[Introduction]

Relatively few species in the Order Carnivora, other than domestic dogs, cats, and ferrets, are kept as pets, but members of the Families Procyonidae and Felidae are the most likely non-domestic carnivores to be kept by private owners. Additionally, many non-domestic felids and procyonids are exhibited by zoos and native wildlife parks. In the wild, contact with non-domestic felids is rare but wild raccoons are common throughout North American, and frequently found near human dwellings and parks.

Reports of zoonoses transmitted from procyonids and non-domestic felids are uncommon, with a few notable exceptions. As with any zoonosis, immuno-compromised individuals and children are at the greatest risk of acquiring zoonoses and particular care must be made to avoid infections in these people.
The Family Procyonidae contains small to medium-sized omnivores that live in the temperate and tropical regions of the Western Hemisphere. The best-known member of this group is the common raccoon, *Procyon lotor*, which lives throughout North America, and has feral populations established in Japan and Europe. Other species of procyonids live in the West Indies, and Central and South America. The coatimundi, *Nasua nasua*, is similar in size to the raccoon and ranges from Arizona to Argentina. The kinkajou, *Potto flavus*, and the olingos, *Bassaricyon* spp., are smaller, mostly arboreal procyonids of Central and South America. This family also includes the rarely seen ring-tailed cats, *Bassariscus* spp., from western North and Central America.

Raccoons are the most common privately-owned procyonid seen in our practice and popular exhibit animals worldwide. Wild raccoons live in urban, suburban, and rural areas and are well adapted to living in close proximity to people. Raccoons will feed on garbage, and also use bird feeders and unattended pet food as food sources. Increased interactions with raccoons are likely as human populations continue to expand. It is estimated that the raccoon population of the US will double over the next 10 years. Kinkajous are prehensile-tailed procyonids and occasionally kept as pets. Other procyonids are rarely kept in the US but may be kept as pets within their range countries. The discussion of zoonoses in this section will refer almost strictly to raccoons, alluding to kinkajous where data is available.

Raccoons are susceptible to most zoonotic diseases which infect domestic dogs.

Serological surveys have also identified wild raccoons infected with a number of less common zoonotic agents, including *Bartonella rochalimaea*, *Francisella tularensis*, influenza virus,
Trichenella spiralis,\(^5\) and Trypanosoma cruzi.\(^6\) Of minor zoonotic pathogens, *Ehrlichia chaffeensis* is probably the only organism for which raccoons are a potential reservoir host.\(^7\)

Remarkably, there are very few reports of humans acquiring infections from raccoons, with the exceptions of two pathogens: rabies, and the ascarid, *Baylisascaris procyonis*. Rabies is endemic in raccoons in the eastern portion of the US and is discussed in another chapter in this book.

*Baylisascaris procyonis*

*Baylisascaris procyonis* is an enteric nematode parasite of raccoons (Figure 1) and has recently been found in a pet kinkajou (A. Greene, personal communication). Domestic dogs have also been found to shed *B. procyonis* ova.\(^8\) *B. procyonis* ova are very hardy and can remain infective in the environment for a long time; making exposure possible long after raccoons are gone. Reported infection prevalence rates in raccoons range up to 85%, with the western, upper Midwest and northeastern parts of the US having the greatest reported prevalences.\(^9\) *B. procyonis* can have a direct life cycle, but raccoons are most likely to acquire this organism via ingestion of an intermediate host, such as an infected rodent. Raccoon infections are typically asymptomatic but younger animals have heavier parasite infections and may show clinical signs. Infected raccoons may pass thousands of *B. procyonis* ova.\(^10\) Diagnosis of infection in procyonids is by identification of characteristic ova on fecal flotation exam or by direct observation of the adult worms at necropsy.

