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ZOONOTIC DISEASES OF CARNIVORES AND OCCUPATIONAL SAFETY ISSUES FOR PREDATOR CONTROL EMPLOYEES

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ABSTRACT: The paper highlights some important zoonotic infections of carnivores in North America. The etiologic agents, routes of transmission, reservoirs, and methods for prevention are emphasized. Occupational safety issues for people working in predator control are discussed.

KEY WORDS: diseases, predators, public health, safety, wildlife management, zoonoses

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INTRODUCTION

Carnivores are an integral component of the ecosystem and in many ways enhance people's lives. Unfortunately, encroachment on wilderness environments has led to potentially dangerous encounters between wildlife and humans. Pet overpopulation has produced unwanted feral domestic dogs and cats in both urban and rural areas. In some instances, livestock and endangered species have suffered devastating losses due to predation by carnivores. As a result, predator control has become an important component of vertebrate pest control and wildlife management.

In addition to the inherent danger from injuries due to attacks, carnivores further represent a health threat because they may harbor diseases transmissible to humans. Acha and Szyfres defined zoonoses as communicable diseases shared by humans and other vertebrate animals (1987). Historically, some of the most deadly diseases known to humans have been zoonoses. For example, rabies has tormented humankind since antiquity and ultimately inspired the pioneering research that led to vaccine development (Steele and Fernandez 1991). Today we are seeing the emergence of newly recognized pathogens and the re-emergence of infectious diseases once thought to be successfully controlled (Morse 1990, Institute of Medicine 1992). In a recent report from the Centers for Disease Control and Prevention (1994a), approximately one-third of the emerging infections mentioned were zoonoses.

BACTERIAL INFECTIONS

The most common bacterial infections transmitted by carnivores to humans are due to wound infections, usually by direct inoculation of the bacteria via a bite or scratch. Bite wounds from felids are ten times more likely to cause infection in comparison with dog bites (California Department of Health Services 1992). Pasteurellosis, caused by *Pasteurella multocida*, represents 90% of the isolates from victims hospitalized with infected bites (Anderson 1992). Pasteurellosis in humans is characterized by moderate to severe cellulitis with swelling and pain. Other agents that may cause wound infections include hemolytic *Streptococcus*, *Bacteroides*, *Fusobacterium*, *Staphylococcus aureus*, and *Capnocytophaga* (CDC Group DF-2) (Benenson 1995). In addition, tetanus, caused by *Clostridium tetani*, is a

life-threatening illness that may be contracted through wounds caused by animal bites or scratches.

Cat scratch disease is another infection acquired by the bite or scratch of an infected animal, usually a domestic cat. Initially, the area at the bite or scratch develops a red papular lesion. The disease progresses to a subacute regional lymphadenopathy. The causative agent, *Bartonella* (formerly *Rochalimaea*) *henselae*, has only recently been described (Regnery et al. 1992, Dolan et al. 1993, Zangwill et al. 1993). *B. henselae* has also been found in the cat flea, *Ctenocephalides felis*, by polymerase chain reaction testing (Koehler et al. 1994); however, the role of fleas in the transmission cycle of *B. henselae* is unclear.

Wild and domestic carnivores have played an increasingly important role in the transmission of plague to humans. Plague is caused by *Yersinia pestis*, a bacteria maintained in nature by a sylvatic cycle involving wild rodents and their fleas in the western United States. There are three clinical forms of plague in humans: bubonic, septicemic, and pneumonic. The initial symptoms are fever, chills, and headache two to six days following exposure to the bacteria. The fatality rate is high without prompt diagnosis and treatment. The most frequent route of transmission of *Y. pestis* to humans is via the bite of an infective flea. Alternatively, humans can contract the illness by direct contact with the secretions of an infected animal or person.

