

SECTION 3 Special Problems in Infectious Disease Practice: Environmental and Occupational Factors

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Infections from Pets

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KEY CONCEPTS

- The majority of dog and cat bite wound infections are due to a mixture of oral aerobic and anaerobic bacteria.
- First-generation cephalosporins and macrolides have poor activity against *Pasteurella* spp.
- Chlamydia psittaci* can be carried and transmitted to humans by any bird (pet or wild) and not just by the Psittacidae family of birds such as parrots, parakeets, and macaws.
- Lymphocytic choriomeningitis virus is carried by mice and other rodents, including pet hamsters and can result in meningitis in humans.
- Cercopithecine herpesvirus type 1 (herpesvirus simiae; B virus) can be passed to humans by saliva or by the bite of a monkey.
- Reptiles and amphibians may excrete *Salmonella* in their feces which can be transmitted to humans, particularly children, when handling the animals.

Introduction

In the USA currently more than one-third of households keep some kind of pet(s), including 53 million dogs, 57 million cats and a plethora of other animals from birds to fish to reptiles. In England, 24% of households own a dog and 52% a pet of some type, while in Australia 66% of households have a domestic pet. The increased exposure can consequently lead to human bite injuries and transmission of microorganisms and diseases.¹

Dog-Associated Infectious Diseases

DOG BITES

Table 73-1 shows a potential list of organisms and infections that are transmitted to humans from contact with dogs. Of the over four million Americans bitten annually by a dog, only 15–20% will seek, or need, medical attention and 3–18% will become clinically infected. Dog bites account for 1% of all emergency department visits, 10 000 hospitalizations and 1–10 deaths annually. Most dog bites are inflicted by the victim's own pets or an animal known to them, often while separating the dog in a fight with another dog. The majority of dog bite wounds are to the hands (50%), followed by 16% to the face, scalp, or neck, 16% to the thigh or leg, and 12% to the shoulder, arm, or forearm.²

The incidence of dog bite wounds peaks in the summer and on weekends. The median age of dog bite victims is 28 years and more than 60% are male. Most dog bite wounds are punctures (60%), lacerations (10%) or both (30%).² Most patients attempt some form of self-therapy before presenting for medical attention, including washing with soap and water, and applying an over the counter antiseptic solution. The median time for presentation for medical care is 35 hours postinjury, often after the onset of clinical signs of infection.

At presentation approximately 60% of wounds exhibit a purulent exudate, 30% have other signs of infection and 10% are abscesses. Approximately one-third of patients reporting to an emergency department will require hospitalization. When cultured, these wounds yield an average of five isolates, usually three aerobes and two

anaerobes. Mixed aerobic and anaerobic infections occur in 50% of dog bite wounds and 35% grow only aerobes. Common aerobic isolates include *Pasteurella* spp., 50% (*P. canis*, 26%; *P. multocida* subspecies *multocida*, 12%; *P. stomatis*, 12%; *P. multocida* subspecies *septica*, 10%); streptococci, 46%; staphylococci, 46% (half of which are *Staphylococcus aureus*); and *Neisseria* spp., 32%.²

Methicillin-resistant *Staph. aureus* (MRSA) carriage and infection in companion animals, including dogs and cats, is common and the isolates are indistinguishable from human isolates; only nonbite transmission of MRSA from humans to animals and vice versa has been reported.^{3,4} In addition, dog bite wounds with multidrug-resistant *Escherichia coli* and enterococci have also occurred. *Capnocytophaga canimorsus* from dog bites has been associated with fatal sepsis, especially in asplenic patients and those with alcoholic liver disease.⁵

Common anaerobic species isolated include *Fusobacterium*, 32%; *Porphyromonas*, 28%; *Prevotella*, 28% (especially *P. heparinolytica*); *Bacteroides*, 18% (especially *B. tectus*); and peptostreptococci, 16%.² Mycoplasmas (e.g., *Mycoplasma canis* and *Mycoplasma spumans*) and other atypical isolates may also be present in dog bite wounds.

Table 73-2 outlines susceptibility patterns of common bite isolates. For hospitalized patients, the mean length of stay is 3 days with one-third requiring some form of surgical procedure. Patients with a severe penicillin allergy may need a combination of agents. Fluoroquinolones and tetracyclines should be avoided during pregnancy and in patients younger than 18 years of age.

First-generation cephalosporins and macrolides have poor activity against *Pasteurella* spp.

