



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Species Inquirendae in the Carnivora

SPECIES INQUIRENDAE AND NOMENA NUDA IN CARNIVORA

INTRODUCTION

Surveys of various animal and plant species or populations are on-going events that occur worldwide on a regular basis by biologists of every persuasion (entomologists, marine biologists, botanists, mammalogists, ornithologists, herpetologists, etc.). Historically, however, collecting parasites or even some parasite stages (e.g., surface organisms or fecal stages) have **not** been part of this survey equation, and parasitic faunas got ignored. However, in recent decades parasites have achieved recognition as important and abundant components of ecosystems, and whole organism surveys now often make at least cursory attempts to determine the presence and identification of some of the parasites of a particular host plant or animal species. In this vein, fecal material is often collected from captured hosts and later examined for parasite transmission stages (cysts, eggs, oocysts) that allow biologists to make either superficial identifications (to parasite genus) from distinctive propagules or in many cases to identify new morphological forms (from oocysts) that can result in new species descriptions. In the former instances, parasite stages may be identified quite superficially

(an amoeba, a ciliate, a sporozoan) or they may be more specifically characterized (a *Toxocara* egg, an eimerian, an *Isoospora* sp., a *Sarcocystis* sporocyst, etc.). It is these species “identifications” that, under certain circumstances, can provide useful information, but only in a general way; the forms with these kinds of names are listed in this chapter because no full specific identifications were made.

We now know that at least four genera covered in our book (*Besnoitia*, *Cystoisospora*, *Sarcocystis*, *Toxoplasma*) produce developmental stages in hosts that may be prey items of carnivores. For example, some *Sarcocystis* species from omnivorous and/or herbivorous hosts that usually employ carnivores as definitive host (e.g., roe deer, *Capreolus capreolus*), but in which there is no mention of a possible carnivore host, will not be mentioned here because there is no way to connect them to any member of the Carnivora, even though the association may have strong circumstantial evidence (e.g., López et al., 2003).

SPECIES INQUIRENDAE (481)

The International Code of Zoological Nomenclature uses this designation for “a species of doubtful identity needing further investigation.” Implicit in this definition for the coccidia is that the taxonomic “species” has been

named in a published document, but without the existence of a “type specimen” of any kind (e.g., line drawing, photosynotype, stages in tissue sections, oocysts in preservative, etc.) and without quantitative and qualitative data on the most widely available stage in the life cycle, the sporulated oocyst, to distinguish it from other similar morphotypes or perhaps closely-related species. All the forms that we include in this chapter have lots of missing data that prevent them from having valid binomial designations.

SUBORDER CANIFORMIA KRETZOI, 1938

FAMILY AILURIDAE GRAY, 1843

GENUS AILURUS F.G. CUVIER, 1825 (MONOTYPIC)

SARCOCYSTIS NEURONA/ SARCOCYSTIS DASYPI OF ZOLL, NEEDLE, FRENCH, LIM, BOLIN, LANGOHR, AND AGNEW, 2015

Definitive host: Unknown.

Intermediate host: *Ailurus fulgens* F.G. Cuvier, 1825, Red Panda.

Remarks: Two neonatal male red panda littermates were submitted for necropsy. One animal was found dead with no prior signs of illness; the other had a brief history of labored breathing. Postmortem examination revealed disseminated protozoal infection. To characterize the causative agent, transmission electron microscopy (TEM), immunohistochemistry (IHC), polymerase chain reaction (PCR) and amplification, and nucleic acid sequencing were performed. IHC was negative for *Toxoplasma gondii* and *Neospora caninum* but was positive for *Sarcocystis* spp. TEM of cardiac muscle and lung revealed numerous intracellular apicomplexan protozoa within parasitophorous vacuoles (PV). PCR and nucleic acid sequencing of partial 18S rRNA and the internal transcribed

spacer (ITS-1) region confirmed a *Sarcocystis* sp. that shared 99% sequence homology to *S. neurona* and *S. dasypi*. This was the first report of sarcocystosis in red pandas. Zoll et al. (2015) believed that their histopathological, immunohistochemical, molecular, and ultrastructural findings support vertical transmission resulting in fatal disseminated disease, but they did not assign a binomial name to the parasite of the red panda, so it must be considered a *species inquirenda*, at least for now.

FAMILY CANIDAE FISCHER, 1817

GENUS CANIS L., 1758 (6 SPECIES)

COCCIDIA-LIKE ORGANISM OF SHELTON, KINTNER, AND MACKINTOSH, 1968 AND OF SANGSTER, STYER, AND HALL, 1985

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Shelton et al. (1968) found what they described as subcutaneous nodules and a non-febrile wasting illness in a 6-month-old border collie in Gallatin, Missouri, USA. Nodules were 10–12 mm wide and located on the lateral surface of the right maxilla. One lump was excised and prepared for standard H & E histological examination. Frequently, trophozoites, meronts with mature merozoites, and micro- and macrogametocytes were all discovered in the same host cell. Mature meronts were 11–20 in fixed tissue, and merozoites appeared to be arranged radially from a nuclear remnant of the meront. Merozoites in tissues were 5.5–6 × 2.0, crescent-shaped with one end thicker and blunter than the other, and a thick basophilic N was near the center of each merozoite. There were 16–20, sometimes 30, merozoites per meront. Microgametocytes were

spheroidal, 8.5–11.5 wide. Spheroidal macrogametocytes, 8–9 wide, were the most prevalent structures seen, and each had a pale N with a distinct, centrally-located karyosome. Levine and Ivens (1981) thought these meronts appeared to be more like *Besnoitia* than any other genus, but they were unaware at the time that *Caryospora bigenetica* from rattlesnakes could produce similar infections in some mammals (see [Chapter 4](#)).

COCCIDIA SPP. OF BRAUN AND THAYER, 1962

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Braun and Thayer (1962) examined fecal samples of dogs in Iowa City, USA. All dogs were >6-months-old, and without clinical signs. “Coccidia spp.” were detected in 18/224 (8%) dogs. No other information was given.

COCCIDIA OF FOK, SZATMÁRI, BUSÁK, AND ROZGONYI, 2001

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Fok et al. (2001) examined 490 fecal samples of dogs from various locations in eastern and northern regions of Hungary. The authors reported a prevalence of “Coccidia” in 3.5%, but only in their abstract. In their Table 1 (p. 97), *Isospora* spp. was reported in 17 dogs, and they placed *Eimeria* spp., into “spurious parasites,” that they found in 18 dogs from a country town and a village. No other details were mentioned.

COCCIDIA OF JOFFE, VAN NIEKERK, GAGNÉ, GILLEARD, KUTZ, AND LOBINGIER, 2011

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Joffe et al. (2011) examined fecal samples of 477 household and 142 sheltered dogs in the Calgary, Alberta, Canada, by centrifugation/flotation in zinc sulfate solution. “Low coccidian oocyst prevalence was found.” No more information was given.

COCCIDIA OF PONCE-MACOTELA, PERALTA-ABARCA, AND MARTÍNEZ-GORDILLO, 2005

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Ponce-Macotela et al. (2005) examined small intestinal contents of dogs from the “Centro de Control Canino Culhuacan” in southern Mexico City; they surveyed 100 dogs during the “cold” season, and another 100 dogs during the “warm” season and reported a presence of “Coccidia” in their Fig. 1 (p. 3), but no other details were given.

COCCIDIA OF STRONEN, SALLOWS, FORBES, WAGNER, AND PAQUET, 2011

Original host: *Canis lupus* L., 1758, Wolf.

Remarks: In the course of 2001–05, Stronen et al. (2011) surveyed fecal samples of gray wolves (*C. lupus*) from the Riding Mountain National Park region in southwestern Manitoba, Canada. “Coccidia (*Isospora* sp. or *Eimeria* sp.)” were detected in 10/601 (2%) samples, but no other information was given.

COCCIDIA OF VISCO, CORWIN, AND SELBY, 1977

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Visco et al. (1977) examined fecal samples of pet dogs in Missouri, USA and said,

“Coccidia” were detected in 56/1,468 (4%) dogs, mostly in those <6-months-old (32 dogs). No other information was given.

Yet it serves as another project for an interested reader and has more questions that need to be answered.

COCCIDIUM OF FARIAS, CHRISTOVÃO, AND STOBBE, 1995

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Farias et al. (1995) examined fecal samples of dogs in the Araçatuba Region, São Paulo, Brazil. Oocysts of “coccidia” were found in 3/314 (<1%) samples, but no other information was given.

COCCIDIUM OF LIPSCOMB, DUBEY, PLETCHER, AND ALTMAN, 1989

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Lipscomb et al. (1989) reported cholangiohepatitis associated with the presence of a coccidium they found by LM and TEM, within intrahepatic biliary epithelial cells of a male Doberman pinscher that had intermittent diarrhea for 3–4 weeks. The dog was treated with metronidazole, trimethoprim, and sulfamethoxazole, but its condition deteriorated, and he eventually died. Lipscomb et al. (1989) found only meronts present in intact biliary epithelial cells and all stages of merogony from uninucleate to fully mature meronts with multinucleate merozoites. They mentioned that six genera of coccidia are known to infect dogs: *Cryptosporidium*, *Hammondia*, *Isospora*, *Neospora*, *Sarcocystis*, and *Toxoplasma*, but none has been described in the biliary epithelium of dogs, and none share the peculiar location and morphology of the parasite they documented. It still remains a mystery to this day.

COCCIDIUM OF NUNES, 1993

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Nunes (1993) examined fecal samples of dogs in São Paulo, Brazil; oocysts of “coccidia” were found in 141/3,222 (4%) samples but were not identified further.

CRYPTOSPORIDIUM SP. OF ABARCA, LÓPEZ, PEÑA, AND LÓPEZ, 2011

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: In Santiago, Chile, Abarca et al. (2011) surveyed feces of pet dogs maintained in families with immunocompromised children (oncology patients, HIV-positive, or patients after transplantations) in two hospitals. *Cryptosporidium* sp. oocysts were detected in 2/41 (5%) dogs, but feces of the two immunocompromised children maintaining the positive dogs were negative.

CRYPTOSPORIDIUM SPP. OF AWADALLAH AND SALEM, 2015

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Awadallah and Salem (2015) surveyed fecal samples from military dogs (40 samples), nomadic dogs (30), and household dogs (60) in Sharkia and Qalyubia provinces, Egypt. *Cryptosporidium* was detected in 7/130 (5%) samples, 4 from nomadic, 2 from a rural household, and 1 from upscale household dogs but none in military dogs.

**CRYPTOSPORIDIUM SP. OF
BARR, GUILFORD, JAMROSZ,
HORNBUCKLE, AND BOWMAN,
1994a**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Barr et al. (1994a) diagnosed cryptosporidiosis in two dogs suffering from diarrhea, based on the presence of *Cryptosporidium* oocysts in their feces. The dogs were administered paromomycin for 5 days, and the diarrhea resolved 5 days after the last dose in both dogs. No other information was given.

**CRYPTOSPORIDIUM SPP. OF
BATCHELOR, TZANNES, GRAHAM,
WASTLING, PINCHBECK, AND
GERMAN, 2007**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Between 2003 and 2005, Batchelor et al. (2007) examined fecal samples of domestic pet dogs, with clinical gastrointestinal signs (usually diarrhea), from all parts of the United Kingdom. *Cryptosporidium* oocysts were detected in 29/4,526 (0.6%) samples, with a higher prevalence of shedding in winter months. No other information was given.

**CRYPTOSPORIDIUM/SARCOCYSTIS
SP. OF BEARUP, 1954**

Original host: *Canis lupus dingo* Meyer, 1793, Dingo.

Remarks: Bearup (1954), in Sydney, Australia, found "oocysts" measuring 17×11, four SZ, ~11×2, and a prominent RB, 7 wide, in 1/4 (25%) dingos, and identified them as *Cryptosporidium*. The dingo was concurrently infected with *Cystoisospora rivolta* and *Eimeria canis* (?). Because these oocysts

were morphologically consistent with the detached sporocysts of *Cystoisospora* and were not noticed until the oocysts of *C. rivolta* developed to the sporozoite stage, Bearup (1954) suggested it was possible they were the released sporocysts from the ruptured oocyst of *Cystoisospora* instead of a *Cryptosporidium* species. Dubey (2009) stated they were probably sporocysts of a *Sarcocystis* sp. based on size. We will never know.

**CRYPTOSPORIDIUM SP. OF
CAUSAPÉ, QUÍLEZ, SÁNCHEZ-
ACEDO, AND DEL CACHO, 1996**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Causapé et al. (1996) examined fresh fecal samples of 37 domestic and 44 stray dogs in an animal shelter in Zaragoza, Spain, and reported oocysts of *C. parvum* (?) in 6/81 (7%) samples, which included 3/37 (8%) from domestic and 3/44 (7%) from stray dogs; all of them shed only a few oocysts. Three of the positive dogs suffered from diarrhea, but two were concurrently infected with *Isospora* spp. and one with *Toxocara canis*. Thus, the role of *Cryptosporidium* in diarrhea remained uncertain. Given that dogs can be host to at least 10 named *Cryptosporidium* species, their identification as *C. parvum* is equivocal.

**CRYPTOSPORIDIUM SP. OF CIRAK
AND BAUER, 2004**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Cirask and Bauer (2004) examined fecal samples of dogs from three animal shelters in central Germany to detect *Cryptosporidium*. Direct fecal smears, fast-stained with carbol fuchsin, found 1/270 (0.4%) fecal samples to have *Cryptosporidium*, whereas the enzyme-linked immunosorbent assay (ELISA) test kit (ProSpecT

Cryptosporidium Microplate Assay) detected it in 62/270 (23%) samples. However, because the fecal samples containing *Isospora burrowsi*/*I. ohioensis* were significantly more often positive by ELISA, which may reflect a false-positive or possible cross-reactions, ELISA should not be uncritically used for detection of *Cryptosporidium* in dogs and cats and should be confirmed with other detection methods. Identification of the *Cryptosporidium* species was not done.

**CRYPTOSPORIDIUM SP. OF COX,
GRIFFITH, ANGLES, DEERE, AND
FERGUSON, 2005**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Cox et al. (2005) examined fecal samples of various domestic, native, and feral animals during a survey for protozoal, bacterial, and viral pathogens in four semiprotected drinking-water watersheds (Wollondilly, Braidwood, Upper Cox's, Wingcarribee) in Sydney, New South Wales. Fecal samples were fluorescence-stained and examined with an epifluorescence microscope. Oocysts of *Cryptosporidium* were detected in 2/8 (25%) of the samples examined from domestic dogs. No attempt was made to identify the species.

**CRYPTOSPORIDIUM SP. OF DADO,
IZQUIERDO, VERA, MONTOYA,
MATEO, FENOY, GALVÁN, GARCÍA,
GARCÍA, ARÁNGUEZ, LÓPEZ, DEL
ÁGUILA, AND MIRÓ, 2012**

Original hosts: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog; *Felis catus* L., 1758, Domestic Cat.

Remarks: Dado et al. (2012) examined 625 soil samples and 79 fecal samples ("presumably from dogs and cats") from playgrounds and public parks in southeastern Madrid, Spain, and examined them using the modified Telemann and MIF (merthiolate-iodine-formalin) methods,

and modified Ziehl-Neelsen staining followed by a rapid immunochromatographic assay. *Cryptosporidium* was not detected in any of the soil samples, but 7/79 (9%) fecal samples from four parks contained *Cryptosporidium* sp.

**CRYPTOSPORIDIUM SPP. OF
DUBNÁ, LANGROVÁ, NÁPRAVNÍK,
JANKOVSKÁ, VADLEJCH, PEKÁR,
AND FECHTNER, 2007**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: From 1998 to 2000, Dubná et al. (2007) surveyed canine fecal samples from two animal shelters in Prague and from rural areas in central Bohemia, Czech Republic. Fecal samples were collected from streets, grass strips, and parks, but some were not collected directly from the animals, so their origin (canine or other host) is unknown. *Cryptosporidium*-like oocysts were detected in 52/3,780 (<2%) samples. Of 524 fecal samples collected directly from stray dogs in two animal shelters, *Cryptosporidium* oocysts were detected in some samples, but neither the number of infected dogs nor the prevalence was given; they only stated, "the prevalence increased sevenfold after a stay in the shelter over the time of admittance to the shelter." In their samples from rural areas in central Bohemia (one-third from dogs, two-third from "soil or street," so their origin is unknown), *Cryptosporidium* spp. was detected in 11/540 (2%) samples. Dubná et al. (2007) said that *Cryptosporidium* was more prevalent in dogs in rural areas.

**CRYPTOSPORIDIUM SPP. OF
EL-AHRAF, TACAL, SOBIH, AMIN,
LAWRENCE, AND WILCKE, 1991**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758.

Remarks: El-Ahraf et al. (1991) collected feces from impounded stray dogs in San Bernardino, California USA, and screened for

Cryptosporidium oocysts. Only 4/200 (2%) dogs were passing cryptosporidial oocysts, but they were not identified to species.

CRYPTOSPORIDIUM SPP. OF FERREIRA, PENA, AZEVEDO, LABRUNA, AND GENNARI, 2016

Original hosts: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog; *Felis catus* L., 1758, Domestic Cat.

Remarks: Ferreira et al. (2016) surveyed fecal samples of pet dogs from the metropolitan region of São Paulo, Brazil. *Cryptosporidium* spp. were detected in 28/3,099 (1%) samples, mostly in younger dogs.

CRYPTOSPORIDIUM SP. OF FONTANARROSA, VEZZANI, BASABE, AND EIRAS, 2006

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Fontanarrosa et al. (2006) surveyed fecal samples of dogs in southern Buenos Aires, Argentina. Oocysts of *Cryptosporidium* were detected in 5/2,193 (0.2%) samples.

CRYPTOSPORIDIUM SP. OF FUKUSHIMA AND HELMAN, 1984

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Fukushima and Helman (1984) reported a pup in Tennessee, USA, with a concurrent infection of *Cryptosporidium* and canine distemper. Formalin-fixed tissues stained with H & E showed the presence of intranuclear and intracytoplasmic acidophilic inclusion bodies in epithelial cells of the biliary tract, stomach, lymphoid cells of the spleen, astrocytes, choroid plexus epithelial cells, and ependymal cells. In

the jejunum, numerous extracellular oocysts of *Cryptosporidium*, 2–3 wide, were attached to villous epithelial cells, occasionally also in the crypts of Lieberkühn. TEM showed a *Cryptosporidium* sp. attached to the intestinal villous epithelial cells. The authors stated this was “the first report of cryptosporidiosis in a domesticated dog (*Canis familiaris*);” however, they were unaware of the work by Tzipori and Campbell (1981) and Wilson and Holscher (1983) that previously had recorded *Cryptosporidium* in domesticated dogs.

CRYPTOSPORIDIUM SP. OF FUNADA, PENA, SOARES, AMAKU, AND GENNARI, 2007

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Funada et al. (2007) examined fecal samples of domestic dogs in São Paulo, Brazil. *Cryptosporidium* oocysts were found in 43/1,755 (2.5%) samples, mostly in dogs <1-year-old.

CRYPTOSPORIDIUM SP. OF GENNARI, KASAI, PENA, AND CORTEZ, 1999

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Gennari et al. (1999) examined fecal samples of household dogs from different areas of São Paulo, Brazil and reported finding oocysts of *C. parvum* in 10/353 (3%) samples. However, because dogs can be host to a number of *Cryptosporidium* species, their identification as *C. parvum* was equivocal.

CRYPTOSPORIDIUM SP. OF GHAREKHANI, 2014

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Gharekhani (2014) examined smears and flotations of fecal samples, from asymptomatic pet dogs in Hamedan, Iran, and found oocysts of *Cryptosporidium* in 8/210 (4%) samples.

**CRYPTOSPORIDIUM SP. OF
GINGRICH, SCORZA, CLIFFORD,
OLEA-POPELKA, AND LAPPIN, 2010**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Gingrich et al. (2010) studied fecal samples of privately-owned domestic dogs from Santa Cruz (51 dogs), San Cristobal (17 dogs), and Isabela (29 dogs) Islands of the Galápagos Archipelago; none of the dogs had diarrhea. *Cryptosporidium* oocysts were seen in only one dog from Santa Cruz Island.

**CRYPTOSPORIDIUM SPP. OF
HACKETT AND LAPPIN, 2003**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Hackett and Lappin (2003) examined fecal samples of pet dogs (59 healthy, 71 with acute diarrhea) in north-central Colorado, USA. *Cryptosporidium* oocysts were detected in 5/130 (4%) samples by IFA, but in none of the samples by flotation; four positive samples were from diarrheic dogs.

**CRYPTOSPORIDIUM SP. OF
HAMNES, GJERDE, AND
ROBERTSON, 2007b**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: In Norway, Hamnes et al. (2007b) studied the occurrence of *Cryptosporidium* in dogs by repeated sampling of their feces between 1- and 12-months-old. Fecal samples of pure-bred, privately-owned household dogs in 57 litters, 75

pooled samples from 43 litters, and 69 samples from their 41 mother bitches were examined by flotation/concentration and immunofluorescent staining; 128/290 (44%) dogs were positive for *Cryptosporidium*, mostly animals 3–4-months-old. The occurrence was higher in winter, when 35 of the positive dogs were concurrently infected with *Giardia*. Only 1/40 (2.5%) litters of 1-month-old pups but none of the 39 bitches were positive for *Cryptosporidium*. Of the 2-months-old pup litters, 8/35 (23%) and 1/29 (3%) bitches were positive for *Cryptosporidium*. Significant differences were observed in prevalence between different regions in Norway, being highest in eastern Norway and lowest in northern Norway (where density of dogs is the lowest). Genotyping of the cryptosporidia was not performed so no specific identity was available.

**CRYPTOSPORIDIUM SPP.
OF HERMOSILLA, KLEINERTZ,
SILVA, HIRZMANN, HUBER,
KUSAK, AND TAUBERT, 2017**

Original host: *Canis lupus* L., 1758, Wolf.

Remarks: Hermosilla et al. (2017) collected fecal samples from wild European wolves in mountainous areas of Croatia. Samples were examined by a sodium acetate–acetic acid–formalin technique, *Cryptosporidium* coproantigen-ELISA (ProSpecT), and fecal smears stained with carbol fuchsin. *Cryptosporidium* oocysts were detected in 7/400 (2%) samples, only by ELISA.

**CRYPTOSPORIDIUM SPP. OF
HIMSWORTH, SKINNER, CHABAN,
JENKINS, WAGNER, HARMS,
LEIGHTON, THOMPSON, AND
HILL, 2010**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Himsworth et al. (2010) collected fecal samples of free-roaming dogs from the

environment around a remote indigenous community in northern Saskatchewan, Canada, to detect oocysts of *Cryptosporidium*; 5/155 (3%) samples had oocysts, but they were not identified to species. The authors admitted that multiple samples may have originated from a single dog, so their prevalence finding was probably distorted.

CRYPTOSPORIDIUM SPP. OF HUBER, BOMFIM, AND GOMES, 2005

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Huber et al. (2005) surveyed fecal samples of stray dogs in an animal shelter and household pet dogs from the West Zone of Rio de Janeiro, to compare the natural infections with *Cryptosporidium* sp. between the two different environments; all dogs were clinically healthy. *Cryptosporidium* sp. was detected in 4/166 (2%) dogs that included 2/94 (2%) shelter dogs and 2/72 (3%) pet dogs. No attempt was made to identify the species of *Cryptosporidium*.

CRYPTOSPORIDIUM SPP. OF KATAGIRI AND OLIVEIRA- SEQUEIRA, 2008

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Katagiri and Oliveira-Sequeira (2008) examined fecal samples of dogs (129 stray from kennels, 125 household) from urban areas of Botucatu, São Paulo State, Brazil. *Cryptosporidium* was detected in 8/254 (3%) samples, 3 from strays and 5 from household dogs.

CRYPTOSPORIDIUM SPP. OF KIM, WEE, AND LEE 1998

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Kim et al. (1998) examined fecal samples of dogs (companion, farm, and watch dogs) from four areas in Korea (Chunchon, Kwachan, Sangju, Songnam) by an immunofluorescence assay using the commercial *Cryptosporidium* diagnostic kit (Meridian Diagnostics). Oocysts of *Cryptosporidium* were detected in 25/257 (10%) samples, mostly from the companion dogs from Kwachan and Chunchon areas. The average oocyst size was $4.7 \pm 0.5 \times 4.4 \pm 0.6 \mu\text{m}$, which suggested their form was *C. parvum*.

CRYPTOSPORIDIUM SPP. OF MIRZAEI, 2012, AND MIRZAEI AND FOOLADI, 2013

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Mirzaei (2012) collected fecal samples from companion and stray dogs near Kerman, southeastern Iran. *Cryptosporidium* oocysts were found in 11/548 (2%) samples, including 4/98 (4%) strays, and 7/450 (1.5%) companion dogs. The oocysts seen were 5.4×4.5 and were said to be morphologically similar to those of *C. parvum*. The oocysts were in dogs <1-year-old, four of which suffered from diarrhea. Mirzaei and Fooladi (2013) surveyed pet dogs in Kerman City, Iran, and *Cryptosporidium* oocysts were seen in 3/100 (3%) dogs.

CRYPTOSPORIDIUM SPP. OF MUNDIM, ROSA, HORTÊNCIO, FARIA, RODRIGUES, AND CRY, 2007

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Mundim et al. (2007) surveyed fecal samples of dogs under different living conditions (89 strays in shelters, 199 kennelled, 145 household pet) in Minais Gerais State, Uberlândia, an urban district of Brazil. Oocysts of *Cryptosporidium* were found in

6/433 (1%) fecal samples, mostly in the stray dogs from shelters.

**CRYPTOSPORIDIUM SPP. OF
OVERGAAUW, VAN ZUTPHEN,
HOEK, YAYA, ROELFSEMA,
PINELLI, VAN KNAPEN, AND
KORTBEEK, 2009**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Overgaauw et al. (2009) collected fecal samples from healthy household dogs in the Netherlands. *Cryptosporidium* sp. was detected in 8/92 (9%) samples. Genotyping based on PCR of 18S rDNA failed; therefore the species/genotype remained unknown.

**CRYPTOSPORIDIUM SPP. OF
PALMER, THOMPSON, TRAUB,
REES, AND ROBERTSON, 2008a**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Palmer et al. (2008a) surveyed fecal samples of dogs from both urban and rural areas across Australia, which were collected from 59 veterinary clinics (810 samples) and 26 refuges (590 samples). *Cryptosporidium* was detected, but not identified, in 8/1,400 (0.6%) of the dogs.

**CRYPTOSPORIDIUM SPP. OF
PAPAZAHARIADOU, FOUNTA,
PAPADOPOULOS, CHLIOUNAKIS,
ANTONIADOU-SOTIRIADOU, AND
THEODORIDES, 2007**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Papazahariadou et al. (2007) examined fecal samples of privately-owned dogs (117

shepherd dogs, 164 hunting dogs) from the Serres prefecture in northern Greece. *Cryptosporidium* was detected in 8/281 (3%) samples, 5 from shepherds and 3 from hunting dogs.

**CRYPTOSPORIDIUM SPP. OF
RINALDI, MAURELLI, MUSELLA,
VENEZIANO, CARBONE, DI
SARNO, PAONE, AND CRINGOLI,
2008**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Rinaldi et al. (2008) examined canine fecal samples in urban Naples, Campania region, southern Italy. Samples were examined by a commercial ELISA kit (ProSpecT® *Cryptosporidium* Microplate Assay) for the presence of coproantigen of *Cryptosporidium*; 7/415 (2%) samples were positive, but the species/genotype was not identified, and because samples were collected from the ground, we will never know whether they were really canine or not.

**CRYPTOSPORIDIUM SPP. OF
SCORZA AND LAPPIN, 2017**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: During their survey on gastrointestinal parasites in dogs and cats, Scorza and Lappin (2017) examined fecal samples of dogs on the Pine Ridge Indian Reservation, South Dakota, USA. Samples were examined by centrifugation–flotation, and by a commercial immunofluorescence assay for *Cryptosporidium* (Merifluor *Crypto/Giardia* kit). PCR amplification of the HSP70 gene was performed with immunofluorescence-positive samples. *Cryptosporidium* was detected in 6/84 (7%) samples, 2 of which could not be identified further (the other 4 were *C. canis*).

**CRYPTOSPORIDIUM SPP. OF
SHUKLA, GIRALDO, KRALIZ,
FINNIGAN, AND SANCHEZ, 2006**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Shukla et al. (2006) examined fecal samples of domestic dogs in the Niagara region, Ontario, Canada, by a fecal concentration method, acid-fast staining, and *Cryptosporidium* enzyme immunoassay (EIA) using the ProSpecT *Cryptosporidium* Microplate Assay. All samples were from dogs in one veterinary clinic; *Cryptosporidium* was detected in 5/68 (7%) samples, and all were found by the EIA test; neither of the other two methods detected *Cryptosporidium*.

**CRYPTOSPORIDIUM SPP. OF
SIMONATO, DI REGALBONO,
CASSINI, TRAVERSA, TESSARIN,
DI CESARE, AND PIETROBELLI,
2017**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Simonato et al. (2017) examined canine fecal samples from public green (270 samples) and urban (435 samples) areas, Padua municipality, Veneto region, northern Italy. Samples were examined by sedimentation–flotation, followed by nested PCR amplification and subsequent sequencing of 18S rRNA gene. For some reason, samples concurrently positive for *Giardia* favored amplification of giardial DNA over the cryptosporidial DNA, so these samples also were examined by a touch-down real-time PCR of the COWP gene. Simonato et al. (2017) said that 12/705 (<2%) samples were positive for *Cryptosporidium* spp., 1 sample identified as *C. canis*, and the other 11 as “*C. parvum* species complex.” However, because the samples were collected from the ground, one may never know whether they were really canine or not.

**CRYPTOSPORIDIUM SP. OF SISK,
GOSSER, AND STYER, 1984**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Sisk et al. (1984) described intestinal cryptosporidiosis in two pups in Georgia, USA. A 6-week-old mixed-breed female was “in a weak, semicomatose condition” and died within 12 hours. It was negative for parvovirus, adenovirus, and herpesvirus. Necropsy revealed mild hyperemia of the small intestinal serosa, mild interstitial pneumonia, and numerous “oval to spherical, dense basophilic bodies 3–4 µm in diameter” in the ileum, attached to the enterocytes, or free in the lumen of the small intestine. “Organisms morphologically consistent with *Cryptosporidium*,” including meronts, merozoites, and trophozoites were observed in the ileum by TEM. The second pup that had suffered seizures was a 6-week-old, mixed-breed, from a cattle farm. It was negative for viral and bacterial agents, but dilated crypts with cellular debris were observed in the small and large intestines, and “sparse coccoid bodies 3–4 µm in diameter” were attached to the surface of enterocytes in the ileum. “Organisms morphologically consistent with *Cryptosporidium*,” also were observed in the ileum by TEM, but the pup likely died of intoxication because 7.0 ppm of the pesticide toxaphene was detected in its liver.

**CRYPTOSPORIDIUM SP. OF
SORIANO, PIERANGELI, ROCCIA,
BERGAGNA, LAZZARINI,
CELESCINCO, SAIZ, KOSSMAN,
CONTRERAS, ARIAS, AND
BASUALDO, 2010**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Soriano et al. (2010) surveyed 1,944 dog fecal samples collected in urban

(646 samples) and rural (1,298 samples) areas in the Province of Neuquén, Patagonia, Argentina. A subset of 100 samples were screened using a modified Ziehl-Neelsen staining for the detection of *Cryptosporidium*. Only 1/100 (1%) samples (an urban dog) was positive for *Cryptosporidium*.

**CRYPTOSPORIDIUM SPP.
OF STRONEN, SALLOWS,
FORBES, WAGNER, AND
PAQUET, 2011**

Original host: *Canis lupus* L., 1758, Wolf.

Remarks: From 2001 to 2005, Stronen et al. (2011) collected fecal samples from gray wolves in Riding Mountain National Park, Manitoba, Canada, and examined them by immunofluorescence. *Cryptosporidium* was detected in 7/601 (1%) samples.

**CRYPTOSPORIDIUM SPP.
OF TANGTRONGSUP,
SCORZA, REIF,
BALLWEBER, LAPPIN,
AND SALMAN, 2017**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Tangtrongsup et al. (2017) examined fecal samples of dogs in the Chiang Mai province, Thailand; 36 from the Small Animal Hospital, Chiang Mai University, 9 from private clinics, 15 from shelters, and 49 from breeders. Samples were examined by immunofluorescence assay (Merifluor *Crypto/Giardia* kit) and by PCR amplification of HSP70 and 18S rRNA genes. The overall prevalence of *Cryptosporidium*-positive samples was 34/109 (31%), mostly in dogs <1-year-old; 14 dogs (13%) were positive by immunofluorescence, and 21 dogs (19%) by either/both of the PCR assays, and 18/109 (16.5%) were concurrently infected with *G. duodenalis*.

**CRYPTOSPORIDIUM SPP. OF
THOMPSON, COLWELL, SHURY,
APPELBEE, READ, NJIRU, AND
OLSON, 2009**

Original host: *Canis latrans* Say, 1823, Coyote.

Remarks: Thompson et al. (2009) examined coyotes in southern Alberta and Saskatchewan, Canada, by sucrose flotation, immunofluorescence of monoclonal antibodies specific for *Cryptosporidium* (Crypt-a-Glo™), and PCR amplification with subsequent sequencing and phylogenetic analyses of 18S rRNA and HSP70 genes. *Cryptosporidium* was detected in 8/70 (11%) samples, all collected in winter, whereas no samples collected in summer were positive. This may be because in winter the coyotes were in poor condition and nutritionally compromised; 6/8 (75%) positive samples could not be successfully amplified by PCR.

**CRYPTOSPORIDIUM SP. OF
TRALDI, 1990**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Traldi (1990) reported oocysts of a *Cryptosporidium* sp. in the feces of a 6-year-old, male Pyrenean Shepherd. The dog suffered from recurrent episodes of diarrhea that stopped spontaneously ~12 days after diagnosis, and follow-up examinations were negative. The oocysts were inoculated *per os* into a 2-day-old mouse that was killed and dissected 7 DPI; both its feces and histological sections of intestine were diagnosed positive for cryptosporidia, but no other information was given.