People acquire *B. procyonis* by ingestion of infective ova. Individuals with a propensity to eating dirt or soil (geophagia), such as very young children or mentally handicapped individuals are at greatest risk for infection. Most human infections appear to be
asymptomatic. Severe clinical presentations are the result of visceral, ocular, or neural larval migrans. Visceral larval migration may affect the heart, lungs, intestines, or mesenteries. Ocular larval migration may cause choroidoretinitis or optic neuritis and may result in visual defects or even blindness. Fewer than 20 cases of neural larval migrans have been reported in North American but most of those cases have resulted in death or persistent, severe neurological deficits. All reports of neural larval migrans have been in males, and either were children or mentally-challenged individuals. Treatment of exposed individuals before the onset of clinical signs with albendazole may be useful.10

There are several strategies for preventing human infection with Baylisasarcis procyonis. Avoiding raccoon latrines and contact with raccoon feces or contaminated areas are the most straightforward methods to avoid infection. Young children and others at increased risk of ingesting ova should be supervised when outside in areas with high raccoon activity. People should not intentionally feed wild raccoons and avoid practices which attract raccoons, such as leaving human and pet food outdoors overnight. Garbage containers should have tight lids and remain sealed overnight. Sealing off or raccoon-proofing areas, such as garages and unattended barns, may prevent the development of raccoon latrines near homes. Removal of raccoon latrines, and treatment of potential intermediate rodent hosts is another strategy for reducing the risk of infection in people.14

NON-DOMESTIC FELIDS

The Family Felidae contains approximately three dozen species, which are native to all continents except Australia. The genus Panthera contains the charismatic large cats: lions (P. leo); tigers (P. tigris); leopards (P. pardus & P. uncia); and jaguars (P. onca). The cheetah
(Acinonyx jubatus) is a distinctive felid and the only member of its genus. The taxonomy of the remainder of the felids is under seemingly continuous debate but some have included all these smaller cats in a single genus, Felis. All felids are strict carnivores.

Non-domestic felids are not recommended as pets, but several species can be legally acquired and are occasionally kept by private individuals. Two small, attractive American felids, the ocelot (Felis pardalis) and margay (F. wiedii), were once popular but are now seldom seen as pets. Serval (F. serval), caracals (F. caracal), and mountain lions (also known as the cougars or puma, F. concolor) are the most commonly seen privately-owned non-domestic felids in our practice.

All non-domestic felids appear to be susceptible to diseases commonly infecting domestic cats. As such, any zoonosis which might be acquired from domestic cats could potentially be acquired from non-domestic felids. Very few zoonoses, however, have been documented to be contracted from a non-domestic felid. Two groups of pathogens, dermatophytes and enteric organisms, deserve mention as risks when working with exotic felids. Of the latter, knowledge of the biology of Toxoplasma gondii is frequently required for counseling owners of exotic felids and animal keepers.

DERMATOPHYTOSIS

Microsporum canis is a keratophilic fungus which causes superficial skin infections in domestic cats and dogs and has been the dermatophyte most commonly associated with disease in exotic felids. Dermatophytosis in exotic cats is similar to the disease in domestic cats, and lesions can include papular and miliary dermatitis or areas of alopecia on the face, body, and
limbs. Inapparent carriers may also exist. Diagnosis is made by clinical signs and fungal culture of lesions.

In most cases, infections appear to be self-limiting. Treatment may be attempted for severe or complicated cases, however, in one study of topical treatments of tigers and their outdoor exhibits, untreated (control group) animals resolved infections as fast as or faster than any treated tigers. Focal lesions on kittens can be clipped, cleaned with a tamed iodine solution, such as povidone iodine, and treated with topical antifungal agents, such as miconazole or clotrimazole. Systemic treatment with oral itraconazole will speed resolution of lesions in adult cats (E. Ramsay, personal experience). Griseofulvin toxicity causing bone marrow depression and death has been reported in cheetahs.

Dermatophytosis in people is characterized as focal, circular skin lesions (Figure 2), but lesions may also include alopecia. Inflammation may be minimal to intense, with vesicles and/or scaling present. The lesions can be pruritic. Diagnosis is based on history of exposure to infected animals, clinical signs, and fungal cultures. Physicians should be consulted regarding treatment. Wearing protective clothing and gloves and otherwise avoiding direct contact with infected cats is advised. Frequent handwashing following contact with infected felids also appears to limit zoonotic infections.

ENTERIC PATHOGENS

Toxocara cati and hookworms, Ancyclostoma spp., are common zoonotic parasites of domestic cats and have been found in several species of non-domestic felids. T. cati infections rarely cause clinical signs in exotic felids but can be persistent, despite aggressive anthelminthic
treatment. Infectious ascarid ova can be sequestered in an exhibit’s crevices or substrate and remain infective for months to years, even in the most diligently cleaned enclosures.