The principles of wound care are noted in Table 73-3. The duration of antimicrobial therapy depends upon the severity of the wound and patient characteristics. Pre-emptive antimicrobial therapy for acute moderate to severe noninfected wounds is usually 3–5 days. Therapy for an established skin infection is usually 7–10 days, while for septic arthritis and osteomyelitis is often 4–6 weeks.

RABIES

During 2012, 6162 rabid animals were reported in the USA.⁶ Most were wild animals (e.g. raccoons, bats and skunks) and only 84 (1.4%) were rabid dogs.⁶ Dog-associated rabies is uncommon in higher-income countries as a result of stray animal control programs and widespread rabies vaccine use. Canine transmission of rabies to humans occurs infrequently in the USA, but is common in low- and middle-income areas of Latin America, Africa, and India (see also Chapter 171).

ENTERIC DISEASES FROM DOGS

Giardiasis

Giardia lamblia is a flagellated protozoan parasite that is an important cause of diarrheal disease worldwide and can cause diarrhea in many mammalian species including dogs and humans. In many hospitals that have pet visitation programs, *G. lamblia* is the most frequent infectious agent identified on screening. The disease is transmitted by fecal-oral spread and causes flatulence, foul-smelling stools, abdominal discomfort and malaise in humans. Diagnosis is made by stool examination and antigen detection. Metronidazole is the antibiotic of choice for treatment and relapses are frequent.

Echinococcosis

Echinococcus granulosus is a dog tapeworm found in the small intestine, the ova of which are shed into the stool. The illness is associated with

TABLE
73-1**Potential List of Organisms Transmitted to Humans from Contact with Dogs and Small Mammal Pets**

Bacteria	Fungi	Parasites	Viruses
POTENTIAL LIST OF ORGANISMS TRANSMITTED TO HUMANS FROM CONTACT WITH DOGS			
<i>Pasteurella</i> spp.	<i>Blastomyces</i> spp.	<i>Giardia</i> spp.	Rabies
<i>Capnocytophaga canimorsus</i>	<i>Microsporum</i> spp.	<i>Babesia</i> spp.	Lymphocytic choriomeningitis
<i>Ehrlichia</i> spp.	<i>Trichophyton</i> spp.	<i>Toxocara</i> spp.	Influenza
<i>Brucella canis</i>		<i>Dipylidium caninum</i>	Mumps
<i>Mycobacterium fortuitum</i>		<i>Echinococcus</i> spp.	
<i>Campylobacter</i> spp.		<i>Ancylostoma</i> spp.	
<i>Anaerobiospirillum thomasii</i>		Scabies	
<i>Yersinia</i> spp.		<i>Cheyletiella</i>	
POTENTIAL LIST OF ORGANISMS CARRIED BY SMALL MAMMAL PETS			
<i>Campylobacter</i> spp.	<i>Sporothrix schenckii</i>	<i>Cryptosporidium</i> spp.	Lymphocytic choriomeningitis virus
<i>Spirillum minus</i>	<i>Penicillium marneffei</i>		Hantavirus
<i>Streptobacillus moniliformis</i>			
<i>Salmonella</i> spp.			
<i>Leptospira interrogans</i>			
<i>Francisella tularensis</i>			
<i>Yersinia pestis</i>			
<i>Listeria monocytogenes</i>			
<i>Pasteurella multocida</i>			
<i>Burkholderia pseudomallei</i>			

TABLE
73-2**Activity of Selected Antimicrobials Against Animal Bite Isolates**

Antimicrobial Agent	<i>Pasteurella multocida</i>	<i>Staphylococcus aureus</i> *	Streptococci	<i>Capnocytophaga</i> spp.	Anaerobes
Penicillin	+	–	+	+	V
Ampicillin	+	–	+	+	V
Amoxicillin-clavulanate	+	+	+	+	+
Ampicillin-sulbactam	+	+	+	+	+
Dicloxacillin	–	+	+	–	–
Cephalexin	–	+	+	–	–
Cefuroxime	+	+	+	+	–
Cefoxitin	+	+	+	+	+
Tetracyclines	+	V	–	V	V
Moxifloxacin	+	+	+	+	++*
Erythromycin	–	+	+	+	–
Azithromycin	+	+	+	+	–
Clarithromycin	V	+	+	+	–
Trimethoprim-sulfamethoxazole	+	+	V	+	–
Clindamycin	–	+	+	–	+

+, active; –, poor or no activity; V, variable activity against listed pathogen.

*Currently, methicillin-resistant staphylococcal isolates are uncommon in animal bites.