**CRYPTOSPORIDIUM SPP. OF UGA,
MATSUMURA, ISHIBASHI, YODA,
YATOMI, AND KATAOKA, 1989**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Uga et al. (1989) examined rectal contents of stray dogs captured in Hyogo Prefecture, Japan, by centrifugation–flotation. Oocysts of *Cryptosporidium* were detected in 3/213 (1%) dogs, mostly in those with normal fecal consistency and ≤6-months-old.

**CRYPTOSPORIDIUM SPP. OF YU,
RUAN, ZHOU, CHEN, ZHANG,
WANG, ZHU, AND YU, 2017**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Yu et al. (2017) examined fecal samples of pet dogs with diarrhea from various regions in Beijing, China, by LM of wet mounts, and nested PCR amplification of 18S rRNA gene. *Cryptosporidium* was detected in 24/485 (5%) samples, mainly in poodles and border collies, but 4/20 (20%) positive samples could not be successfully identified using the PCR amplification.

**CRYPTOSPORIDIUM SPP.
OF ZIEGLER, WADE, SCHAAF,
STERN, NADARESKI, AND
MOHAMMED, 2007**

Original host: *Canis latrans* Say, 1823, Coyote.

Remarks: Ziegler et al. (2007) examined fecal samples from coyotes live-trapped in a New York City Watershed in southeastern New York state, USA. Samples were concentrated by flotation and examined by LM and by polyclonal *Cryptosporidium* antigen capture ELISA (positive with an optical density ≥ 0.05). They found *Cryptosporidium* in 5/19 (26%) samples.

**CYCLOSPORA CAYETANENSIS OF
AWADALLAH AND SALEM, 2015**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: *Cyclospora cayetanensis* Ortega, Gioman, and Sterling, 1994 is a parasite of humans and most closely related to *Eimeria*. Awadallah

and Salem (2015) surveyed fecal samples from military (40 samples), nomadic (30 samples), and household dogs (60 samples) in Sharkia and Qalyubia provinces, Egypt. Samples were examined by centrifugation–flotation. Awadallah and Salem (2015) reported finding some *C. cayetanensis* oocysts in 1/130 (<1%) samples from a nomadic dog. Their photomicrograph is blurred, and the oocyst shown does not resemble a *Cyclospora* oocyst (in our opinion). Knowing that dogs are coprophagous, we suspect this is a spurious finding of an oocyst passing through the dog's gut after ingesting infected human feces.

**CYCLOSPORA SP. OF YAI, BAUAB,
HIRSCHFELD, DE OLIVEIRA, AND
DAMACENO, 1997**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Yai et al. (1997) reported an infection with *Cyclospora* sp. in each of two dogs from São Paulo, Brazil, 1 Siberian husky and 1 Rottweiler. Both dogs had a history of watery diarrhea, weight loss, and lethargy. However, their photomicrographs of (presumably) sporulated oocysts of *Cyclospora* were not convincing.

**CYSTOISOSPORA OHIOENSIS
COMPLEX OF PALMER,
THOMPSON, TRAUB, REES,
AND ROBERTSON, 2008a**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Palmer et al. (2008a) surveyed fecal samples of dogs from both urban and rural areas across Australia, which were collected from 59 veterinary clinics (810 samples) and 26 refuges (590 samples). Samples were examined by centrifugation–flotation. “*I. (=C.) ohioensis* complex” was detected in 49/1,400 (3.5%) dogs, mostly from refuges.

CYSTOISOSPORA OHIOENSIS-LIKE OF GATES AND NOLAN, 2009

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Between 1997 and 2007, Gates and Nolan (2009) surveyed fecal samples of dogs in Pennsylvania, USA, for the prevalence of endoparasite infections. Samples were examined mostly by zinc sulfate centrifugation. "*Cystoisospora ohioensis-like*" was detected in 129/6,555 (2%) samples, mostly in dogs <1-year-old.

CYSTOISOSPORA SPP. OF BARUTZKI AND SCHAPER, 2003

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Barutzki and Schaper (2003) examined fecal samples of dogs in Freiburg, Germany. Each sample was examined by five standard, nonmolecular methods. *Cystoisospora* oocysts were detected in 1,881/8,438 (22%) samples, and the infection was higher in dogs up to 1-year-old.

CYSTOISOSPORA SPP. OF DUBNÁ, LANGROVÁ, NÁPRAVNÍK, JANKOVSKÁ, VADLEJCH, PEKÁR, AND FECHTNER, 2007

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: From 1998 to 2000, Dubná et al. (2007) surveyed canine fecal samples from the metropolitan area of Prague's city center animal shelters and from rural areas of central Bohemia, Czech Republic. Oocysts of *Cystoisospora* spp. were detected in 92/3,780 (2%) samples, mainly from Prague 1 and Prague 2 (city center districts). Fecal

samples of 23/524 (4%) stray dogs in two animal shelters were positive for *Cystoisospora* spp. at their admittance. Surprisingly, the prevalence increased fourfold after a stay in the shelter from the time of admittance to the shelter. Of fecal samples collected from rural areas of central Bohemia (one-third from dogs, two-third from "soil or street"), *Cystoisospora* spp. was detected in 43/540 (8%) samples. Dubná et al. (2007) said that *Cystoisospora* was more prevalent in rural dogs.

CYSTOISOSPORA SPP. OF FERREIRA, PENA, AZEVEDO, LABRUNA, AND GENNARI, 2016

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Ferreira et al. (2016) surveyed fecal samples of pet dogs at the University of São Paulo, from metropolitan São Paulo, Brazil. Oocysts of *Cystoisospora* were detected in 46/3,099 (1.5%) samples, mostly in younger dogs.

CYSTOISOSPORA SPP. OF FUNADA, PENA, SOARES, AMAKU, AND GENNARI, 2007

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Funada et al. (2007) examined fecal samples of domestic dogs in São Paulo, Brazil. Samples were examined by various standard concentration techniques. Oocysts of *Cystoisospora* were detected in 77/1,755 (4%) samples.

CYSTOISOSPORA SPP. OF GENNARI, KASAI, PENA, AND CORTEZ, 1999

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Gennari et al. (1999) examined fecal samples of domestic dogs from different areas of São Paulo, Brazil. Samples were examined by flotation and oocysts of *Cystoisospora* sp. were detected in 9/353 (2.5%) samples.

CYSTOISOSPORA SPP. OF GILL, SINGH, VADEHRA, AND SETHI, 1978

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Gill et al. (1978) found unsporulated *Isoospora* oocysts in the feces of dogs that were fed diaphragm from water buffalo (*Bubalus bubalis*) naturally-infected with macroscopic sarcocysts of *S. fusiformis* (but they did not examine the diaphragm for microscopic cysts). Four dogs that had never been fed meat each were fed 25 g of buffalo diaphragm, and all four dogs started shedding unsporulated oocysts on 9 (three dogs) or 10 DPI (one dog), and the infected dogs continued shedding oocysts daily for 15, 18, 23, and 25 days. Sporulation was completed in 8–16 hours at room temperature. Sporulated oocysts were L×W (n=25): 18.2×13.3 (17.5–24×16–19), L/W ratio: 1.1 (1.0–1.3), and M, OR, PG: all absent. Sporocysts were L×W (n=25): 13.3×9.8 (11–16×9–11), L/W ratio: 1.4 (1.1–1.6), and SB, SSB, PSB: all absent, but with a large SR. Gill et al. (1978) said that these oocysts either were *Hammondia* or *Isoospora* but neglected to assign their form to either. Levine and Ivens (1981, pp. 49–50) suggested this may be a *Toxoplasma* species, even though the sporulated oocysts are about the same size as those of *C. burrowsi* and *C. ohioensis*, but gave no reason to support calling it *Toxoplasma* sp.

CYSTOISOSPORA SPP. OF HUBER, BOMFIM, AND GOMES, 2005

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Huber et al. (2005) surveyed fecal samples of 94 stray dogs from an animal shelter and 72 household pet dogs from the West Zone of Rio de Janeiro, Brazil. All the dogs were clinically healthy. Oocysts of *Cystoisospora* were detected in “some samples”; however, the number of positive samples was not given.

CYSTOISOSPORA SPP. OF LITTLE, JOHNSON, LEWIS, JAKLITSCH, PAYTON, BLAGBURN, BOWMAN, MOROFF, TAMS, RICH, AND AUCOIN, 2009

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Little et al. (2009) reported a scale study of fecal samples of 1,199,293 pet dogs presented to veterinary clinics throughout the United States. The samples were submitted to Antech Diagnostics (national service laboratories), for examination; *Cystoisospora* spp. was detected in 53,176 (4%) dogs, mostly <6-months-old and originated mostly from the West (Arizona, Oregon; 16,113 dogs) and Midwest (Illinois, Nebraska; 11,377 dogs).

CYSTOISOSPORA SP. OF MUNDIM, ROSA, HORTÊNCIO, FARIA, RODRIGUES, AND CRY, 2007

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Mundim et al. (2007) surveyed fecal samples of 89 stray dogs in shelters, 199 kenneled, and 145 household pets in Uberlândia, state of Minas Gerais, Brazil. Oocysts of *Cystoisospora* sp. were detected in 12/433 (3%) samples.

**CYSTOISOSPORA SPP. OF
PAPAZAHARIADOU, FOUNTA,
PAPADOPOULOS, CHLIOUNAKIS,
ANTONIADOU-SOTIRIADOU, AND
THEODORIDES, 2007**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Papazahariadou et al. (2007) examined fecal samples of privately-owned shepherd (117) and hunting (164) dogs from the Serres prefecture, northern Greece. *Cystoisospora* oocysts were detected in 11/281 (4%) samples, 5 from shepherds and 6 from hunting dogs, and prevalence was significantly higher in young dogs.

**CYSTOISOSPORA SPP. OF SALB,
BARKEMA, ELKIN, THOMPSON,
WHITESIDE, BLACK, DUBEY, AND
KUTZ, 2008**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Salb et al. (2008) examined fresh fecal samples of dogs from two remote northern Canadian communities (Fort Chipewyan, Alberta; Fort Resolution, Northwest territories). The authors detected *Cystoisospora*-like oocysts, but the number of positive samples was not given.

**CYSTOISOSPORA SPP.
OF SIMONATO, DI REGALBONO,
CASSINI, TRAVERSA,
BERALDO, TESSARIN, AND
PIETROBELLI, 2015**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Simonato et al. (2015) examined canine fecal samples collected from dogs kept in eight rescue shelters in northeastern Italy (seven

in Veneto region and one in Friuli-Venezia Giulia region). Oocysts of *Cystoisospora* were detected in 18/318 (6%) samples, 9 from each region.

**CYSTOISOSPORA SPP. OF YU,
RUAN, ZHOU, CHEN, ZHANG,
WANG, ZHU, AND YU, 2017**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Yu et al. (2017) examined fecal samples of pet dogs with diarrhea from various regions in Beijing, China. Samples were examined by LM of wet fecal smears, and *Cystoisospora* oocysts were detected in 21/485 (4%) samples, mainly in poodles and golden retrievers, but the parasites were not further identified to the species.

**EIMERIA RAYII OF RAO AND
BHATAVDEKAR, 1957**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Rao and Bhatavdekar (1957) described ovoidal to ellipsoidal oocysts from a dog in Bombay, India, which were L×W (n=50): 26.8×19.8 (22–29×18–22); L/W ratio: 1.35. The oocysts had a MC and a M, the former was 5.8 (4–7) and the latter was 1.7 (1–4) wide. Unfortunately, the oocysts were unsporulated so sporocyst numbers and size were not recorded. Levine and Ivens (1981) believe these oocysts resemble those of *E. arloingi* from goats merely passing through the gut of the dog. Whatever they were, they were not a parasite of the dog and thus can only be relegated to *species inquirenda*.

**EIMERIA SPP. OF FOK, SZATMÁRI,
BUSÁK, AND ROZGONYI, 2001**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Fok et al. (2001) examined fecal samples of dogs in eastern and northern Hungary and reported a presence of *Eimeria* spp., which they called “spurious parasites” (Table 1, p. 97), in 18/490 (4%) dogs from a country town and a village, but gave no details.

EIMERIA SP. OF STREITEL AND DUBEY, 1976

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Streitl and Dubey (1976) surveyed feces from stray dogs in a humane shelter in Ohio, USA and reported 2/500 (0.5%) samples to have oocysts of an *Eimeria* species. After sporulating the oocysts, they were inoculated via stomach tube, into one coccidia-free, 1-month-old lab-reared pup. The feces of the pup were monitored for 30 DPI, but no additional oocysts were ever found. Although there are several *Eimeria* species described from dogs, they suggested that, “*Eimeria* are probably accidental ‘parasites’ of dogs because the *Eimeria* sp. found in this survey was not infectious to a dog.”

EIMERIA STIEDAE OF GUILLEBEAU, 1916

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Guillebeau (1916) described a small coccidium that he identified as *E. stiedae* in the liver cells of dogs, even though the oocysts only measured L×W: 12×7, far too small to be those of *E. stiedae* found in the liver of rabbits. Coccidial developmental stages in the liver of dogs would be an unusual finding, indeed, given all of the domestic dogs that have been examined worldwide in the last 100 years! Guillebeau’s (1916) figures do not help in deciding even the nature of

the organism at which he was looking; thus, another *species inquirenda*.

HAMMONDIA-LIKE OOCYSTS OF CIRAK AND BAUER, 2004

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Cirak and Bauer (2004) examined fecal samples of healthy dogs from animal shelters in Germany to compare conventional coproscopical methods versus a commercial coproantigen ELISA kit, to best detect *Cryptosporidium*. *Hammondia*-like oocysts were found in 2/270 (<1%) dogs using the ZnCl₂-NaCl flotation method.

HAMMONDIA–NEOSPORA OF BARUTZKI AND SCHAPER, 2003

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Barutzki and Schaper (2003) examined fecal samples of dogs in Freiburg, Germany. Each sample was examined by 4–5 standard isolation techniques; *Hammondia–Neospora*-like oocysts were detected in 143/8,438 (<2%) samples.

HAMMONDIA–NEOSPORA SPP. OF DUBNÁ, LANGROVÁ, NÁPRAVNÍK, JANKOVSKÁ, VADLEJCH, PEKÁR, AND FECHTNER, 2007

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Dubná et al. (2007) reported on their survey of canine and ground-collected fecal samples from various areas in and around Prague and from rural areas in central Bohemia, Czech Republic. They reported *Neospora/Hammondia* spp. in 19/3,780 (0.5%) samples.

HAMMONDIA–NEOSPORA OF EPE, COATI, AND SCHNIEDER, 2004

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: In northern Germany, Epe et al. (2004) surveyed fecal samples of dogs from 1998 to 2002 and found 3/1,281 (0.2%) to pass *Hammondia*-like oocysts. Based on only the oocyst morphology, however, it was impossible to differentiate between the oocysts of *Hammondia* and *Neospora*.

HAMMONDIA–NEOSPORA OF FERREIRA, PENA, AZEVEDO, LABRUNA, AND GENNARI, 2016

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Ferreira et al. (2016) surveyed fecal samples of pet dogs in São Paulo, Brazil. Oocysts of *Hammondia/Neospora* were detected in 2/3,099 dogs, both ≥ 1 -year-old. Based only on oocyst morphology, it was impossible to differentiate between genera or species.

HAMMONDIA–NEOSPORA OF FONTANARROSA, VEZZANI, BASABE, AND EIRAS, 2006

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Fontanarrosa et al. (2006) surveyed fecal samples of dogs in southern Buenos Aires, Argentina. Oocysts they identified as *Hammondia–Neospora* were detected in 66/2,193 (3%) samples, mostly in young dogs 0–6-months-old.

HAMMONDIA–NEOSPORA OF FUNADA, PENA, SOARES, AMAKU, AND GENNARI, 2007

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Funada et al. (2007) examined fecal samples of domestic dogs also in São Paulo, Brazil. Samples were examined by several concentration techniques. *Hammondia–Neospora*-like oocysts were detected in 7/1,755 (0.4%) samples.

HAMMONDIA–NEOSPORA OF HERMOSILLA, KLEINERTZ, SILVA, HIRZMANN, HUBER, KUSAK, AND TAUBERT, 2017

Original host: *Canis lupus* L., 1758, Wolf.

Remarks: Hermosilla et al. (2017) surveyed fecal samples of wild European wolves in mountainous areas of the Gorski Kotar Region, Croatia. *Hammondia/Neospora*-like oocysts were detected in 10/400 (3%) samples. Based on the morphology, it was not possible to identify these oocysts beyond these genera.

HEPATOZOON SP. OF DAVIS, ROBINSON, AND CRAIG, 1978

Original host: *Canis latrans* Say, 1823, Coyote.

Remarks: Davis et al. (1978) reported a naturally-occurring case of hepatozoonosis in a coyote in Austwell, Aransas county, Texas, USA. Meronts of *Hepatozoon* were found in the myocardium of an adult coyote that had been shot in Aransas National Wildlife Refuge. They said this was, “the first time hepatozoonosis has been recorded in Canidae in the Western Hemisphere.” There was no attempt to reach a species identity.

HEPATOZOON SP. OF MATJILA, LEISEWITZ, JONGEIAN, BERTSCHINGER, AND PENZHORN, 2008

Original host: *Canis lupus* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Matjila et al. (2008) collected blood samples from wild dogs at the De Wildt Cheetah and Wildlife Centre, Pretoria, and five game

reserves (four in the North-West province, one in Limpopo province), South Africa. Specimens were screened for *Babesia*, *Theileria*, *Hepatozoon*, and *Ehrlichia/Anaplasma* species using PCR and reverse line blot assays. Two dogs were positive for *Hepatozoon* sp.

HEPATOZOON SPP. OF MCCULLY, BASSON, BIGALKE, DE VOS, AND YOUNG, 1975

Original hosts: *Canis adustus* Sundevall, 1878, Side-striped Jackal; and Lions, Cheetahs, Hyaenas, and Leopards.

Remarks: McCully et al. (1975) studied hepatozoonosis in hyaenas, lions, jackals, cheetahs, and one leopard in the Kruger National Park, to compare possible symptoms with those seen in some dogs in South Africa. Meronts of *Hepatozoon* were found in many wild carnivores and they illustrated the progressive development of microschizonts. They reported meronts in the lung, myocardium, and skeletal muscle, and sometimes also in the spleen, liver, and lymph nodes. Gametocytes were present in leukocytes, but they saw very little of a host response to the presence of *Hepatozoon* infection, and there was no attempt to determine the species. Sporogony in ticks was reported in *Rhipicephalus simus* females removed from an infected hyaena and *R. sanguineus* adults fed on an infected jackal in the nymphal stage. Attempts to transmit *Hepatozoon* from a jackal to domestic dogs by means of ticks gave "inconclusive results."

HEPATOZOON SP. OF MERCER, JONES, RAPPOLE, TWEDT, LAACK, AND CRAIG, 1988

Original host: *Canis latrans* Say, 1823, Coyote.

Remarks: Mercer et al. (1988) collected skeletal and/or cardiac muscle samples from coyotes trapped in Robertson, Brazoria, Refugio,

Wharton, and Calhoun counties, Texas, USA; the authors found that 12/59 (20%) were infected with a *Hepatozoon* species. They made no attempt to name or identify the species.

HOAREOSPORIDIUM PELLERDYI OF PANDE, BHATIA, AND CHAUHAN, 1972

Original host: *Canis lupus* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Pande et al. (1972) reported an unusual coccidium in the rectal contents of four pups slaughtered in India. It was similar to *Cryptosporidium* because of its asexual, tetrazoic oocysts, which they saw in fresh scrapings of the jejunum; however, it was intracellular in epithelial and subepithelial cells of the villi, rather than in the intracellular, but extracytoplasmic, location typical for *Cryptosporidium* species, so they decided to create a new genus for their organism. They measured their "oocysts" both extracellularly and intracellularly. Fresh "oocysts" were $L \times W$ ($n=50$): 14.8×9.1 ($12-17 \times 8.5-10.5$), L/W ratio: 1.6 (1.2-1.8); the OR was a prominent mass of large-sized granules, and sausage-shaped SZ were 9.3×2.7 ($9-10.5 \times 2.6-3$). Intracellular "oocysts" were $L \times W$ ($n=25$): 14.2×8.8 ($12-17 \times 7-10$); L/W ratio: 1.6, and SZ were 8.2×2.4 ($6-10.5 \times 2-2.5$). They said, "though the dimensions given for the oocysts in *V. vulpis* Wetzel, 1938 (from common red fox) are well within the range encountered in our material, the oocysts in this species, according to Pellérdy, could possibly be the freshly-shed sporocysts of some known or as yet unknown isosporan species." We are convinced that what Pande et al. (1972) reported actually were sporocysts of some *Sarcocystis* species developing in the dog's jejunal epithelial cells, which they mistook for oocysts of their new *Hoareosporidium pellerdyi*. We must conclude that this form can only be regarded as a *species inquirenda*.

ISOSPORA BIGEMINA (STILES, 1891) OF LÜHE, 1906

Synonyms: *Cystospermium villorum intestina-
lium canis* Rivolta, 1878, *nomen nudum*; *Coccidium
rivolta* Grassi, 1879, *pro parte*; *Coccidium rivoltae*
Leuckart, 1886, *pro parte*; *Coccidium bigemina*
Stiles, 1891, *pro parte*; *Coccidium bigeminum* var.
canis Railliet and Lucet, 1891; *Diplospora bigem-
ina* Martin, 1909; *Coccidium bigeminum* Wigdor,
1918, *pro parte*; *Isospora cati* Marotel, 1922, *pro
parte*; *Lucetina bigemina* (Stiles, 1891) Henry and
Leblois, 1926; *Isospora bigemina* Gousseff, 1933,
lapsus; *Isospora bigemina* var. *bahiensis* de Moura
Costa, 1956; and others.

Type host: *Canis lupus familiaris* (syn. *C. familia-
ris*) L., 1758, Domestic Dog.

Remarks: Stiles (1891) found some para-
sites developing in the lamina propria of the
domestic dog and called it *Coccidium bige-
mina*; Lindsay et al. (1997) suggested that
he was likely looking at a *Sarcocystis* species
because oocysts and sporocysts were seen to
develop in the gut tissue and we agree. This
organism was placed in the genus *Isospora*
by Lühe (1906) and 2 decades later, Wenyon
(1926a) suggested there were two "races" of *I.
bigemina*, a large and a small race. The larger
race, which was excreted as sporocysts and
sporulated oocysts was a *Sarcocystis* species,
and the smaller race, excreted as unsporulated
oocysts, is now known to be *Hammondia
heydorni*, an obligatory heteroxenous parasite
(Heydorn et al., 1975c; Lindsay et al., 1997).
Nukerbaeva and Svanbaev (1974, 1977) col-
lected oocysts from domestic dogs, which they
identified as *I. bigemina*. They tried to transmit
their oocysts to one 40-day-old Arctic fox (*V.
lagopus*), and two 1-year-old minks (*N. vison*),
but none of these animals became infected.
They were successful in transmitting their
oocysts to a control dog, which shed oocysts
in its feces on the 8th DPI.

ISOSPORA BIGEMINA FREE SPORO CYSTS OF GASSNER, 1940

Original host: *Canis lupus familiaris* (syn. *C.
familiaris*) L., 1758, Domestic Dog.

Remarks: In Fort Collins, Colorado, USA,
Gassner (1940) examined dogs and said that
253/320 (79%) dogs were infected with the
small form of *Isospora bigemina* and discharged
either sporocysts or oocysts in their feces;
Because free sporocysts and sporulated oocysts
were being discharged in the feces, we now
know Gassner (1940) was seeing a species of
Sarcocystis.

ISOSPORA BURROWSI/ISOSPORA OHIOENSIS-LIKE OF CIRAK AND BAUER, 2004

Original host: *Canis lupus familiaris* (syn. *C.
familiaris*) L., 1758, Domestic Dog.

Remarks: Cirak and Bauer (2004) examined
fecal samples of healthy dogs with normal
stools in central Germany; oocysts of *Isospora
burrowsi/Isospora ohioensis* were found in 3/270
(1%) dogs. They were unable to determine iden-
tity beyond that general observation.

ISOSPORA OHIOENSIS COMPLEX OF FONTANARROSA, VEZZANI, BASABE, AND EIRAS, 2006

Original host: *Canis lupus familiaris* (syn. *C.
familiaris*) L., 1758, Domestic Dog.

Remarks: Fontanarrosa et al. (2006) surveyed
fecal samples of dogs in southern Buenos Aires,
Argentina. They detected an "*Isospora ohioensis*
complex" of oocysts in 263/2,193 (12%) samples,
mostly in young dogs 0–6-months-old.

**ISOSPORA SPP. OF BLAZIUS,
EMERICK, PROPHIRO, ROMÃO,
AND DA SILVA, 2005**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Blazius et al. (2005) examined fecal samples of stray dogs in Itapema City, Santa Catarina, Brazil, and found *Isoospora* oocysts they did not identify to species in 10/158 (6%) samples.

**ISOSPORA SPP. OF CAUSAPÉ,
QUÍLEZ, SÁNCHEZ-ACEDO, AND
DEL CACHO, 1996**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Causapé et al. (1996) examined fresh fecal samples of 37 domestic and 44 stray dogs in Zaragoza, Aragón, Spain; oocysts of *Isoospora* spp. were detected in 8/81 (10%) samples, including 7/37 (19%) domestic and 1/44 (2%) stray dogs.

**ISOSPORA SPP. OF COLLINS,
EMSLIE, FARROW, AND WATSON,
1983**

Original host: *Canis lupus* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Collins et al. (1983) reported *Isoospora* spp. in 6/110 (5.5%) fecal samples from dogs in Sydney, Australia, which were examined for "sporozoa." No other information was given.

**ISOSPORA SPP. OF DE OLIVEIRA,
DA SILVA, PARREIRA, RIBEIRO,
AND GOMES, 1990**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: de Oliveira et al. (1990) examined fecal samples of 11,563 dogs from Uberlândia, Minas Gerais, Brazil and found *Isoospora* oocysts in 148/3,202 (5%) samples but did not identify them to species.

**ISOSPORA SP. OF DUBEY,
WEISBRODE, AND ROGERS, 1978b**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Dubey et al. (1978b) found a coccidium in the villar epithelium, lamina propria, and intestinal glands in the distal half of the ileum, cecum, and colon of a 10-week-old puppy that apparently died from the infection in Ohio, USA. They said that sporulation was exogenous and oocysts were L×W: 19×16 (16–23×14–20) in fecal smears and 13×11.5 (12–17×10–13) in tissue sections and speculated that the infection might be a mixture of *I. neorivolta* and *I. ohioensis*, but had to conclude that they could not identify the parasite because the culture was "inadvertently discarded." They also reported at least two structurally different meronts and three different-sized merozoites in tissue stages of the pup. For more descriptive information on these various stages, see either Dubey et al. (1978b) or Levine and Ivens (1981, p. 22).

**ISOSPORA SPP. OF EPE, COATI,
AND SCHNIEDER, 2004**

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: In northern Germany, Epe et al. (2004) surveyed fecal samples of domestic dogs between 1998 and 2002 and found 29/1,281 (2%) passing *Isoospora* oocysts, which were not identified to species.

ISOSPORA SPP. OF EPE, ISING-VOLMER, AND STOYE, 1993

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Epe et al. (1993), in Germany, surveyed fecal samples from dogs between 1984 and 1991 and found 140/3,329 (4%) passing *Isospora* oocysts, which were not identified to species.

ISOSPORA SPP. OF FOK, SZATMÁRI, BUSÁK, AND ROZGONYI, 2001

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Fok et al. (2001) examined fecal samples of dogs in eastern and northern Hungary and reported a presence of *Isospora* spp. in 17/490 (3%) dogs (their Table 1, p. 97).

ISOSPORA SPP. OF HACKETT AND LAPPIN, 2003

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Hackett and Lappin (2003) examined fecal samples of 59 clinically healthy pet dogs and an additional 71 with acute diarrhea in north-central Colorado, USA. Oocysts of *Isospora* were detected in 3/130 (2%) samples, all in diarrheic dogs.

ISOSPORA SPP. OF INPANKAEW, TRAUB, THOMPSON, AND SUKTHANA, 2007

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Inpankaew et al. (2007) examined fecal samples of dogs from 20 different temples and their surrounding communities in Bangkok, Thailand. *Isospora* oocysts were detected in 23/229 (10%) samples.

ISOSPORA SPP. OF JASKOSKI, BARR, AND BORGES, 1982

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Jaskoski et al. (1982) reported collecting fecal samples from public areas (streets, parks, etc.) in Edgewater and Rogers Park, Chicago, Illinois, USA, areas where pet dogs were kept inside and leashed when outside. In 1970, 14/846 (<2%) samples had *Isospora* oocysts, but during 1979–1980, only 1/806 (0.1%) samples was found with *Isospora*-type oocysts. Unfortunately, fecal samples were not collected directly from dogs, so whether they all were canine was highly probable, but unknown for certain.

ISOSPORA SPP. OF JORDAN, MULLINS, AND STEBBINS, 1993

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Jordan et al. (1993) examined 12,515 canine fecal samples in Stillwater, Oklahoma, USA; they stated that *Isospora* spp. were found in “low prevalence (<5%) in the routine fecal examinations.”

ISOSPORA SPP. OF ITOH, KANAI, HORI, HOSHI, AND HIGUCHI, 2009

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Itoh et al. (2009) surveyed fecal samples of household dogs in the Hachinohe area, Tohoku region, Aomori province, Japan, in 1997 (420 samples), 2002 (350 samples), and 2007 (335 samples). Oocysts of *Isospora* spp. were detected in 40/420 (9.5%) samples in 1997, 26/350 (7%) samples in 2002, and 15/335 (4%) samples in 2007; most infected dogs were <1-year-old, kept

indoors, and originated from pet shops or breeding kennels.

ISOSPORA SPP. OF KATAGIRI AND OLIVEIRA-SEQUEIRA, 2008

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Katagiri and Oliveira-Sequeira (2008) examined fresh fecal samples of 129 stray, and 125 household dogs from urban areas of Botucatu, São Paulo State, Brazil. Samples were examined by multiple techniques. *Isospora* oocysts were found in 9/254 (3.5%) samples including 5/129 (4%) from stray and 4/125 (3%) from household dogs, but not identified to species.

ISOSPORA SPP. OF LORENZINI, TASCA, AND CARLI, 2007

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Lorenzini et al. (2007) examined fecal samples of dogs from different neighborhoods in Porto Alegre, Rio Grande do Sul, Brazil. They said that *Ancylostoma*, *Toxocara*, *Isospora*, and *Giardia* spp. were the most frequent parasites encountered. Dogs <6-months-old showed a high infection rate with 582/1,473 (39.5%) dogs demonstrating parasite stages in their feces, and the highest infection rates with *Isospora* and *Toxocara* spp. Summer was the season with the highest prevalence rate.

ISOSPORA SPP. OF MALLOY AND EMBIL, 1978

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Malloy and Embil (1978) examined fecal samples of stray dogs in Halifax, Nova

Scotia, Canada; oocysts of *Isospora* spp. were detected in 14/474 (3%) dogs, mostly young dogs up to 2-years-old.

ISOSPORA SP. OF MECH AND KURTZ, 1999

Original host: *Canis lupus* L., 1758, Wolf.

Remarks: Mech and Kurtz (1999) found three 4-month-old *C. lupus* pups in the Superior National Forest of Minnesota, USA, which died in August/September, 1997, apparently of coccidiosis. Two of the pups had hemorrhagic feces and the third had a severely autolyzed intestine. The intestinal mucosa of two pups had many developmental stages in both enterocytes and in the lamina propria, which the authors attributed to an *Isospora* (probably *Cystoisospora*) species. No other information was provided.

ISOSPORA SP. OF MELONI, THOMPSON, HOPKINS, REYNOLDS, AND GRACEY, 1993

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Meloni et al. (1993) examined fecal samples of dogs from eight Aboriginal communities in the tropics of the western Kimberley region, Western Australia. Oocysts of what was presumably a single *Isospora* sp. were detected in 4/182 (2%) samples.

ISOSPORA SPP. OF MILLER, LIGGETT, RADI, AND BRANCH, 2003

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Miller et al. (2003) reported a concurrent infection with *Cryptosporidium canis* and *Isospora* spp. in an 8-week-old female Yorkshire terrier puppy in Tifton, Georgia, USA.

The puppy suffered weakness and diarrhea. Histology revealed severe gastric and intestinal cryptosporidiosis, severe intestinal isosporiasis, and thymic atrophy with lymphoid depletion. Numerous sexual and asexual stages of *Isospora* spp. were observed in the luminal and crypt epithelial cells of the small intestine.

ISOSPORA SP. OF NIESCHULZ, 1925

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Nieschulz (1925) discussed *Isospora* infections in dogs and cats in the Netherlands; in addition to brief descriptions of *I.* (=C.) *rivolta* and *I.* (=C.) *felis*, he said he saw "free sporocysts (not whole oocysts) of an *Isospora* species in intestinal material of a young dog," which were ellipsoidal, L×W: 15.5×9.2 (14–17×8–10). Clearly, he saw and measured sporocysts of a *Sarcocystis* species.

ISOSPORA SPP. OF RAMÍREZ-BARRIOS, BARBOZA-MENA, MUÑOZ, ANGULO-CUBILLÁN, HERNÁNDEZ, GONZÁLEZ, AND ESCALONA, 2004

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Ramírez-Barrios et al. (2004) examined fecal samples of pet dogs in Maracaibo, Zulia state, Venezuela. Oocysts of *Isospora* spp. were detected in 50/614 (8%) dogs, mostly in (39) dogs younger than 6-months-old.

ISOSPORA SPP. OF SORIANO, PIERANGELI, ROCCIA, BERGAGNA, LAZZARINI, CELESCINCO, SAIZ, KOSSMAN, CONTRERAS, ARIAS, AND BASUALDO, 2010

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Soriano et al. (2010) studied dog fecal samples collected in urban streets, parks, squares (646 samples), and in peridomicile and farm settings (1,298 samples) of the Province of Neuquén, Patagonia, Argentina. Oocysts of *Isospora* spp. were detected in 19/1,944 (1%) samples, mostly from rural areas (18 of 19 samples).

ISOSPORA SP. OF STEHR-GREEN, MURRAY, SCHANTZ, AND WAHLQUIST, 1987

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Stehr-Green et al. (1987) examined fecal samples of pups from 14 pet stores in metropolitan Atlanta, Georgia, USA and detected an *Isospora* sp. in 13/143 (9%) samples.

