those in contact with potentially infected animals (Currier 1990).

Coccidioidomycosis

Coccidioidomycosis is a systemic fungal infection similar to histoplasmosis or cryptococcosis. This disease is caused by *Coccidioides immitis*. It occurs in arid regions in the southwestern United States, and may initially resemble influenza with fever, chills, cough, and chest pain with later systemic spread. The fungus grows in soil, especially around Indian middens and rodent burrows. Transmission is via inhalation of fungal spores, incubation is from one to four weeks, and dust control is the most effective method of prevention.

Diarrheal Diseases

Cryptosporidiosis.—Cryptosporidiosis is a diarrheal disease of human beings, domestic, and numerous other animal species caused by the protozoan, *Cryptosporidium parvum*. The organism is of worldwide distribution, and reservoirs include man, cattle, and other domestic animals. Infection has been reported in numerous species and typically occurs in young animals. Transmission is by the fecal-oral route following contact with an infected person or animals, or by ingestion of contaminated food or water. The incubation period is 1-12 days with an average of 7 days. Preventive measures include hygiene, sanitation, and boiling or filtering contaminated water as chemical treatment may be ineffective (Fayer and Ungar 1986).

Giardiasis.—*Giardia lamblia* is another protozoan organism of worldwide distribution that may cause chronic diarrhea in numerous species including human beings. Giardiasis in the United States is seen most frequently in mountain communities with an unfiltered water source. Reservoirs of the protozoa include man and possibly beaver (*Castor canadensis*) and other wild animals. Transmission is by ingestion after handling materials or drinking water contaminated with the protozoa. The incubation period averages 7-10 days but may range from 5-25 days. The best methods of prevention are proper hygiene, and boiling or filtering drinking wa-

ter. Chlorine does not kill the organisms.

Coliform diarrhea.—Diarrhea caused by *Escherichia coli* bacteria occurs in human beings, domestic, exotic, and wild animals around the world. The recently reported diarrhea with secondary kidney disease in humans in the United States resulted from ingestion of undercooked ground beef contaminated with a specific type of the bacteria known as *E. coli* O157:H7. Cattle are the apparent reservoirs of this type of bacteria. This organism has not been associated with wild animals. Transmission is by ingestion of contaminated, undercooked meat, particularly ground beef, or by contact with infected persons. The incubation period is usually 12-72 hours. Preventive measures include proper hygiene, sanitation, and thorough cooking of ground meat (Griffin and Tauxe 1991).

Salmonellosis.—Diarrhea may also be caused by numerous species of the bacteria, *Salmonella*. Salmonellosis may produce nausea and dehydration in addition to diarrhea. Distribution is worldwide and numerous domestic and wild animals including cattle, swine, horses, rodents, turtles, poultry, as well as human beings may serve as reservoirs. Transmission is by the fecal-oral route or by ingestion of contaminated foods including eggs, raw meat, poultry, and dairy products. Incubation is usually about 12-36 hours. Prevention is through sanitation, proper hygiene, and thorough cooking of foods (Pelzer 1990). Other bacteria including *Arizonae*, *Campylobacter*, and *Shigella* can produce illnesses similar to salmonellosis and essentially have the same epidemiology.

Ehrlichiosis

Ehrlichiosis is a recently identified disease caused by a rickettsial organism known as *Ehrlichia chafeensis*. Clinical effects may range from asymptomatic to fatal, but the most common syndrome is one of fever, headache, malaise, myalgia, skin rash, and nausea. Ehrlichiosis has been reported throughout the United States with most reports from the Southeast and Midwest. The natural history of the organism is unknown, but white-tailed deer (*Odocoileus virginianus*) have been suggested as a potential reservoir. Although vectors have not been identified with certainty, human infections appear to be associated with bites of the Lone Star tick, *Amblyomma americanum*. The incubation period averages 14 days, but ranges from less than 7 to more than 30 days. Prevention is by avoidance of tick bites (Dawson et al. 1994, Eng et al. 1990).