**Except *Fusobacterium canefelatum*.

TABLE
73-3**Components of Care for Animal Bites**

History	Situation, pet ownership
Geographic location	
Examination	Tendon and nerve function Blood supply Presence of edema, crush injury Proximity to joint and bone penetration
DIAGRAM (OR PHOTOGRAPH) OF WOUND(S) FOR THE RECORD, IF POSSIBLE	
Wound care	Irrigation; debridement, if necessary
Antimicrobials	Antimicrobial prophylaxis, 3–5 days (oral route) Therapy for established infection; empiric vs animal specific
Management	Culture (if infected) Baseline radiographs Tetanus toxoid and rabies prophylaxis, if required Health Department report, if required
Decision regarding need of hospitalization	Worsening infection Severe sepsis or septic shock Acute septic arthritis, osteomyelitis, or tenosynovitis

dogs found in sheep-raising areas, especially if the dogs are fed offal. These ova may remain viable for up to 1 year in appropriate conditions. Humans, the intermediate host, can ingest the ova, which hatch in the small intestine into oncospheres that penetrate the bowel wall. Oncospheres can reach the liver (60%), lung (25%) and other organs (15%). Rupture of a hydatid cyst can cause catastrophic disease and anaphylaxis. A variety of serologic tests are available to assist in the diagnosis; however, the presence of septation in a liver cyst (indicating daughter cysts) is considered diagnostic. Therapy is primarily surgical but some suggest aspiration combined with oral antiparasitic agents may be acceptable without surgical excision, although there is a risk of spillage and complications. Scolicidal agents, such as albendazole and mebendazole, remain as adjunctive therapies (see also Chapter 120).

Echinococcus multilocularis causes a severe form of alveolar hydatid disease, often involving the human liver. This parasitic infection is found primarily in the arctic regions of the northern hemisphere and often necessitates aggressive surgical resection for successful removal. *Echinococcus vogeli* is found in canines of Columbia, Ecuador, Panama and Venezuela, and can also cause human disease.

Miscellaneous Enteric Infections Acquired from Dogs

Isospora species infection of the gastrointestinal tract is common in dogs. Transmission to humans has not been clearly proven, but it remains possible, especially in the immunocompromised patient. *Trichuris vulpis*, the whipworm of dogs, resembles the human whipworm *Trichuris trichiura*. However, the ova of the *Trichuris vulpis* are twice the size of the ova of the *Trichuris trichiura*. Infections have been reported in children, institutionalized patients and, rarely, in immunocompetent adults with possible association of dog contact.

Toxocara canis is a ubiquitous roundworm in dogs that causes both cutaneous larva migrans and visceral larva migrans in humans, and affects many puppies (often less than 6 months old) and adult dogs (via ingestion of embryonated ova). Visceral infection in humans is usually associated with children who have pica (1–6 years old) who acquire it from backyards and contaminated sandboxes. Most infections in humans are asymptomatic and eosinophilia (>30%) may be the only laboratory finding. The larvae may migrate anywhere in the human body and their final location determines the associated symptoms. Some patients develop an asthma-like illness; others present with pallor, weight loss, hepatomegaly or pruritic skin lesions. Diag-

nosis is based on a compatible history coupled with specific serology. Dogs may also transmit *Ancylostoma caninum* and *Ancylostoma braziliense*, which also cause cutaneous larva migrans as these soil nematodes burrow through the exposed skin and unsuccessfully attempt to disseminate throughout the tissues.

Infections from Contact with Dog Urine

Leptospirosis

Leptospires are finely coiled, motile spirochetes that can be carried asymptotically for many months by dogs.⁷ Dogs may also become ill, manifested by fever, jaundice, conjunctivitis and hematuria. Dogs are often vaccinated for leptospirosis, but vaccine failures (greater than 1 year postvaccination) have been reported. Humans may become infected through contact with the urine of an infected dog, infected tissues or indirectly from contaminated soil or water. Warm temperatures and moist soil favors survival of leptospires in the environment.

Most humans will have subclinical infection or an anicteric 'viral-type' illness. Some may develop the classic biphasic illness and proceed onto Weil's disease. During the first phase, leptospires may be isolated from the blood, urine and spinal fluid. Later, antibodies may develop and recurring fever, arthralgia, hepatitis, skin rash and conjunctivitis may appear. Therapy with penicillin or doxycycline may shorten the course of disease if started within the first 4 days of illness. A Jarisch-Herxheimer reaction can occur after the first dose of therapy (see also Chapter 130).