*T. cati* and hookworms can cause visceral and cutaneous larval migrans, respectively, in people. Human infections with *T. cati* are acquired through ingestion of infective ova. Hookworm infections most typically occur when free-living larvae penetrate the skin. Both infections are more common in individuals who might consume contaminated soil or have considerable exposure to contaminated earth, such as children. A number of common anthelminthics are used to treat human infections.

Non-domestic cats fed raw meat diets can commonly be asymptomatic carriers of *Salmonella* spp.\(^\text{18}\) Diets are presumed to be the source of the bacteria, but cultures of food items do not always reveal the same organisms cultured from feces. Salmonellosis may occur in felids, but more frequently they shed *Salmonella* spp. without showing clinical signs. Providing diets with low bacterial contamination, such as by acquiring meat from processors with human food quality hygiene practices, will limit shedding of *Salmonella* spp. in non-domestic felids.\(^\text{19}\)

Gastrointestinal signs, such as vomiting and diarrhea, are the most common clinical presentations associated with salmonella infections in people. Systemic signs are seen in severe infections. No reports could be found of human salmonellosis acquired from an exotic felid.

Serologic surveys of our collections have shown non-domestic felids to be commonly infected with *Toxoplasma gondii*. Domestic cats are known to be the definitive host for this organism, and it is assumed that all felids may act as definitive hosts. While no records of
transmission of *T. gondii* from exotic felids to humans could be found, veterinarians are frequently called upon to council private owners, animal caretakers, and zoological collection managers about the risks of people becoming infected, especially when owners or keepers are pregnant.

Cats recently infected with *Toxoplasma gondii* shed the organism in feces for two to three weeks. Oocysts require at least 24 hours outside the body to sporulate and become infective. Transmission to people occurs following consumption of infective oocysts. The vast majority of human toxoplasmosis infections cause few signs or only mild flu-like disease, and are not diagnosed. In immunocompromised individuals, severe clinical disease including encephalitis may occur. Infection during pregnancy may result in fetal infection and cause fetal death or miscarriage. *In utero* toxoplasmosis can cause fetal chorioretinitis and result in blindness of the neonate.

Avoiding contact with cat feces is the primary method to avoid infection with all enteric pathogens. Frequent hand washing and not eating, drinking, or smoking while feeding felids or cleaning enclosures will limit an individual’s exposure to these pathogens. Wearing gloves when cleaning cat boxes or enclosures, and digging in soils contaminated with cat feces is also recommended. Hookworm infections can be avoided by wearing shoes in areas contaminated with cat feces. Animal keepers feeding felids raw meat should wear gloves when handling diets.

BITES

As with any wild animal, care must be taken when dealing with procyonids and non-domestic felids to avoid injury to the owner, technicians, and the veterinarian. Heavy leather gloves can
be used to restrain smaller procyonids but many can still bite through gloves. Even those
animals most accustomed to captivity should be anesthetized or chemically restrained for
physical examination and collection of biological samples. Procyonids and small felids can be
netted and hand-injected with anesthetic agents. Alternately, we frequently leave the animal
in its transport container and place the entire container in a plastic bag, creating a type of
anesthetic chamber. The bag is filled with inhalation anesthetic gases, such as isoflurane in
oxygen, and the animal induced without needing to be handled. Larger felids typically require
darting.

CONCLUSIONS
There are very few reports of zoonotic diseases having been acquired from procyonids and non-
domestic felids. *Baylisascaris procyonis* is the most commonly documented zoonotic agent in
these taxa. Routine personal protective strategies, such as wearing gloves and avoiding contact
with contaminated environments, remain the best strategies for preventing zoonotic infections
from procyonids and non-domestic felids.


Figure legends

Figure 1. Ova (inset) and adult *Baylisascaris procyonis* from a raccoon. Courtesy of The University of Tennessee, College of Veterinary Medicine’s Parasitology Laboratory.
Figure 2. The arm of a veterinarian infected with Microsporum canis, acquired from a tiger (Panthera tigris). Courtesy of Dr. Edward Ramsay.