ISOSPORA SPP. OF UEHLINGER, GREENWOOD, MCCLURE, CONBOY, O'HANDLEY, AND BARKEMA, 2013

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Uehlinger et al. (2013) examined fecal samples of dogs <1-year-old on Prince Edward Island, Canada. Dogs originated from a local animal shelter, private veterinary clinics, and a pet store. *Isospora* spp. oocysts were detected in 4/62 (6%) samples from the shelter, 10/78 (13%) samples from veterinary clinics, and 34/69 (49%) samples from the pet store.

ISOSPORA THEILERI OF YAKIMOFF AND LEWKOWITSCH, 1932

Original host: *Canis aureus* L., 1758, Golden Jackal.

Remarks: Yakimoff and Lewkowitsch (1932) reported finding oocysts in one golden jackal in Azerbaijan (former USSR). Their oocysts

were spheroidal or slightly ovoidal, $L \times W$: 21.2×17.1 – 18.0 , and had ellipsoidal sporocysts that were 16×11 (sic) (13 – 16×9 – 11); oocysts lacked a M, OR, and PG, and sporocysts lacked SB, SSB, PSB but were illustrated to have a granular SR. They said that sporocysts were found free in the intestine, which suggests they had seen a *Sarcocystis* sp., and that during transportation to Leningrad almost all of the oocysts' walls broke and disappeared, which would support this idea. Yakimoff and Lewkowitsch (1932) failed to transmit this form to the domestic dog with sporulated oocysts. Glebezdin (1978) surveyed wild mammals in southwestern Turkmenistan from 1974 to 1977; he reported finding, in *C. aureus*, ellipsoidal oocysts of *I. theileri* that measured $L \times W$: 23.0×17.5 (22 – 25×17 – 20), L/W ratio: 1.3; sporocysts were $L \times W$: 11.6×9.1 (11 – 14×8 – 11). Levine and Ivens (1981, p. 51) hoped that someone will find this form again and suggested, "it too should be restudied if it is ever rediscovered." The data available are so sketchy and tentative, that we strongly agree.

OOCYSTS OF CARLSLAKE, HILL, SJÖLANDER, HII, PRATTLEY, AND ACKE, 2017

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Carlslake et al. (2017) examined dog fecal samples in Samoa, South Pacific. All dogs were mixed-breed and free-roaming, and Carlslake et al. (2017) reported the presence of "oocysts" in 9/204 (4%) dogs.

SARCOCYSTIS CAPREOLI OF LEVCHENKO, 1963

Synonym: *Sarcocystis capreolicanis* Erber, Boch, and Barth, 1978.

Definitive hosts: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog; *Vulpes vulpes* (L., 1758), Red Fox.

Intermediate host: *Capreolus capreolus* (L., 1758), European Roe Deer.

Remarks: The relationship of this species to *S. gracilis* and *S. sibirica* is unknown, but we can find no other information on this species that was listed as a valid species by Levine (1986). Levine and Ivens (1981) did not mention this species nor did Dubey et al. (2015a). Sedlacek and Wesemeier (1995) examined 66 roe deer in Germany and Poland to compare the ultrastructure of their sarcocysts. They identified three distinct species, and when defining one of them, *S. capreolicanis* Erber et al. (1978), they said that Levchenko's (1963) "species" is not recognizable in its original description and, therefore, should be a *species inquirenda*. We agree.

SARCOCYSTIS FUSIFORMIS OF MEHLHORN, SENAUD, HEYDORN, AND GESTRICH, 1975a

Definitive hosts: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog; *Felis catus* L., 1758, Domestic Cat.

Intermediate host: *Bos taurus* L., 1758, Aurochs.

Remarks: Mehlhorn et al. (1975b) published a paper in which they tried to compare the ultrastructure of sarcocysts of (what they called) *S. fusiformis* in the muscles of naturally-infected cows with sarcocysts in cow muscle after experimental infection by sporocysts of *I. hominis* and sporocysts of the large forms of *I. bigemina* from the dog and cat. In naturally-infected cows they found two kinds of sarcocysts, probably *S. fusiformis* from cats and *S. cruzi* from dogs, but in their defense, these life cycles were still unknown at the time. They concluded that one type of sarcocyst in cows was produced by the large form of *I. bigemina* from dogs and the second type of sarcocysts "were caused by infection

with *I. hominis* and the large form of *I. bigemina* from the cat.”

SARCOCYSTIS MIESCHERIANA OF FARMER, HERBERT, PARTRIDGE, AND EDWARDS, 1978

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Farmer et al. (1978) surveyed feces from 123 working sheepdogs in Gwynedd, 33 greyhounds from the London area, and 41 red foxes killed on Anglesey or in the Bangor area of England. They found sporocysts of *Sarcocystis* spp. in 35/123 (28%) sheepdogs, 8/33 (24%) greyhounds, and 7/41 (17%) red foxes (their Table 1, p. 79). Based only on sporocyst dimensions, they said that *S. porcifelis* (syn. their *S. miescheriana*) sporocysts were identified in 11/47 (23%) sheepdogs and 2/8 (25%) greyhound samples they measured (their Table 3, p. 79). At that early stage in time, when we knew little about the true identity and life cycles of most *Sarcocystis* species, using only sporocyst measurements to place them into the correct species diagnosis was a bit risky; and we now know that *S. porcifelis* (syn. their *S. miescheriana*) seems to only be transmitted by felids so we must relegate their form to a *species inquirenda*.

SARCOCYSTIS SP. OF ABARCA, LÓPEZ, PEÑA, AND LÓPEZ, 2011

Definitive hosts: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Abarca et al. (2011) surveyed feces of dogs maintained as pets of families with immunocompromised children (oncology patients, HIV-positive, or patients after transplantations) in Santiago, Chile. A *Sarcocystis* sp. was detected in 1/41 (2%) dogs.

SARCOCYSTIS SPP. OF BARHAM, STÜTZER, KARANIS, LATIF, AND NEISS, 2005

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: *Capra hircus* L., 1758, Goat.

Remarks: Barham et al. (2005) surveyed goats slaughtered in the winter in northern Iraq and found three morphologically distinct types of sarcocysts, macrocysts (both fat and thin), and microcysts; macrocysts occurred in 281/826 (34%) goats, but these were not identified.

SARCOCYSTIS SPP. OF BARUTZKI AND SCHAPER, 2003

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: During a coprological survey of dogs and cats in Germany, Barutzki and Schaper (2003) examined feces from both hosts in Freiburg, Germany; sarcocysts of *Sarcocystis* spp. were detected in 759/8,438 (9%) samples.

SARCOCYSTIS SP. OF BLAGBURN, BRAUND, AMLING, AND TOIVIO-KINNUCAN, 1989

Definitive host: Unknown.

Intermediate host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Blagburn et al. (1989) found a single sarcocyst in the biceps femoris muscle of a dog in Alabama, USA. The sarcocyst was spheroidal to ovoidal and measured 52 × 47 with a wall thickness of ~2.3. Sarcocyst wall projections were barely visible with the LM, but under TEM they appeared as irregularly-spaced electron-dense projections that were 1.5 × 0.9. Septa were visible in the sarcocyst and contained numerous,

irregularly arranged bradyzoites, but no merozoites were seen. The sarcocyst did not elicit an inflammatory response in the adjacent muscle tissue.

SARCOCYSTIS SPP. OF BUGG, ROBERTSON, ELLIOT, AND THOMPSON, 1999

Definitive host: Unknown.

Intermediate host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Bugg et al. (1999) examined fecal samples of urban dogs from four pet shops, three refuges, six breeding kennels, eight veterinary clinics, and two exercise areas in Perth, Western Australia. *Sarcocystis* sporocysts were detected in 26/421 (6%) samples, mostly in puppies from refuges.

SARCOCYSTIS SP. OF CARLSLAKE, HILL, SJÖLANDER, HIL, PRATTLEY, AND ACKE, 2017

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Carlslake et al. (2017) examined fecal samples from mixed-breed, free-roaming dogs in Samoa, South Pacific. Sporocysts of a *Sarcocystis* spp. were detected in 1/204 (0.5%) dogs.

SARCOCYSTIS SP. OF CAUSAPÉ, QUÍLEZ, SÁNCHEZ-ACEDO, AND DEL CACHO, 1996

Definitive host: Unknown.

Intermediate host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Causapé et al. (1996) examined fecal samples of 37 domestic and 44 stray dogs in

shelters in Zaragoza, Aragón, Spain. *Sarcocystis* sporocysts were found in 1/81 (1%) dogs, a stray.

SARCOCYSTIS SPP. OF CHHABRA, MAHAJAN, GUPTA, AND GAUTAM, 1984

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Chhabra et al. (1984) examined fecal samples of domestic dogs from North India (Delhi, Rishikesh, and Lucknow). Sporocysts of *Sarcocystis* were detected in 2/118 (2%) samples.

SARCOCYSTIS SPP. OF CIRAK AND BAUER, 2004

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Cirak and Bauer (2004) examined fecal samples of dogs from three animal shelters in central Germany; all dogs were without diarrhea. *Sarcocystis* sporocysts were found in 4/270 (1.5%) dogs.

SARCOCYSTIS SP. OF CRUM, FAYER, AND PRESTWOOD, 1981

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: *Odocoileus virginianus* (Zimmermann, 1780), White-tailed Deer.

Remarks: Crum et al. (1981) described *S. odocoileocanis* from sarcocysts in the white-tailed deer and determined that the dog was the definitive host. However, one cat fed sarcocysts from a wild-caught *O. virginianus* from West Virginia, USA, began to shed sporocysts 14 DPI, and sporocysts were detected intermittently between 14 and 38 DPI. These sporocysts measured L×W

(n=35): 11.5×8.1 (11–13×7). No one to our knowledge has yet named this species so it must remain a *species inquirenda*.

SARCOCYSTIS SPP. OF DUBEY, 1980a

Definitive hosts: *Canis latrans* Say, 1823, Coyote; *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate hosts: *Ovis aries* L., 1758, Red Sheep; *Capra hircus* L., 1758, Goat; *Bos taurus* L., 1758, Aurochs; *Alces alces* (L., 1758), Eurasian Elk, Moose; *Bison bison* (L., 1758), American Bison; *Cervus elaphus* L., 1758 (syn. *Cervus canadensis* Erxleben, 1777), Red Deer, Elk, Wapiti.

Remarks: Dubey (1980a) fed 1 kg of tissues from bison, cattle, elk, goats, moose, and sheep to different *Sarcocystis*-free coyotes, and all 12 coyotes shed sporocysts of *Sarcocystis* in their feces with prepatent periods of 9–15 DPI. Dubey (1980a,b) said that sporocysts in coyote feces fed infected musculature of cattle, sheep, goats, and elk were all structurally similar and that this was the first report of the completion of the life cycle of *Sarcocystis* species in moose and bison. One other cross-transmission experiment indicated that one goat *Sarcocystis* species completed its life cycle in both the dog and coyote and that ovine *Sarcocystis* is not transmissible to goats. None of the *Sarcocystis* species were identified, thus all must remain *species inquirendae*.

SARCOCYSTIS SPP. OF DUBEY, CALERO-BERNAL, ROSENTHAL, SPEER, AND FAYER, 2015a

Definitive host: Unknown.

Intermediate hosts: Cattle, Wild Ruminants.

Remarks: Dubey et al. (2015a) listed various *Sarcocystis species inquirendae* from cattle and wild ruminants (27 species) in their Table 24.3. Some of those indeterminant species/forms are

listed here, others are not. The interested reader is referred to their work.

SARCOCYSTIS SPP. OF DUBEY, CALERO-BERNAL, ROSENTHAL, SPEER, AND FAYER, 2015a

Definitive host: Unknown.

Intermediate hosts: Marine carnivores.

Remarks: Dubey et al. (2015a) listed five *Sarcocystis species inquirendae* from a sea lion, bearded seal, ringed seal, northern fur seal, and sea otter in their Table 24.3. Some of those indeterminant species are listed here, others are not. The interested reader is referred to their work.

SARCOCYSTIS SPP. OF DUBEY, CALERO-BERNAL, ROSENTHAL, SPEER, AND FAYER, 2015a

Definitive hosts: Wild carnivores.

Intermediate hosts: Wild carnivores.

Remarks: Dubey et al. (2015a) listed 18 *Sarcocystis species inquirendae* from a variety of wild carnivores (e.g., jackals, otters, raccoons, red foxes, others) in their Table 24.3. Some of those indeterminant species are listed here, others are not. The interested reader is referred to their work.

SARCOCYSTIS SPP. OF DUBEY, CALERO-BERNAL, ROSENTHAL, SPEER, AND FAYER, 2015a

Definitive host: Unknown.

Intermediate hosts: Small mammals.

Remarks: Dubey et al. (2015a) listed 15 *Sarcocystis species inquirendae* from a variety of small mammals (e.g., rabbits, rats, squirrels, others) in their Table 24.3. In most, the definitive hosts are unknown so they are not covered in this book, but a few of those species in which the

definitive host is/may be known are listed here. The interested reader is referred to their work.

**SARCOCYSTIS SP. OF DUBEY,
COSENZA, LIPSCOMB, TOPPER,
SPEER, HOBAN, DAVIS, KINCAID,
SEELY, AND MARRS, JR., 1991a**

Definitive host: Unknown.

Intermediate host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Dubey et al. (1991a) examined a litter of eight dogs born to a primiparous 2-year-old Rottweiler in Maryland, USA. All of the pups had medical issues, but one (dog 1), at 7-weeks-old, was listless and anorectic with mild anemia after surgery for entropion. It was killed 2 days later and specimens of liver and small intestine were examined histologically. Protozoan meronts were seen free in the cytoplasm of hepatocytes adjacent to necrotic foci; the parasites were without a PV, divided by merogony, and resembled *Sarcocystis* structurally and antigenically, as it reacted with *Sarcocystis* antiserum. It was uncertain how the pup became infected, but was noteworthy to find *Sarcocystis* in the visceral tissues of dogs. There was no way to know what species they saw so this must be considered as another *species inquirenda*.

**SARCOCYSTIS SP. OF DUBEY,
DUNCAN, SPEER, AND
BROWN, 1992a**

Definitive host: Unknown.

Intermediate host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Dubey et al. (1992a) examined paraffin-embedded tissue samples of liver, spleen, lungs, and kidneys of a 2-day-old female bullmastiff puppy that died 2½ days after birth. Initially deparaffinized tissues reacted with antisera to *T. gondii*, *N. caninum*, and *S. cruzi*.

To better identify the protozoan, they studied tissue sections for developmental stages, documented some of the pathology, and isolated meronts to find whether they reacted with *S. cruzi* antiserum, but not with antisera to *T. gondii* or *N. caninum*. Lesions were seen in all tissues examined. The main lung lesion was interstitial pneumonia characterized by infiltration of mononuclear cells and neutrophils in the alveolar wall and alveolar hemorrhage and necrosis due to numerous meronts in the vascular endothelium. Hepatic lesions included necrosis of hepatocytes, moderate perivascular infiltration of mononuclear cells, and the presence of meronts and merozoites in hepatocytes and Kupffer cells. Renal lesions showed necrosis of glomeruli associated with all developmental stages of meronts, and multifocal areas of necrosis were present. Mature meronts with merozoites were L×W (n=13): 14–20×10–20, contained 12–28 merozoites, and they are divided by endopolygony. They were located in the host cell cytoplasm without a PV. The authors said, "The parasite was antigenically and structurally identical to the newly named protozoan *Sarcocystis canis* from Rottweiler dogs (Dubey and Speer, 1991)," but they declined to say that *Sarcocystis* found in this Louisiana puppy was *S. canis*.

**SARCOCYSTIS SP. OF DUBEY,
SLIFE, SPEER, LIPSCOMB, AND
TOPPER, 1991c**

Definitive host: Unknown.

Intermediate host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Dubey et al. (1991c) examined a 10-month-old Rottweiler from Illinois, USA that had multiple cutaneous abscesses over its body, particularly in its hind limbs that were swollen, hot, and painful. The dog died shortly after a few biopsies were taken, so portions of skin, liver, lungs, kidney, and lymph nodes were processed for examination. *Toxoplasma gondii*, *N. caninum*,

and *Caryospora* species are parasites that can cause dermatitis and disseminated infection in dogs, but these were all eliminated by not reacting with the appropriate antisera and/or physical structure of the protozoan stages found. Dubey et al. (1991c) concluded, "the present case resembles the *Sarcocystis* parasite that causes fatal encephalomyelitis in horses, cattle, and sheep. Although the central nervous system in the infected dog was not examined, its littermate died of protozoan encephalomyelitis."

SARCOCYSTIS SPP. OF DUBEY AND STREITEL, 1976c

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate hosts: *Ovis aries* L., 1758, Red Sheep; *Bos taurus* L., 1758, Aurochs.

Remarks: Dubey and Streitl (1976c) did cross-infections between dogs, cats, sheep, pigs, and cattle from Iowa or Ohio, USA. Two dogs fed 100 sheep esophagi and hearts from Iowa shed sporocysts, but cats did not. Sporocysts were L×W (n=11): 14.0×9.2 (13–15×9–10), L/W ratio: 1.5 and were shed for >8 days. Dogs shed large numbers of sporocysts and sporulated oocysts for >8 days after ingesting bovine tissue; sporocysts were L×W (n=27): 15.0×9.5 (14–17×8–10), L/W ratio: 1.6. Because cats also shed sporocysts when fed bovine tissues, Dubey and Streitl (1976c) suggested that separate species of *Sarcocystis* parasitize cattle in different areas of the United States, but they did not suggest a name for any of these *Sarcocystis* species.

SARCOCYSTIS SPP. OF DUBNÁ, LANGROVÁ, NÁPRAVNÍK, JANKOVSKÁ, VADLEJCH, PEKÁR, AND FECHTNER, 2007

Original host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Dubná et al. (2007) reported on a survey of canine and ground-collected fecal samples from various areas in and around Prague, and from rural areas in central Bohemia, Czech Republic. Sporocysts of *Sarcocystis* spp. were detected in 24/3,780 (<1%) samples.

SARCOCYSTIS SP. OF ENTZEROTH, 1982b

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: *Capreolus capreolus* (L., 1758), European Roe Deer.

Remarks: Entzeroth (1982b) studied the ultra-structure of gamonts and gametes and fertilization of a *Sarcocystis* species in dogs after they were fed sarcocysts from roe deer in Germany. Unfortunately, he did not attempt to name the species. He may have been dealing with the same species seen by Erber (1978) 4 years earlier (below) and both may have been working with *S. gracilis*, which is now known from the European roe deer. Nonetheless, we can only call it a *species inquirenda* based on the information provided by Entzeroth (1982b).

SARCOCYSTIS SPP. OF ENTZEROTH, SCHOLTYSECK, AND GREUEL, 1978

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: *Capreolus capreolus* (L., 1758), European Roe Deer.

Remarks: In Germany, Entzeroth et al. (1978) fed muscles of roe deer infected with sarcocysts to a coccidia-free fox, dog, and cat (species not stated). After a prepatency of 8 DPI, the fox shed sporulated sporocysts in its feces that were L×W: 14.5×8.5, and after the 11th day, unsporulated oocysts discharged by the fox were 13.1×11.6 and "resembled the small form of *Isospora bigemina* (*Hammondia*)."
The dog shed sporulated sporocysts that were L×W: 15.6×10, with a prepatent

period of 10–14 days, and sporocysts continued to be discharged for 51 days. The cat fed sarcocyst-infected deer meat shed unsporulated oocysts on the 8th DPI that were $L \times W$: 12.2×10.9 . The small isosporan oocysts from the fox and the cat were inoculated into mice; Entzeroth et al. (1978) reported they found typical *Toxoplasma* cysts in the brain of the mice and cysts typical of *Hammondia hammondi* in the muscle of the mice with oocysts from the cat but that “oocysts from the fox did not cause any visible infection in mice.” When they (Entzeroth et al., 1978) examined the muscle sarcocysts in roe deer with the TEM, they said there were three types of sarcosporidian cysts, but nothing else. Thus, more *species inquirendae*.

SARCOCYSTIS SP. OF ENTZEROOTH, STUHT, CHOBOTAR, AND SCHOLTYSECK, 1982b

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: *Odocoileus virginianus* (Zimmermann, 1780), White-tailed Deer.

Remarks: Entzeroth et al. (1982b) found 14/48 (29%) white-tailed deer infected with *Sarcocystis*, with a preference in location for the tongue. This was only about 4 months after Crum et al. (1981) named a species with sarcocysts in white-tailed deer tissue (especially tongue), and dogs as definitive hosts that discharged sporocysts as *S. odocoileocanis*. Entzeroth et al. (1982b) said their sarcocysts were spindle-shaped and measured $300\text{--}620 \times 60\text{--}120$, had a thin wall, and were divided into compartments by septa. They fed a lab-reared dog infected venison flesh and on 14 DPI the dog began to discharge sporulated sporocysts that were $L \times W$: 14.9×10.6 ($13.5\text{--}16.5 \times 9\text{--}11$); patency lasted at least 10 days, after which no fecal samples were checked. This deer/dog cycle is remarkably similar to that described by Crum et al. (1981), and their sporocyst size, prepatent and patent periods also overlap, but the sarcocysts in the Michigan deer were larger than those reported by Crum et al. (1981) in deer from several southeastern

states (e.g., 264×40 ($150\text{--}536 \times 30\text{--}51$) versus $300\text{--}620 \times 60\text{--}120$). Unfortunately, Entzeroth et al. (1982b) were unaware of the paper published by Crum et al. (1981) and they chose not to name their species “until additional details of the life cycle are known.” Thus, their form can only be considered a *species inquirenda*.

SARCOCYSTIS SPP. OF EPE, ISING- VOLMER, AND STOYE, 1993

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Epe et al. (1993), in Germany, surveyed 3,329 fecal samples from dogs between 1984 and 1991 and found 100 (3%) to pass *Sarcocystis* spp. sporocysts, which were not identified to species.

SARCOCYSTIS SPP. OF ERBER, 1978

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: *Capreolus capreolus* (L., 1758), European Roe Deer.

Remarks: Erber (1978) reported three types of sarcocysts in the tongues and abdominal musculature of 391/421 (93%) *C. capreolus*, in West Germany. He fed raw muscles infected with his type 1 and type 2 sarcocysts to dogs, foxes, and cats. On 10–11 DPI, the dogs and foxes shed sporocysts in their feces that were $L \times W$: $16\text{--}18 \times 9\text{--}12$, and the patent period lasted 50 days. The cats did not shed oocysts (Levine and Ivens, 1981). To our knowledge, these forms were never studied again.

SARCOCYSTIS SPP. OF FERREIRA, PENA, AZEVEDO, LABRUNA, AND GENNARI, 2016

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Ferreira et al. (2016) surveyed fecal samples of pet dogs from the metropolitan region of São Paulo, Brazil. *Sarcocystis* sporocysts were detected in 16/3,099 (0.5%) samples, mostly in dogs ≥ 1 -year-old.

SARCOCYSTIS SPP. OF FONTANARROSA, VEZZANI, BASABE, AND EIRAS, 2006

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Fontanarrosa et al. (2006) surveyed fecal samples of dogs in southern Buenos Aires, Argentina and detected sporocysts of *Sarcocystis* in 219/2,193 (10%) samples, mostly in young dogs 0–11-months-old, and its prevalence decreased with increasing age.

SARCOCYSTIS SPP. OF FUNADA, PENA, SOARES, AMAKU, AND GENNARI, 2007

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Funada et al. (2007) examined fecal samples of domestic dogs in the city of São Paulo, Brazil. *Sarcocystis* sporocysts were detected in 25/1,755 (1%) samples.

SARCOCYSTIS SPP. OF GATES AND NOLAN, 2009

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: From 1997 to 2007, Gates and Nolan (2009) studied fecal samples of dogs in Philadelphia, Pennsylvania, USA, and *Sarcocystis* sporocysts were seen in only 5/6,555 (<0.1%) samples.

SARCOCYSTIS SPP. OF GENNARI, KASAI, PENA, AND CORTEZ, 1999

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Gennari et al. (1999) examined fecal samples of domestic dogs from São Paulo, Brazil. *Sarcocystis* sporocysts were found in 6/353 (2%) samples.

SARCOCYSTIS SP. OF GOMPPER, GOODMAN, KAYS, RAY, FIORELLO, AND WADE, 2003

Definitive host: *Canis latrans* Say, 1823, Coyote.

Intermediate host: Unknown.

Remarks: Gompper et al. (2003) said they found sporocysts of a *Sarcocystis* sp. in 3/23 (12.5%) *C. latrans* collected from Black Rock Forest near Cornwall, New York, USA; their identification was based on finding some sporocysts in the feces, so it should be taken with caution.

SARCOCYSTIS SPP. OF HERMOSILLA, KLEINERTZ, SILVA, HIRZMANN, HUBER, KUSAK, AND TAUBERT, 2017

Definitive host: *Canis lupus* L., 1758, Wolf.

Intermediate host: Unknown.

Remarks: Hermosilla et al. (2017) surveyed fecal samples of wild European wolves in mountainous areas of the Gorski Kotar region, Croatia. *Sarcocystis* sporocysts were seen in 76/400 (19%) samples.

SARCOCYSTIS SP. OF HILL, CHAPMAN, JR., AND PRESTWOOD, 1988

Definitive host: Unknown.

Intermediate host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Hill et al. (1988) saw sarcocysts in the myocardium of a 2-year-old, spayed, female

Doberman pinscher in Georgia, USA and said the dog's sarcocysts were similar in size and structure to sarcocysts they found in two cats, when examined by LM and TEM. The minor difference in sarcocysts from the dog (vs. cat sarcocysts) were a thinner layer of ground substance associated with the cyst wall and slightly larger bradyzoites. The cyst wall of both the dog and cats had striations, septa for compartmentalization, and fairly large bradyzoites.

SARCOCYSTIS SPP. OF JANITSCHKE, PROTZ, AND WERNER, 1976

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: *Nanger granti* (Brooke, 1872) (syn. *Gazella granti*), Grant's Gazelle.

Remarks: Janitschke et al. (1976) found sarcocysts in Grant's gazelle in Tanzania, fed infected flesh to both cats and dogs, and reported finding sporocysts and sporulated oocysts in the feces of both. Sporocysts shed by the dog were L×W: 16×11 (13–18×8–12), L/W ratio, 1.45; the prepatent period in the dog was 10 days, and patency lasted 42 days. They thought they were dealing with two *Sarcocystis* species, but without further infection and/or molecular studies, it is not possible to determine which-was-which. Therefore, these must remain *species inquirendae* until they can be differentiated and named. There are at least three *Sarcocystis* species that have been named from gazelles, but only from sarcocysts in their muscle tissues. All three, *S. gazellae* Balfour, 1913, *S. mongolica* Matschoulsky, 1947, and *S. woodhousei* Dogel, 1916, are mentioned in Levine (1986) and in Dubey et al. (2015a), but the carnivore definitive host is not known for any of them. Clearly a lot of work still needs to be done in sorting out the various *Sarcocystis* species in gazelles.

SARCOCYSTIS SPP. OF KATAGIRI AND OLIVEIRA-SEQUEIRA, 2008

Definitive host: Unknown.

Intermediate host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Katagiri and Oliveira-Sequeira (2008) examined fecal samples of 129 stray and 125 pet dogs from urban Botucatu, São Paulo State, Brazil. Samples were examined by multiple techniques. *Sarcocystis* sporocysts were found in 7/254 (3%) samples, 4 from strays and 3 from household dogs.

SARCOCYSTIS SPP. OF KING, BROWN, JENKINS, ELLIS, FLEMING, WINDSOR, AND ŠLAPETA, 2012

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: King et al. (2012) mentioned briefly in the discussion of their paper on the presence of *N. caninum* in Australian Aboriginal dogs that they had seen "*Sarcocystis* spp. sporocysts in many of the dog feces examined," but gave no other information.

SARCOCYSTIS SPP. OF MCKENNA AND CHARLESTON, 1980d

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: McKenna and Charleston (1980d) examined fecal samples from domestic dogs on the North Island of New Zealand and found 283/481 (59%) samples had oocysts/sporocysts they identified as *Sarcocystis* spp.

SARCOCYSTIS SPP. OF MELONI, THOMPSON, HOPKINS, REYNOLDS, AND GRACEY, 1993

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Meloni et al. (1993) examined fecal samples of dogs from eight Aboriginal communities located in the tropical west Kimberley region, Western Australia. Fecal samples were examined by direct stool microscopy and zinc sulfate flotation. *Sarcocystis* sporocysts were seen in 8/182 (4%) samples.

SARCOCYSTIS SPP. OF PALMER, THOMPSON, TRAUB, REES, AND ROBERTSON, 2008a

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Palmer et al. (2008a) surveyed fecal samples of dogs from urban and rural areas across Australia, including 810 samples (59 veterinary clinics) and 590 samples (26 refuges). *Sarcocystis* sporocysts were found in 50/1,400 (4%) dogs, mostly from vet clinics.

SARCOCYSTIS SP. OF PECKA, 1990

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: *Phasianus colchicus* L., 1758, Common or Ring-necked Pheasant.

Remarks: Pecka (1990) found 3/90 (3%) pheasants, from two pheasant farms in the Czech Republic, infected with a *Sarcocystis* species with banana-shaped cystozoites, 6×2, and 46/90 (51%) were infected with a *Sarcocystis* species with lancet-shaped cystozoites, 14–16×2–3. A dog was infected experimentally with the latter species and pheasants were successfully reinfected, presumably with sporocysts from the dog, but this was not stated. Pecka (1990) said he suspected foxes to be the main final host for the pheasant species. No other information was given.

SARCOCYSTIS SP. OF SAHASRABUDHE AND SHAH, 1966

Definitive host: Unknown.

Intermediate host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Sahasrabudhe and Shah (1966) reported finding sarcocysts in the muscles of an esophageal nodule of a dog in India. These sarcocysts had no septa, were 110–250 wide, and contained thousands of crescent-shaped merozoites, 4–5×1.5. They said that theirs was the first report of a *Sarcocystis* species from a domestic carnivore.

SARCOCYSTIS SPP. OF SALB, BARKEMA, ELKIN, THOMPSON, WHITESIDE, BLACK, DUBEY, AND KUTZ, 2008

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Salb et al. (2008) examined fresh fecal samples of dogs presented to veterinary clinics from two remote northern Canadian communities (Fort Chipewyan, Alberta, Fort Resolution, Northwest Territories). The authors detected *Sarcocystis* sporocysts, but the number of positive samples and further details were not provided.

SARCOCYSTIS SPP. OF SORIANO, PIERANGELI, ROCCIA, BERGAGNA, LAZZARINI, CELESCINCO, SAIZ, KOSSMAN, CONTRERAS, ARIAS, AND BASUALDO, 2010

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Soriano et al. (2010) surveyed dog fecal samples in urban (646 samples) and rural (1,298 samples) areas of Neuquén province, Patagonia, Argentina. *Sarcocystis* sporocysts were found in 110/1,944 (6%) samples, mostly from rural areas (99 of 110 samples).

SARCOCYSTIS SPP. OF STREITEL AND DUBEY, 1976

Definitive host: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: Unknown.

Remarks: Streitl and Dubey (1976) surveyed feces from stray dogs in a humane shelter in Ohio, USA and found only 9/500 (2%) samples to have sporocysts of a *Sarcocystis* species. The sporocysts measured L×W: 13.5–16.2×8–11, but the species was neither identified nor was there an attempt to transmit it to another animal; thus, another *species inquirenda*.

SARCOCYSTIS SPP. OF STRONEN, SALLOWES, FORBES, WAGNER, AND PAQUET, 2011

Definitive host: *Canis lupus* L., 1758, Wolf.

Intermediate host: Unknown.

Remarks: From 2001 to 2005, Stronen et al. (2011) surveyed fecal samples of gray wolves from Riding Mountain National Park, south-western Manitoba, Canada. *Sarcocystis* sporocysts were seen in 224/601 (37%) samples.

SARCOCYSTIS SPP. OF WEI, CHANG, DUONG, WANG, AND XIA, 1985

Definitive hosts: *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog; or *Felis catus* L., 1758, Domestic Cat.

Intermediate host: *Bos grunniens* L., 1766 (syn. *Poephagus grunniens* Gray, 1843), Yak.

Remarks: Wei et al. (1985) named two species of *Sarcocystis* from yaks, using LM, TEM, and SEM to distinguish between their sarcocysts, *S. poephagi* and *S. poephagicanis*. Wei et al. (1989) then examined 23 3–5-month-old fetuses taken from slaughtered yaks in Gan Su province, China and examined their tissues (heart, liver, kidney, mesenteric lymph nodes, femoral and diaphragm muscles, intestines) histologically for sarcocysts. They detected sarcocysts in 6/23 (26%) fetuses, three in diaphragm and three in myocardium and found meronts, but not clear merozoites. They did not name the species of *Sarcocystis*, even though they had named the only two known species in yaks (Wei et al., 1985) and did cross-transmission work with both species a year later (Wei et al., 1990). This was not the first time that various stages of sarcocyst development were seen in fetal tissue; earlier, Munday and Black (1976) had reported *Sarcocystis* spp. in brain tissue of two aborted bovine fetuses, and Hong et al. (1982) found the vascular epithelium over all body parts contained immature and mature meronts of *Sarcocystis* in aborted bovine fetuses. These two studies, and their own work (Wei et al., 1985), led them to conclude that at least some *Sarcocystis* species can be transmitted vertically from naturally-infected mothers to their fetuses. This is certainly an area that deserves further exploration.

SARCOCYSTIS SPP. OF WESEMEIER, ODENING, WALTER, AND BOCKHARDT, 1995

Definitive host: Unknown.

Intermediate host: *Canis mesomelas* Schreber, 1775, Black-backed Jackal.

Remarks: Wesemeier et al. (1995) examined fixed tissue sections of pieces of tongue from 25 black-backed jackals from Namibia in 1993.

In one tongue (4%), using LM and TEM, they found two structurally different sarcocysts. Type 1 sarcocysts had a thick wall and were textured, palisade-like, and villar protrusions had a finger-shaped outline that arose from the cyst wall. These protrusions were interwoven with microtubules in the core and showed small invaginations on their surface; the microtubules did not penetrate into the ground substance. Type 2 sarcocysts had a relatively thin wall and showed minute, naplike elevations on the surface; villar protrusions arose from the cyst walls that were flat and mushroom-like with granules in their core. Apparently, finding sarcocysts in top carnivores is not uncommon, but no other information on these, apparently different, *Sarcocystis* species has not been forthcoming, to our knowledge, so they must remain *species inquirendae*.