Brucellosis

Brucellosis is a disease of both wild and domestic animals that can be transmitted to humans. Dogs may be infected with *Brucella canis*, a small gram-negative coccobacillary organism that is found in kennel-raised dogs and is the least common cause of human brucellosis. Many infections with *B. canis* are acquired in laboratory animals. Dogs may have persistent carriage of the organism and shed it in the urine and the gestational tissues. It can be transmitted between dogs during mating. Human disease occurs 2–4 weeks after exposure (see Chapter 129).

TICK/FLEA-BORNE INFECTIOUS DISEASES ASSOCIATED WITH DOGS

Ehrlichiosis

Canine ehrlichiosis was first described in 1932 in Algeria. Since then it has been noted worldwide that dogs can be hosts to a variety of tick-borne, intraerythrocytic parasites including *Ehrlichia canis*, *Ehrlichia chaffeensis* (associated with human monocytic ehrlichiosis), *Anaplasma phagocytophilia* (associated with human granulocytic ehrlichiosis), *Ehrlichia ewingii* and *Ehrlichia platys* (associated with canine pancytopenia). Dog-to-human transmission is unlikely.

In humans, ehrlichiosis is contracted by a tick bite that inoculates the organism into the skin spreading through the lymphatics. Clinical manifestations include fever, headache, chills and malaise and with an associated leukopenia, thrombocytopenia and elevated liver enzymes. Therapy is with tetracycline or doxycycline.

INFECTIONS ACQUIRED FROM DIRECT CONTACT WITH DOGS

Canine scabies due to *Sarcoptes scabiei* var. *canis* is also known as mange. The mites feed on the stratum granulosum of the skin and deposit the eggs in a burrow. After hatching, the larval forms migrate to the surface. Transmission to humans has been noted and is manifested as an erythematous, nonfollicular dermatitis, in part due to hypersensitivity reaction. Skin scrapings will not demonstrate the mite and diagnosis rests upon history and clinical response to scabicides. Dogs should also be treated with the application of a scabicidal agent. A similar condition known as 'walking dandruff' in dogs is due to *Cheyletiella* (mites). These mites do not burrow and disease is

TABLE
73-4**Possible Infections Transmissible from Cats**

Inhalation	Vector-Borne	Fecal-Oral	Bites, Scratches	Direct Contact
Bordetellosis* Plague Q fever	Ehrlichiosis Cat-scratch disease Bacillary angiomatosis	Campylobacteriosis <i>Helicobacter</i> spp. Cryptosporidiosis Toxoplasmosis Salmonellosis <i>Anaerobiospirillum</i> Yersiniosis Toxocariasis Opisthorchiasis Dipylidiasis	<i>Pasteurella</i> spp. Rabies <i>Erysipelothrix rhusiopathiae</i> Anthrax Tularemia	Plague Histoplasmosis Dermatophytosis Scabies <i>Cheyletiella</i>

**Bordetella bronchiseptica*.

manifested in humans with erythematous macules, which may become pustular or vesicular or have other manifestations of allergic reaction such as urticaria and erythema multiforme.

Cat-Associated Infectious Diseases

CAT BITES

Cats can transmit a number of diseases to humans, as listed in Table 73-4. In the USA, annually approximately 500 000 cat bites are reported. Most wounds are often trivial and victims do not seek medical care. Cat bites affect more women (72%) than men, with an average age of 39 years for the victim.² The majority of cat bite wounds are to the hands (63%), followed by 23% to the shoulder, arm, or forearm, 9% to the thigh or leg, and less commonly to the feet or the face, scalp or neck.²

At the time of presentation, the most common type of infection is nonpurulent wound with cellulitis (42%) followed by purulent cellulitis (39%) and abscess (19%). An associated lymphangitis may be present in 28% of cases. The majority (85%) of the wounds are puncture wounds, 3% lacerations, and 10% are combinations of both.² Cats' teeth are small, sharp and can easily penetrate the bones, tendons and joints of the hand and possibly lead to osteomyelitis, tendonitis and septic arthritis, respectively.

The bacteriology of these wounds reflects the normal oral flora of the biting cat. An average of six bacterial species is isolated in a typical wound (range 0–13). The most common aerobic isolate is *Pasteurella* spp., 75% (*P. multocida* subspecies *multocida*, 54%; *P. multocida* subspecies *septica*, 28%). These two subspecies are associated with more severe injury and have a propensity for bacteremia and central nervous system infections, respectively. Other common aerobic species include streptococci (46%), staphylococci (35%), *Neisseria* (35%), *Moraxella* (35%) and *Corynebacterium* (28%).