In recent years, almost all human cases of the most lethal form of the disease, pneumonic plague, have been linked to domestic cats (Centers for Disease Control and Prevention 1994b). Both wild and domestic cats may develop symptomatic plague infection, including abscesses or buboes and pneumonia. The secretions (e.g., pus, respiratory secretions) are highly contagious to humans, particularly if inhaled. In contrast, canids do not usually develop clinical illness following plague infection; thus, they are less important in the transmission of the disease to humans. Other carnivores that may be infected include badgers, raccoons, skunks, bears, and opossums. Serologic titers have been demonstrated in many species of carnivores, making them useful sentinels for plague surveillance (Barnes 1982, Clover et al. 1989, Smith 1994, Chomel et al. 1994).

Tularemia, caused by *Francisella tularensis*, may also be harbored by carnivores and transmitted by bites,

scratches, or direct contact with infected tissues; however, carnivores are rarely involved in transmission to humans.

Leptospirosis is an important zoonotic infection worldwide. The disease is caused by a spirochete, *Leptospira interrogans*. The spectrum of illness ranges from no symptoms in some people to severe illness in others. The illness usually begins with fever, chills, and headache, and may progress to vomiting, jaundice, anemia, and a rash. Leptospirosis may cause damage to the kidneys, liver, brain, lungs, or heart, but it is not usually fatal. Wild and domestic animals are the reservoirs, including many species of carnivores (badgers, foxes, skunks, opossums, domestic dogs). Wild rodents are well-adapted to the bacteria and represent the most important reservoirs in nature. *L. interrogans* is shed in urine and may contaminate water and moist environments. Transmission to humans occurs by direct contact of the skin (especially if cut or abraded) or mucous membranes with the urine of infected animals. Less commonly, the route of transmission is by ingestion or inhalation of contaminated water or aerosols, respectively.

Enteric infections of carnivores are another important group of zoonoses. These bacteria cause a mild to severe

illness in humans, but may be life-threatening in the very young, very old, and immunosuppressed individuals. *Salmonella* spp. and *Campylobacter jejuni* are examples of bacteria frequently isolated from mammals, birds, and reptiles (Altekruse and Hunt 1994). These bacteria are classically known for causing outbreaks of food poisoning. However, they can also be transmitted directly to humans by ingestion of fecal material or via objects contaminated by feces.

VIRAL INFECTIONS

There are surprisingly few documented viral diseases of carnivores transmissible to humans. However, rabies, perhaps the most important zoonotic infection ever, falls into this group. Rabies virus belongs in the family *Lyssavirus*. Symptoms in humans include a sense of apprehension, headache, fever, and unexplained sensations, usually at the site of the bite. The disease may progress to more severe neurologic disorders. Rabies infection is invariably fatal. There is no specific treatment, but pre- and post exposure prophylaxis is available (Centers for Disease Control and Prevention 1991). Table 1 summarizes risk categories and pre-exposure immunization regimens.

Table 1. Rabies pre-exposure immunization criteria.*

Risk Category	Nature of Risk	Typical Population	Pre-Exposure Regimen
Continuous	Virus present continuously often in high concentrations aerosol, mucous membrane, bite, or nonbite exposure possible. Specific exposures may go unrecognized.	Rabies research lab workers. Rabies biologics production workers.	Primary pre-exposure immunization course. Serology every 6 months. Booster immunization when titer falls below acceptable level.
Frequent	Exposure usually episodic with source recognized, but exposure may also be unrecognized. Aerosol/mucous membrane, bite or nonbite exposure.	Rabies diagnostic lab workers, spelunkers, veterinarians, animal control, wildlife workers, travelers to epizootic rabies areas for >30 days.	Primary pre-exposure immunization course. Serology every 2 years.
Infrequent, but greater than population-at-large	Exposure nearly always episodic with source recognized. Mucous membrane, bite, or non-bite exposure.	Veterinarians, animal control, wildlife workers in low rabies endemic areas. Travelers to foreign epizootic areas, veterinary students.	Primary pre-exposure immunization course. No routine booster immunization or serology.
Rare (population-at-large)	Exposure rare and episodic, mucous membrane or bite with source recognized.	U.S. population-at-large including individuals in rabies epizootic areas.	No pre-exposure immunization necessary.

*Adapted from Guidelines for the treatment, investigation, and control of animal bites, 1992, California Department of Health Services, Sacramento, California.