Hantaviral Pulmonary Syndrome

A hantavirus was identified as the cause of an acute respiratory distress syndrome in the Four Corners area of the United States in 1993. Since June 1993, 98 cases of hantaviral pulmonary syndrome (HPS) have been reported in 21 states ranging from the northwest to the southeast, with more than 95% of these cases occurring west of the Mississippi River. The earliest retrospectively identified case occurred in Utah in 1959. The deer mouse (*Peromyscus maniculatis*) is the main reservoir in the western United States, although antibodies to the virus have been identified in several other rodent species. At least 4 cases have been reported outside the range of *P. maniculatis*. In Florida, the cotton rat (*Sigmodon hispidus*) is the apparent reservoir of another type of hantavirus that causes HPS, but differs somewhat from the southwestern hantavirus. Other types of hantavirus not associated with human disease have been identified previously in rodents in the United States. Additionally, other hantaviruses found in Europe and Asia are the cause of hemorrhagic fever with renal syndrome, a disease suffered by many American troops during the Korean War (Centers for Disease Control and Prevention 1994, Duchin et al. 1994).

Initially, HPS may be characterized by fever, myalgia, cough, headache, and nausea. Rapidly progressive pulmonary edema and hypotension lead to death in approximately 52% of reported cases. Transmission is via inhalation of hantavirus that has been aerosolized from rodent saliva, urine, or feces. Direct contact with rodent tissues and rodent bites have not been ruled out as modes of transmission. The incubation period is unknown. Prevention of HPS is centered on avoidance of exposure to rodents and their excreta. Persons with increased exposure to rodents through occupational, leisure, or domestic activities should eliminate rodents, properly dispose of carcasses, and reduce availability of food and nesting sites. Protective clothing, gloves, boots, and filtered respirators are recommended when handling rodents in areas where rodents are known to be infected with the virus. Because the geographic range of the virus continues to spread, these measures may be recommended throughout the country (Centers for Disease Control and Prevention 1993).

Hydatid Disease

Echinococcosis may be caused by the tapeworms *Echinococcus multilocularis* or *E. granulosus*. The latter causes hydatid disease of humans which has been reported in northern Arizona and southern Utah. This disease results in unilocular cysts in internal organs including the lungs and liver. Canids, including wolves (*Canis* spp.) and dogs, are the definitive hosts of the parasite and herbivores are intermediate hosts. Humans become infected following ingestion of eggs passed in the feces of infected canids. The incubation period ranges from months to years. Prevention is through proper hygiene, gloves, and other protective clothing (Bryan and Schantz 1989).

Alveolar hydatid disease.—*Echinococcus multilocularis* causes alveolar hydatid disease of humans which may result in unrestricted growth of space-occupying lesions in internal organs, particularly the liver. This disease carries a grave prognosis. The tapeworm occurs in the northcentral United States, Alaska, and Canada. Adult worms are normally found in the intestinal tract of foxes and coyotes and intermediate forms occur in rodents. Human infection follows ingestion of eggs, and the incubation period may range from months to years. Prevention is through hygiene, protective clothing, and gloves. This parasite has been identified in foxes (*Vulpes vulpes*, *Urocyon cinereoargenteus*) translocated from northcentral states to fox-chasing enclosures in the southeastern United States (Bryan and Schantz 1989, Davidson et al. 1992).

Leptospirosis

Leptospirosis is a disease of worldwide distribution caused by numerous serovars of *Leptospira interrogans* bacteria. Symptoms may include fever, headache, myalgia, and jaundice. Reservoirs of the bacteria include numerous wild and domestic animals including rodents, skunks (*Mephitis* spp.), raccoons (*Procyon lotor*), cattle, and swine. Transmission occurs by contact of the skin and mucous membranes with water, soil, or vegetation contaminated with urine of infected animals, or by direct contact with tissues or fluids of infected animals. The incubation period is usually 7-10 days. Preventive measures include rodent control, protective clothing and gloves, and avoidance of bodies of water contaminated with the organism (Songer and Thiermann 1990).

Lyme Disease

The causative agent of Lyme disease is *Borrelia burgdorferi*, a bacterium that is transmitted to humans and some domestic animals by tick bites. Lyme disease has been reported throughout most of the United States, with most reports from the Northeast, upper Midwest, and California. A "bullseye" skin rash may develop from 3-30 days following the bite of an infected tick. If untreated, symptoms including chronic arthritis, cardiac problems, and neurologic abnormalities may develop. The reservoir of the bacteria is the white-footed mouse (*Peromyscus leucopus*), and the bacteria are maintained in nature by ticks of the *Ixodes* genus through transstadial transmission. Several wild animals including white-tailed deer are involved in maintenance of the tick life cycle, but apparently do not serve as reservoirs of the bacteria. Preventive measures include avoidance of tick bites and prompt removal of any attached ticks (Steere 1989). Other preventive measures include taping of pants legs and use of effective repellents.