Anaerobes are usually present in mixed cultures with aerobic organisms and associated with more severe infections and abscesses. Common anaerobic isolates include *Fusobacterium* (33%), *Porphyromonas* (30%), *Bacteroides tectus* (28%), and *Prevotella* (19%) spp.^{2,8–10} Most anaerobes isolated from cat bites are not producers of β-lactamase. *Fusobacterium* spp. are often resistant to fluoroquinolones and a new subspecies (*F. nucleatum* subspecies *canifelum*) has been proposed.¹¹

Erysipelothrix rhusiopathiae has also been isolated from cat bites. Usually, a localized infection manifests as a painful ulceration and a papular skin lesion; however, a disseminated form also exists. Anthrax uncommonly infects cats and results from contact with infected soil, especially associated with herbivores. The differential diagnosis of the cutaneous papular lesion that starts as a vesicle and can progress to brawny edema and central necrosis also includes brown recluse spider bite, cat-scratch disease (CSD), tularemia and plague.¹² Tularemia has been associated with cat bites.

Antimicrobial therapy and principles of wound care are delineated in Tables 73-2 and 73-3, respectively. Severely penicillin-allergic patients may need a combination of agents. Long-standing pain out of

proportion to the injury and in proximity to a bone or joint may suggest periosteal penetration.

RABIES

Rabies is a widespread zoonotic infection affecting numerous wild animals in many regions of the world. Domestic cats account for less than 5% of rabid animals in the USA and usually acquire it from a spillover effect from exposure to infected wildlife.⁶

CSD

Bartonella henselae is a fastidious gram-negative rod that is the etiologic agent of CSD and is associated with bacillary angiomatosis in HIV-infected individuals. *B. henselae* is often transmitted by direct inoculation (scratch or bite), and over 80% of cases are in people younger than 21 years old. Children younger than 14 years old are typically infected after exposure to a newly-acquired cat. Strays and cats from pounds have a higher frequency of infection and may be bacteremic (>40%) compared to household cats (6%). Most infections in cats are asymptomatic and can last for several months.¹² Domestic dogs, while accidental hosts, may also act as an important reservoir.

Approximately 1 week (range 3–10 days) after exposure, 25–60% of patients may develop a primary inoculation papule at the site of injury, which may become vesicular or crusty. In approximately 2 weeks (5–12 days), tender and regional lymphadenopathy develops. These nodes may be the only manifestation in approximately half of the cases, often lasting more than 3 weeks (6–12 weeks) and usually resolving spontaneously but may suppurate in 15% of cases. Accompanying symptoms include fatigue and malaise (28%), fever of 101°F–106°F (38.3°C–41.1°C) (12%), exanthem (4%), parotid swelling (2%) and seizures (<1%). Other manifestations may include ocular granuloma, erythema nodosum, thrombocytopenic purpura and osteomyelitis.¹³ Endocarditis due to *Bartonella quintana*, a related organism, and rarely *B. henselae*, are both associated with cat fleas, and has been reported in homeless men.

Diagnosis is usually on clinical grounds coupled with a history of cat exposure. The organism is very difficult to isolate and serologies are of variable reliability. Biopsies are sometimes performed to exclude diseases such as Hodgkin's lymphoma, and show granuloma formation with stellate microabscesses. While the Warthin–Starry stain has been recommended, it is difficult to interpret, especially in the absence of a positive control specimen. Serology using IgG antibodies may remain positive for over one year, while IgM antibodies usually resolve in less than three months.¹⁴

Therapy is usually supportive. Antimicrobial therapy with azithromycin has been reported to diminish the size and duration of the adenopathy. Doxycycline and rifampin have been used for CSD-associated retinitis. *In vitro* resistance to first-generation cephalosporins has been correlated with therapeutic failure. Prevention is by control of fleas in pets and sometimes treatment of the pet at the time of acquisition.

Bacillary angiomatosis encountered in immunocompromised hosts manifests as purplish skin lesions resembling Kaposi's sarcoma or as

colorless subcutaneous nodules. Biopsy of the lesions reveals vascular proliferation. DNA probes have also been used to diagnose this disease. Antimicrobial therapy, although its efficacy is poorly defined, includes macrolides, quinolones or doxycycline.