In the United States, wild animals account for over 90% of all rabid animals identified and most of these are carnivores (Krebs et al. 1995). In areas where canine rabies is not yet controlled, dogs represent the majority of rabid animals. The reservoir of rabies varies by antigenic variant and geographical area. The predominant vectors of rabies in developed portions of North America are raccoons (East Coast), arctic and red foxes (Alaska to New York), skunks (Canada to central U.S. to Mexico), gray foxes (western Texas, southeastern Arizona), and dogs and coyotes (southern Texas). Bats are reservoirs throughout North America. Although these species are the primary reservoirs, virtually all mammals are susceptible to rabies in varying degrees and, therefore, pose a health threat to humans.

In 1994, there were 8,224 cases of rabies in animals and 6 cases in humans reported to the Centers for Disease Control and Prevention in the United States (Krebs et al. 1995). Because of ongoing epizootics of rabies on the East Coast in raccoons and in southern Texas involving dogs and coyotes, rabies has become one of the targeted re-emerging infectious diseases (Krebs et al. 1995, Clark et al. 1995).

The rabies virus is shed in the saliva of infected animals and it is usually transmitted by bites. Scratches or contamination of wounds, abrasions, or mucous membranes with saliva or nervous system tissue of an infected animal and airborne transmission (very rare) are other documented routes of transmission. Rabies often causes abnormal behavior in animals and it should be suspected in any wild animal showing a lack of fear of humans, activity during the day (if normally nocturnal), or aggression and unprovoked attacks. Other signs of rabies in animals include weakness, paralysis, and increased excitability.

FUNGAL INFECTIONS

Several zoonotic fungal infections are found in carnivores. Young animals are particularly susceptible. These infections may be transmitted to people by direct contact with the infected animal or via fomites such as soil. Dermatophytosis or "ringworm" is a very common fungal infection caused by members of the genera *Microsporum* or *Trichophyton*. In humans, infection generally results in a self-limiting dermatitis characterized by reddish, flat, spreading, ring-like lesions. These fungi may or may not cause visible lesions on an infected animal. Sporotrichosis is a more serious, but rare, fungal infection caused by *Sporothrix schenckii*. Soil and decaying vegetation are the reservoirs. People and animals, especially felids, become infected by introduction of the organism into wounds caused by thorns, splinters, or other trauma (Reed et al. 1993).

PARASITIC INFECTIONS

Parasitic infections represent the largest group of zoonoses transmitted by carnivores, especially in tropical and subtropical regions. However, many are not transmitted directly; often these parasites require an intermediate host or maturation in the environment to complete their life cycle.

Several important protozoal diseases are carried by carnivores. Felid species of the genera *Felis* and *Lynx*

are the definitive hosts of *Toxoplasma gondii*, one of the most widespread parasites in the world. In most people, the disease is asymptomatic. However, when women are infected early in pregnancy the fetus may suffer congenital infection causing congenital defects or fetal death. There may be a recrudescence of a subclinical infection in people who are immunosuppressed resulting in a severe, often fatal, infection of the nervous system. Infected felids shed oocysts in their feces, but these are not infective to humans and other intermediate hosts until they sporulate in the environment; sporulation may be as short as one day in favorable environmental conditions. The life cycle of *T. gondii* is very complex, but it is usually transmitted to humans by ingestion of sporulated oocysts from cat feces in the environment, ingestion of raw or undercooked meat of an infected intermediate host, or transplacentally (Acha et al. 1987).

Two other common protozoa, *Giardia* spp. and *Cryptosporidium* spp., are also transmitted by the fecal-oral route and may be found in many mammal species, including domestic and wild carnivores. These parasites may contaminate the environment, especially water. Infected humans may be asymptomatic or suffer from a severe diarrheal illness, particularly if they are immunosuppressed.