Plague

Plague is a bacterial disease caused by *Yersinia pestis* and is endemic in the western third of the United States. Bubonic plague results when lymph nodes draining the site of a bite from an infected flea become swollen, inflamed, and painful. The swollen nodes are known as buboes and occur most frequently in the inguinal area. Infection may progress to pneumonia and septicemia with untreated cases resulting in 50% mortality. The reservoirs of the bacteria are wild rodents, although lagomorphs and carnivores may also be sources of infection. Transmission occurs most frequently by the bite of infected fleas, although handling of tissues of infected animals and inhalation of aerosolized bacteria from humans or pets with pneumonic plague may also result in infection. The incubation period is 2-6 days. Preventive measures are centered around rodent and flea control and proper handling of infected animals. Vaccine is available for persons at high risk of exposure (Texas Department of Health 1994).

Rabies

Rabies is a viral disease of worldwide distribution resulting in severe neurologic abnormalities and death. Infection most frequently occurs following the bite of an infected animal. Rabies reservoirs include bats, foxes, skunks, raccoons, coyotes (*Canis latrans*), and dogs in different regions of the United States. Rabies infections are seen in numerous domestic and wild mammals. Reports are rare in lagomorphs and rodents. Transmission occurs when virus-laden saliva or tissue enters a skin wound such as a bite. Airborne transmission in caves harboring bat roosts has also occurred. Incubation is usually 2-8 weeks, but may extend beyond 1 yr. Preventive measures include avoidance of contact with infected animals, their tissues, and saliva. Prompt cleansing and flushing of bite wounds with soap should reduce chances of infection with rabies virus as well as with other pathogens associated with animal bites such as *Pasteurella* bacteria. Dogs and cats must be observed for signs of rabies for 10 days after biting a person, but wild animals and unwanted domestic animals should be euthanized immediately and examined by a public health laboratory for rabies infection. A physician should be contacted following possible exposure. Post-exposure therapy may be administered by the physician based on the likelihood of actual exposure to rabies virus. Pre-exposure immunization is common in persons at high risk of exposure. Vaccination of domestic animals in the United States has markedly reduced human cases of rabies since the 1940's and 1950's (Fishbein and Robinson 1993, Krebs et al. 1994)

Ringworm

Ringworm, also known as dermatophytosis, is a skin infection caused by numerous fungal species of the genera *Microsporum* and *Trichophyton*. Skin lesions are usually ring-shaped. The causative fungi are found worldwide and reservoirs include man and many animals including dogs, cats (*Felis domesticus*), and rodents. Transmission is by direct contact with infected persons or animals, or by contact with contaminated objects. Ringworm is prevented by avoiding contact with infected persons or animals, and by laundering, washing, and the use of fungicides.

Scabies

Scabies or sarcoptic mange is a skin disease due to mites, *Sarcoptes scabiei*, that are found throughout the world. Scabies is characterized by skin rashes with intense itching. Reservoirs for the mites include man and most furred animals. Severe sarcoptic mange is not uncommon in red foxes. Disease caused by mites from an animal host usually results in transient infection in man because the mites do not reproduce in human skin. Transmission occurs by direct contact with infected persons or animals or by indirect contact with contaminated materials. The incubation period is 2-6 weeks. Avoidance of direct contact is the best preventive measure (Arlian 1989).

Toxoplasmosis

Toxoplasmosis is caused by the protozoan, *Toxoplasma gondii,* and occurs worldwide in domestic and wild animals and birds, as well as in human beings. Disease is characterized most frequently by fever and swollen lymph nodes; however, pneumonia, skin rash, neurologic and cardiac dis-

ease, and death can occur. Infection during early pregnancy can result in fetal death or congenital eye and nervous system anomalies. Felines are the only animals in which the sexual cycle of the protozoan occurs. Intermediate hosts that also serve as sources of infection include cattle, sheep, goats, swine, poultry, birds, rodents, and wild animals including deer. Human infection occurs following ingestion of oocysts from cat feces or by ingestion of undercooked meat, food, water, or dust containing cysts. The incubation period is 10-24 days following ingestion of cysts in meat, or 5-20 days following ingestion of oocysts from cat feces. Preventive measures include thorough cooking of meat, proper disposal of cat feces, and handwashing following contact with raw meat, contaminated soil, and cat feces (Dubey 1994).