CAT-ASSOCIATED ENTERIC INFECTIONS

Cats may acquire salmonellosis from infected foods, especially offal, live prey (such as songbirds), uncooked meat or fishmeal, or contaminated water. Kennel transmission has also occurred. Cats may shed *Salmonella* spp. via the feces, the conjunctiva or the oral route. In addition, their fur may become contaminated and pass infection as can their water dishes. Newly-acquired young cats are more likely to carry *Campylobacter jejuni* than older cats. *Helicobacter bizzozeronii* and *Helicobacter felis* are found in cat stomachs and rare association with human cases has been noted. *H. pylori* has also been isolated from cats and is thought to have been transmitted to them by human caretakers. Cryptosporidiosis in cats presents with watery diarrhea and some cats can be colonized. Transmission between cats and humans has been reported.¹⁵

Cats are definitive hosts for *Toxoplasma gondii* and millions of oocysts may be excreted daily in their feces. Approximately 1% of US cats are thought to be excreting oocysts on any given day. While ingestion of undercooked meat is the usual mode of transmission of toxoplasmosis, infection may develop from exposure to fecal oocysts when changing litter boxes or gardening in soil contaminated with oocysts by cat feces. The oocysts that pass from the feces are noninfectious and nonsporulated. However, 2–3 days after shedding, the oocysts may sporulate depending on temperature and climactic factors and may remain infective in soil for up to 1 year.

Less common isolates include *Anaerobiospirillum thomasi*, which causes diarrhea in cats and is associated with bacteremia in humans. Cats may be asymptomatic carriers or infected with *Yersinia pseudotuberculosis*, which can cause diffuse diarrhea and abdominal pain in humans. *Toxocara cati* is a helminthic parasite that affects cats with which humans may become incidentally infected when ingesting infected cat feces (usually children with pica). Most human infection is asymptomatic but can present as asthma, abdominal pain, hepatomegaly and eosinophilia. The disease is usually self-limiting. The cat liver fluke, *Opisthorchis felineus*, can be transmitted to humans from ingestion of rare or raw fish infected with the parasite. *Dipylidium caninum* is a cat tapeworm that can be transmitted to humans, usually children, when they ingest infected fleas. Patients develop mild abdominal discomfort and eosinophilia. Demonstrating proglottids upon parasitologic examination of the feces makes the diagnosis.

INFECTIOUS DISEASES ASSOCIATED WITH DIRECT CONTACT WITH CATS

Dermatophytosis

Domestic cats can harbor a wide variety of dermatophytes on their hairs and skin. They may also acquire human dermatophytosis from their owners and transmit it to others with an incubation period of 1–3 weeks. Asymptomatic, as well as symptomatic carriage occurs. *Microsporum canis* has been found in up to 90% of long-haired show cats. Up to 50% of exposed humans will develop symptomatic infection, including ringworm and tinea capitis. Other organisms isolated include *Epidermophyton floccosum*, *Microsporum* and *Trichophyton* spp. Infectious arthrospores can disseminate from the hair and skin to the local environment where they remain viable for months. Contaminated fomites may also act as vectors of transmission. In cats, dermatophyte infection can manifest as patchy alopecia or even a scaly dermatitis.

To break a cycle of transmission, cats may be treated with topical antifungals and, on occasion, oral antifungals. In addition, cleaning areas of cat hair and removal of dander from carpets and restriction of pet cats from the bedroom may facilitate control. Diagnosis is by skin scrapings and microscopic examination after potassium

hydroxide addition or by use of a Wood's lamp. Human infection can be treated with topical or oral antifungals.

Cats may also directly transmit *Dermatophilus congolensis*, an actinomycete that can cause cutaneous exudative or pustular dermatitis. In cats, the hair around the lesion should be clipped and the lesion kept dry. The human dermatitis is usually self-limiting but on occasion antimicrobial therapy (penicillin) may be required if extensive skin involvement with cellulitis develops. *Cryptococcus neoformans* can infect cats and cause feline disease; however, human transmission from infected cats has not been documented.¹⁶

Mites

Cats may become infected with *Sarcoptes scabiei* (scabies) and transmit this to humans. The mites cause a hypersensitivity reaction in humans, manifested by pruritic papular lesions and nocturnal itching. As cat scabies do not burrow into human skin, skin scrapings will not be diagnostic and diagnosis is by clinical presentation. Therapy is by removal of the mites from the cat and laundering the household bedding and clothing. *Cheyletiella* spp. is another type of animal mite that can be transmitted from cats to humans.

CAT INFECTIONS ACQUIRED BY INHALATION

Bordetella bronchiseptica is a gram-negative coccobacillus that can be found in the respiratory tracts of domestic cats and for which they should be vaccinated. In dogs, it has been associated with kennel cough but its clinical manifestations are often less prominent in cats. This organism can cause a pertussis-like (whooping cough) illness in humans, especially children or immunocompromised hosts. Although cross-immunity may exist in humans from pertussis immunization during childhood, immunity wanes by adulthood. Human illness may range from a mild upper respiratory tract infection to frank pneumonia. The organism can be cultured but requires special media and can be misidentified in routine clinical laboratories.