Larva migrans is a class of syndromes caused by parasites in the order Nematoda, primarily *Toxocara* spp. (carried by canids and felids) and *Baylisascaris* spp. (carried by raccoons, bears, skunks, fishers, martens, and badgers) (Glickman and Schantz 1981). The larvae of these parasites may migrate aberrantly in the organs and tissues of infected humans. The infection is usually inapparent or mild, but sometimes symptoms persist for many years causing lesions in the liver, kidneys, lungs, brain, and eye (visceral larva migrans) or skin (cutaneous larva migrans). Children are more commonly infected, probably because of poor hygiene and a tendency to eat dirt. The signs are more severe if large numbers of eggs are ingested. The adult worm is found in the intestine of the infected carnivore, especially in lactating mothers and their young. Eggs are shed in the feces and require maturation in the environment where they may survive for extended periods of time.

Echinococcus infections are caused by a group of tapeworms (Order Cestoda) harbored by carnivores. Echinococcosis or hydatid disease is a very serious illness of humans. The parasite causes a highly invasive, slow-growing cyst to form in the internal organs, especially the liver. The cysts may spread throughout the body like malignant cancer. There is no specific treatment and the disease is frequently fatal.

Two species of the tapeworm occur in the United States, *Echinococcus granulosus* and *E. multilocularis*. The adult tapeworm lives in the intestine of the carnivore and eggs are shed in the feces. The eggs are infective at the time of shedding and may have prolonged survival in the environment. The life cycle of *E. granulosus* primarily involves a domestic dog (definitive host) and sheep or other ruminants (intermediate host) cycle; thus people working in the sheep industry, slaughterhouse workers, and veterinarians are at highest risk.

E. granulosus is found in the western United States and Alaska, Central America, and Canada. The parasite

can be eliminated from domestic dogs with treatment and by denying them access to infected meat. *E. multilocularis* is maintained in nature primarily by arctic foxes (definitive host) and microtine rodents (intermediate host). Domestic dogs and cats, wolves, and coyotes may also carry the parasite. *E. multilocularis* is currently found in the tundra zone including Alaska, south central Canada, and the north central United States and it appears to be spreading (Hildreth et al. 1991). The practice of illegal translocation of foxes from tapeworm-endemic areas for release in fox-chasing enclosures has become of great concern because of the potential for introduction of this parasite into tapeworm-free areas (Lee et al. 1993).

ECTOPARASITES AND ZOONOTIC INFECTIONS

There are numerous species of ectoparasites that infest carnivores and potentially carry infectious diseases. Examples of tick-borne infections that may be harbored by carnivores include Lyme disease, tularemia, Q fever, Rocky Mountain Spotted Fever, and Endemic Relapsing Fever. As previously discussed, fleas transmit plague. Phlebotomine flies vector visceral leishmaniasis, a serious human illness for which canids are the reservoir. Scabies is caused by the mite, *Sarcoptes* spp., and may cause a superficial dermatitis characterized by a skin rash with intense itching. Ectoparasites may be transferred directly from an infested carnivore to a person handling the animal. Alternatively, carnivores may transport ectoparasites to human environments. Ectoparasites will usually leave a host that has died and immediately seek a new, nearby host, which may or may not be of the same species. Appropriate use of insecticides when handling carnivores or working in their environments is important to prevent transmission of vector-borne diseases.

PREVENTION STRATEGIES AND OCCUPATIONAL SAFETY ISSUES

Awareness of the diseases potentially carried by the species of carnivores that employees are exposed to is cornerstone to an occupational safety program. Education about zoonoses should be incorporated into regular training programs related to occupational safety. In addition, special precautions should be followed when working with carnivores including: 1) wearing protective clothing including gloves (rubber and leather), coveralls, boots, goggles, and respiratory protection when applicable; and 2) practicing good personal hygiene such as thorough hand washing and abstinence from eating, drinking, and smoking while working with potentially infectious animals or with contaminated objects or environments. Employers may want to collect and store (at 20°C) a baseline serum sample from employees, preferably drawn before activities placing the worker at risk are initiated. Any employee who is injured by a carnivore or develops a febrile illness or skin condition should seek medical attention immediately and inform the attending physician of the potential occupational risk of a zoonotic infection (Weinberg 1991, Anderson 1992, Communicable Disease Report 1992). Employees whose duties include direct contact with carnivores should have a tetanus immunization and strongly consider receiving rabies pre-exposure prophylaxis (Table 1).

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