GENUS CHRYSOCYON C.E.H. SMITH, 1839 (MONOTYPIC)

CRYPTOSPORIDIUM SP. OF GILIOLI AND SILVA, 2000

Definitive host: *Chrysocyon brachyurus* (Illiger, 1815), Maned Wolf.

Remarks: Gilioli and Silva (2000) looked at fecal samples of captive maned wolves from 11 zoos in the state of São Paulo, Brazil; they found 6/31 (19%) wolves had oocysts in their feces that they identified only as *Cryptosporidium* sp.

EIMERIA SP. OF GILIOLI AND SILVA, 2000

Definitive host: *Chrysocyon brachyurus* (Illiger, 1815), Maned Wolf.

Remarks: Gilioli and Silva (2000) looked in fecal samples of captive maned wolves from 11 zoos in the state of São Paulo, Brazil; they found

3/31 (10%) wolves had oocysts in their feces that they identified only as *Eimeria* sp.

ISOSPORA SP. OF GILIOLI AND SILVA, 2000

Definitive host: *Chrysocyon brachyurus* (Illiger, 1815), Maned Wolf.

Remarks: Gilioli and Silva (2000) looked in fecal samples of captive maned wolves from 11 zoos in the state of São Paulo, and found that 1/31 (3%) wolves had oocysts in their feces that they determined only as *Isoospora* sp.

SARCOCYSTIS SP. OF GILIOLI AND SILVA, 2000

Definitive host: *Chrysocyon brachyurus* (Illiger, 1815), Maned Wolf.

Intermediate host: Unknown.

Remarks: Gilioli and Silva (2000) looked in fecal samples of captive maned wolves from 11 zoos in the state of São Paulo, and found that 9/31 (29%) wolves had oocysts/sporocysts in their feces that they determined only as *Sarcocystis* sp.

GENUS CUON HODGSON, 1838 (MONOTYPIC)

SARCOCYSTIS SP. OF JOG, MARATHE, GOEL, RANADE, KUNTE, AND WATVE, 2003; SARCOCYSTIS AXICUONIS (?) OF JOG, MARATHE, GOEL, RANADE, KUNTE, AND WATVE, 2005

Definitive host: *Cuon alpinus* (Pallas, 1811), Dhole.

Intermediate host: *Axis axis* (Erxleben, 1777), Chital.

Remarks: Jog et al. (2003) surveyed both *C. alpinus* and *A. axis* in two protected areas near Maharashtra, India, the Mudumalai National

Park and Wildlife Sanctuary in Tamil Nadu and Tadoba National Park, in both areas chital is the most predominant ungulate species. They reported that chital is the *intermediate host* for *Sarcocystis* species in dhole. Dhole scats were sampled from 1998 to 2001, and 184/239 (77%) scats from Tadoba and 161/209 (77%) scats from Mudumalai were positive for sporocysts of a *Sarcocystis* species. Sporocysts measured $L \times W$: 16×10 , L/W ratio: 1.6, and it was common for densities of 5,000–10,000, up to 26,000, sporocysts/g of feces. Skeletal and heart muscles of chital killed by dhole, or found dead due to other causes, were collected for histopathological examination, but Jog et al. (2003) never definitively stated the number of tissue samples of chital they examined for sarcocysts. They only said that sarcocysts were small, usually <1 mm long, they were not compartmentalized, and “there was no distinct cyst wall” (?). They also said the sarcocysts were found in large numbers in the heart (prevalence 50%) and skeletal muscles (19.5%) collected from Tadoba, whereas in samples collected from Mudumalai, the prevalences were 45% and 48%, respectively. Because neither chital nor dhole are available for experimentation in India, they were unable to demonstrate the life cycle directly; however, Jog et al. (2003) were convinced of the chital–dhole life cycle because of: (1) the consistent occurrence of sarcocysts in chital and sporocysts in dhole; (2) the high proportions of chital among dhole kills; (3) the absence or very low prevalence of sporocysts in other carnivores in the region; and (4) the failure to infect domestic dogs via feeding them chital sarcocysts. Jog et al. (2005) used the same data from their 2003 paper to investigate ecological and coevolutionary aspects of this relationship. Importantly, with no more information than they provided in their 2003 paper, or addressing the guidelines for naming new species, they named the coccidian, *Sarcocystis axicuonis*. Results of their analyses indicated that sarcocyst density in heart muscles of dhole kills was greater than in chital that died of other causes, and density of sarcocysts in skeletal

muscle did not differ between dhole kills and nondhole kills. Jog et al. (2005) further argued that, if *Sarcocystis* infection in chital does not alter the probability of death due to other causes, then the effect of infection increased the probability of death due to dhole predation. Large numbers of cysts in heart muscle may negatively affect chital stamina making infected chital more susceptible to pack predators (dhole), than stalkers (tigers and leopards), which reinforces the parasite–prey and parasite–host relationships in this system. Jog et al. (2005) argued that if dhole kill more infected than uninfected chital, they are “benefited” by the parasite but, is there a cost to dhole to effectively disseminate the parasite? Dhole scat with large numbers of sporocysts was not diarrheic or otherwise abnormal, which suggested to them that infection in dhole is not pathogenic but no quantitative assessment was conducted. They noted that parasites were overdispersed in the dhole pack (i.e., only a few pack members were passing large numbers of sporocysts at any time). From these observations, they made the interesting suggestion that if carrying the parasite negatively impacts hunting efficiency, then uninfected dhole may do most of the hunting, and if consistent, the “cost” would be negligible to the dhole pack. Maintaining this division of labor between infected and uninfected dhole would be maintained if infected dhole preferentially ate heart tissue with high densities of cysts, and uninfected dhole ate other tissues with no/low densities. Unfortunately, they noted there are no parasite-free dhole–chital populations to serve as a control to estimate actual costs of infection in the two hosts, thus precluding demonstration of cost-benefit analysis of *Sarcocystis* infection to dhole. If readers are interested, Jog and Watve (2005) further developed their theoretical examination and modeling of parasite–host coevolution and development of mutualistic interactions using the dhole–chital *Sarcocystis* model. Unfortunately, Jog et al. (2003, 2005) never completed the basic process of properly naming the *Sarcocystis* they studied, so it must remain a *species inquirenda*.

**GENUS LYCALOPEX
BURMEISTER, 1854 (6 SPECIES)**

**ISOSPORA SP. OF JIMÉNEZ, BRICEÑO,
ALCAÍO, VÁSQUEZ, FUNK, AND
GONZÁLEZ-ACUÑA, 2012**

Original host: *Lycalopex* (syn. *Pseudalopex*) *fulvipes* (Martin, 1837), Darwin's Fox.

Remarks: Jiménez et al. (2012) did a fecal survey of Darwin's foxes from seven areas of Chiloe Island, Chile; they found 4/189 (2%) foxes to shed *Isospora* sp. oocysts in three of these areas (Huillinco, Lliuco, Quilán). No other information was given.

**GENUS LYCAON BROOKES, 1827
(MONOTYPIC)**

**ISOSPORA SP. OF BERENTSEN,
BECKER, STOCKDALE-WALDEN,
MATANDIKO, MCROBB, AND
DUNBAR, 2012**

Original host: *Lycaon pictus* (Temminck, 1820), African Wild Dog.

Remarks: Berentsen et al. (2012) surveyed *L. pictus* and other African carnivore species from the Luangwa Valley, Zambia, for gastrointestinal parasites; they reported *Isospora* species in 1/13 (8%) wild dogs but gave no other information about this parasite.

**ISOSPORA SP. OF FLACKE,
SPIERING, COOPER, GUNTHER,
ROBERTSON, PALMER, AND
WARREN, 2010**

Original host: *Lycaon pictus* (Temminck, 1820), African Wild Dog.

Remarks: Flacke et al. (2010) surveyed fecal samples of *L. pictus* from the KwaZulu-Natal province, South Africa, for internal parasites; they

reported *Isospora* species in 2/12 (17%) wild dogs but gave no other information about this parasite.

**SARCOCYSTIS SP. OF BERENTSEN,
BECKER, STOCKDALE-WALDEN,
MATANDIKO, MCROBB, AND
DUNBAR, 2012**

Definitive host: *Lycaon pictus* (Temminck, 1820), African Wild Dog.

Intermediate host: Unknown.

Remarks: Berentsen et al. (2012) surveyed wild dogs and other African carnivore species from the Luangwa Valley, Zambia, for gastrointestinal parasites; they reported a *Sarcocystis* species in 12/13 (92%) *L. pictus* but gave no other information about this parasite.

**SARCOCYSTIS SP. OF FLACKE,
SPIERING, COOPER, GUNTHER,
ROBERTSON, PALMER, AND
WARREN, 2010**

Definitive host: *Lycaon pictus* (Temminck, 1820), African Wild Dog.

Intermediate host: Unknown.

Remarks: Flacke et al. (2010) surveyed *L. pictus* in the KwaZulu-Natal province, South Africa, for parasites; they found sporocysts of a *Sarcocystis* sp. in 12/12 (100%) fecal samples from *L. pictus* but gave no other information. Knowledge on the parasites of this dog could prove important to its future survival because *L. pictus* is currently the most endangered carnivore in South Africa, with its total population estimated to be only 300–400 individuals.

**SARCOCYSTIS SP. OF PENZHORN,
DURAND, LANE, IDE, AND
HOFMEYR, 1998**

Definitive host: *Lycaon pictus* (Temminck, 1820), African Wild Dog.

Intermediate host: Unknown.

Remarks: Penzhorn et al. (1998) euthanized and necropsied a terminally ill, subadult female *L. pictus*, and isolated scrapings of the intestinal mucosa; thin-walled sporulated oocysts and many free sporocysts were found, consistent with *Sarcocystis* species. Two oocysts measured 21×15 and 19×16 . Sporocysts were $L \times W$ ($n=12$): 15.7×10.2 ($14-17 \times 9-11$), L/W ratio: 1.5; and SZ ($n=4$) measured $9-11 \times 2$ (10.3×2). On histological examination, they saw large numbers of thin-walled, sporulated oocysts, each with two sporocysts and four crescent-shaped SZ with prominent N in their caudal third. Oocysts were present in the lamina propria at the tips of almost all small intestinal villi but there was no evidence of inflammatory reaction or tissue necrosis.

GENUS NYCTEREUTES TEMMINCK, 1838 (MONOTYPIC)

CRYPTOSPORIDIUM SP. OF MATSUBAYASHI, TAKAMI, KIMATA, NAKANISHI, TANI, SASAI, AND BABA, 2005

Original host: *Nyctereutes procyonoides* (Gray, 1834), Raccoon Dog.

Remarks: Matsubayashi et al. (2005) surveyed fecal samples of one captive raccoon dog, at the Osaka Municipal Tennoji Zoological Gardens in Osaka City, Japan and reported ovoidal oocysts of a *Cryptosporidium* sp. measuring 4–5 wide. The animal was asymptomatic.

CRYPTOSPORIDIUM SP. OF OSTEN-SACKEN, SŁODKOWICZ- KOWALSKA, PACON, SKRZYPCZAK, AND WERNER, 2017

Original host: *Nyctereutes procyonoides* (Gray, 1834), Raccoon Dog.

Remarks: Osten-Sacken et al. (2017) surveyed endoparasites from the latrines of *N. procyonoides*

in two areas of western Poland. They collected 38 samples in Ujście Warty National Park, and 13 in the Bogdaniec Forestry District. Numerous oocysts of a *Cryptosporidium* sp. measuring $3-6 \times 4-6$, were detected in 17/51 (33%) samples.

SARCOCYSTIS SP. OF BRITOV, 1970

Definitive host: Unknown.

Intermediate host: *Nyctereutes procyonoides* (Gray, 1834), Raccoon Dog.

Remarks: Levine and Ivens (1981) listed this form and said that sarcocysts were found in the muscles of the raccoon dog in Primorye (former USSR). However, neither Pellérdy (1974) nor Levine and Ivens (1981), nor Levine (1986), nor Dubey et al. (2015a,b) listed the original reference (Britov, 1970), nor does it come up in Google Scholar.

SARCOCYSTIS SP. OF KUBO, OKANO, ITO, TSUBOTA, SAKAI, AND YANAI, 2009

Definitive host: Unknown.

Intermediate host: *Nyctereutes procyonoides viverrinus* Temminck, 1838, Japanese Raccoon Dog.

Remarks: Kubo et al. (2009) examined 65 free-living carnivores on Honshu Island for muscle sarcocysts of *Sarcocystis*; 12 Japanese raccoon dogs had sarcocysts in their muscles, but no inflammatory host response was associated with them. Ultrastructurally, the sarcocyst wall was thin and showed minute undulations. Kubo et al. (2009) said these sarcocysts were similar to sarcocysts seen in the Japanese red fox (*V. v. japonica*) and Japanese martens (*M. m. melampus*) during the same survey. This was the first published report of muscular sarcocystosis in Japanese carnivores. There was no attempt to identify to species so this form is a *species inquirenda*.

**SARCOCYSTIS SP. OF KUBO,
KAWACHI, MURAKAMI, KUBO,
TOKUHIRO, AGATSUMA, ITO,
OKANO, ASANO, FUKUSHI,
NAGATAKI, SAKAI, AND YANAI,
2010b**

Definitive host: Unknown.

Intermediate host: *Nyctereutes procyonoides viverrinus* Temminck, 1838, Japanese Raccoon Dog.

Remarks: Kubo et al. (2010b) found a free-living, adult male, Japanese raccoon dog in Gifu, Japan; the dog was weak, emaciated, and had neurological signs including head tilt, tremor, and tic. At necropsy, microscopic examination showed severe meningoencephalitis associated with asexual developmental stages consistent with *Sarcocystis* spp. Immunohistochemical tests were negative for *T. gondii* and *N. caninum* but weakly positive with antiserum specific for *S. cruzi*. Analysis of the partial 18S rRNA gene sequence indicated to Kubo et al. (2010b) that this form was most closely related to an unidentified *Sarcocystis* species isolated from the white-fronted goose (*Anser albifrons*). For the moment, this can only be considered a *species inquirenda*.

**GENUS VULPES FRISCH,
1775 (12 SPECIES)**

**COCCIDIA OF CRIADO-FORNELIO,
GUTIERREZ-GARCIA, RODRIGUEZ-
CAABEIRO, REUS-GARCIA,
ROLDAN-SORIANO, AND
DIAZ-SANCHEZ, 2000**

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Criado-Fornelio et al. (2000) did a fecal survey of wild red foxes in three valleys of Tajo basin (Jarama, Henares, and Sorbe) in Guadalajara province, central Spain. "Coccidia oocysts (*Isospora* spp.)" were detected in 2/67 (3%) foxes (1 each from Jarama, Henares).

**COCCIDIA OF WILLINGHAM,
OCKENS, KAPEL, AND
MONRAD, 1996**

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Willingham et al. (1996) surveyed the feces of road-killed red foxes in metropolitan Copenhagen, Denmark; "coccidia oocysts" were detected in 2/68 (3%) foxes, mostly juveniles, but no other information was given.

**CRYPTOSPORIDIUM SP. OF
ELMORE, LALONDE, SAMELIUS,
ALISAUSKAS, GAJADHAR, AND
JENKINS, 2013**

Original host: *Vulpes* (syn. *Alopex*) *lagopus* (L., 1758), Arctic or Blue Fox.

Remarks: Elmore et al. (2013) examined fecal samples of Arctic foxes collected from the central Canadian Arctic (Karrak Lake ecosystem, central Nunavut, Canada). *Cryptosporidium* sp. oocysts were detected in 9/95 (9%) samples. The species was not identified.

**CRYPTOSPORIDIUM SP.
OF HAMNES, GJERDE, FORBERG,
AND ROBERTSON, 2007a**

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Hamnes et al. (2007a) collected feces from wild Norwegian red foxes and examined them for *Giardia* and *Cryptosporidium* spp. Only 6/269 (2%) foxes had *Cryptosporidium* oocysts in their feces. Hamnes et al. (2007a) did PCR of the *Cryptosporidium* 18S rRNA gene but it did not yield positive results, so they could not identify the *Cryptosporidium* species or genotype. They said that the size, morphology, and morphometry of all the oocysts seen were consistent with those described for *C. parvum* and other *C. parvum*-like species, including *C. canis*.

**CRYPTOSPORIDIUM SP. OF
RAVASZOVA, HALANOVA,
GOLDOVA, VALENČAKOVA,
MALČEKOVA, HURNÍKOVÁ,
AND HALAN, 2012**

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Ravaszova et al. (2012) examined feces of *V. vulpes* from central and eastern Slovakia from June 2010–March 2011, using *in vitro* immunoassay for the quantitative detection of the *Cryptosporidium* antigen by the sandwich ELISA method. They said 24/62 (39%) samples were positive. They said that stained fecal smears using LM was a less sensitive method, with only 13/62 (21%) positive samples.

**CRYPTOSPORIDIUM SP.
OF STURDEE, CHALMERS,
AND NULL, 1999**

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Sturdee et al. (1999) detected what they said was *C. parvum* in 22/184 (12%) red fox fecal samples tested with a genus-specific monoclonal antibody for *C. parvum*. Their results purportedly emphasized the widespread distribution of *Cryptosporidium* among wild mammals in Britain and allowed them to suggest the potential for transmission between wild mammals, via direct exposure, to those using the countryside for professional or recreational purposes (e.g., farmers and ramblers).

**CRYPTOSPORIDIUM SPP.
OF ZHOU, FAYER, TROUT,
RYAN, SCHAEFER III, AND
XIAO, 2004**

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Zhou et al. (2004) collected the feces of 471 wild mammals from four counties in the Chesapeake Bay area of Maryland, USA, and found 6/76 foxes (8%), presumably *V. vulpes* (?) (the host binomial was not stated), to be infected with the *C. canis* fox genotype (4), the *C. canis* dog genotype (1), and a *Cryptosporidium* muskrat genotype (1). The species and genotypic nature of *Cryptosporidium* in each fecal sample was determined by a PCR-restriction fragment length polymorphism (RFLP) method based on the small-subunit rRNA gene.

**EIMERIA IMANTAUICA
OF NUKERBAEVA AND
SVANBAEV, 1973**

Original host: *Vulpes* (syn. *Alopex*) *lagopus* (L., 1758), Arctic or Blue Fox.

Remarks: Nukerbaeva and Svanbaev (1973) said they found this form in 30/1,089 (3%) Arctic foxes in Kazakhstan of the former USSR. Their oocysts were ellipsoidal, 14×10 (13–15×8–11), L/W ratio: 1.4, with a 2-layered wall, ~1 thick; OR: present; M, PG: both absent. Sporocysts were ellipsoidal, 6–7×3–4, SB, SSB, PSB, SR: all absent. Nukerbaeva and Svanbaev (1973) presented a modest line drawing, but little structural data and this species has not been seen since its original description.

**EIMERIA MESNILI OF
RASTÉGAÏEFF, 1929c**

Original host: *Vulpes* (syn. *Alopex*) *lagopus* (L., 1758), Arctic or Blue Fox.

Remarks: Rastégaïeff (1929c) published a note préliminaire naming this “species” from oocysts in the feces of an Arctic fox collected in Murmansk Oblast, northern Russia, on the south side of the Barents Sea. Oocysts were spheroidal to ovoidal, 18×11–14, with a 1-layered wall

and a M occupying the entire small end of the oocyst, which lacked an OR. Sporocysts were ellipsoidal. Pellérdy (1974a) questioned whether this was a real species (?) of the fox, and Levine and Ivens (1981) thought it looked like a rabbit coccidium. Rastégaïeff (1930) said she found it in the same fox on both October 10 and November 19, 1928. Levine and Ivens (1981) indicated they had seen a very poor line drawing, but we have a copy of her (1929) preliminary note, which does not have a line drawing. Unfortunately, she named the species in honor of Professor F. Mesnil, Laboratory of the Parasitology School, Leningrad, but this can only be considered a *species inquirenda*.

EIMERIA SP. OF GOLEMANSKY AND RIDZHAKOV, 1975

Original host: *Vulpes vulpes* (L., 1758), (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Golemansky and Ridzhakov (1975) said they found oocysts of an unnamed *Eimeria* sp. in 6/146 (4%) red foxes in Bulgaria with oocysts that were L×W: 33×20 (28–38×17–23) and had sporocysts that measured 13–15×8–10, without a SB. They said these likely were a pseudoparasite of the fox, probably oocysts of a rabbit species just passing through the gut of the fox. We agree.

EIMERIA SPP. OF MAGI, MACCHIONI, DELL'OMODARME, PRATI, CALDERINI, GABRIELLI, IORI, AND CANCRINI, 2009

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Magi et al. (2009) examined fecal samples of red foxes in Tuscany (Cecina, Grosseto, Pisa, Siena), central Italy. Samples were examined by “coprological methods and

microscopy,” and “oocysts of *Eimeria* spp.” were detected in 10/110 (9%) samples.

EIMERIA VULPIS OF GALLI-VALERIO, 1929b

Original host: *Vulpes vulpes* (L., 1758), (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Galli-Valerio (1929a) found this form in *V. vulgaris* collected at 1,650 m, in the Val de Bagnes, Switzerland; oocysts were ovoidal, with one end “barely flattened” as a nearly invisible M, measured 17×14, with ovoidal sporocysts, each 6×4.5, and contained two SZ, ~4×2.4. A year later he found this species in another *V. vulgaris* collected on Fignards Mountain near Torgon, Switzerland (Galli-Valerio, 1930). Watkins and Harvey (1942) reported this species in 11/52 (21%) silver fox cubs dying in England and reportedly found it in ~10% of the adults and perhaps 25% of the fox cubs from 15 fox farms in England. Svanbaev (1960) reported it in 4/18 (22%) silver foxes in the Alma Atinsk Oblast, Kazakhstan and said the oocysts sporulated in 3–4 days at 25°C in 2% K₂Cr₂O₇ solution. Golemansky and Ridzhakov (1975) said they found oocysts of this species in the feces of 15/146 (10%) foxes in Bulgaria. Combining descriptive features from these other authors, the sporulated oocysts are ovoidal; number of walls, 1 (?); wall characteristics: smooth, colorless, 0.8–1.5 thick; L×W: 17×14 (16–26×12–24), L/W ratio: 1.2; M; barely visible or absent; OR, PG: both absent. Likewise, sporocysts may be ovoidal to ellipsoidal; L×W: 6×4.5 (5–6×3–6); L/W ratio: 1.3; SB, SSB, PSB: all absent; SR: present; SZ: comma-shaped, 4–5×2. Frank (1978) said she found this species in *V. vulpes* trapped near Lake Neusiedl, Austria, on the border with Hungary. Nonetheless, no published description to date has provided either a line drawing or a photomicrograph of a sporulated oocyst. Thus, this form must be relegated as a *species inquirenda*.

HAMMONDIA SP. OF DAHLGREN AND GJERDE, 2010b

Original hosts: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox; *Vulpes* (syn. *Alopex*) *lagopus* (L., 1758), Arctic or Blue Fox.

Remarks: Dahlgren and Gjerde (2010b) infected six of each fox species with fresh portions of esophagus, diaphragm, and abdominal muscles from moose, *Alces alces*, from Norway. They reported unsporulated, subspheroidal *Hammondia* oocysts were found in the mucus along the entire posterior half of the small intestine in one of each species of fox killed on the 7th DPI and a few *Hammondia* oocysts also found in the ileum of one silver fox killed on 14 DPI. Oocysts were shed in large numbers during the first 1–5 days of patency, then in small numbers or intermittently thereafter; patency began ~13–14 DPI after foxes ingested moose meat. *Hammondia* oocysts were detected microscopically in 11/12 foxes that ingested moose flesh (their Table 2, p. 1552), and samples from 7 foxes, 4 *V. vulpes* and 3 *V. lagopus*, were positive on agarose gels after PCR using *Hammondia*-specific primers. Moose previously were reported to be an intermediate host of *H. heydorni* infecting dogs (Dubey and Williams, 1980), but this was the first report of moose as intermediate host of a *Hammondia* species infecting foxes. Citing recent molecular comparisons of *Hammondia* isolates from dogs and foxes, Dahlgren and Gjerde (2010b) suggested that the *Hammondia* oocysts they found in red and arctic foxes in Norway might be different from *H. heydorni* known from dogs.

ISOSPORA CANIVELOCIS-LIKE OOCYSTS OF DAHLGREN AND GJERDE, 2010b

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Dahlgren and Gjerde (2010b) found oocysts in the feces of one fox, on the 8th DPI,

which measured ~35 × 25, and “resembled those of *Isospora canivelocis*.” No other information was given.

ISOSPORA-LIKE OF STUART, GOLDEN, ZINTL, DE WAAL, MULCAHY, MCCARTHY, AND LAWTON, 2013

Original host: *Vulpes vulpes* (L., 1758), (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Remarks: Stuart et al. (2013) surveyed fecal samples of red foxes killed throughout Ireland, and “*Isospora*-like oocysts” were seen in 8/91 (9%) samples, but no other information was given.

ISOSPORA VULPIS OF GALLI-VALERIO, 1931

Synonym: *Eimeria vulpes* Patnaik and Acharjyo, *lapsus*.

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox.

Remarks: Galli-Valerio (1931) measured oocysts that were 25 × 24, with a visible M, and two sporocysts each with four SZ, but gave no other measurements or qualitative descriptive information and then named this “species” as new! His description was less than marginal and he did not provide a line drawing or photomicrograph as a type. Nonetheless, Svanbaev and Rachmatullina (1971) said they found it in 6/85 (7%) common foxes (*V. vulpes*). The oocysts they studied were ovoidal (25–28 × 20–22) or spheroidal (25–28 wide), light gray, with a bilayered smooth wall, ~2 thick, and M, OR, and PG all absent. Sporocysts were ovoidal (14–17 × 11–14), without SB, SSB, and PSB. Golemansky and Ridzhakov (1975) measured oocysts that were 20–23 × 18–21. The measurements by Galli-Valerio (1931) suggest that many of the oocysts measured were end-on views resulting in the mean

of the measurements to be erroneously more spheroidal. It is possible that this is *Isospora ohioensis*, *Isospora neorivolta*, or *Isospora burrowsi*, but the oocyst sizes are somewhat larger suggesting *Isospora vulpis* Galli-Valerio, 1931 may represent a separate species. The exception is Golemansky and Ridzhakov (1975), who may indeed have seen a member of the *Isospora ohioensis*-complex. It is likely that Bledsoe (1976a,b) actually was working with *I.* (=C.) *vulpis* rather than *I.* (=C.) *vulpina*. However, Galli-Valerio (1931) stated that the oocysts had a micropyle and his measurements suggest subspheroidal rather than ellipsoidal oocysts. It is likely that he was in error on both accounts and that the description by Svanbaev and Rachmatullina (1971) is the most accurate. Unfortunately, however, no published description to date has provided either a line drawing or a photomicrograph of a sporulated oocyst. Thus, this form must be relegated to a *species inquirenda*.

ISOSPORAS SP. (ASHFORD, 1977) OF LEVINE AND IVENS, 1981

Synonym: *Hammondia* sp. Ashford, 1977.

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox.

Remarks: Levine and Ivens (1981) placed this form in the genus *Isospora*, but it is probably best left a *species inquirenda*. Ashford (1977) found some oocysts, 14 × 12 in the feces of 1/22 (4.5%) red foxes in England. He (Ashford, 1977) said the oocysts resembled those of "*Hammondia hammondi*", but they were not infective for mice so he suggested they might belong to another species of *Hammondia*. Levine and Ivens (1981) thought it could just as well be an *Isospora* or a *Besnoitia* species. It is probably best relegated to a *species inquirenda*.

KLOSSIA SP. OF GOLEMANSKY AND RIDZHAKOV, 1975

Original host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox.

Remarks: Golemansky and Ridzhakov (1975) found oocysts in 2/146 (1%) red foxes in Bulgaria and measured a few; oocysts were L × W: 38 × 33 (30–52 × 25–35) and contained 5–16 spheroidal sporocysts that were about 11–12 wide, without a SB, but with a SR consisting of many residual granules. They likely had found oocysts of an *Adelina* sp. from an arthropod or annelid and this was a spurious finding.

SARCOCYSTIS CORSACI PAK, 1979

Definitive host: Unknown.

Intermediate host: *Vulpes corsac* (L., 1758), Corsac Fox.

Remarks: Levine (1986) listed this species as a valid, named *Sarcocystis* species, but gave no other information. Odening (1998) said that Pak (1979) named this species from sarcocysts found in the corsac fox, but specimens were not preserved so follow-up molecular examination of the specimens cannot be done. Gjerde and Schulze (2014) suggested that because the specimen described is unrecognizable today, it should be considered a *species inquirenda* and its name should become a *nomina dubia*. Neither Levine (1986) nor the three of us were able to secure a copy of the original paper, so we must concur with the opinion of Gjerde and Schulze (2014). We do, however, list its complete citation in our References.

SARCOCYSTIS GRACILIS-LIKE OF GIANNETTO, POGLAYEN, BRIANTI, GAGLIO, AND SCALA, 2005

Definitive hosts: *Vulpes* (syn. *Alopex*) *lagopus* (L., 1758), Arctic or Blue Fox; *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox.

Intermediate host: *Ovis aries* L., 1758, Red Sheep.

Remarks: Giannetto et al. (2005) used Dubey et al.'s (1989b) classification of 24 sarcocyst-types to identify a few sarcocysts of this form (type 10 villar protrusions) in one semi-thin tissue

section of diaphragm from a sheep in Sicily, Italy. Sarcocysts were 800×300 and divided into compartments by septa. The cyst wall was ~5 thick, with radial striations. Villar protrusions had microtubules that extended from the apex to the base of the villi, all characteristics of *S. gracilis* from roe deer. However, this identification is only circumstantial, and this form should be regarded as a *species inquirenda*. We mention this form here because we know from recent work (Gjerde, 2012) that *S. gracilis* sarcocysts in roe deer muscle can be transmitted to both *V. vulpes* and *V. lagopus*, which then shed sporocysts in their feces 9 DPI with infected deer flesh.

SARCOCYSTIS GRACILIS OF ODENING, STOLTE, AND BOCKHARDT, 1996a

Definitive hosts: *Vulpes* (syn. *Alopex*) *lagopus* (L., 1758), Arctic or Blue Fox; *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox.

Intermediate host: *Bos taurus* L., 1758, Aurochs.

Remarks: Odening et al. (1996a) found sarcocysts in the musculature of a dwarf zebu born in a German zoo. One of the four forms they found, “mostly resembles *Sarcocystis gracilis* Rätz, 1909 from roe deer.” We mention this form here because we know from recent work (Gjerde, 2012) that *S. gracilis* sarcocysts in roe deer muscle can be transmitted to both *V. vulpes* and *V. lagopus*, which then shed sporocysts in their feces 9 DPI with infected deer flesh. Obviously, this form must remain a *species inquirenda* because no other data were given to confirm its identification as *S. gracilis* in the dwarf zebu.

SARCOCYSTIS RHOMBOMYS PAK, PERMINOVA, DYMKOVA, KIM, AND PINAYEVA, 1984

Definitive host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox.

Intermediate host: *Rhombomys opimus* (Lichtenstein, 1823), Great Gerbil.

Remarks: Odening (1998) mentioned this species as valid in his compilation of 189 *Sarcocystis* names and noted that it had a TEM type 1 sarcocyst wall (Dubey et al., 1989b). However, the authors were cited only in a Russian reference book (Anon, 1984) that is unavailable to us. Odening (1998) gave such little detail in his citation that we think it is best, at this time, to relegate this form to a *species inquirenda*. To our knowledge, there have been no other references to this species since 1984, other than by Odening (1998).

SARCOCYSTIS UNDULATI PAK, YESHTOKINA, PERMINOVA, AND KIM, 1984

Definitive hosts: *Vulpes* (syn. *Alopex*) *corsac* (L., 1758), Corsac Fox; *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox; *Mustela eversmanni* Lesson, 1827, Steppe Polecat.

Intermediate host: *Urocitellus* (syn. *Citellus*) *undulatus* (Pallas, 1778), Long-tailed Ground Squirrel.

Remarks: Odening (1998) mentioned this species as valid in his compilation of 189 *Sarcocystis* names and said it was similar to *S. citellivulpes*. However, the authors are cited only in a Russian reference book (Anon, 1984) that is unavailable to us. Odening (1998) gave such little detail in his citation, that we think it is best, at this time, to relegate this form to a *species inquirenda*. To our knowledge, there have been no other references to this species since 1984, other than by Odening (1998).

SARCOCYSTIS VULPIS PAK, SKLYAROVA, AND DYMKOVA, 1991

Definitive host: Unknown.

Intermediate host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox.

Remarks: Odening (1998), who listed this as a valid *Sarcocystis* species name, said that Pak et al. (1991) named it from sarcocysts found in the red fox, but specimens were not preserved so follow-up molecular examination of specimens cannot be done. Dubey et al. (2015a) listed the form by Pak (1991) from the red fox as *Sarcocystis* sp. Gjerde and Schulze (2014) suggested that because the specimen described is unrecognizable today, it should be considered a *species inquirenda* and its name should be a *nomina dubia*. We were not able to secure a copy of the original paper, so we must concur with the opinion of Gjerde and Schulze (2014).

SARCOCYSTIS SP. OF ASHFORD, 1977

Definitive host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox.

Intermediate host: Unknown.

Remarks: Ashford (1977) said that fecal samples of 12/22 (55%) *V. vulpes* collected near Wales and Exmoor contained *Sarcocystis*-like sporocysts in their feces. The sporocysts (n=25) measured L × W: 13.4–14.2 × 9.2–9.5. No attempt was made to identify the species nor to transmit these sporocysts to any other host. Thus, a *species inquirenda*.

SARCOCYSTIS SPP. OF BIOCCA, BALBO, GUARDA, AND COSTANTINI, 1975 AND PROBABLY OF CORNAGLIA, GIACCHERINO, AND PERACINO, 1998

Definitive hosts: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox; *Canis lupus* L., 1758, Wolf; *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Intermediate host: *Capra ibex* L., 1758, Alpine Ibex.