Yersinia pestis is the gram-negative coccobacillus that causes plague. Cat fleas are considered poor vectors for transmission but the cats themselves may contract the illness, especially in the summer months by exposure to rat fleas. Fatal cases in humans of inhalation plague and exposure to infected cats have been reported.

Humans directly exposed to infected material from parturient or aborted tissue from cats infected with Q fever (*Coxiella burnetii*) may also acquire disease. Cats may acquire infection from a tick bite or from infected material in the environment.

Infectious Diseases Associated with Bird Exposure

Contact with pet birds may vary from kissing or feeding the bird from the owner's mouth to cleaning cages or allowing the bird free range of a home or a yard. It is difficult to determine how often some of the organisms, such as *Campylobacter jejuni*, *Pasteurella multocida* or *Mycobacterium tuberculosis*, are passed to humans, but *Chlamydia psittaci* is regularly transmitted, as are *Salmonella* spp.

INHALATION INFECTIONS FROM BIRDS

Psittacosis

Chlamydia psittaci can be carried and transmitted to humans by any bird (pet or wild) not just by the Psittacidae family of birds such as parrots, parakeets, and macaws. The disease is better called ornithosis rather than psittacosis. Ducks and turkeys have been responsible for outbreaks of ornithosis in humans as well as birds kept in the home. Although respiratory symptoms are usually the result of transmission from birds to humans, there have been rare reports of human-to-human transmission. Too little is known about the incidence of infection with *C. psittaci* because few studies have been done of different human populations using modern, accurate serologic techniques. If the respiratory symptoms are mild, the infection is often undiagnosed. Even in patients who have pneumonia, the diagnosis needs to be

confirmed by showing a fourfold rise in acute and convalescent serum titers 2–4 weeks apart, but this is seldom pursued.

Pneumonia in humans can be severe, and is often lobar accompanied by high fevers and chills. The sputum may be purulent with a lack of potential pathogens on smear, because *C. psittaci* does not take up the Gram stain. There are no rapid diagnostic techniques available. Tetracycline is preferred, although erythromycin has been reported to be effective. A safe duration of therapy is 2 weeks, although a shorter period may be adequate. Complications such as meningoencephalitis, arthritis or endocarditis may occur.

A specific diagnosis is important because epidemiologic factors may need to be investigated. A bird dealer may be importing carriers without appropriate quarantine and treatment and cases of human-to-human transmission may be uncovered, including possible nosocomial spread. Control measures for *C. psittaci* infection of birds and humans have been detailed by the US Public Health Service.

Histoplasmosis

Histoplasma capsulatum has been found in bird droppings, especially from chickens and blackbirds. *Histoplasma capsulatum* has been found throughout the world, but it is especially common in river valleys of central North America, parts of Mexico and in the Caribbean. Histoplasmosis is usually not due to exposures to pets, with the exception of exposure to chickens, which are sometimes kept and regarded as pets. The fungus grows in the feces of chickens, but does not infect them. Most human infections are asymptomatic but others may result in an influenza-like illness or, rarely, a progressive pneumonia. The majority of symptomatic infections are self-limiting; however, treatment when necessary (especially in the immunocompromised host) can begin with lipid formulations of amphotericin B followed by itraconazole for acute, progressive infections or itraconazole alone for more indolent disease (see also Chapter 33).

Cryptococcosis

Cryptococcus neoformans can thrive in pigeon feces.¹⁶ Pigeon fanciers who keep flocks of pigeons for sport are exposed to *C. neoformans* more than the general population, as demonstrated by serologic testing; however, an increased incidence of disease has not been documented in these people. Cryptococcosis initially begins as a self-limiting respiratory infection. The fungus may disseminate widely to multiple organs including the central nervous system. It has a predilection for people who have CD4⁺ T-helper-1 lymphocyte defects, and if untreated cryptococcal meningitis is associated with high mortality (>50%). Complications can include noncommunicating hydrocephalus and blindness.

The diagnosis is aided by the presence of cryptococcal polysaccharide antigen in the blood or cerebrospinal fluid. Amphotericin B with or without flucytosine is the treatment for the acute episode, followed by fluconazole for more chronic therapy (see also Chapters 94 and 189).

Tuberculosis has been reported in patients with exposure to tuberculosis-infected macaws.¹⁷ It is difficult to determine whether spread is from birds to humans or vice versa. Other psittacine birds may become infected with *M. tuberculosis*.