Tularemia

Tularemia is a bacterial disease caused by *Francisella tularensis*. Tularemia, also known as rabbit fever, is characterized by indolent ulcers on the hands with swelling of the regional lymph nodes. A pneumonic form may develop following inhalation of the organisms whereas gastrointestinal disease may follow ingestion. This disease occurs throughout the United States with higher incidence in summer when ticks are abundant, and in early winter when rabbit hunting occurs. Rabbits (*Sylvilagus* spp.), hares (*Lepus* spp.), muskrats (*Ondatra zibethicus*), beaver, some domestic animals, and some hard ticks are reservoirs. Transmission occurs by direct contact with blood or tissues of an infected animal, primarily rabbits, by the bite of infected ticks and deerflies, by ingestion of undercooked meat or contaminated water, and by inhalation. Rare cases have occurred following bites by carnivores presumed to have been feeding on infected carcasses. The incubation period is usually 3 days and may range from 2-10 days. Preventive measures include avoidance of arthropod bites, careful handling of tissues of infected animals, and thorough cooking of meat (Rohrbach 1990).

Typhus Fever

Typhus fever or louse-borne typhus is caused by the rickettsial organism *Rickettsia prowazekii*. In the United States, the disease is regarded as a zoonosis of flying squirrels (*Glaucomys* spp.), and is seen primarily in eastern states. Illness is characterized by fever, headache, and prostration with skin rash developing on the fifth or sixth day. The fatality rate ranges from 10-40% in the absence of therapy. Man is the primary reservoir of the rickettsia throughout the world; importance of the flying squirrel as a reservoir is unknown. Transmission occurs when louse feces containing the rickettsia come in contact with broken skin. The incubation period is 1-2 weeks. Preventive measures include hygiene and the use of insecticides.

Visceral Larva Migrans

Visceral larva migrans (VLM) is a condition that occurs worldwide and is caused by roundworm larvae travelling through the internal tissues of aberrant hosts. Human infection with larvae of the dog or cat roundworm, *Toxocara* spp., may cause damage to the liver, spleen, lungs, eyes, and nervous system eventually resulting in death. Another cause of larva migrans is the raccoon roundworm, *Baylisascaris procyonis*. Larvae of this roundworm may cause central nervous system disease in numerous species of wild and domestic animals. Two fatal human cases have been confirmed and many additional instances of larval damage to the eye have been reported. Infection occurs following ingestion of eggs from the feces of infected dogs, cats, and raccoons. Sandboxes contaminated by cats are a freqently identified source of roundworm eggs. The incubation period is variable and may be from weeks to months. Proper hygiene and disposal of animal waste are appropriate preventive measures (Kazacos and Boyce 1990, Schantz and Stehr-Green 1990)

SUMMARY

Numerous diseases affecting humans are associated with contact with animals that may serve as sources of the infectious agents. Wildlife damage control agents or other wildlife professionals often cannot avoid situations that put them at risk. However, these diseases may be prevented by knowledge of the risk, and by following simple procedures to minimize risk. Risk may be minimized in many cases with knowledge of transmission modes, endemic areas, and specific preventative measures (e.g., insecticide to prevent tick bites). Recurring themes among prevention methods are avoidance of known sources of infection, proper handling of potentially infected animals or materials, control of reservoirs and vectors, hygiene, thorough cooking of food, and treatment of water. Proper handling may entail protective clothing, such as boots, gloves, masks, and in certain instances, respirators. Vaccination, when available, may be warranted where there is a high risk of exposure of personnel to infectious agents.

Sources of additional information regarding zoonotic diseases are numerous. A physician should be consulted first in any instance of possible human exposure to pathogens. Local and state public health personnel may be able to provide information on a regional basis. Finally, the Centers for Disease Control and Prevention in Atlanta, Georgia may provide information and recommendations concerning the risks associated with potential exposure to human pathogens.

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