Remarks: Biocca et al. (1975) found sporocysts in the feces of “some” of 12 red foxes in

the Gran Paradiso National Park (GPNP) in Italy; these sporocysts measured 13–15 × 8–10, with a large SR, but no SB. They also found an ibex with sarcocysts in its muscles. Levine and Ivens (1981) reported that Biocca et al. (1975) infected both the timber wolf and domestic dog by feeding them sarcocyst-infected esophageal, heart, diaphragm, intercostal, and abdominal muscles from the infected ibex. The prepatent period in the fox was 11 days, in the wolf it was 12 days, and in the domestic dog it was 20 days; the patent period in these hosts was 62, 67, and 66 days, respectively. They also tried, unsuccessfully, to infect a domestic cat, a lion, a ferret, and a kestrel (*Falco tinnunculus*) with sarcocysts from the ibex, but none of them passed sporocysts. However, there is no evidence or correlation that the sporocysts in the foxes were the same species as the sarcocysts in the ibex. Later, Cornaglia et al. (1998) described the ultrastructural morphology of the sarcocyst wall in the muscles from an ibex found dead in the same national park in Italy. They also took samples of the diaphragm from 52 ibexes of different age and sex, from the GPNP. The morphology of the cyst wall led to the identification of three types of sarcocysts in the ibex of the GPNP and a further type in one Hispanic ibex was also collected. Cornaglia et al. (1998) concluded, “the morphology of the sarcocysts’ walls was similar to the wall of the species described in the domestic ruminants from several authors.”

SARCOCYSTIS SPP. OF DUBEY, 1982b

Definitive host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Red or Silver Fox.

Intermediate host: Unknown.

Remarks: Dubey (1982b) surveyed the feces for coccidians from a variety of wild carnivores from Montana, USA. He reported sporocysts of *Sarcocystis* in the feces of 20/198 (10%) red foxes. He measured from 3 to 14 sporocysts

from each of eight different foxes and found size differences that varied from 16.3×11 (largest) to 11.6×6.7 (smallest). No attempt was made to identify the species beyond genus; thus, a *species inquirenda*.

SARCOCYSTIS SP. OF KUBO, OKANO, ITO, TSUBOTA, SAKAI, AND YANAI, 2009

Definitive host: Unknown.

Intermediate host: *Vulpes vulpes japonica* J.E. Gray, 1868, Japanese Red Fox.

Remarks: Kubo et al. (2009) examined 65 free-living carnivores on Honshu Island for muscular sarcocysts of *Sarcocystis*. Only one Japanese red fox had sarcocysts in its muscles and no inflammatory host response was associated with the sarcocysts. Ultrastructurally, the sarcocyst wall was thin and showed minute undulations. Kubo et al. (2009) said that these sarcocysts were similar to sarcocysts they found in the Japanese raccoon dog (*N. procyonoides viverrinus*) and Japanese martens (*M. m. melampus*) during the same survey. This is the first published report of muscular sarcocystosis in Japanese carnivores. There was no attempt to identify this species so this form must remain a *species inquirenda*.

SARCOCYSTIS SPP. (?) OF GOLEMANSKY, 1975b

Definitive host: *Vulpes vulpes* (L., 1758) (syn. *V. vulgaris* Oken, 1816), Silver or Red Fox.

Intermediate host: Unknown.

Remarks: Golemansky (1975b) found free oocysts and sporocysts in the feces of 14/146 (10%) *V. vulpes* in Soria, Bulgaria. Oocysts measured $L \times W$: 18.6×14.0 ($17-20 \times 10-18$) and sporocysts were 15.3×10.2 ($13-18 \times 9.5-11$). He thought these oocysts/sporocysts resembled those of *S. fusiformis* and *S. tenella*, but the only

conclusion he drew was “the European common red fox is one of the vectors in the maintenance and distribution of sarcosporidiosis in nature.” This can only be considered *species inquirenda*.

FAMILY MEPHITIDAE BONAPARTE, 1845

GENUS MEPHITIS É. GEOFFROY SAINT-HILAIRE AND F.G. CUVIER, 1795 (2 SPECIES)

CRYPTOSPORIDIUM SP. OF ZIEGLER, WADE, SCHAAF, STERN, NADARESKI, AND MOHAMMED, 2007

Original host: *Mephitis mephitis* (Schreber, 1776), Striped Skunk.

Remarks: Ziegler et al. (2007) collected fecal samples of *M. mephitis* live-trapped in the New York City Watershed, southeastern New York state, USA. Feces were examined by LM, and by polyclonal *Cryptosporidium* antigen-capture ELISA (considered positive based on an optical density ≥ 0.050). They found *Cryptosporidium* in 12/86 (14%) samples.

GENUS SPILOGALE GRAY, 1865 (4 SPECIES)

SARCOCYSTIS SPP. OF LESMEISTER, MILLSPAUGH, WADE, AND GOMPPER, 2008

Definitive host: *Spilogale putorius* (L., 1758), Eastern Spotted Skunk.

Intermediate host: Unknown.

Remarks: Lesmeister et al. (2008) did a fecal survey of *S. putorius* in western Arkansas, USA and found 5/17 (29%) had sporocysts of (one or more) *Sarcocystis* species in their feces, but no

other information was given on these structures, so this identification remains a *species inquirenda*.

However, to our knowledge it has never formally been named.

FAMILY MUSTELIDAE
FISCHER, 1817

SUBFAMILY LUTRINAE
BONAPARTE, 1838

GENUS ENHYDRA FLEMMING,
1822 (MONOTYPIC)

SARCOCYSTIS SP. OF
DUBEY, ROSYPAL,
ROSENTHAL, THOMAS,
LINDSAY, STANEK, REED,
AND SAVILLE, 2001c

Definitive host: Unknown.

Intermediate host: *Enhydra lutris* (L., 1758), Sea Otter.

Remarks: Dubey et al. (2001c) found two adult female sea otters at Olympic National Park, Washington USA, naturally-infected with *Sarcocystis* sarcocysts. Their otter No. 1 had *S. neurona*, but otter No. 2 had mature sarcocysts in skeletal muscles and the tongue, which were distinctly different than those of *S. neurona*. Later, Dubey et al. (2003a) characterized this second *Sarcocystis* (otter No. 2) using TEM and saw it had thin-walled sarcocysts that were 0.5–0.7 thick, lacking protrusions, and exhibiting minute type 1 (Dubey et al., 1989b) undulations on the wall. Two of these sarcocysts measured 95×60 and 110×65. Under TEM the sarcocyst wall had minute, electron-dense undulations located at irregular intervals. Only bradyzoites were seen and three of them, in longitudinal section, were 5.0–5.7×1.6–1.9. Rhoptries were prominent, their bulbous blind end was sometimes turned toward the conoidal end, and their micronemes were in the anterior half of the bradyzoite; all these features making this species ultrastructurally distinct from *S. neurona*.

GENUS LONTRA GRAY, 1843
(4 SPECIES)

CRYPTOSPORIDIUM SPP. OF
GAYDOS, MILLER, GILARDI, MELLI,
SCHWANT, ENGELSTOFT, FRITZ,
AND CONRAD, 2007b

Original host: *Lontra canadensis* (Schreber, 1777), North American River Otter.

Remarks: Gaydos et al. (2007b) collected feces from *L. canadensis* living along the Puget Sound Georgia Basin (PSGB) marine ecosystem between Washington state, USA, and the southern tip of Vancouver Island, British Columbia, Canada, to look for the presence of *Cryptosporidium* and *Giardia* oocysts and cysts, respectively. In Washington state, they collected fecal samples from 13 locations in PSGB, and off Vancouver Island, from 30 locations; they found 4/57 (7%) samples from 4 locations in Washington state, and 5/36 (14%) fecal samples from 2 locations on Vancouver to have *Cryptosporidium* oocysts in their fecal material. Overall, they found *Cryptosporidium* oocysts in 9/93 (10%) fecal samples from river otters in the PSGB. Even when some parasites, such as *Cryptosporidium*, are only identified to genus in wildlife surveys, we can see that there are so many examples of the potential for these and other parasites to be transmitted between wildlife and humans.

GENUS LUTRA BRISSON,
1762 (3 SPECIES)

CRYPTOSPORIDIUM SPP. OF
MÉNDEZ-HERMIDA, GÓMEZ-
COUSO, ROMERO-SUANCES,
AND ARES-MAZÁS, 2007

Original host: *Lutra lutra* (L., 1758), European Otter.

Remarks: Méndez-Hermida et al. (2007) did a fecal survey of 437 European otters from 161 sites in Galicia, Spain, using a direct immunofluorescence antibody test (IFAT). They found *Cryptosporidium* oocysts in 17/437 (4%) samples.

SARCOCYSTIS SP. OF WAHLSTRÖM, NIKKILÄ, AND UGGLA, 1999

Definitive host: Unknown.

Intermediate host: *Lutra lutra* (L., 1758), European Otter.

Remarks: Wahlström et al. (1999) found sarcocysts in the skeletal muscle of one *L. lutra* raised in Norway but had died in captivity in Sweden. The sarcocysts were 0.3–2.3 mm long and 0.05–0.25 mm wide. Under LM, sarcocyst walls were thin, <3 µm, and had a serrated surface, but did not have visible projections. By TEM, the sarcocyst wall was 0.6–1.8 thick and had minute undulations covering its entire surface, giving the wall a wavy appearance. Septa were indistinct and the sarcocysts had few merozoites, but many bradyzoites. These sarcocysts were found in only 1/70 (1%) otters subjected to necropsy in Sweden.

SUBFAMILY MUSTELINAE FISCHER, 1817

GENUS MARTES PINEL, 1792 (8 SPECIES)

COCCIDIA SP. OF MATSCHOULSKY, 1947a,b

Original host: *Martes zibellina* (L., 1758), Sable.

Remarks: Matschoulsky (1947a,b) reported three species of coccidia in 32/144 (22%) sables, “two already known and one is new.” In one sable he found oocysts that were round/ovoidal and surrounded by a 2-layered wall, ~1 thick, without a M. Ovoidal oocysts were L × W: 13.1 × 11.3 (12–14 × 10–12), L/W ratio, 1.2. Although he

could not get oocysts of this “species” to sporulate, he said the defining feature of this species is its small size, which “differs drastically from coccidia that were found in sables before. That is why we name this species as new.” Fortunately, he did not give it a name, and because he never saw sporulated oocysts, it cannot be placed into a genus.

CRYPTOSPORIDIUM SP. OF RADEMACHER, JAKOB, AND BOCKHARDT, 1999

Original host: *Martes foina* (Erxleben, 1777), Beech Marten.

Remarks: Rademacher et al. (1999) reported temporary episodes of diarrhea in four captive beech martens that were not related to each other, and they found numerous oocysts of a *Cryptosporidium* sp. in the feces of all of them. The oocysts measured, L × W (n=30): 3.6 × 3.1 (3–4 × 3–4); L/W ratio: 1.2, but no other information was given.

EIMERIA SP. OF YAKIMOFF AND GOUSSEFF, 1934

Original host: *Martes martes* (L., 1758), European Pine Marten.

Remarks: Yakimoff and Gousseff (1934) described oocysts from the marten as L × W (n=101): 21.6 × 18.0 (20–31 × 16–20), L/W ratio: 1.2; M, OR, PG: all absent with elongate-ovoidal sporocysts (line drawing), 7.2 wide, SB, SSB, PSB: all absent, and SR: present (line drawing). Yakimoff and Gousseff (1934) described oocysts from the feces of one marten and one sable from the same zoo, and oocysts from the sable were L × W (n=50): 21.6 × 18.0 (18–25 × 16–20), L/W ratio: 1.2. They concluded, “The coccidia from this sable with those previously described as *E. sibirica* reveals no differences.” Their (unstated) implication was that

the oocysts from both the marten and the sable represented the same *Eimeria* species.

**HEPATOZOON SP. OF
YANAI, TOMITA, MASEGI,
ISHIKAWA, IWASAKI, YAMAZOE,
AND UEDA, 1995**

Original host: *Martes melampus* (Wagner, 1840), Japanese Marten.

Remarks: Yanai et al. (1995) studied Japanese martens in Gifu prefecture, Japan and found nodular lesions containing meronts and merozoite-gametocytes of a *Hepatozoon* species in 67/70 (96%) wild martens. The heart was the most commonly parasitized organ (67/70, 96%) followed by perirenal adipose tissue (25/70, 36%), diaphragm (9/58, 16%), mesentery (10/68, 14%), tongue (1/7, 14%), omentum (8/57, 14%), and perisplenic adipose tissues (7/70, 10%). Two types of nodular lesions were seen, each based on different developmental stages: nodules containing meronts, and nodules that consisted of an accumulation of phagocytes containing merozoites or gamonts. Nodules containing meronts were 50–400 wide. Yanai et al. (1995) studied mature meronts and membrane-bound merozoites with LM and TEM but chose not to name the parasite.

**SARCOCYSTIS SP. OF
DUBEY, 1982b**

Definitive host: *Martes pennanti* (Erxleben, 1777), Fisher.

Intermediate host: Unknown.

Remarks: Dubey (1982b) surveyed feces for coccidians from a variety of wild carnivores in Montana, USA and reported sporocysts of *Sarcocystis* in the feces of 1/6 (17%) fishers. Sporocysts from this host varied from 12.5–13.0 × 8.5–9.0 (n=3).

No attempt was made to identify the species beyond genus; thus, a *species inquirenda*.

**SARCOCYSTIS SP. OF
GERHOLD, HOWERTH, AND
LINDSAY, 2005**

Definitive host: Unknown.

Intermediate host: *Martes pennanti* (Erxleben, 1777), Fisher.

Remarks: Gerhold et al. (2005) described **meningoencephalitis** due to *S. neurona* in a fisher from Maryland, USA; they also found intramuscular sarcocysts “of a possibly unrecognized *Sarcocystis* species.” Although the structure and ultrastructure of the muscle sarcocysts from the fisher were similar to those of *S. neurona*, they were unable to amplify *S. neurona* DNA from these muscle forms; they said this may be related to technical difficulties, or this organism may be an unrecognized species that has sarcocysts morphologically similar to those of *S. neurona*.

**SARCOCYSTIS SPP. OF KUBO,
OKANO, ITO, TSUBOTA, SAKAI,
AND YANAI, 2009**

Definitive host: Unknown.

Intermediate host: *Martes melampus melampus* Gray, 1865, Japanese Marten.

Remarks: Kubo et al. (2009) examined 65 wild carnivores on Honshu, Japan for sarcocysts and found three Japanese red martens had sarcocysts in their muscles, and no inflammatory host response was associated with the sarcocysts. Ultrastructurally, the sarcocyst wall was thin and showed minute undulations. Kubo et al. (2009) said these sarcocysts were similar to sarcocysts they found in the Japanese raccoon dog (*N. procyonoides viverrinus*) and the Japanese red fox (*V. v. japonica*) during the same survey. This

was the first published report of muscular sarcocystosis in Japanese carnivores. There was no attempt to identify the species; thus, a *species inquirenda*.

**SARCOCYSTIS SPP. OF
LARKIN, GABRIEL,
GERHOLD, YABSLEY, WESTER,
HUMPHREYS, BECKSTEAD,
AND DUBEY, 2011**

Definitive host: Unknown.

Intermediate host: *Martes pennanti* (Erxleben, 1777), Fisher.

Remarks: Larkin et al. (2011) examined road-or trapper-killed fishers in Pennsylvania, USA for *Sarcocystis* spp. and *Toxoplasma gondii*. DNA samples were extracted from thoracic and pelvic limb skeletal muscles using 18S rRNA PCR primers and analysis showed 38/46 (83%) fishers were positive for *Sarcocystis* species, but no specific identification was given.

**GENUS MELES BRISSON,
1762 (3 SPECIES)**

**COCCIDIA SP. OF KAMIYA
AND SUZUKI, 1975**

Original host: *Meles anakuma* Temminck, 1844, Japanese Badger.

Remarks: Kamiya and Suzuki (1975) examined the preserved intestine of one badger, mostly for trematodes, but when they looked at tissue sections of the jejunum mucosa they saw endogenous stages of a coccidium represented by macro- and microgametocytes and oocysts. Microgametocytes with many microgametes were ~20 wide, macrogametocytes with many basophilic granules were 15–22 × 13–20, and unsporulated oocysts were 20–21 × 14–17.

Although they concluded these stages represented an *Eimeria* species there is no way to know that from the few tissue stages measured and unsporulated oocysts.

**ISOSPORA-LIKE OF STUART,
GOLDEN, ZINTL, DE WAAL,
MULCAHY, MCCARTHY, AND
LAWTON, 2013**

Original host: *Meles meles* (L., 1758), European Badger.

Remarks: Stuart et al. (2013) surveyed fecal samples of *M. meles* and found “*Isospora*-like oocysts” in 8/50 (16%) samples, but no additional information was provided.

**SARCOCYSTIS SP. OF
KUBO, OKANO, ITO,
TSUBOTA, SAKAI, AND
YANAI, 2009**

Definitive host: Unknown.

Intermediate host: *Meles anakuma* Temminck, 1844, Japanese Badger.

Remarks: Kubo et al. (2009) examined 65 free-living carnivores on Honshu, Japan for muscular *Sarcocystis* and two Japanese badgers had sarcocysts in their muscles, but no inflammatory host response was associated with them. Ultrastructurally, the sarcocyst wall was thick with numerous finger-like protrusions that contained microtubules. Kubo et al. (2009) said these sarcocysts were **not** similar to sarcocysts they found in the Japanese raccoon dog (*N. p. viverrinus*), the Japanese red fox (*V. v. japonica*), and the Japanese marten (*M. m. melampus*) during the same survey. This was the first published report of muscular sarcocystosis in Japanese carnivores, but there was no attempt to identify it to species, so this form must remain a *species inquirenda*.

**SARCOCYSTIS SP. OF ODENING,
STOLTE, WALTER, BOCKHART,
AND JAKOB, 1994a**

Definitive host: Unknown.

Intermediate host: *Meles meles* (L., 1758), European Badger.

Remarks: Odening et al. (1994a) found a dead female *M. meles* on the road, ~50 km northeast of Berlin, Germany. Macroscopic sarcocysts were found in the tongue and, after fixation and sectioning, they were examined through TEM. Sarcocysts were up to 1.4 mm long, with a maximum width of 185 μ m, and had compartments of various sizes, with bradyzoites that measured $L \times W$ ($n=30$): 12.3×3.1 ($11-13 \times 2.8-3.5$). Odening et al. (1994a) said, "No sarcocysts from mustelids have been described by electron microscopy so far," but they obviously missed the paper by Cawthorn et al. (1983), who used TEM to look at sarcocysts in experimentally-infected Richardson's ground squirrels after they had fed on *Sarcocystis* sporocysts recovered from the American badger, *Taxidea taxus* (Schreber, 1777). Odening et al. (1994a) compared their form to similar sarcocysts studied from roe deer by Entzeroth (1982a,b), and Sugár et al. (1990), and said, "the similarity of the...forms from roe deer with each other and with the form from the European badger is so great, that we can regard all these forms as most likely being identical." Without more substantive data, this form must remain a *species inquirenda*.

**SARCOCYSTIS SP. OF ODENING,
STOLTE, WALTER, AND
BOCKHART, 1994b**

Synonym: cf. *Sarcocystis sebeki* of Tadros and Laarman, 1976.

Definitive host: Unknown.

Intermediate host: *Meles meles* (L., 1758), European Badger.

Remarks: Odening et al. (1994b) found four dead *M. meles* (Nos. 3, 2, 6, 9; 1 male and 3 females, respectively) on various roads, 45–75 km from Berlin, Germany. Sarcocysts were found in the tongue, thigh, loin, and thorax and, after fixation and sectioning, they were examined via LM and TEM. Sarcocysts were 6.5–9.0 mm long, and 172–200 μ m wide in the fresh state, and their bradyzoites were squat and fusiform, 6.9×1.9 ($6.1-7.2 \times 1.6-2.2$). In semi-thin sections bradyzoites were 5.9×2.0 ($5.7-6.3 \times 1.7-2.2$). TEM showed a cyst wall 0.9–1.4 thick with no protrusions. Small elevations of the primary cyst wall were 0.08–0.09 long, the fossule-like invaginations in-between had a maximum diameter of 0.05. These small elevations and invaginations were underlaid with an osmiophilic layer. The authors (1994b) "assigned" this form to be near *S. sebeki* (cf. Tadros and Laarman, 1976, 1978, 1979, 1980a,b, 1982) "because it is morphologically very similar" to it.

**GENUS MELLIVORA STORR,
1780 (MONOTYPIC)**

**SARCOCYSTIS SP. OF
VILJOEN, 1921**

Definitive host: Unknown.

Intermediate host: *Millivoora capensis* (Schreber, 1776), Honey Badger.

Remarks: According to Levine and Ivens (1981), Viljoen (1921) found sarcocysts in the striated muscles of a honey badger, but they did not see his actual paper and got the citation from Nietz (1965). Levine (1986) did not list this species, and Dubey et al. (2015a) list neither the Viljoen nor Nietz references and make no mention of a *Sarcocystis* species in the honey badger. Viljoen (1921) does not retrieve in Google Scholar and we were unable to obtain a copy of the Nietz paper.

**GENUS MELOGALE I.
GEOFFROY SAINT-HILAIRE,
1831 (4 SPECIES)**

**SARCOCYSTIS SP. OF
CHIOU, YEH, JENG,
CHANG, CHANG, WU,
CHAN, AND PANG, 2015**

Definitive host: Unknown.

Intermediate host: *Melogale moschata subaurantiaca* (Swinhoe, 1862), Taiwan Ferret Badger.

Remarks: Chiou et al. (2015) examined Taiwan ferret badgers in Taiwan and found 1/31 (3%) had *Sarcocystis* sarcocysts. No other information was presented; thus, a *species inquirenda*.

**GENUS MUSTELA L., 1758
(17 SPECIES)**

**COCCIDIA SP. OF BLANKENSHIP-
PARIS, CHANG, AND
BAGNELL, 1993**

Original host: *Mustela* (syn. *Putorius*) *putorius furo* (L., 1758), Domestic Ferret.

Remarks: Blankenship-Paris et al. (1993) examined a 4-month-old ferret that was ill, dehydrated, and had pasty, dark feces. The ferret was housed with another sibling and its dam, but neither showed similar signs, and repeated fecal exams of both were negative for coccidial oocysts. Also, fecal exams of other members of the colony and necropsy of eight other ferrets in the colony did not demonstrate any coccidia. However, when the 4-month-old ferret was necropsied, Blankenship-Paris et al. (1993) reported that "enteric coccidiosis" was the cause of its illness, based on histological findings of some endogenous stages. No other identification was made.

**COCCIDIA SP. OF BRONSON,
BUSH, VINER, MURRAY, WISELY,
AND DEEM, 2007**

Original host: *Mustela* (syn. *Putorius*) *putorius furo* (L., 1758), Domestic Ferret.

Remarks: Bronson et al. (2007) examined mortality, retrospectively, based on the pathology records of 107 captive animals held at the Smithsonian's National Zoological Park, Washington, D.C., USA from 1989 to 2004. They said that "the most common cause of death among juvenile ferrets was gastrointestinal disease, found in 11/21 (52%)," with seven of those cases caused by coccidiosis. No identity of the coccidian nor other information was given.

**COCCIDIA SP. OF DAVIS, CHOW,
AND GORHAM, 1953**

Original host: *Neovison vison* (Schreber, 1777) (syn. *Mustela vison* L., 1766), American Mink.

Remarks: Davis et al. (1953) were among the first to notice liver coccidiosis in a mink, and they described characteristic pathological and anatomical changes caused by this parasite, but because they examined only visceral organs, they did not identify the coccidian.

**COCCIDIA SP. 1 OF JOLLEY,
KINGSTON, WILLIAMS,
AND LYNN, 1994**

Original host: *Mustela nigripes* (Audubon and Bachman, 1851), Black-footed Ferret.

Remarks: Jolley et al. (1994) reported seeing meronts and oocysts of a small coccidian in the cells lining the trachea, a bronchus, and in associated bronchial glands in one black-footed ferret, which also had canine distemper. Because no sporulated oocysts could be found they could

not name or characterize it further. No lesions in tracheal tissue could be attributed to the presence of this parasite.

COCCIDIA SP. 2 OF JOLLEY, KINGSTON, WILLIAMS, AND LYNN, 1994

Original host: *Mustela nigripes* (Audubon and Bachman, 1851), Black-footed Ferret.

Remarks: Jolley et al. (1994) reported seeing merozoites of another unidentified coccidian in an impression smear of the epithelium of the urinary bladder of the same ferret in which they saw the respiratory coccidian stages (above). No lesions in bladder tissue could be attributed to the presence of this parasite, but they cautioned that this form would need differentiation from *Toxoplasma*, *Neospora*, and *Hepatozoan* species, which it resembles in size, ability to invade a variety of tissue types, and merogonic development.

COCCIDIA SP. OF LI, PANG, AND FOX, 1996

Original host: *Mustela* (syn. *Putorius*) *putorius furo* (L., 1758), Domestic Ferret.

Remarks: Li et al., 1996 described proliferative bowel disease in 4/19 (21%) ferrets they found to be coinfecting with a *Desulfovibrio* sp. (gram negative, comma- to spiral-shaped bacteria, often associated with proliferative bowel disease) and coccidia. Thick, rigid colons, and enlarged mesenteric lymph nodes were palpable in all four, which had a history of lethargy, anorexia, weight loss, and diarrhea. These ferrets were dehydrated and emaciated, and one had occult blood in its feces whereas another had a prolapsed rectum. Tissue sections showed proliferative changes that included a marked increase in mucosal thickness, and glandular or crypt length and irregularity with pseudovillus

formation. Epithelial cells were markedly hyperplastic, hyperchromatic, and piled on each other with numerous mitotic figures. Inflammatory cells consisted predominantly of neutrophils (two ferrets) or lymphocytes and macrophages (two ferrets), and some eosinophils in all four. They described the coccidian organisms to consist predominantly of meronts and merozoite stages. Many coccidian stages were seen within the apical cytoplasm of hyperplastic epithelial cells, but feces were not examined and no attempt was made to identify the organism other than to call them coccidia. They mentioned that the mechanism by which *Desulfovibrio* sp. and its relatives induce proliferative bowel disease is unknown, but "the presence of a second organism may in some instances be required for ICOs to cause intestinal lesions."

CRYPTOSPORIDIUM SP. OF GÓMEZ- VILLAMANDOS, CARRASCO, MOZOS, AND HERVÁS, 1995

Original host: *Mustela* (syn. *Putorius*) *putorius furo* L., 1758, Domestic Ferret.

Remarks: Gómez-Villamandos et al. (1995) reported that four of five ferrets shipped to their department in Córdoba, Spain became ill several days after arrival showing anorexia, depression, and yellow diarrhea; they died 48–72 hours after onset of the illness began. The ferrets were non-pregnant females weighing 500–550 g and originated on a goat farm. Tissue samples were fixed and prepared for LM and TEM. Microscopic examinations of the intestinal tract of all ferrets showed numerous spheroidal to ovoidal bodies, in various stages of development, attached to the brush border of enterocytes and cryptal epithelial cells of the distal large intestine. Villous atrophy was severe and a cellular infiltrate composed of neutrophils, eosinophils, and macrophages was seen in the submucosa, whereas desquamated epithelial cells with parasitic

stages were seen in the intestinal lumen. All stages of the life cycle were observed including trophozoites, two types of meronts with their merozoites, macro- and microgametes, and unsporulated and sporulated oocysts. No attempt was made to name the parasite.

CRYPTOSPORIDIUM SPP. OF REHG, GIGLIOTTI, AND STOKES, 1988

Original host: *Mustela* (syn. *Putorius*) *putorius furo* L., 1758, Domestic Ferret.

Remarks: Rehg et al. (1988) identified the first case of *Cryptosporidium* in ferrets. Two unrelated young ferrets, 4- and 8-months-old, died from unknown causes on the same day. They made stained fecal smears, and then took sections of both gastrointestinal (GI) tracts and stained paraffin-embedded sections with hematoxylin-eosin for the histopathology; they also fixed, cut, and stained the GI with uranyl acetate and lead citrate for TEM. Fecal smears showed *Cryptosporidium* oocysts that were ~3–5. Histological sections demonstrated cryptosporidial stages, 2–5 wide, associated with the brush border of the epithelial cells at the tips and lateral margins, but not in the crypts, only in the small intestine (predominantly ileum); no such stages were seen in the gall bladder, trachea, or lungs. Trophozoites, meronts, macrogametes, and oocysts were detected by TEM in the small intestine. Subsequently, examination of fresh fecal samples of the ferret population at the research facility, and of the new arrivals, revealed the presence of *Cryptosporidium* as a subclinical disease in a high percentage of ferrets. The infection persisted for several weeks both in immunocompetent and immunocompromised (treated with dexamethasone) animals. Fecal smears showed *Cryptosporidium* oocysts in 9/22 (41%) ferrets at the facility, and in 31/44 (70%) new arrivals. Neither species nor genotypes of

the isolates were identified because only LM, TEM, and histopathological methods were used.

CRYPTOSPORIDIUM SP. OF SKÍRNISSON AND PÁLMAÐÓTTIR, 1993

Original host: *Neovison* (syn. *Mustela*) *vison* (Schreber, 1777), American Mink.

Remarks: Very small oocysts, 4–5 long, identified as *Cryptosporidium* sp. were found in the feces of 11/40 (27.5%) mink pups on 5/13 (38%) fur farms in Iceland, but no further account of this species was ever published (SkírNisson and Pálmadóttir, 1993).

CRYPTOSPORIDIUM SP. OF ZIEGLER, WADE, SCHAAF, STERN, NADARESKI, AND MOHAMMED, 2007

Original host: *Mustela erminea* L., 1758, Ermine.

Remarks: Ziegler et al. (2007) collected fecal samples of three wild *M. erminea* and one *Mustela frenata* Lichtenstein, 1831, in the New York City Watershed, southeastern New York state, USA. Their samples were examined both by LM, and by polyclonal *Cryptosporidium* antigen-capture ELISA (considered positive based on an optical density ≥ 0.050). They found *Cryptosporidium* in 1/3 (33%) *M. erminea*, but not in the sample of *M. frenata*, the long-tailed weasel.

EIMERIA BASKANICA OF NUKERBAEVA AND SVANBAEV, 1972 OR 1973 (?)

Original host: *Mustela erminea* L., 1758, Ermine or Stoat.

Remarks: The paper of Nukerbaeva and Svanbaev (1972) is unavailable to us or it may

not even exist. In their survey of fur animals in Kazakhstan, Nukerbaeva and Svanbaev (1977) said they found 1/7 (14%) stoats infected with *E. baskanica* Nukerbaeva and Svanbaev, 1972; however, Global Names Index (gni.globalnames.org/) listed the authority as Nukerbaeva and Svanbaev, 1973. In their 1977 paper they briefly mentioned the oocysts of this form to be ovoidal with tapered poles, dimensions of 11.2–12.6 × 8.4–9.8, lacking both M and PG, but having an OR; the sporocysts were described only as ovoidal, with two bean-shaped SZ and an SR, but no mention was made about presence/absence of a SB.

***EIMERIA MEPHITIDIS* OF YAKIMOFF AND GOUSSEFF, 1936**

Original host: *Mustela* (syn. *Putorius*) *putorius furo* (L., 1758), Domestic Ferret.

Remarks: Yakimoff and Gousseff (1936) reported finding oocysts in two polecats taken from the Polotsk District, in the Republic of Belarus on the Dvina River. They found only small numbers of perfectly round oocysts with a smooth, double-layered wall, that measured 21.6–23.4 wide; these oocysts lacked M, OR, and PG. The elongate-ovoidal sporocysts were 12.6 × 5.2, and apparently lacked SB, SSB, PSB. They said the oocysts they observed were somewhat similar to those of *E. furonis*, which they are not (21.6–23.4 vs. 12.8 × 12.0). Ultimately, they identified their oocysts as *E. mephitidis*, a species described from the striped skunk (*M. mephitis*) from Ohio, USA, by Andrews (1928); the oocysts are similar in size, but those of *E. mephitidis* have a circular M, which was not seen in those described by Yakimoff and Gousseff (1936). The line drawing provided by Yakimoff and Gousseff (1936) is strikingly similar to the line drawing of *E. hiepei*, which was described from the European mink by Gräfner et al. (1967), but *E. hiepei* has smaller oocysts (13.5–16.6 wide).

***EIMERIA* SP. OF JOLLEY, KINGSTON, WILLIAMS, AND LYNN, 1994**

Original host: *Mustela nigripes* (Audubon and Bachman, 1851), Black-footed Ferret.

Remarks: Jolley et al. (1994) reported finding oocysts representing three *Eimeria* species in 6/6 (100%) *M. nigripes* in Wyoming, USA. Two of the species were identified as *E. furonis* and *E. ictidea*. The third form, which they said was seen only rarely, had oocysts that were larger than those of the first two, but they made no attempt to identify or characterize it in any way other than to say it was oval and five oocysts they measured were L × W: 37.0 × 22.3 (35–39 × 21–23), L/W: 1.7. Confirming that this was likely an eimerian they said, “sporulated oocysts of the large oval form were rarely seen,” and “attempts to sporulate this species were variably successful under the conditions described, often with little or no development seen after a 10-day incubation period in the potassium dichromate solution. Oocysts taken from the intestinal lumen failed to sporulate, whereas some of those passed in the feces successfully did so.” They also pointed out that neither Levine and Ivens (1981), from mustelids and other carnivores, nor Levine and Ivens (1990) and Thomas and Stanton (1994) from prairie dogs, rock squirrels, or ground squirrels had reported *Eimerian* oocysts with these measurements.

***EIMERIA* SP. OF MUSAEV AND VEISOV, 1983**

Original host: *Mustela nivalis* L., 1766, Least Weasel.

Remarks: Musaev and Veisov (1983) found oocysts of an *Eimeria* sp. in 1/43 (2%) weasels they examined; they thought these oocysts were slightly different from those of *E. mustelae*, but they declined to name their form even though they provided a line drawing. The oocyst wall

was smooth, colorless, 1.5–2.0 thick. Sporulated oocysts were L×W (n=49): 20.3×14.8 (17–22×12–17), L/W ratio 1.4 (1.2–1.6); M, OR, PG: all absent. Sporocysts were described as ovoidal to pear-shaped although this is not evident in their line drawing. Sporocysts were L×W: 8.5×6.5 (6–10×4–8); SB, SSB, PSB: all absent (line drawing); SR: present, as a group of fine granules. Sporozoites measured were 5–9×3–7 and each had a RB at their broader end. Sporulation time was 48–72 hours in 2.5% potassium dichromate (K₂Cr₂O₇) solution at 25–30°C. They said the oocysts measured were obtained from the contents of the large intestine and the host was collected in the Batabag Shahbusk region of the Nakhitshevansk, Azerbaijan.

ISOSPORA OHIOENSIS OF PATTERSON AND FOX, 2007

Original host: *Mustela* (syn. *Putorius*) *putorius furo* (L., 1758), Domestic Ferret.