ENTERIC DISEASES ASSOCIATED WITH BIRD EXPOSURE

Salmonella spp. and *G. lamblia*, are clearly implicated in transmission to humans. Mites may be spread by direct and indirect contact with infested birds.

VIRAL DISEASES FROM PET BIRDS

Identical strains of influenza virus have been found in both humans and domestic ducks and chickens where contact has been documented. The incidence of ducks or other birds serving as reservoirs for influenza is not certain. Avian influenza is central to the evolution of human outbreaks of influenza where Asian avian influenza A (H5N1)

and avian influenza A (H7N9) remain major risks with pandemic potential.

Small Mammal Pets

Small mammal pets include mice, rats, hamsters, gerbils, guinea pigs and rabbits. People may also keep more exotic animals such as mink, ferrets and ocelots. These animals carry organisms similar to those carried by mice and rats; ocelots carry organisms similar to those carried by cats. Table 73-1 lists organisms carried by small mammal pets. Most pets, regardless of type, can carry *Salmonella* and *Campylobacter* spp. Many, including rabbits, carry *Pasteurella multocida* as part of their mouth flora.

RAT-BITE FEVER

Rats can carry *Spirillum minus* and *Streptobacillus moniliformis*. Rat-bite fever due to *S. minus* (also known as spirillary rat-bite fever and sodoku) is seen worldwide but is most common in Asia.¹⁸ A rash with reddish or purplish plaques accompanies the fever. The healed bite wound may reactivate when fever develops. The diagnosis requires highly specialized laboratories for confirmation. Treatment consists of penicillin or tetracycline.

Rat-bite fever due to *S. moniliformis* (also called Haverhill fever) is more common in the USA and may be due to a rat bite or to exposure to contaminated milk or water during an outbreak. The fever is usually accompanied by a maculopapular or petechial rash that is most pronounced on the extremities. Arthritis of large joints is common, as are relapses. Focal abscesses and endocarditis may occur. A specialized laboratory can confirm the diagnosis if a sterile site is positive on culture. Treatment is with penicillin or tetracycline.

Lymphocytic choriomeningitis virus is carried by mice and other rodents, including pet hamsters. It has been isolated from guinea pigs and dogs. Infection in humans results from exposure to the urine, feces or saliva of the rodent and may result in no symptoms, although a flu-like syndrome or meningitis may occur. The flu-like syndrome may be followed by recovery and then relapse with meningitis. Orchitis, parotitis and thrombocytopenia have also been observed. Diagnosis is made by isolation of the virus from a sterile site such as the cerebrospinal fluid or acute and convalescent serum specimens showing a fourfold rise in titer. There is no specific treatment. If a case occurs in a pet hamster, the entire colony should be screened for the virus.

Miscellaneous Pets

MONKEYS

Cercopithecine herpesvirus type 1 (herpesvirus simiae; B virus) can be passed to humans by saliva or by the bite of a monkey. It causes progressive encephalitis with high rates of morbidity and mortality. If diagnosed early, treatment with aciclovir or other antiviral herpes agents may result in improvement and possibly recovery. Although it is a legal requirement to screen imported pet monkeys, this does not always occur and may even miss carriers.

Nonhuman primates (and prairie dogs) can also transmit hepatitis A and B, and monkeypox, which is clinically indistinguishable from smallpox. Patients with bites or scratches are more likely to have a shorter incubation period (9 days vs 13 days) and more severe disease and require hospitalization than noninvasive exposures such as cleaning cages.¹⁹ Monkeys may also transmit salmonellosis, shigellosis, campylobacteriosis, amebiasis, strongyloidiasis, giardiasis, yersiniosis, and dermatophyte infection.

REPTILES, AMPHIBIANS AND FISH

Reptiles and amphibians may excrete *Salmonella* in their feces, which can be transmitted to humans. This has been best exemplified by outbreaks in humans who have pet turtles. Fish may harbor *Salmonella* spp., including multidrug-resistant isolates, *Aeromonas hydrophila*, *Citrobacter diversus*, *Pseudomonas aeruginosa*, *Providencia stuartii* and *Vibrio* spp.

Vibrio vulnificus can cause a rapidly fatal infection in patients with liver dysfunction. In addition, *Mycobacterium marinum* has been found in fish tanks (both fresh and salt water). It can cause a purplish rash with granulomatous lesions, usually on the hands of those cleaning the tanks and handling the fish. The diagnosis is made when the skin lesion is biopsied and cultured. Treatment with rifampin and ethambutol, minocycline or trimethoprim-sulfamethoxazole has been successful in eradicating this infection.

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