Remarks: Patterson and Fox (2007) reported oocysts they identified as *I. ohioensis* in fecal samples of healthy domestic ferret kits in a large ferret breeding operation on the same premise as juvenile domestic dogs; they neglected to mention how they arrived at this identification. It is likely their identification was either a spurious finding of a dog oocyst passing through the gut of the ferrets or is a new/different species morphologically indistinguishable from the oocysts of *I. (=C.) ohioensis*.

ISOSPORA SP. OF BELL, 1994

Original host: *Mustela* (syn. *Putorius*) *putorius furo* (L., 1758), Domestic Ferret.

Remarks: Bell (1994) reported that *Isospora* sp. oocysts are commonly shed by ferrets 6–16 weeks of age and is the same species that commonly affects puppies and kittens, but the “species” was not identified.

ISOSPORA SP. OF PANTCHEV, GASSMANN, AND GLOBOKAR-VRHOVEC, 2011

Original host: *Mustela* (syn. *Putorius*) *putorius furo* (L., 1758), Domestic Ferret.

Remarks: Pantchev et al. (2011) reported the results of fecal samples from domestic ferrets they examined between 2002 and 2004 and identified the species found, based on the structure of their sporulated oocysts as *E. furonis*, *E. ictidea*, *I. (=C.) laidlawi*, and an unidentified *Isospora* species. No other information was given about this unidentified isosporan.

SARCOCYSTIS SP. OF TADROS AND LAARMAN, 1979

Definitive host: Unknown.

Intermediate host: *Mustela nivalis* L., 1766, Least Weasel.

Remarks: Tadros and Laarman (1979) reported muscular sarcosporidiosis for the first time from the common European weasel in the Netherlands. They examined the morphology of sarcocysts both in fresh and stained histological preparations. The sarcocysts were several mm long by 0.15 mm wide and had a smooth wall without cytophaneres; the cysts were compartmentalized and had merozoites 3.5 wide and bradyzoites about 9×2.5. Levine and Ivens (1981) speculated that these were very similar to the sarcocysts of *S. sebeki* found in *Apodemus sylvaticus* (L., 1758). In addition to its muscle sarcocysts, the weasel also had sporocysts of *S. putorii* in its feces. They attempted to complete the sexual cycle by feeding muscle sarcocysts to the tawny owl, *Strix aluco* L., 1758 and obtained a few oocysts for a short time from its feces. However, they believed that this was an abnormal host and that another genus of strigid bird might be a better definitive host. They never attempted to name the species of the weasel sarcocysts.

**GENUS NEOVISON
BARYSHNIKOV AND
ABRAMOV, 1997 (2 SPECIES)**

**CRYPTOSPORIDIUM SP.
OF ZIEGLER, WADE, SCHAAF,
STERN, NADARESKI, AND
MOHAMMED, 2007**

Original host: *Neovison* (syn. *Mustela*) *vison* (Schreiber, 1777), American Mink.

Remarks: Ziegler et al. (2007) collected feces from wild *N. vison*, trapped in the New York City Watershed, southeastern New York state, USA. Samples were examined by flotation/centrifugation with sugar and/or zinc sulfate solution followed by LM and by polyclonal *Cryptosporidium* antigen-capture ELISA (considered positive based on an optical density ≥ 0.050). They reported finding *Cryptosporidium* in 10/58 (17%) samples.

**EIMERIA SP. OF FOREYT
AND TODD, 1976**

Original host: *Neovison* (syn. *Mustela*) *vison* (Schreiber, 1777), American Mink.

Remarks: Foreyt and Todd (1976) collected fecal samples on 29 mink ranches (22 counties) in Wisconsin, USA, from June–December, 1975. They found that 45/79 (57%) mink feces collected from ranches that fed dry pelleted rations contained coccidian oocysts, whereas 128/244 (52%) samples from ranches that fed a wet meat mixture contained oocysts. They mentioned finding oocysts resembling an undescribed *Eimeria* species in mink on 19/29 (66%) of the ranches, but the number of mink with this species was not mentioned, stating only “the coccidia of domestic mink in Wisconsin are prevalent and widespread.” They said the oocysts were 12.5×11.8 but gave no additional descriptive information. To our

knowledge, this species has never been mentioned again in the literature.

**HAMMONDIA SP. OF RYAN,
WYAND, AND NIELSEN, 1982**

Original host: *Neovison* (syn. *Mustela*) *vison* (Schreiber, 1777), American Mink.

Remarks: Ryan et al. (1982) studied skinned muskrat (*Ondatra zibethica*) carcasses from Connecticut and New Jersey, USA and found coccidia-like zoites in their muscles using a pepsin digestion technique. They then fed seven pairs of coccidia-free mink half of an infected muskrat carcass each. Four pairs of mink fed muskrats shed unsporulated coccidian oocysts in their feces 6–8 DPI and patency lasted 4–6 days. Sporulated oocysts were $L \times W$ ($n=80$): 11.6×10.7 ($11.5-12 \times 10-11$), L/W ratio: 1.1. They reported that the oocysts had a M, but we did not see one in a photomicrograph presented (their Fig. 4), and the oocysts lacked a PG and OR. Sporocysts were $L \times W$ ($n=160$): 8.8×6.5 ($8-9 \times 6-7$), L/W ratio: 1.4 and had a granular SR, but lacked SB and SSB. They also fed another seven pairs of coccidia-free mink ~200,000 sporulated oocysts each that were derived from the previous four pairs that shed the oocysts, but none of the second seven pairs shed oocysts during the course of the experiment. After 30 DPI, all 14 pairs of mink (those fed tissue cysts and those fed only oocysts) were killed and sections of gastrointestinal tract, pancreas, ileocecal lymph node, liver, kidney, lung, heart, brain, diaphragm, tongue, esophagus, and masseter muscles were examined for coccidian cysts and skeletal muscles were examined via pepsin digestion. All were negative. The authors concluded that their work was insufficient to establish whether this *Hammondia*-like parasite was identical to an already known species or was a new species. This interesting study certainly deserves more attention, especially now that we have molecular tools with which to work.

HEPATOZOON SP. OF PRESIDENTE AND KARSTAD, 1975

Original host: *Neovison* (syn. *Mustela*) *vison* (Schreiber, 1777), American Mink.

Remarks: Presidente and Karstad (1975) found meronts of a *Hepatozoon* in the lungs of 10/18 (56%) American minks they examined in southwestern Ontario, Canada. Meronts were found in the pulmonary parenchyma, and focal aggregations of lymphocytes, macrophages, plasma cells, and eosinophils were associated with small groups of meronts. Two kinds of meronts were seen: subspheroidal forms, 22–29 × 19–24, with a single row of 18–24 macromerozoites around the perimeter; and larger, oblong to spheroidal meronts, 29–38 × 19–24, with 34–38 micromerozoites located throughout the meront. They made no attempt to further identify or name the parasite.

ISOSPORA BIGEMINA OF SEALANDER, 1943

Original host: *Neovison* (syn. *Mustela*) *vison* (Schreiber, 1777), American Mink.

Remarks: Sealander (1943) examined 158 mink carcasses that he obtained from southern Michigan fur-buyers in the winters of 1940 and 1941. He was looking specifically to catalog helminth parasites, but briefly mentioned that “coccidia, *Isospora bigemina*, were frequently noted in fecal samples.” In all likelihood, he was seeing sporocysts of an unknown *Sarcocystis* species.

SARCOCYSTIS SP. OF RAMOS-VERA, DUBEY, WATSON, WINN-ELLIOT, PATTERSON, AND YAMINI, 1997

Definitive host: Unknown.

Intermediate host: *Neovison* (syn. *Mustela*) *vison* (Schreiber, 1777), American Mink.

Remarks: Ramos-Vera et al. (1997) had three 2–3-month-old minks with signs of progressive

neurological disease. One mink had variable numbers of sarcocysts, which measured up to 300 × 20, in multiple skeletal muscles. The sarcocyst wall had numerous elongated villar protrusions that measured 1.7 μm × 250 nm. These protrusions had microtubules and irregularly distanced minute undulations. The most important lesions were seen in the brains of all three minks. The authors said this was the first time *Sarcocystis* sarcocysts were described in mink muscles. The parasite was not identified to species and is considered a *species inquirenda*.

FAMILY OTARIIDAE GRAY, 1825

GENUS CALLORHINUS J.E. GRAY, 1859 (MONOTYPIC)

SARCOCYSTIS SP. OF BROWN, SMITH, AND KEYES, 1974

Definitive host: Unknown.

Intermediate host: *Callorhinus ursinus* (L., 1758), Northern Fur Seal.

Remarks: Brown et al. (1974) found sarcocysts in the masseter muscle of one adolescent northern fur seal among a group of 30 pups and two adults on St. Paul Island, Pribiloff Islands, Alaska, USA. Although this was the first report of an apparent *Sarcocystis* species in marine mammals, the life cycle of this species is still unknown. No other information was provided. This species has not been identified since 1974 and must remain a *species inquirenda*.

GENUS OTARIA PÉRON, 1816 (MONOTYPIC)

CRYPTOSPORIDIUM SPP. OF HERMOSILLA, SILVA, NAVARRO, AND TAUBERT, 2016

Original host: *Otaria flavescens* (Shaw, 1800), South American Sea Lion.

Remarks: Hermosilla et al. (2016) examined 40 fecal samples of South American sea lions, *O. flavescens*, along the shores of the river Calle-Calle and in the local fish market in Valdivia, Chile, for the presence of *Cryptosporidium*. All feces were screened by LM of stained fecal smears and also by ELISA. They determined that 4/40 (10%) samples were infected with *Cryptosporidium* species, but the authors did not identify the organism to species. This was the first report of *Cryptosporidium* in *O. flavescens*, but without more information it must remain a *species inquirenda*.

GENUS ZALOPHUS GILL, 1866 (3 SPECIES)

COCCIDIAN PARASITES “A,” “B,” “C” OF COLEGROVE, GRIGG, CARLSON-BREMER, MILLER, GULLAND, FERGUSON, REJMANEK, BARR, NORDHAUSEN, MELLI, AND CONRAD, 2011

Original host: *Zalophus californianus* (Lesson, 1828), California Sea Lion.

Remarks: Colegrove et al. (2011) discovered coccidian endogenous stages in the small intestine of five free-ranging California sea lions during routine postmortem examinations. In each case, multiple stages of both asexual (meronts, merozoites) and sexual (micro- and macrogamonts) stages were seen in the apical cytoplasm of distal jejunal enterocytes. Using standard histological techniques, IHC, TEM, DNA extraction, and PCR amplification of ITS-1 and 18S rRNA genes they were able to conclude that they identified previously undescribed intestinal protozoan species representing three previously uncharacterized gene sequences representing three new coccidian species that are most closely related to, but not identical with *Neospora caninum*.

COCCIDIA A, B, C, CSL AÑO 11 OF GIRARD, JOHNSON, FRITZ, SHAPIRO, PACKHAM, MELLI, CARLSON-BREMER, GULLAND, REJMANEK, AND CONRAD, 2016

Original host: *Zalophus californianus* (Lesson, 1828), California Sea Lion.

Remarks: Girard et al. (2016) found 16/139 (11.5%) sea lions, stranded in California, USA in 2010 and 2012, shedding oocysts in their feces. In 2011–12, they collected more fecal samples at sea lion haul-out sites at three locations in central California and 13/212 (6%) had oocysts present. Amplified ITS-1 from the samples strongly supported the presence of Coccidia A and B of Colegrove et al. (2011). One sample produced a novel sequence that had 97%–98% pairwise similarity to previously published coccidian DNA isolates in Guadalupe fur seal tissues (Gibson et al., 2011). Coccidia A and B were sporulated and inoculated into mice to investigate infectivity and pathogenicity, but no remarkable clinical signs or histologic changes were observed except ~40% of the mice had slight nephritis, pneumonia, and inflammation in lung, spleen, and lymph nodes. Brain, heart, and tongue all tested negative using pan-coccidian primers that included the ITS-1 region. Results of phylogenetic analyses using ITS-1 indicated the Coccidia A, B, C, CSL Año 11, and isolates from harbor seals and Guadalupe fur seals all shared a common ancestor with *N. caninum*. Girard et al. (2016) concluded that additional genetic and morphologic studies are required to resolve the taxonomy of these novel marine mammal coccidia, and they believe it is likely these organisms are either a new *Neospora* species or a new genus in the Sarcocystidae.

Girard et al. (2016) also inoculated excysted SZ of Coccidia A and B into tissue flasks of Green Monkey-derived MA104 cells. At 14, 21, and 35 DPI, 3/4 (75%) cultures had intra- and extracellular propagating organisms morphologically similar to *Sarcocystis* spp. Extracellular zoites were 8–11 × 1–2. As the cultures aged, the number

of zoites increased suggesting they were merozoites produced via merogony, and they described active zoites to exhibit movement typical of *S. neurona*. Antigen slides, prepared from zoites, tested positive to *S. neurona* antisera from a horse and a sea lion by IFAT. PCR amplification of zoite DNA confirmed that zoites were similar to *S. neurona*, which allowed Girard et al. (2016) to conclude that in addition to the observed *Coccidia* A and B, a *S. neurona*-like organism is excreted by sea lions in low concentrations and sea lions are mechanical vectors.

CRYPTOSPORIDIUM SP. OF ADELL, SMITH, SHAPIRO, MELLI, AND CONRAD, 2014

Original host: *Zalophus californianus* (Lesson, 1828), California Sea Lion.

Remarks: Adell et al. (2014) collected fecal samples from 303 *Z. californianus* at three sites in Central California, USA: White Rock near Cambria, Point Lobos State Reserve near Monterey, and Año Nuevo Island near Pescadero. Using the direct fluorescent antibody (DFA) method they detected *Cryptosporidium* oocysts in 30/303 (10%) samples including, 11/133 (8%) from White Rock, 17/113 (15%) from Point Lobos, and 2/57 (3.5%) from Año Nuevo Island. They were unable to PCR amplify the 18S rRNA and COWP gene sequences of their *Cryptosporidium* isolates, probably because of the small number of oocysts in their samples, and, thus could not confirm their specific identification by genotype analysis.

SARCOCYSTIS SP. OF MENSE, DUBEY, AND HOMER, 1992

Definitive host: Unknown.

Intermediate host: *Zalophus californianus* (Lesson, 1777), California Sea Lion.

Remarks: Mense et al. (1992) did not proof the galley of their manuscript before it went

to press, so their published title reads, "Acute hepatic necrosis associated with a *Sarcocystis*-like..." instead of *Sarcocystis*-like. We mention this only to aid those doing a search online, who may have trouble bringing up this title. In addition, the first line of their report says, "A 10-year-old (sic) male California sea lion..." so it is not clear if the affected sea lion from an aquarium in Florida, USA was 1- or 10-years-old. This animal died after 3 days of exhibiting lethargy and anorexia. Tissues were fixed and preserved for both LM and TEM and later stained with anti-*T. gondii*, anti-*N. caninum*, and anti-*S. cruzi* serum; parasite stages in the liver reacted only with the anti-*Sarcocystis* serum. Sections of infected liver demonstrated coagulative and lytic necrosis with associated nuclear pyknosis, karyorrhexis, and hepatocyte loss in areas adjacent to parasite stages. Sarcocysts in myocytes, however, were unassociated with inflammation. Parasites in the liver divided by endopolygony and both meronts and merozoites were seen there. Meronts were up to 32 long and contained 6–35 merozoites, each ~5 × 1. Their TEM sections demonstrated the meronts to be located free in the hepatocyte cytoplasm, without a PV, and merozoites contained numerous micronemes, a conoid, but no rhoptries. The parasite they identified as a *Sarcocystis* species, likely was *S. neurona*, but there is no way to state that unequivocally, so their form must be relegated to a *species inquirenda*.

FAMILY PHOCIDAE GRAY, 1821

GENUS CYSTOPHORA NILSSON, 1820 (MONOTYPIC)

CRYPTOSPORIDIUM SP. OF BASS, WALLACE, YUND, AND FORD, 2012

Original host: *Cystophora cristata* (Erxleben, 1777), Hooded Seal.

Remarks: Bass et al. (2012) examined one fecal sample from a hooded seal, *C. cristata*, in the Gulf of Maine, USA, using a nested PCR amplification and subsequent sequencing of the 18S rRNA gene they determined the presence of *Cryptosporidium* sp. and found it most closely related to the genotype *Cryptosporidium* sp. seal 1 and seal 2 described by Santín et al. (2005) from ringed seals.

GENUS ERIGNATHUS GILL, 1866 (MONOTYPIC)

SARCOCYSTIS SP. OF BISHOP, 1979

Definitive host: Unknown.

Intermediate host: *Erignathus barbatus* (Erxleben, 1777), Bearded Seal.

Remarks: Bishop (1979) found a small number of sarcocysts in the skeletal muscle of the tongue of a bearded seal that had been killed by polar bears in the Arctic. Obviously, the life cycle of this species is unknown. No other information was provided. This species has not been identified since 1979 and must remain a *species inquirenda*.

GENUS LEPTONYCHOTES GILL, 1872 (MONOTYPIC)

CRYPTOSPORIDIUM SP. OF RENGIFO-HERRERA, ORTEGA-MORA, GÓMEZ- BAUTISTA, GARCÍA-PENA, GARCÍA-PÁRRAGA, AND PEDRAZA-DÍAZ, 2013

Original host: *Leptonychotes weddellii* (Lesson, 1826), Weddell Seal.

Remarks: Rengifo-Herrera et al. (2013) examined fecal samples of 14 *L. weddellii* from Deception Island in South Shetland Islands. Using PCR amplification of 18S rRNA, HSP70,

and COWP genes, they found two individuals (14%) positive for a *Cryptosporidium* sp. that represented a novel genotype they called the Weddell seal genotype.

EIMERIA SP. 2 OF DRÓZDŹ, 1987

Original host: *Leptonychotes weddellii* (Lesson, 1826), Weddell Seal.

Remarks: Drózdź (1987) reported cherry-orange, ellipsoidal oocysts with a thin, wrinkled, bilayered wall, M: absent, that measured L×W: 25.7×18.8 (22–31×14–22), L/W ratio: 1.4, in 5/65 (8%) Weddell seals from King George Island, South Shetlands from April, 1981 to January, 1982. No other information was provided, and this species has not been identified since 1987; thus, it must be relegated to a *species inquirenda*.

EIMERIA SP. 3 OF DRÓZDŹ, 1987

Original host: *Leptonychotes weddellii* (Lesson, 1826), Weddell Seal.

Remarks: Drózdź (1987) found gray, spherical oocysts with a thin, smooth wall without a M, that were 25–33 wide, L/W ratio: 1.0, in 3/65 (5%) Weddell seals from King George Island, South Shetlands from April, 1981 to January, 1982. No other information was provided, and this species has not been identified since 1987; thus, it must be relegated to a *species inquirenda*.

SARCOCYSTIS SP. OF IPPEN AND HENNE, 1989

Definitive host: Unknown.

Intermediate host: *Leptonychotes weddellii* (Lesson, 1826), Weddell Seal.

Remarks: Ippen and Henne (1989) examined chest, back, tongue, esophagus, diaphragm, and heart muscle tissue from a Weddell seal collected

in the Antarctic. Large numbers of cysts were observed in the chest, back, tongue, and esophagus. Cross-sections of cysts were 40–70 × 50–110, and cystozoites were 4–5 × 1. Longitudinal slices of cysts were “serpentine” and measured 30–100 × 100–180. No other information was provided, and this species has not been identified since 1989; thus, it must be regarded a *species inquirenda*.

GENUS LOBODON GRAY, 1844 (MONOTYPIC)

EIMERIA SP. 1 OF DRÓZDŹ, 1987

Original host: *Lobodon carcinophaga* (Hombron and Jacquinet, 1842), Crabeater Seal.

Remarks: Drózdź (1987) said he found yellow-gray, ovoidal oocysts with a smooth, bilayered wall without a M, that measured L × W: 30.0 (sic) × 24.3 (38–40 × 24–25), L/W ratio: 1.2, in 6/43 (14%) crabeater seals from King George Island, South Shetlands from April, 1981 to January, 1982. No other information was provided, and this species has not been identified since 1987; thus, it must be regarded as a *species inquirenda*.

SARCOCYSTIS SP. OF IPPEN AND HENNE, 1989

Definitive host: Unknown.

Intermediate host: *Lobodon carcinophaga* (Hombron and Jacquinet, 1842), Crabeater Seal.

Remarks: Ippen and Henne (1989) examined chest, back, tongue, esophagus, diaphragm, and heart muscles from two crabeater seals, a male and a female, collected in the Antarctic. Male tissues were negative, but the female had a “moderate” infection with sarcocysts in her back, tongue, and esophagus. Cysts in cross-section were 40–80 × 60–110. Cysts in the esophagus measured 30–90 × 70–340. No other information was provided, and this species has not been seen

again since 1989; thus, it must be relegated to a *species inquirenda*.

GENUS MIROUNGA GRAY, 1827 (2 SPECIES)

CRYPTOSPORIDIUM SP. OF RENGIFO-HERRERA, ORTEGA- MORA, GÓMEZ-BAUTISTA, GARCÍA-MORENO, GARCÍA- PÁRRAGA, CASTRO-URDA, AND PEDRAZA-DÍAZ, 2011

Original host: *Mirounga leonina* (L., 1758), Southern Elephant Seal.

Remarks: Rengifo-Herrera et al. (2011) collected fecal samples from southern elephant seals, on the Antarctic Peninsula. Using immunofluorescence microscopy, and PCR amplification of 18S rRNA and HSP70 genes, they found 1/53 (2%) seals from Avian Island, Marguerite Bay, to be positive for a *Cryptosporidium* sp. they said was most closely related to a skunk genotype.

CRYPTOSPORIDIUM SP. OF RENGIFO-HERRERA, ORTEGA-MORA, GÓMEZ- BAUTISTA, GARCÍA-PENA, GARCÍA-PÁRRAGA, AND PEDRAZA-DÍAZ, 2013

Original host: *Mirounga leonina* (L., 1758), Southern Elephant Seal.

Remarks: Rengifo-Herrera et al. (2013) examined fecal samples from *M. leonina* in the South Shetland Islands and Antarctic Peninsula. Using PCR amplification of the 18S rRNA, HSP70, and COWP genes, they found 3/111 (3%) seals positive for a *Cryptosporidium* sp. they said was most closely related to the southern elephant seal genotype. One positive seal was from Avian Island, Marguerite Bay, Antarctic Peninsula, one from

Biscoe Point, and one from Byers Peninsula, Livingston Island, South Shetland Island.

**SARCOCYSTIS SP. OF
IPPEN AND HENNE, 1989**

Definitive host: Unknown.

Intermediate host: *Mirounga leonina* (L., 1758), Southern Elephant Seal.

Remarks: Ippen and Henne (1989) examined chest, back, tongue, esophagus, diaphragm, and heart muscles from two male elephant seals, one adult and one juvenile, collected in the Antarctic. Adult tissues were negative, but the juvenile had cysts present in the chest, tongue, and diaphragm. Cysts were smaller than those observed in Weddell and crabeater seals reported in the same paper, measuring 20–40 × 30–80 in cross-section. Ippen and Henne (1989) suggested that in the juvenile the cysts might be the result of a recent infection and had not reached their full size. No other information was given by the authors, and this species has not been reported again since 1989: thus, it must be relegated to a *species inquirenda*.

**GENUS PAGOPHILUS
GRAY, 1844 (MONOTYPIC)**

**CRYPTOSPORIDIUM SP.
OF BASS, WALLACE, YUND,
AND FORD, 2012**

Original host: *Pagophilus groenlandicus* (Erxleben, 1777), Harp Seal.

Remarks: Bass et al. (2012) examined 24 fecal samples from harp seals in the Gulf of Maine, USA using a nested PCR amplification, and subsequent sequencing of the 18S rRNA and HSP70 genes, and found one harp seal (4%) with a *Cryptosporidium* sp. genotype most closely related to the seal 1 and seal 2 genotypes described by Santín et al. (2005) from ringed seals.

**GENUS PHOCA L., 1758
(2 SPECIES)**

**CRYPTOSPORIDIUM SP.
OF BASS, WALLACE, YUND,
AND FORD, 2012**

Original host: *Phoca vitulina* (L., 1758), Harbor Seal.

Remarks: Bass et al. (2012) collected fecal samples from *P. vitulina* in two localities in Maine, USA, and using nested PCR amplification, with subsequent sequencing of the 18S rRNA and HSP70 genes, they reported detecting *Cryptosporidium* in 11/176 (6%) samples that were most closely related to the genotype *Cryptosporidium* sp. seal 1 and seal 2 described by Santín et al. (2005) from ringed seals.

**CRYPTOSPORIDIUM SP. OF
GREIG, GULLAND, SMITH,
CONRAD, FIELD, FLEETWOOD,
HARVEY, IP, JANG, PACKHAM,
WHEELER, AND HALL, 2014**

Original host: *Phoca vitulina* (L., 1758), Harbor Seal.

Remarks: Greig et al. (2014) collected fecal samples from *P. vitulina* (40 stranded, 13 wild-caught) from San Francisco, and seven wild-caught from Tomales Bay, California USA, and examined them using a direct immunofluorescent antibody test (DFA). *Cryptosporidium* was detected in only one sample of a weaned pup. Its genotype was not successfully determined.

**SARCOCYSTIS SP. OF
HADWEN, 1922**

Definitive host: Unknown.

Intermediate host: *Phoca vitulina* L., 1758, Harbor Seal.

Remarks: While examining reindeer and caribou muscle for sarcocysts in Alaska, Hadwen (1922) also found sarcocysts in the heart and esophagus of a seal. In the heart, the sarcocysts were numerous and averaged 0.43 mm × 0.17 mm. Sarcocysts in the esophagus and other muscles were larger, 0.87 mm × 0.14 mm, with the longest cyst 2.5 mm. Hadwen (1922) said these sarcocysts looked similar to those of *Sarcocystis tenella* of sheep. Nothing more is known about this form.

**SARCOCYSTIS SP. OF LAPOINTE,
DUIGNAN, MARSH, GULLAND,
BARR, NAYDAN, KING, FARMAN,
BUREK-HUNTINGDON, AND
LOWENSTINE, 1998**

Definitive host: Unknown.

Intermediate host: *Phoca vitulina richardii* (Gray, 1864), Pacific Harbor Seal.

Remarks: Lapointe et al. (1998) reported seven Pacific harbor seals that, upon examination, had meningoencephalitis associated with *S. neuronae*-like parasites. One seal was reported to have “rare” sarcocysts of an undetermined species in its **cardiomyocytes**.

**GENUS PUSA SCOPOLI,
1771 (3 SPECIES)**

**CRYPTOSPORIDIUM SP.
OF DIXON, PARRINGTON,
PARENTEAU,
LECLAIR, SANTÍN,
AND FAYER, 2008**

Original host: *Pusa hispida* (Schreber, 1775), Ringed Seal.

Remarks: Dixon et al. (2008) examined the intestinal contents of *P. hispida* in the Nunavik region, northern Québec, Canada. Using flow cytometric analyses combining fluorescence

and morphological parameters, they detected *Cryptosporidium* in 5/55 (9%) of the samples. Coinfection with *Giardia duodenalis* was detected in 4/5 samples.

**CRYPTOSPORIDIUM SP.
OF HUGHES-HANKS,
RICKARD, PANUSKA,
SAUCIER, O’HARA, DEHN,
AND ROLLAND, 2005**

Original host: *Pusa hispida* (Schreber, 1775), Ringed Seal.

Remarks: Hughes-Hanks et al. (2005) examined fecal samples of *P. hispida* from northern Alaska, near Barrow, using the immunofluorescent assay. *Cryptosporidium* was detected in 7/31 (23%) samples (5 males, 2 females). No specific identification was attempted.

**EIMERIA SP. OF KUIKEN,
KENNEDY, BARRETT, VAN DE
BILD, BORGSTEEDE, BREW,
Codd, DUCK, DEAVILLE,
EYBATO, FORSYTH, FOSTER,
JEPSON, KYDYRMANOV,
MITROFANOV, WARD, WILSON,
AND OSTERHAUS, 2006**

Original host: *Pusa caspica* (Gmelin, 1788) (syn. *Phoca caspica*), Caspian Seal.

Remarks: Kuiken et al. (2006) reported a large die-off of Caspian seals in the spring and summer, 2000, which they attributed to a canine distemper epidemic, and they mentioned finding *Eimeria*-like oocysts in the cytoplasm of jejunal enterocytes in 1 of the of the 18 seals they necropsied. They said the oocysts “consisted of 4–8 banana-shaped zoites (2 μm × 8 μm) with a central blue nucleus and surrounded by a narrow, birefringent wall.” They did not try to identify the oocysts they saw more specifically but said

they were similar to those of *E. phocae* from harbor seals. This species has not been identified since 2006 and must remain a *species inquirenda*.

**SARCOCYSTIS SP. OF KUIKEN,
KENNEDY, BARRETT, VAN DE
BILDT, BORGSTEEDE, BREW,
CODD, DUCK, DEAVILLE,
EYBATOV, FORSYTH, FOSTER,
JEPSON, KYDYRMANOV,
MITROFANOV, WARD, WILSON,
AND OSTERHAUS, 2006**

Definitive host: Unknown.

Intermediate host: *Pusa caspica* (Gmelin, 1788) (syn. *Phoca caspica*), Caspian Seal.

Remarks: Kuiken et al. (2006), reported on a die-off of Caspian seals in the spring and summer, 2000, which they attributed to canine distemper, and mentioned finding *Sarcocystis*-like cysts containing many banana-shaped bradyzoites, $\sim 6\ \mu\text{m} \times 2\ \mu\text{m}$, with a distinct N, in myocytes of the esophageal muscularis and skeletal muscle of 1/18 (5.5%) seals. The cysts distended the infected myocyte but did not induce an inflammatory response in adjacent tissue (their Fig. 12, p. 328). No other information was provided. This species has not been identified since 2006 and must remain a *species inquirenda*.

**SARCOCYSTIS SP. OF
MIGAKI AND ALBERT, 1980**

Definitive host: Unknown.

Intermediate host: *Pusa hispida* (Schreber, 1775), Ringed Seal.

Remarks: Migaki and Albert (1980) found sarcocysts in the skeletal muscles, but not in the heart, of 12/18 (67%) apparently healthy *P. hispida* from the Arctic Ocean near Barrow, Alaska, USA. The cysts were compartmented, elongate, 60–550 wide and had moderately thick, well-defined cell walls, 0.8–1.0 thick. Bradyzoites were 10–12 \times 2–3. Obviously, the life cycle of this

species is unknown. No other information was provided. This species has not been identified since 1980 and must remain a *species inquirenda*.

**FAMILY PROCYONIDAE
GRAY, 1825**

**GENUS POTOS É. GEOFFROY
SAINT-HILAIRE AND F.G.
CUVIER, 1795 (MONOTYPIC)**

SARCOCYSTIS SP. OF TAKOS, 1957

Definitive host: Unknown.

Intermediate host: *Potos* sp., Kinkajou.

Remarks: Takos (1957) found a sarcosporidian infection in an old male kinkajou shot near the Rio Mandinga Bridge, Panama Canal Zone, Panama. Sarcocysts were found in striated muscle, but not in the myocardium or other organs. Sarcocysts were broadly ovoidal and measured 123–216 \times 85–100. Each sarcocyst was bounded by a dense, well-defined, unstriated wall, ~ 1 thick. Sarcocysts were divided into compartments by thin septa and the chambers they formed were densely packed with banana-shaped zoites that measured 7.5–9 \times 2. Takos (1957) said there was no evidence of tissue reaction to the parasite and that this was the first report of a *Sarcocystis* species in the muscles of a kinkajou. No other information was given.

**GENUS PROCYON STORR,
1780 (3 SPECIES)**

**COCCIDIUM OF CARLSON
AND NIELSEN, 1982**

Original host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Carlson and Nielsen (1982) reported the presence of “macrogametocytes containing multiple substructures identified as macrogametes and red-staining residual bodies, as well as oocysts” in the villi and intestinal lumen of the

small intestine of a young raccoon in which they also described a *Cryptosporidium* sp. (below). No other information was given.

CRYPTOSPORIDIUM SP. OF CARLSON AND NIELSEN, 1982

Original host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Carlson and Nielsen (1982) first reported the presence of *Cryptosporidium* in a young male raccoon from Waterford, Connecticut, USA. The raccoon did not show any clinical signs of infection. Histology revealed endogenous stages of a *Cryptosporidium* sp. at the tips of the small intestinal villi, but not in the crypts. The villi were reduced in length, blunted, and increased in width; lamina propria was infiltrated with eosinophils and mononuclear cells.

CRYPTOSPORIDIUM SPP. OF FENG, ALDERISIO, YANG, BLANCERO, KUHNE, NADARESKI, REID, AND XIAO, 2007

Original host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Feng et al. (2007) surveyed fecal samples of wild *P. lotor* from the watershed of the New York City drinking water supply, USA, for *Cryptosporidium* spp. Using 18S rDNA and RFLP gene sequencing and analysis they reported 4/21(19%) positive samples, 1 for a cervine genotype (syn. genotype W4) and 3 for a skunk genotype (syn. genotype W13).

CRYPTOSPORIDIUM SPP. OF LEŚNIAŃSKA, PEREC- MATYSIAK, HILDEBRAND, BUNKOWSKA-GAWLIK, PIRÓG, AND POPIOŁEK, 2016

Original host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Leśniańska et al. (2016) collected feces from *P. lotor* that were introduced and

are now invasive, to Europe; 32 samples were from two areas in Poland (Kostrzyn on the Oder, and Warta Mouth National Park), and 17 samples from Germany (Müritz National Park, Mecklenburg-Vorpommern). *Cryptosporidium* was detected in 17/49 (35%) samples (14 from Poland, 3 from Germany). Amplification of 18S rRNA, COWP, and actin genes demonstrated that 9/17 (53%) infected raccoons had *Cryptosporidium* skunk genotype. This study was the first evidence of *Cryptosporidium* in raccoons from Poland and Germany.

CRYPTOSPORIDIUM SP. OF MARTIN AND ZEIDNER, 1992

Original host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Martin and Zeidner (1992) described a case of cryptosporidiosis in a juvenile *P. lotor* found moribund in Fort Collins, Colorado, USA. The animal was emaciated, dehydrated, and had diarrhea. Microscopically, *Cryptosporidium* endogenous stages, spheroidal to ovoidal, 2–7 wide, were seen on intact intestinal villi. The raccoon also was infected with coronavirus and parvovirus.

CRYPTOSPORIDIUM SP. OF ZHOU, FAYER, TROUT, RYAN, SCHAEFER III, AND XIAO, 2004

Original host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Zhou et al. (2004) collected the feces of 471 mammals from four counties in the Chesapeake Bay area of Maryland, USA; they found 2/51 (4%) raccoons (presumably *P. lotor*) to be infected with a *Cryptosporidium* skunk genotype. The species and genotype of *Cryptosporidium* in each fecal sample was determined by a PCR-RFLP method based on the 18S rRNA gene.

**CRYPTOSPORIDIUM SPP.
OF ZIEGLER, WADE, SCHAAF,
STERN, NADARESKI, AND
MOHAMMED, 2007**

Original host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Ziegler et al. (2007) collected fecal samples of wild *P. lotor* in the New York City Watershed, southeastern New York state, USA. Samples were examined by LM and by polyclonal *Cryptosporidium* antigen-capture ELISA (considered positive based on an optical density ≥ 0.050). They found *Cryptosporidium* in 49/173 (28%) samples.

**EIMERIA (?) SPP. OF ROBEL,
BARNES, AND UPTON, 1989**

Original host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Robel et al. (1989) collected raccoons from two locations in Kansas, USA and reported that 8/36 (22%) raccoons from Ft. Riley and 25/92 (27%) from rural Manhattan had eimerian oocysts in their rectal contents. However, because all intestinal tracts had been frozen for 1–3 months at -5°C , which should have prevented sporulation, it is not clear to us how they were able to state these were eimerian oocysts.

**EIMERIA SPP. OF SNYDER,
1984, 1988**

Original host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Snyder (1984, 1988) reported oocysts of *Eimeria* spp. in 67/100 (67%) fecal samples from *P. lotor* in Illinois, USA. He examined the samples for *C. parvum*, using sucrose flotation (1984) or an indirect immunofluorescent detection procedure (1988) and reported that “*Eimeria* spp. oocysts were routinely seen in samples but never exhibited any fluorescence.”

**EIMERIA SP. OF FOSTER,
MCCLEERY, AND FORRESTER, 2004**

Original host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Foster et al. (2004) recovered oocysts of three *Eimeria* spp. from raccoons collected in Key Largo, Monroe county, Florida, USA; two were previously described (*E. procyonis*, *E. nuttalli*), but the third form, found in 2/61 (3%) samples, was unknown. Oocysts were ellipsoidal, $L \times W$ ($n=22$): 29.2×15.7 ($28-31 \times 14-17$), L/W ratio: 1.9; with a smooth, 2-layered wall; M, OR, PG: all absent. Sporocysts were ellipsoidal, 10.1×7.7 ($10-11 \times 6-8$); SB, SSB, PSB, SR: all absent. Foster et al. (2004) speculated this was likely a spurious coccidium originating from a food item passing through the raccoon’s gastrointestinal tract.

**SARCOCYSTIS SP. OF ADAMS,
LEVINE, AND TODD, JR., 1981**

Definitive host: *Procyon lotor* (L., 1758), Raccoon.

Intermediate host: Unknown.

Remarks: Adams et al. (1981) mentioned finding two naturally-infected raccoons in Illinois, USA that were discharging *Sarcocystis*-like sporocysts in their feces, but they did not attempt to determine the species. Sporocysts were ellipsoidal or had one side flattened, $L \times W$ ($n=17$): 13.0×9.3 ($11-13 \times 8-10$), with a smooth wall; SB, SSB, PSB: all absent; SR: present, and SZ were “elongate” lying lengthwise in SP. An attempt to infect four pigs resulted in no sarcocysts in pig muscles or other tissues at necropsy and no oocysts in the pig’s feces.

**SARCOCYSTIS SP. OF DUBEY,
HAMIR, HANLON, TOPPER,
AND RUPPRECHT, 1990b**

Definitive host: Unknown.

Intermediate host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Dubey et al. (1990b) received 45 raccoons from Ohio, USA for experiments to develop an oral rabies recombinant vaccine for wildlife. One juvenile female was unsteady on its feet, had difficulty with balance, and its head was constantly turned to the left. Seven days after arrival, it was anorectic, had mucopurulent nasal and serous ocular discharge, and was moribund. On necropsy they observed the carcass was dehydrated, mucous membranes were pale, and lungs were consolidated. Numerous developmental stages of a *Sarcocystis* species were found in the cytoplasm of macrophages, neurons, and multinucleated giant cells. In mature meronts, merozoites were arranged in a rosette around a residual body; individual merozoites measured 4–5×1 and were seen in mononuclear cells located within meningeal blood vessels. Organisms were located in host cell cytoplasm without a PV, and merozoites had no rhoptries. Moderate numbers of sarcocysts were found in striated muscles of the heart, tongue, diaphragm, esophagus, masseter, and extraorbital muscles. In all likelihood, this species is *S. neurona* but must be considered a *species inquirenda* at this time.

SARCOCYSTIS SP. OF FOSTER, MCCLEERY, AND FORRESTER, 2004

Definitive host: *Procyon lotor* (L., 1758), Raccoon.

Intermediate host: Unknown.

Remarks: Foster et al. (2004) collected sporocysts from the feces of 2/61 (3%) raccoons on Key Largo, Monroe county, Florida, USA. Sporocysts were ellipsoidal, L×W (n=10): 13.3×8.5 (12–14×7–10). There was no attempt to identify the species.

SARCOCYSTIS (?) SP. OF ROBEL, BARNES, AND UPTON, 1989

Definitive host: *Procyon lotor* (L., 1758), Raccoon.

Intermediate host: Unknown.

Remarks: Robel et al. (1989) collected raccoons from two locations in Kansas, USA and reported that 5/92 (5%) from rural Manhattan, but 0/36 from Ft. Riley, had sporocysts of a *Sarcocystis* sp. in their rectal contents. However, these numbers only were present in their Table I, and they never mentioned the presence of *Sarcocystis* in the body of their paper. It also should be noted that all intestinal tracts had been frozen, for 1–3 months at –5°C, before they were examined, so it is not clear to us if the sporocysts they saw had SZ in them or not.

SARCOCYSTIS SP. OF SENEVIRATNA, EDWARD, AND DEGIUSTI, 1975

Definitive host: Unknown.

Intermediate host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Seneviratna et al. (1975) examined the muscles of domestic animals and a few wild animals killed in Detroit, Michigan, USA from April to September, 1973. They found 2/6 (33%) raccoons, both female, with sarcocysts in their muscles. They were unable to make a species identification; thus, another *species inquirenda*.

SARCOCYSTIS SPP. OF THULIN, GRANSTROM, GELBERG, MORTON, FRENCH, AND GILES, 1992

Definitive host: *Procyon lotor* (L., 1758), Raccoon.

Intermediate host: *Procyon lotor* (L., 1758), Raccoon.

Remarks: Thulin et al. (1992) reported an adult male raccoon with protozoal encephalitis associated with a *Sarcocystis*-like organism and concurrently infected with canine distemper. The *Sarcocystis* species was intracellular in the cytoplasm, without a PV. Histologically, sarcocysts were present in skeletal muscle and occasionally

in the heart; these cysts were 19×25 to 40×506 and had striated walls that were 1.5–2.0 thick. Individual merozoites were 2.0×1.5 . A second raccoon had numerous *Sarcocystis*-type oocysts in the lamina propria of its small intestine. It is possible that the form in the first raccoon was *S. neurona* because of its intracellular location without a PV, with the raccoon serving as an intermediate host; similarly, the isosporoid oocysts in the gut of the second raccoon may represent another species of *Sarcocystis*, with the raccoon serving as the definitive host. Both forms can only be considered *species inquirendae* at this time.

FAMILY URSIDAE FISCHER DE WALDHEIM, 1817

GENUS AILUROPODA MILNE- EDWARDS, 1870 (MONOTYPIC)

CRYPTOSPORIDIUM SP. OF LIU, HE, ZHONG, ZHANG, WANG, DONG, WANG, LI, DENG, PENG, AND ZHANG, 2013

Original host: *Ailuropoda melanoleuca* (David, 1869), Giant Panda.

Remarks: Liu et al. (2013) examined fecal samples of 57 giant pandas from the China Conservation and Research Centre for the Giant Panda in Ya'an City, Sichuan, China. No clinical signs were observed in the pandas at the time of feces collections. One 18-year-old panda was positive for *Cryptosporidium* oocysts that were $L \times W$ ($n=50$): 4.6×4.0 ($4-6 \times 3-5$). Using the sequences of 18S rRNA, HSP70, COWP, and actin genes, Liu et al. (2013) discovered that this parasite represented a new genotype of *Cryptosporidium*, which was most closely related to the *Cryptosporidium* bear genotype, and they designated this new genotype, *Cryptosporidium* giant panda genotype, but did not give it a binomial.

GENUS HELARCTOS HORSFIELD, 1825 (MONOTYPIC)

CRYPTOSPORIDIUM SP. OF SIAM, SALEM, GHONEIM, MICHAEL, AND EL-REFAY, 1994

Original host: *Helarctos malayanus* (Raffles, 1821), Sun Bear.

Remarks: Siam et al. (1994) examined 81 captive carnivores in the Giza Zoological Gardens Zoo, Egypt, including two sun bears; they found 1/2 (50%) sun bears to be passing oocysts of a *Cryptosporidium* sp. No other information was provided.

CRYPTOSPORIDIUM SP. OF WANG AND LIEW, 1990

Original host: *Helarctos malayanus* (Raffles, 1821), Sun Bear.

Remarks: Wang and Liew (1990) first reported the presence of oocysts of *Cryptosporidium* in both captive sun bears in a bird park in Taiwan. Parasites were detected in fecal smears stained with modified Ziehl-Neelsen karbol-fuchsin staining method. No other information was provided.

SARCOCYSTIS SP. OF LATIF, VELLAYAN, OMAR, ABDULLAH, AND DESA, 2010

Definitive host: Unknown.

Intermediate host: *Helarctos malayanus* (Raffles, 1821), Sun Bear.

Remarks: Latif et al. (2010) examined one Malayan sun bear in a zoo in Korea and found that it had sarcocysts of *Sarcocystis* only in the diaphragm, but they did not find sarcocysts in the tongue, esophagus, heart, or skeletal muscles. There was no attempt to identify the

species beyond genus so their finding can only be considered a *species inquirenda*.

GENUS *URSUS* L., 1758 (4 SPECIES)

COCCIDIA SPP. OF GAU, KUTZ, AND ELKIN, 1999

Original host: *Ursus arctos* L., 1758 (syn. *Ursus horribilis* Ord, 1815), Brown Bear.

Remarks: Gau et al. (1999) reported the presence of "gastrointestinal coccidia" in 8/56 (14%) fecal samples of *U. arctos* from the Central Canadian Arctic (Northwest Territories, Canada), but they neither measured oocysts nor identified the genus of the coccidia they observed (probably because fecal samples all had been frozen in the field and stored at -20°C until analyzed, which would have prevented sporulation). They suggested that the coccidians may be enzootic in *U. arctos* in the central Arctic, rather than incidentally occurring through the ingestion of infected prey species. This species, or these species, can only be considered *species inquirendae*.

COCCIDIUM OF BEMRICK AND O'LEARY, 1979

Original host: *Ursus arctos* L., 1758 (syn. *Ursus horribilis* Ord, 1815), Brown Bear.

Remarks: Bemrick and O'Leary (1979) reported that a 1-week-old female grizzly (brown) bear cub, from the Como Park Zoo, St. Paul, Minnesota, USA had severe diarrhea. The cub weighed only 454 g and died. Routine histological examination of the lamina propria of the small intestine showed exceptionally large asexual stages (meronts) present, but these were not measured and, although four photomicrographs of tissue sections were published, no structural measurements were given. Bemrick

and O'Leary (1979) mentioned that fecal samples of other grizzly bears in the zoo had been examined periodically in previous years, but no coccidian oocysts were found. They could not say with certainty that these endogenous stages were the etiological agent of the diarrhea seen in the bear cub or not. Their coccidium must be considered a *species inquirenda*.

CRYPTOSPORIDIUM SPP. OF FAGIOLINI, LIA, LARICCHIUTA, CAVICCHIO, MANNELLA, CAFARCHIA, OTRANTO, FINOTELLO, AND PERRUCCI, 2010

Original host: *Ursus thibetanus* G. [Baron] Cuvier, 1823, Asian Black Bear.

Remarks: Fagiolini et al. (2010) reported finding oocysts of a *Cryptosporidium* species in an Asian black bear at the Fasano Zoo Safari in Italy. No other information was given.

CRYPTOSPORIDIUM SPP. OF RAVASZOVA, HALANOVA, GOLDOVA, VALENČAKOVÁ, MALCEKOVÁ, HURNÍKOVÁ, AND HALAN, 2012

Original host: *Ursus arctos* L., 1758 (syn. *Ursus horribilis* Ord, 1815), Brown Bear.

Remarks: Ravaszova et al. (2012) studied the feces of brown bears from central and eastern Slovakia (Europe) from June 2010–March 2011, using *in vitro* immunoassay for the quantitative detection of *Cryptosporidium* antigen by the sandwich ELISA method and found 35/63 (56%) samples to be positive. They also examined the fecal smears stained by a modified Kinyoun's acid-fast stain using LM; this method was less sensitive and only 17/63 (27%) of the samples were positive. No attempt to identify the species was made.

**CRYPTOSPORIDIUM SP. OF SIAM,
SALEM, GHONEIM, MICHAEL,
AND EL-REFAY, 1994**

Original host: *Ursus arctos* L., 1758 (syn. *Ursus horribilis* Ord, 1815), Brown Bear.

Remarks: Siam et al. (1994) examined 81 captive carnivores in the Giza Zoological Gardens Zoo, Egypt, including brown bears; they found 2/7 (29%) brown bears passing oocysts of a *Cryptosporidium* sp. No other information was provided.

**CRYPTOSPORIDIUM SP.
OF SIAM, SALEM, GHONEIM,
MICHAEL, AND EL-REFAY, 1994**

Original host: *Ursus maritimus* Phipps, 1774, Polar Bear.

Remarks: Siam et al. (1994) examined 81 captive carnivores in the Giza Zoological Gardens Zoo, Egypt, including polar bears; they found 1/7 (14%) polar bears passing oocysts of a *Cryptosporidium* sp. No other information was provided.

**EIMERIA SP. OF AGHAZADEH,
ELSON-RIGGINS, RELJIC,
AMBROGI, HUBER, MAJNARIC,
AND HERMOSILLA, 2015**

Original host: *Ursus arctos* L., 1758 (syn. *Ursus horribilis* Ord, 1815), Brown Bear.

Remarks: Aghazadeh et al. (2015) examined fecal samples from European brown bears collected in Croatia and found 1/94 (1%) positive for *Eimeria* oocysts. The authors provided no description except that oocysts were unsporulated and had a thin, white-gray double oocyst wall, but no M. They noted that the oocysts could have occurred incidentally via infected prey.

**ISOSPORA SP. OF
YAKIMOFF AND
MATSCHOULSKY, 1935**

Original host: *Ursus arctos* L., 1758 (syn. *Ursus horribilis* Ord, 1815), Brown Bear.

Remarks: *Isospora* oocysts were found in 2/7 (29%) brown bears in the Leningrad Zoo, former USSR. The animals were imported from north of the former USSR, which likely is the natural habitat for both the host and these oocysts. Oocysts sporulated in 4 days in 2% $K_2Cr_2O_7$ solution at 24°C. The oocysts had two forms, with a wall ~1.5 thick. Spheroidal oocysts were 24.6 (19–32), whereas ovoidal oocysts were $L \times W$: 26.4 × 24.0 (23–33 × 21–29), L/W ratio: 1.1; M: absent; OR: present (line drawing); PG: present. Ovoidal to piriform sporocysts were $L \times W$: 16.9 × 11.6 (15–19 × 11–13), L/W ratio, 1.5; SB, SSB: both present; PSB: absent; SR: present; SR characteristics: a clump of granules or granules spread among SZ; SZ: crescent-shaped. Yakimoff and Matschoulsky (1935) thought this was not a parasite of bears, but may be a bird isosporan because its morphological features were similar to sporulated oocysts described as *Isospora lacazei* (Labbé, 1893). Its occurrence in this bear's feces may be explained by the fact that bears lick their paws contaminated by the soil where the sparrows defecate. No one knows for sure.

**SARCOCYSTIS SP. OF
CRUM, NETTLES, AND
DAVIDSON, 1978**

Definitive host: Unknown.

Intermediate host: *Ursus americanus* Pallas, 1780, American Black Bear.

Remarks: Crum et al. (1978) found 6/53 (11%) *U. americanus* collected from six states in the southeastern United States to have sarcocysts, which they found histologically in the

cardiac and skeletal muscles. No other information was given.

SARCOCYSTIS SP. OF DUBEY, HUMPHREYS, AND FRITZ, 2008a

Definitive host: Unknown.

Intermediate host: *Ursus americanus* Pallas, 1780, American Black Bear.

Remarks: Sarcocysts were found in 1/374 (~0.3%) black bears legally shot in Pennsylvania, USA, but only one cyst was found in this bear. The sarcocyst from this bear was structurally different from the sarcocysts found in two bears, during the same collection, which allowed Dubey et al. (2008a) to name a new species at that time, *S. ursusi*. The wall of these sarcocysts was ~2 thick and had finger-like villi on the cyst wall giving the sarcocyst wall a striated appearance that the sarcocysts of *S. ursusi* lacked. Nothing else is yet known about the identity of the *Sarcocystis* species in bears with these kinds of sarcocysts.

SARCOCYSTIS SP. OF DUBEY, TOPPER, AND NUTTER, 1998b

Definitive host: Unknown.

Intermediate host: *Ursus americanus* Pallas, 1780, American Black Bear.

Remarks: Dubey et al. (1998b) were able to examine diaphragm, abdominal muscles, and carcass muscles from 92 hunter-killed bears in North Carolina, USA. They found two sarcocysts in cross-sections of muscle from one bear (1%). The sarcocysts were 45×37.5 and 67.5×50 . Under TEM they saw that the bradyzoites butted against the ground substance of the cyst wall; five longitudinally-cut bradyzoites were $6.0\text{--}6.6 \times 2.5\text{--}3.3$ and contained organelles typically found in *Sarcocystis* bradyzoites. Dubey et al. (1998b) reiterated a previous (perhaps

questionable) argument that the structure of the sarcocyst wall is a reliable taxonomic criterion to distinguish *Sarcocystis* species within a given host. They concluded their reasoning as to why they did not call this the same species as the one seen by Zeman et al. (1993), below, by saying, "A *Sarcocystis*-like parasite has been reported as causing fatal hepatitis in a black bear from South Dakota (Zeman et al., 1993) and in two polar bears from Alaska (Garner et al., 1997). Only schizonts and merozoites were found in bears that died of hepatitis; sarcocysts were not seen." Thus, the observational data between this report and those of Zeman et al. (1993) and Garner et al. (1997) is not comparable, and all of these can only be considered as *species inquirendae*.

SARCOCYSTIS SP. OF GARNER, BARR, PACKHAM, MARSH, BUREK-HUNTINGTON, WILSON, AND DUBEY, 1997

Definitive host: Unknown.

Intermediate host: *Ursus maritimus* Phipps, 1774, Polar Bear.

Remarks: Garner et al. (1997) diagnosed fatal hepatic sarcocystosis in two zoo polar bears in Anchorage, Alaska, USA. Gross lesions were icterus and systemic petechiae, whereas microscopic lesions were detected only in the liver and included severe random necrotizing hepatitis with hemorrhage. They observed only asexual stages of the parasite within hepatocytes along with rare extracellular zoites. This parasite divided by endopolygony, and occasionally merozoites formed rosettes around a central residual body. TEM of merozoites showed a conoid and a small number of micronemes at their apical pole, a central N, but rhoptries were absent. These parasites failed to react with anti-*Neurospora* sp., anti-*T. gondii*, and anti-*S. neurona* sera. Nothing more

about this parasite is known, including the life cycle. Thus, it must be considered a *species inquirenda*.

**SARCOCYSTIS SP. OF ZEMAN,
DUBEY, AND ROBISON, 1993**

Definitive host: Unknown.

Intermediate host: *Ursus americanus* Pallas, 1780, American Black Bear.

Remarks: Zeman et al. (1993) reported a case of fatal sarcocystosis in an American black bear from a wild-animal park, Black Hills, South Dakota, USA; initially, they found different developmental stages of a protozoan parasite in the cytoplasm of several hepatocytes. There was no inflammation associated with parasitized hepatocytes, but they saw both inflammation and necrosis associated with maturation and rupture of mature meronts. Zeman et al. (1993) reported that mature meronts occupied 50%–80% of hepatocyte cytoplasm and moved the HCN to the periphery of the cell. They also noted that the meronts divided by **endopolygeny**, characteristic of *Sarcocystis* species. Mature meronts were 30 × 20 and contained up to 36 merozoites. When liver tissue sections were deparaffinized, they reacted with antiserum to *T. gondii*, *N. caninum*, and *S. cruzi*, but the parasite tissue only reacted with *S. cruzi*, not with *T. gondii* or *N. caninum* antisera. Zeman et al. (1993) compared the hepatic lesions seen in the bear to those reported from a sea lion (Mense et al., 1992) and said these lesions also were identical to those described in a 2-day-old dog with congenital sarcocystosis (Dubey et al., 1992a). The canine parasite was morphologically and antigenically identical to *Sarcocystis canis*, but unlike in the bear, the *S. canis* infection was found in many of the dog's tissues including skin, brain, liver, and lungs. This was the first report of a fatal hepatic sarcocystosis in a bear, but its true identity is still unknown.

**SUBORDER FELIFORMIA
KRETZOI, 1945**

**FAMILY FELIDAE FISCHER
DE WALDHEIM, 1817**

**SUBFAMILY FELINAE FISCHER
DE WALDHEIM, 1817**

**GENUS ACINONYX BROOKES,
1828 (MONOTYPIC)**

**CRYPTOSPORIDIUM SP. OF
SIAM, SALEM, GHONEIM,
MICHAEL, AND EL-REFAY, 1994**

Original host: *Acinonyx jubatus* (Schreber, 1775), Cheetah.

Remarks: Siam et al. (1994) examined 81 captive carnivores in the Giza Zoological Gardens Zoo, Egypt including four cheetahs; they found 2/4 (50%) to be passing oocysts of a *Cryptosporidium* sp. No other information was provided.

GENUS FELIS L., 1758 (7 SPECIES)

**BESNOITIA SP. OF MCKENNA
AND CHARLESTON, 1980c**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: McKenna and Charleston (1980c) infected rats with isosporan oocysts recovered from the feces of a feral cat. Later, they found macroscopically visible, spheroidal cysts up to 260 wide, which resembled a *Besnoitia* cyst. Kittens were fed infected rats and, at 11–12 DPI, they shed similar oocysts that measured 16.9 × 14.6 in their feces. These sporulated oocysts were fed to mice, rats, rabbits, and guinea pigs, all of which developed *Besnoitia*-type cysts, except the guinea pigs. Unfortunately, they did not attempt to name their organism.

**COCCIDIA SPP. OF BALLWEBER,
PANUSKA, HUSTON,
VASILOPULOS, PHARR,
AND MACKIN, 2009**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Ballweber et al. (2009) surveyed fecal samples of domestic cats both indoor and outdoor, with and without diarrhea, from 159 households in northeastern Mississippi, and northwestern Alabama, USA. "Coccidial oocysts" were found in 19/250 (8%) cats, but the authors did not differentiate them.

**COCCIDIA SPP. OF DE SANTIS-
KERR, RAGHAVAN, GLICKMAN,
CALDANARO, MOORE, LEWIS,
SCHANTZ, AND GLICKMAN, 2006**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: De Santis-Kerr et al. (2006) surveyed the feces of 211,105 pet cats for feline *Giardia* and coccidia by visiting pet hospitals in 40 US states, 2003–04. Coccidia were detected in 14/1,000 fecal tests (1%), mostly in cats under 4 years of age, and in summer months; most infections were in the Southeast Central region, with the fewest in the North Pacific. Patient medical records did not distinguish between *T. gondii*, *Cryptosporidium* species, *Isospora* species, and other coccidial intestinal parasites.

**COCCIDIA SPP. OF FARIAS,
CHRISTOVÃO, AND STOBBE, 1995**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Farias et al. (1995) examined fecal samples of cats in the Araçatuba Region, São Paulo, Brazil. Oocysts of "coccidia" were seen in 3/32 (9%) samples, but no identifications were determined.

**COCCIDIA SPP. OF JOFFE, VAN
NIEKERK, GAGNÉ, GILLEARD,
KUTZ, AND LOBINGIER, 2011**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Joffe et al. (2011) examined fecal samples of 68 household and 85 sheltered cats in the Calgary, Alberta, Canada; "Coccidian oocysts" were detected in 1 (<1%) sheltered cat.

**COCCIDIA SPP. OF KRECEK,
MOURA, LUCAS, AND KELLY, 2010**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Krecek et al. (2010) examined feces of trapped stray cats in Basseterre, St. Kitts, West Indies. "Coccidian oocysts" were detected in 12/100 (12%) samples; identifications were not attempted.

**COCCIDIA OF NASH, MTAMBO,
AND GIBBS, 1993**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Nash et al. (1993) surveyed fecal samples of cats from eight farms in Glasgow, Scotland, United Kingdom. "Coccidial oocysts measuring 11 × 8 to 13 μm × 12 μm in diameter" were detected in 2/57 (3.5%) cats. The authors stated that based on oocyst size, these may represent *T. gondii*, *Sarcocystis* sp., or *Hammondia* sp.

**COCCIDIA OF VISCO, CORWIN,
AND SELBY, 1978**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Visco et al. (1978) examined pet cats in Missouri, USA, from 1974 to 1976. "Coccidia"

were detected in 87/1,294 (7%) cats of all age categories but mostly in those <6-months-old. Oocysts found were not determined to genus or species, and the authors admit that everything was reported as *Isospora* sp. or as "coccidia."

CRYPTOSPORIDIUM BAILEYI (?) OF MCGLADE, ROBERTSON, ELLIOT, READ, AND THOMPSON, 2003

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: McGlade et al. (2003) examined 418 fecal samples of 125 domestic cats, from various sources in Perth, Western Australia; 40 randomly-selected samples were screened by nested PCR of the 18S rRNA gene. None of the 418 samples was positive by microscopy, but 4/40 (10%) PCR-sequenced samples were positive for *Cryptosporidium* spp. and one successfully-sequenced PCR product, "most closely resembled" *C. baileyi* (commonly found in chickens).

CRYPTOSPORIDIUM SPP. OF NASH, MTAMBO, AND GIBBS, 1993

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Nash et al. (1993) studied fecal samples of cats from 8 farms in Glasgow, Scotland, by several tests including a specific monoclonal antibody against *Cryptosporidium* (Northumbria Biologicals); *Cryptosporidium* was detected in 7/57 (12%) cats (3 kittens, 4 adults) on three farms. They euthanized 32 cats, all without diarrhea, and processed them for histology. Histology revealed the presence of endogenous developmental stages and oocysts in the epithelium of the ileum, and two types of oocysts were recorded, smaller, 5.0×4.5, and larger, 6.0×5.0, which were detected in one farm, whereas in the other two farms only smaller oocysts were found.

CRYPTOSPORIDIUM CURYI (?) CITED BY OGASSAWARA, BENASSI, LARSSON, AND HAGIWARA, 1986

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Ogassawara et al. (1986) surveyed the feces of domestic cats from different areas in São Paulo, Brazil, and reported finding oocysts of a "species" they called *C. curyi* in 8/215 (4%) cats. However, the citation they gave for this species (Ogassawara, S., Benassi, S., Larsson, C.E., Hagiwara, M.K. 1986. *Cryptosporidium curyi* n. sp. in the feces of *Felis catus domesticus* in the city of São Paulo, Brazil. Rev. Microbiol., São Paulo.) apparently was never published. They refer to *C. curyi*, and the paper in which it was presumably published as follows: "This agent has recently been described by us and is still being studied for its true identity." This species and citation do not appear in Wikipedia, Google Scholar, or in more recent reviews of *Cryptosporidium* species names by Plutzer and Karanis (2009) and by Fayer (2010).

CRYPTOSPORIDIUM SP. OF ASAHI, KOYAMA, ARAI, FUNAKOSHI, YAMAURA, SHIRASAKA, AND OKUTOMI, 1991

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Asahi et al. (1991) reported a cat in Japan, naturally-infected with "a small type of *Cryptosporidium* sp. oocysts," measuring 4.5 wide. Necropsy showed endogenous stages in the villous epithelia of the small intestine and cecum, but not in the stomach. Oocysts from this cat were inoculated per os into six cats (weight <1 kg), and all six discharged oocysts; the prepatent period was 8–10 days and peak oocyst shedding was 14–19 DPI, followed by 7–14 more peaks during patency (i.e., 69–203 DPI). All the cats were asymptomatic. After patency ended, the cats were injected s.c. with prednisolone, 10 mg/kg daily for 4–9 days, which caused the

recurrence of oocyst shedding. Experimental infections with oocysts in specific pathogen-free (SPF) mice, BALB/c mice, BALB/c mice injected with hydrocortisone acetate, SPF Wistar rats, SPF guinea pigs, and dogs, all failed.

**CRYPTOSPORIDIUM SP.
OF BARR, GUILFORD,
JAMROSZ, HORNBUCKLE,
AND BOWMAN, 1994a**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Barr et al. (1994a) diagnosed cryptosporidiosis in three cats suffering from diarrhea, based on the presence of *Cryptosporidium* oocysts in their feces. The cats were administered paromomycin for 5 days, and the diarrhea resolved 5 days after the last dose in two cats, and within 30 days in the third cat. No other information is given.

**CRYPTOSPORIDIUM SP. OF
BARR, JAMROSZ, HORNBUCKLE,
BOWMAN, AND FAYER, 1994b**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Barr et al. (1994b) diagnosed *Cryptosporidium* oocysts and *Toxocara cati* eggs in the feces of a 6-month-old spayed domestic cat that had diarrhea for 2 months. The cat was properly vaccinated and was both FeLV and FIV negative. It was administered pyrantel pamoate (against *Toxocara*), metronidazole (against protozoans), and a special diet (Hill's c/d), but after 14 days the cat still had diarrhea and still shed *Cryptosporidium* oocysts in its feces. It was then given paromomycin, 165 mg/kg, p.o., twice daily for 5 days, and *Cryptosporidium* was not detected in its feces 1, 8, or 34 days after treatment. On days 1 and 8, the diarrhea persisted, but by day 34 the cat was nondiarrheic ~80% of the time. Thus, paromomycin successfully treated the *Cryptosporidium* infection, although it was not identified to species.

**CRYPTOSPORIDIUM SP. OF
BORKATAKI, KATOCH,
GOSWAMI, GODARA, KHAJURIA,
YADAV, AND KAUR, 2013**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Borkataki et al. (2013) surveyed fecal samples of stray cats in Jammu, a humid subtropical zone in northwestern India. Oocysts of *Cryptosporidium* were detected in 4/100 (4%) samples, but not identified to species.

**CRYPTOSPORIDIUM SPP. OF CIRAK
AND BAUER, 2004**

Original hosts: *Felis catus* L., 1758, Domestic Cat; *Canis lupus familiaris* (syn. *C. familiaris*) L., 1758, Domestic Dog.

Remarks: Cirak and Bauer (2004) examined fecal samples of cats in Germany to compare conventional fecal exam methods versus a commercial coproantigen ELISA kit (ProSpecT *Cryptosporidium* Microplate Assay) to detect *Cryptosporidium*. No cats examined had diarrhea. Direct fecal smears, fast-stained with carbol fuchsin, found only 1/100 (1%) cats infected with *Cryptosporidium*, whereas ELISA detected infection in 30/100 (30%) cats. Thus, the ELISA kit used can better determine the presence of *Cryptosporidium* but cannot distinguish between the species.

**CRYPTOSPORIDIUM SP.
OF COELHO, DO AMARANTE,
DE SOUTELLO, MEIRELES,
AND BRESCIANI, 2009**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Coelho et al. (2009) examined fecal samples of cats in Andradina, São Paulo, Brazil. Samples were collected from the rectum,

and *Cryptosporidium* oocysts were detected in 2/51 (4%) cats using a malachite green negative stain, and in 3/51 (6%) cats with ELISA. Positive samples mostly originated from young animals and did not depend on the sex or breed.

**CRYPTOSPORIDIUM SP. OF
COX, GRIFFITH, ANGLES, DEERE,
AND FERGUSON, 2005**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Cox et al. (2005) examined fecal samples of various domestic, native, and feral animals during a survey of protozoal, bacterial, and viral pathogens, in four drinking-water watersheds in Sydney, Australia. Fecal samples were fluorescence-stained and examined with an epifluorescence microscope. Oocysts of *Cryptosporidium* were detected in 3/7 (43%) domestic cats, but not in the only feral cat examined.

**CRYPTOSPORIDIUM SP. OF DADO,
IZQUIERDO, VERA, MONTOYA,
MATEO, FENOY, GALVÁN, GARCÍA,
GARCÍA, ARÁNGUEZ, LÓPEZ, DEL
ÁGUILA, AND MIRÓ, 2012**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Dado et al. (2012) examined 625 soil samples and 79 fecal samples (“presumably from dogs and cats”) from 67 playgrounds and public parks in southeastern Madrid, Spain. Soil samples were examined using the modified Telemann and MIF methods and fecal samples by a modified Ziehl-Neelsen staining, followed by a rapid immunochromatographic assay. *Cryptosporidium* oocysts were only found in 7/79 (9%) fecal samples found in four parks.

**CRYPTOSPORIDIUM SP. OF
DE OLIVEIRA LEMOS,
ALMOSNY, SOARES, AND
ALENCAR, 2012**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: de Oliveira Lemos et al. (2012) examined fecal samples of diarrheic (acute or chronic) domestic cats from Rio de Janeiro, Niterói, and Praia de Mauá, Brazil. *Cryptosporidium* oocysts were detected in 5/60 (8%) samples, and 4 of the positive samples also were FeLV-positive. They noted that animals infected with retroviruses were more prone to the *Cryptosporidium* infection and may exhibit more severe clinical signs.

**CRYPTOSPORIDIUM SP. OF
DUBEY AND PANDE, 1963b**

Original host: *Felis chaus* Schreber, 1777, Jungle Cat.

Remarks: Dubey and Pande (1963b) found a “sporulated stage” that measured 11 × 7 (10–12 × 7–8), L/W ratio: 1.2–1.5; this “stage” had 4 SZ that were 7–9 × 1–2, each with a large RB at their broader end. They called these stages “Cryptosporodial/Coccidial bodies,” in their discussion and labeled their drawing (Fig. 16) a *Cryptosporidium*. It’s likely they were looking at a sporocyst of a *Sarcocystis* sp. because we think the cyst was too large to be a *Cryptosporidium*.

**CRYPTOSPORIDIUM SP. OF
EGGER, NGUYEN, SCHAAD,
AND KRECH, 1990**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Egger et al. (1990) described intestinal cryptosporidiosis in an 8-year-old boy who suffered from coughing and bronchitis prior to having watery, nonbloody diarrhea, vomiting, and **colics**. The boy became ill during a visit to

a dairy farm, where some kittens suffered from diarrhea and showed failure to thrive. The boy's stool was negative for rotaviruses and pathogenic bacteria, but using auramine fluorescence staining, oocysts of *Cryptosporidium* were found both in the stool of the boy and in feces of a skinny kitten he had contact with. This indicated that the infection "was acquired from a cat that had probably been infected by feces from calves."

**CRYPTOSPORIDIUM SPP.
OF FUNADA, PENA, SOARES,
AMAKU, AND GENNARI, 2007**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Funada et al. (2007) examined fecal samples of domestic cats in São Paulo, Brazil. *Cryptosporidium* oocysts were detected in 37/327 (11%) samples, mostly in cats younger than 1-year-old.

**CRYPTOSPORIDIUM SP.
OF HOOPES, POLLEY, WAGNER,
AND JENKINS, 2013**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Hoopes et al. (2013) surveyed fecal samples of cats in Saskatchewan and Alberta, western Canada; 3/635 (0.4%) samples were positive when examined by sucrose flotation, and 6/635 (1%) were positive when examined by a commercial immunofluorescence assay.

**CRYPTOSPORIDIUM SP.
OF HOOPES, HILL, POLLEY,
FERNANDO, WAGNER, SCHURER,
AND JENKINS, 2015**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Hoopes et al. (2015) examined fecal samples of rural, free-roaming, and pet cats

from urban areas of Saskatchewan and from a rural region in southwestern Alberta, Canada. *Cryptosporidium* was detected in 11/161 (7%) free-ranging cats, only in Saskatchewan, but not in 31 cats from pet shops in Saskatchewan nor in 27 cats tested from rural Alberta.

**CRYPTOSPORIDIUM SP. OF HUBER,
BOMFIM, AND GOMES, 2002**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Huber et al. (2002) examined fecal samples of 28 shelter, and 20 household adult cats in Rio de Janeiro, Brazil; all cats were apparently healthy. Oocysts of *Cryptosporidium* were detected in 6/48 (12.5%) samples, 5/20 (25%) household cats, and 1/28 (4%) shelter cats. The authors said that household cats were more parasitized with protozoa, whereas more shelter cats harbored worms.

**CRYPTOSPORIDIUM SP.
OF KORKMAZ, GOKPINAR,
AND YILDIZ, 2016**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Korkmaz et al. (2016) examined fecal samples of pet and stray cats in Kirikkale province, Turkey. Oocysts of *Cryptosporidium* were detected in 1/100 (1%) samples.

**CRYPTOSPORIDIUM SP.
OF LIM, NGUI, SHUKRI,
ROHELA, AND NAIM, 2008**

Original host: *Felis chaus* Schreber, 1777, Jungle Cat.

Remarks: Lim et al. (2008) found *Cryptosporidium* oocysts in the feces of 1/3 (33%) jungle cats examined at Zoo Negra, Kuala Lumpur, Malaysia. No other information was given.

CRYPTOSPORIDIUM SPP. OF LUCIO-FORSTER AND BOWMAN, 2011

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Lucio-Forster and Bowman (2011) examined 1,272 fecal samples from two shelters and 50 from foster homes in upstate New York, USA. *Cryptosporidium* oocysts were detected in 50/1,322 (4%) samples.

CRYPTOSPORIDIUM SPP. OF MARKS, HANSON, AND MELLI, 2004

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Marks et al. (2004) examined 416 feces of 104 domestic shorthair kittens, 8–16-week-old, in Davis, California, USA, which were naturally-exposed to *Cryptosporidium* spp. The kittens were housed individually, and their fecal samples were collected once daily for four consecutive days. Samples were examined by five diagnostic tests to evaluate and compare their sensitivity: (1) a modified Ziehl-Neelsen acid-fast staining technique (mZN); (2) direct immunofluorescence (DIC) by a commercial kit (Merifluor *Cryptosporidium*/*Giardia* direct immunofluorescent kit) that used a monoclonal antibody against antigen of *C. parvum*; (3) enzyme immunoassay-1 (EIA-1) that used a monoclonal antibody (Premier *Cryptosporidium* EIA); (4) EIA-2 that used a polyclonal antibody (ProSpecT *Cryptosporidium* microplate assay) and (5) EIA-3 that used a polyclonal antibody (ProSpecT *Cryptosporidium* rapid assay) to detect *Cryptosporidium* antigen in feces. *Cryptosporidium* was detected in at least one test in 101/104 (92%) kittens. Regarding positive cats, 96 (92%) were positive by EIA-2, 91 (88%) by EIA-1, 89 (86%) by mZN, 80 (77%) by DIC, but only 46 (44%) by EIA-3. Similarly, regarding the number of positive samples, 344/416 (83%) were positive

by EIA-2, 304/416 (73%) by EIA-1, 259/416 (62%) by mZN, 195/416 (47%) by DIC, and only 77/416 (19%) by EIA-3. Marks et al. (2004) suggested higher sensitivity of mZN over DIC due to the preparation procedure in the manufacturer's guidelines (loss of oocysts during the rinsing procedure), and because oocyst fluorescence intensity was variable. A markedly low sensitivity of EIA-3 was likely caused by its high detection limit compared with that of EIA-1 and EIA-2. To summarize: EIA-2 and EIA-1 had the highest sensitivities when only a single fecal sample was examined, and mZN and EIA-1 had similar sensitivities when two consecutive samples were examined.

CRYPTOSPORIDIUM SPP. OF MEKARU, MARKS, FELLE, Y, CHOUICHA, AND KASS, 2007

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Mekaru et al. (2007), in northern California, USA, examined feces of 344 diarrheic and nondiarrheic cats from four animal shelters. Samples were examined by three methods to evaluate/compare their specificity and sensitivity: flotation, commercial available enzyme (ProSpecT *Cryptosporidium* Microplate Assay), and nonenzymatic (ImmunoCard STAT! *Cryptosporidium*/*Giardia* Rapid Assay, Xpect *Giardia*/*Cryptosporidium*) immunoassay; these were compared with a reference standard, the MeriFluor direct immunofluorescence assay. They wanted to test the credibility of using human-based immunoassays for the diagnosis of *Cryptosporidium* spp. infections in cats and other animals. *Cryptosporidium* spp. was detected in 14/344 (5%) cats (9/177 diarrheic, 5/177 nondiarrheic). Two diarrheic cats were coinfecting with *Giardia*. Flotation only detected 3/14 positive samples; the best specificity and sensitivity was found using the enzyme immunoassay ProSpecT *Cryptosporidium* Microplate Assay.

**CRYPTOSPORIDIUM SPP. OF
MIRZAGHAVAMI, SADRAEI,
AND FOROUZANDEH, 2016**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Mirzaghavami et al. (2016) surveyed fecal samples of stray cats in Tehran, Iran. *Cryptosporidium* oocysts, measuring 6.9×4.6 , were detected in 5/50 (10%) samples.

**CRYPTOSPORIDIUM SPP. OF
NUTTER, DUBEY, LEVINE,
BREITSCHWERDT, FORD, AND
STOSKOPE, 2004**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Nutter et al. (2004) surveyed the blood and fecal samples of feral cats and healthy pet cats (mostly strays or in shelters) in rural Randolph county, North Carolina, USA. Fecal samples were concentrated by sedimentation, and then tested by a commercially-available indirect fluorescent antibody test (Merifluor, Meridian Diagnostics, Cincinnati, Ohio). *Cryptosporidium* was detected in 6/87 (7%) feral and in 4/66 (6%) pet cats. The antibody test reacted with both *C. parvum* and *C. felis* and, thus, was not able to distinguish between these *Cryptosporidium* species.

**CRYPTOSPORIDIUM SPP. OF
NYAMBURA NJUGUNA, KAGIRA,
MUTURI KARANJA, NGOTHO,
MUTHARIA, AND WANGARI
MAINA, 2017**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Nyambura Njuguna et al. (2017) examined fecal samples of household cats (indoors and outdoors) in Thika, Kiambu

county, Kenya. *Cryptosporidium* oocysts were seen in 42/103 (41%) cats.

**CRYPTOSPORIDIUM SPP. OF
OVERGAAUW, VAN ZUTPHEN,
HOEK, YAYA, ROELFSEMA,
PINELLI, VAN KNAPEN, AND
KORTBEEK, 2009**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Overgaauw et al. (2009) surveyed fecal samples of 22 clinically healthy household cats from different provinces in the Netherlands. *Cryptosporidium* sp. was detected in 1 (5%) sample. Genotyping based on PCR of 18S rDNA failed, therefore the species/genotype remained unknown.

**CRYPTOSPORIDIUM SPP. OF
PALMER, THOMPSON, TRAUB,
REES, AND ROBERTSON, 2008a**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Palmer et al. (2008a) surveyed fecal samples of cats from both urban and rural areas across Australia, which were collected from 59 veterinary clinics (572 samples) and 26 refuges (491 samples). *Cryptosporidium* was detected in 23/1,063 (2%) cats, mostly from refuges.

**CRYPTOSPORIDIUM SPP. OF PARIS,
WILLS, BALZER, SHAW, AND
GUNN-MOORE, 2014**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Paris et al. (2014) examined fecal samples of diarrheic cats in the United Kingdom. Samples were examined by the real-time PCR assay for the 18S rRNA gene. *Cryptosporidium* was detected in 265/1,088 (24%) cats, mostly in young animals.

CRYPTOSPORIDIUM SP. OF PAVLÁSEK, 1983

Original hosts: *Bos taurus* L., 1758, Aurochs; *Felis catus* L., 1758, Domestic Cat.

Remarks: Pavlásek (1983) isolated oocysts of *Cryptosporidium* from a 12-day-old calf in the Czech Republic, purified them on a sugar gradient, and inoculated 5×10^5 sporulated oocysts *per os* into a 21-day-old coccidia-free cat and two chickens, and examined their feces for 45 DPI. The cat started to discharge cryptosporidial oocysts 5–12 DPI and diarrhea was observed 5–9 DPI. Chickens discharged oocysts within several hours after the inoculation until 2 DPI, so the author supposed it was just a passage through the gut and that their transmission was not successful.

CRYPTOSPORIDIUM SP. OF POONACHA AND PIPPIN, 1982

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Poonacha and Pippin (1982) reported a case of a 5-year-old male domestic longhair cat suffering from anorexia, weight loss, and persistent diarrhea for 2.5 months. The cat was FeLV negative, and did not respond to treatment with Azithromycin, B-12, B-plex, fluids, and lincocin. Both fecal flotation and direct microscopic examination of feces also were negative. Exploratory surgery followed by necropsy revealed dilatation and thickening of the small intestine and cecum, enlarged mesenteric lymph nodes, fusion of small intestinal villi, increased number of goblet cells, and hyperplastic crypt epithelium with a few dilated cystic crypts containing necrotic cell debris. Changes were apparent only in the small intestine and cecum, where numerous round or ovoidal organisms, 1–3 wide, were found located more in crypts and the lower half of the villi, and only rarely on the villous tips. TEM showed meronts and trophozoites in the lumen and attached to the microvillous border

of intestinal epithelial cells. Morphology of the organisms and lesions corresponded to those caused by *Cryptosporidium*.

CRYPTOSPORIDIUM SPP. OF QUEEN, MARKS, AND FARVER, 2012

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Queen et al. (2012) examined feces of 22 different breeds of diarrheic and nondiarrheic cats from northern California, USA, and *Cryptosporidium* was detected in 6/190 (3%) diarrheic and in 0/54 nondiarrheic cats. Younger cats were significantly more likely to be infected.

CRYPTOSPORIDIUM SPP. OF RAMBOZZI, MENZANO, MANNELLI, ROMANO, AND ISAIA, 2007

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Rambozzi et al. (2007) surveyed fecal samples of domestic cats in Turin, Italy. *Cryptosporidium* oocysts were seen in 49/200 (24.5%) samples, mostly in cats <1-year-old, with diarrhea, and concurrently infected with other enteric parasites (*Cystoisospora*, *Toxocara*, *Toxascaris*). Oocysts found were spheroidal, 4.5 wide.

CRYPTOSPORIDIUM SPP. OF SABSHIN, LEVY, TUPLER, TUCKER, GREINER, AND LEUTENEGGER, 2012

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Sabshin et al. (2012) surveyed fecal samples of cats in Alachua county, Florida, USA; 50 cats had diarrhea and 50 cats had normal feces. Fecal samples were examined using fecal flotation and RT-PCR assay for *Cryptosporidium* 18S rDNA. *Cryptosporidium*

was detected in 5/50 (10%) cats with diarrhea and in 10/50 (20%) cats with normal feces.

**CRYPTOSPORIDIUM SP. OF
SHUKLA, GIRALDO, KRALIZ,
FINNIGAN, AND SANCHEZ, 2006**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Shukla et al. (2006) collected fecal samples from domestic cats in the Niagara Region, Ontario, Canada. Samples were examined by three different methods to test and compare their sensitivity: a concentration method, acid-fast staining, and *Cryptosporidium* EIA (ProSpecT *Cryptosporidium* Microplate Assay). *Cryptosporidium* was detected only by EIA in 3/41 (7%) cats.

**CRYPTOSPORIDIUM SPP.
OF SPAIN, SCARLETT, WADE,
AND MCDONOUGH, 2001**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Spain et al. (2001) surveyed cats, 1–12-month-old, in central New York state, USA. Fecal samples were examined by sugar and zinc-sulfate flotation, and by ELISA kit (ProSpecT *Cryptosporidium* Microplate Assay), with 90% sensitivity, originally developed for use in humans. *Cryptosporidium* oocysts were found in 10/263 (4%) cats, but the number of ELISA-positive cats was not given.

**CRYPTOSPORIDIUM SP. OF
TYSNES, GJERDE, NØDTVEDT,
AND ŠKANCKE, 2011**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Tysnes et al. (2011) examined feces of clinically healthy cats participating in cat

shows in Norway. *Cryptosporidium* was detected in only 1/52 (2%) samples.

**CRYPTOSPORIDIUM SPP. OF
TZANNES, BATCHELOR, GRAHAM,
PINCHBECK, WASTLING, AND
GERMAN, 2008**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Tzannes et al. (2008) examined cat fecal samples from mainland Great Britain, Northern Ireland, the Isle of Man, and the Channel Islands. Three populations of cats were surveyed: (1) 1,355 domestic cats displaying signs of gastrointestinal disease; (2) 48 domestic cats with signs of gastrointestinal disease; and (3) 45 pet cats with no gastrointestinal signs. *Cryptosporidium* was detected only in population No. 1, where 13/1,355 (1%) cats had oocysts of a *Cryptosporidium* in their feces.

**CRYPTOSPORIDIUM SP. OF
TZIPORI AND CAMPBELL, 1981**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Tzipori and Campbell (1981) did a serosurvey for antibodies to *Cryptosporidium* by an indirect immunofluorescence test of the sera of cats, probably all from the Glasgow area, United Kingdom; they found 20/23 (87%) sera were positive. This was the first serological procedure for the detection of antibodies against *Cryptosporidium*, but there was no attempt to identify the species.

**CRYPTOSPORIDIUM SPP. OF UGA,
MATSUMURA, ISHIBASHI, YODA,
YATOMI, AND KATAOKA, 1989**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Uga et al. (1989) examined rectal contents of cats captured in Hyogo prefecture, Japan. Oocysts of *Cryptosporidium* were detected

in 20/507 (4%) cats, mostly in those with diarrhea. Cats suffering from diarrhea shed significantly more oocysts than cats without diarrhea.

CRYPTOSPORIDIUM SPP. OF YANG, YING, MONIS, AND RYAN, 2015

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Yang et al. (2015) examined fecal samples of both kittens and adult cats of different breeds from Perth, Western Australia. Cats originated from a cat refuge center (179), three pet shops (29), a breeding establishment (10), and private homes (127); none of the cats showed any clinical symptoms. Samples were examined by nested PCR amplification and sequencing of the 18S rRNA gene. *Cryptosporidium* was detected in 34/345 (10%) samples; five were identified as *Cryptosporidium* rat genotype III, and one as *Cryptosporidium* related to *C. rat* genotype III. This was the first report of *Cryptosporidium* rat genotype III in cats.

CYSTOISOSPORA RIVOLTA-LIKE OF GATES AND NOLAN, 2009

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Between 1997 and 2007, Gates and Nolan (2009) surveyed fecal samples of cats at the University of Pennsylvania, USA; "*Cystoisospora rivolta*-like" oocysts were detected in 19/1,566 (1%) samples, mostly in cats less than 3-years-old but increased when the cats were >13-years-old.

CYSTOISOSPORA SPP. OF BARUTZKI AND SCHAPER, 2003

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: During a survey on endoparasites, Barutzki and Schaper (2003) examined fecal samples of cats in Freiburg, Germany. *Cystoisospora* oocysts were detected in 693/3,167 (22%) samples, and the infection was higher in cats up to 1-year-old.

CYSTOISOSPORA SPP. OF COELHO, DO AMARANTE, DE SOUTELLO, MEIRELES, AND BRESCIANI, 2009

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Coelho et al. (2009) examined fecal samples of cats in Andradina, São Paulo, Brazil. *Cystoisospora* oocysts were reported in 22/51 (43%) samples, but they did not attempt to determine the species.

CYSTOISOSPORA SPP. OF FUNADA, PENA, SOARES, AMAKU, AND GENNARI, 2007

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Funada et al. (2007) examined fecal samples of domestic cats in São Paulo, Brazil. *Cystoisospora* oocysts were detected in 27/327 (8%) samples but no identifications were made.

CYSTOISOSPORA SPP. OF GENNARI, KASAI, PENA, AND CORTEZ, 1999

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Gennari et al. (1999) examined fecal samples of domestic cats from different areas of the city of São Paulo, Brazil. *Cystoisospora* oocysts were detected in 72/187 (38.5%) samples, but no attempt was made to identify the oocysts to species.

**CYSTOISOSPORA SP. OF
HUBER, BOMFIM, AND
GOMEZ, 2002**

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Huber et al. (2002) examined fecal samples of healthy adult cats (28 in a shelter, 20 pet cats from six different owners) in Rio de Janeiro, Brazil. Oocysts of a *Cystoisospora* species were detected in 4/48 (8%) samples, all shelter cats, but the species was not identified.

**CYSTOISOSPORA SP. OF
HUBER, DA SILVA, BOMFIM,
TEIXEIRA, AND BELLO, 2007**

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Huber et al. (2007) surveyed fecal samples of stray cats in an animal shelter in Nova Iguaçu, Rio de Janeiro State, Brazil; 4/30 (13%) samples were positive for a *Cystoisospora* species. No attempt was made to identify the oocysts.

**CYSTOISOSPORA SPP.
OF LUCIO-FORSTER AND
BOWMAN, 2011**

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Lucio-Forster and Bowman (2011) surveyed fecal samples of cats from two shelters (1,272 cats) and affiliated foster homes (50 cats) in upstate New York, USA. *Cystoisospora* oocysts were detected in 278/1,322 (21%) samples, but there was no attempt to identify to species.

**CYSTOISOSPORA SPP. OF
RAMBOZZI, MENZANO, MANNELLI,
ROMANO, AND ISAIA, 2007**

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Rambozzi et al. (2007) surveyed fecal samples of domestic cats in Turin, Italy. Oocysts of *Cystoisospora*, not identified to species, were detected in 15/200 (7.5%) samples and 5/200 (2.5%) positive samples were concurrently infected with *Cryptosporidium* oocysts.

**CYSTOISOSPORA SPP. OF
SABSHIN, LEVY, TUPLER,
TUCKER, GREINER, AND
LEUTENEGGER, 2012**

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Sabshin et al. (2012) surveyed fecal samples of cats in Alachua county, Florida, USA; 50 cats had diarrhea and 50 cats had normal feces. *Cystoisospora* oocysts were detected in 7/50 (14%) cats with diarrhea, and in 5/50 (10%) cats with normal feces.

**CYSTOISOSPORA SPP. OF
SERRA, UCHÔA, AND
COIMBRA, 2003**

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Serra et al. (2003) examined fecal samples of domestic and stray cats in Rio de Janeiro, Brazil. *Cystoisospora* oocysts were detected in 57/131 (43.5%) samples, with 8/65 (12%) domestic cats and 49/66 (74%) stray cats demonstrating oocysts in their feces.

**EIMERIA SP. OF CHRISTIE,
DUBEY, AND PAPPAS, 1976**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Christie et al. (1976) surveyed feces from cats, all >3-months-old, from a humane shelter in Ohio, USA; they found 4/1,000 (0.4%) samples to have oocysts of an *Eimeria* species. After sporulation in 2.5% K₂Cr₂O₇ solution, they inoculated ~1,000 oocysts into 16 mice and 2 cats. After 1 month, the mice were fed to 4 SPF cats. None of the 6 cats shed oocysts within the next 30 days. Thus, this must be considered a *species inquirenda*.

**EIMERIA SP. OF MILSTEIN
AND GOLDSMID, 1997**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Milstein and Goldsmid (1997) surveyed feral cats in southern Tasmania. Rectal fecal samples and intestinal contents at necropsy demonstrated oocysts of an *Eimeria* species in 2/39 (5%) samples.

**EIMERIA SP. OF
OGASSAWARA, BENASSI,
LARSSON, AND
HAGIWARA, 1986**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Ogassawara et al. (1986) examined fecal samples of domestic cats from different areas of São Paulo, Brazil. "Coccidia" were found in 73/215 (34%) samples, along with ascarid and hookworm eggs. Oocysts of an *Eimeria* were reported in 1/215 (<0.5%) samples, in an animal 4–6-months-old, but no attempt was made to identify the eimerian.

**EIMERIA SP. OF YAMAMOTO,
KON, SAITO, MAENO, KOYAMA,
SUNAOSHI, YAMAGUCHI,
MORISHIMA, AND
KAWANAKA, 2009**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Yamamoto et al. (2009) surveyed fecal samples of cats in animal shelters in the Saitama prefecture, Japan. LM examination revealed the presence of *Eimeria* oocysts in 3/1,079 (0.3%) of the samples, but the species identification was not attempted.

**HAMMONDIA–TOXOPLASMA OF
BARUTZKI AND SCHAPER, 2003**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: During a survey of endoparasites, Barutzki and Schaper (2003) examined fecal samples of cats in Freiburg, Germany. They reported *Hammondia–Toxoplasma*-like oocysts in 142/3,167 (4.5%) samples.

**HAMMONDIA–TOXOPLASMA
OF FUNADA, PENA, SOARES,
AMAKU, AND GENNARI, 2007**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Funada et al. (2007) examined fecal samples of domestic cats in São Paulo, Brazil. *Hammondia–Toxoplasma*-like oocysts were detected in 2/327 (<1%) samples.

**HAMMONDIA–TOXOPLASMA
OF GENNARI, KASAI, PENA,
AND CORTEZ, 1999**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Gennari et al. (1999) examined fecal samples of domestic cats from São Paulo,

Brazil. *Hammondia-Toxoplasma*-like oocysts were reported in 3/187 (<2%) samples.

HAMMONDIA–TOXOPLASMA OF PALMER, THOMPSON, TRAUB, REES, AND ROBERTSON, 2008a

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Palmer et al. (2008a) surveyed fecal samples of cats from 59 veterinary clinics (572 samples) and 26 refuges (491 samples), from both urban and rural areas across Australia. *Hammondia-Toxoplasma*-like oocysts (not identified to genus) were detected in only 1/1,063 cats, the one from a refuge.

HAMMONDIA–TOXOPLASMA–BESNOITIA OF SPAIN, SCARLETT, WADE, AND MCDONOUGH, 2001

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Spain et al. (2001) surveyed 1–12-month-old cats in central New York state, USA. Fecal samples from 149 cats in three county shelters and from 144 cats with their primary-care veterinarians were examined and *Toxoplasma/Hammondia/Besnoitia*-like oocysts were detected incidentally in the fecal flotations of 3/263 (1%) cats, all from the shelters. A serological test confirming the identity of the oocysts was not performed.

HEPATOZOON SP. OF PEREZ, RUBINI, AND O'DWYER, 2004

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Perez et al. (2004) were the first to diagnose *Hepatozoon* sp. in three naturally-infected

domestic cats from São Paulo State, Brazil. During a hematological exam, *Hepatozoon* gamonts were identified within polymorphonuclear cells of a cat with renal failure. Two other cats, which lived in the same house, also were positive for this hemoparasite.

ISOSPORA RIVOLTA OF TRIFFITT, 1927

Original host: *Felis catus* L., 1758, Domestic Cat or *Felis silvestris* Schreber, 1777, Wildcat (?).

Remarks: Triffitt (1927) described oocysts from an Eyot cat in the Zoological Gardens, London. Yakimoff et al. (1933b) said that Triffitt found the oocysts in an ocelot, but an Eyot cat is not an ocelot. Aston's Eyot is a 12ha "island" owned by Christ Church and bordered by the Thames, Cherwell New Cut, and Shire Lake Ditch. It can be approached from Meadow Lane via the Kidneys and across a footbridge, or from Jackdaw Lane off Iffley Road (<http://friendsofastonseyot.org.uk/history/>). Levine and Ivens (1981) speculated that the cat examined by Triffitt (1927) was either *F. catus* or *F. silvestris*, but although domestic cats sometimes penetrate deep into the Eyot from nearby housing, there is no evidence of feral cats doing so (<http://friendsofastonseyot.org.uk/wildlife/197-2/>). Oocysts found by Triffitt (1927) were described by her to be L×W: 20–26×14–18, with a M that was distinct, ~3 wide, but oocysts of *I. rivolta* do not have a M, so there is no way to determine what species Triffitt (1927) examined.

ISOSPORA SP. OF BORKATAKI, KATOCH, GOSWAMI, GODARA, KHAJURIA, YADAV, AND KAUR, 2013

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Borkataki et al. (2013) surveyed fecal samples of stray cats in Jammu, a humid

subtropical zone in northwestern India. Oocysts of *Isospora* were detected in 80/100 (80%) samples. There was no attempt to identify these oocysts to species, thus a *species inquirenda*.

ISOSPORA SPP. OF COLLINS, EMSLIE, FARROW, AND WATSON, 1983

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Collins et al. (1983) reported *Isospora* spp. in 3/71 (4%) fecal samples from cats in Sydney, Australia, which were examined for "sporozoa." No other information was given.

ISOSPORA SPP. OF EPE, COATI, AND SCHNIEDER, 2004

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Epe et al. (2004), in northern Germany, surveyed fecal samples of cats between 1998 and 2002 and found 47/441 (11%) to pass *Isospora* spp. oocysts, which were not identified further.

ISOSPORA SPP. OF EPE, ISING-VOLMER, AND STOYE, 1993

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Epe et al. (1993), in Germany, surveyed fecal samples from cats between 1984 and 1991 and found 53/1,147 (5%) to pass *Isospora* spp. oocysts, which were not identified to species.

ISOSPORA SPP. OF HOOPES, HILL, POLLEY, FERNANDO, WAGNER, SCHURER, AND JENKINS, 2015

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Hoopes et al. (2015) examined fecal samples of rural, free-roaming, and pet cats

from urban areas of Saskatchewan, and from a rural region in southwestern Alberta, Canada. *Isospora* spp. were detected in 19% rural cats from Alberta, 6% free-ranging cats in Saskatchewan, and in 3% pet cats in Saskatchewan. Moreover, blood was observed in two samples to be positive for *Isospora*.

ISOSPORA SPP. OF KORKMAZ, GOKPINAR, AND YILDIZ, 2016

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Korkmaz et al. (2016) examined fecal samples of owned and stray cats in Kirikkale province, Turkey; oocysts of *Isospora* spp., which were not identified to species, were detected in 31/100 (31%) samples.

ISOSPORA SPP. OF MALLOY AND EMBIL, 1978

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Malloy and Embil (1978) examined fecal samples of stray cats in Halifax, Nova Scotia, Canada. Oocysts of *Isospora* spp. were detected in 19/299 (6%) cats, mostly in young animals 0.5–2-years-old, but no attempt was made to identify the species of these isosporans.

ISOSPORA SP. OF MILSTEIN AND GOLDSMID, 1997

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Milstein and Goldsmid (1997) surveyed feral cats in southern Tasmania. Rectal fecal samples and intestinal contents from necropsy were examined, and oocysts of an *Isospora* sp. were recorded, but not identified, in 3/39 (8%) cats.

**ISOSPORA SPP. OF NYAMBURA
NJUGUNA, KAGIRA, MUTURI
KARANJA, NGOTHO, MUTHARIA,
AND WANGARI MAINA, 2017**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Nyambura Njuguna et al. (2017) examined fecal samples of household cats (both indoors and outdoors) in Thika, Kiambu county, central Kenya. Oocysts of *Isospora* spp. were detected in 45/103 (44%) cats but no attempt was made to identify them to species.

**ISOSPORA SP. OF SPADA,
PROVERBIO, DELLA PEPA,
DOMENICHINI, BAGNAGATTI DE
GIORGI, TRAJDI, AND FERRO, 2013**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Spada et al. (2013) examined fecal samples of stray colony cats in Milan, Italy. They reported the presence of *Isospora* sp. oocysts in 6/139 (4%) samples. There was no attempt to identify to species.

**ISOSPORA SPP. OF LORENZINI,
TASCA, AND CARLI, 2007**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Lorenzini et al. (2007) examined fecal samples of 288 cats from different neighborhoods in Porto Alegre, Rio Grande do Sul, Brazil, and they detected the presence of oocysts of *Isospora* spp.

**SARCOCYSTIS SP. OF ARBABI
AND HOOSHYAR, 2009**

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Arbabi and Hooshyar (2009) examined fecal samples of stray cats trapped and necropsied in urban and rural areas of the Kashan region, central Iran. Sporocysts of *Sarcocystis* were detected in 9/113 (8%) samples, in 5 males and 4 females.

**SARCOCYSTIS SPP. OF BARUTZKI
AND SCHAPER, 2003**

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Barutzki and Schaper (2003) examined fecal samples of 3,167 cats in Freiburg, Germany. Sporocysts of *Sarcocystis* were detected in 70/3,167 (2%) samples.

**SARCOCYSTIS SP. OF BÖTTNER,
CHARLESTON, POMROY, AND
ROMMEL, 1987**

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: *Bos taurus* L., 1758, Aurochs.

Remarks: Böttner et al. (1987) surveyed muscle samples by LM, TEM, and SEM of 500 beef cattle slaughtered in New Zealand and found 100% to be infected; of these, 399/500 (80%) were infected with thick-walled sarcocysts, but they were not able to distinguish whether these sarcocysts were *S. hirsuta* or *S. hominis*. They took 305 cysts from 31 samples of diaphragm and esophagus, measured them, and examined them via LM, TEM, and SEM; cyst wall thickness was ~5 (2–7) and was normally distributed throughout the cyst. Protrusion widths were ~1.0 (0.6–2.2) and they formed a continuous, though skewed, distribution. They fed these thick-walled cysts to 3 cats and one human volunteer; the human did not pass sporocysts, but 1/3 (33%) cats shed a few sporocysts in its feces on 11–17 DPI. Nonetheless, they chose not to name this form so it must remain a *species inquirenda*, until further study.

SARCOCYSTIS SP. OF CHRISTIE, DUBEY, AND PAPPAS, 1976

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Christie et al. (1976) surveyed feces from cats, all >3-months-old, from a shelter in Ohio, USA, but found only 2/1,000 (0.2%) samples had sporocysts of a *Sarcocystis* species. These sporocysts were orally inoculated into mice on the same day they were collected from cats. The mice were killed 1–6 months PI, and unstained squashes of skeletal muscles and brain were examined for cysts of *Sarcocystis* species and *Toxoplasma*. The remainder of mouse carcasses were homogenized in a blender and force-fed to 29 SPF cats. Neither of the two mice that had sarcocysts were infectious for either mice or cats. This indicated the species was not *S. muris*.

SARCOCYSTIS SP. (DUBEY AND PANDE, 1963b) OF LEVINE AND IVENS, 1981

Synonym: *Cryptosporodial/Coccidial* (sic) bodies of Dubey and Pande, 1963b.

Definitive host: *Felis chaus* Schreber, 1777, Jungle Cat.

Intermediate host: Unknown.

Remarks: Dubey and Pande (1963b) looked at the feces of three *F. chaus* and found coccidian oocysts in two. They said these oocysts represented six species. Three of the forms they identified were already named, *E. cati* Yakimoff, 1933, *E. felina* Nieschulz, 1924b, and *I. rivolta* (Grassi, 1879) Wenyon, 1923, and two of the forms they named as new species, *E. hammondi* and *E. mathurai*. The sixth form they found was thought to represent a species of *Cryptosporidium*, but these “oocysts,” of course were sporocysts of a *Sarcocystis* species, and Levine and Ivens (1981) corrected the name. The sporocysts were ellipsoidal and measured L×W: 11×7 (10–12×7–8), L/W ratio, 1.6; the sausage-shaped SZ measured 7–9×1–2 and had

a clear RB at their rounded ends. The presence of an SR was not mentioned but their drawing (their Fig. 16) indicated it consisted of large globules congregated at one end of the SP.

SARCOCYSTIS SP. DUBEY AND STREITEL, 1976c

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: *Bos taurus* L., 1758, Aurochs.

Remarks: Dubey and Streitl (1976c) did cross-infections between dogs, cats, sheep, pigs, and cattle from Iowa or Ohio, USA. Cats fed bovine tissues shed sporocysts in small numbers; two cats had patent periods that lasted for 2 and 12 days after ingesting bovine tissue; sporocysts (n=72) were 12.4×8.5 (11–14×8–11). The sporocysts they measured in cat feces were smaller than those in canine feces after ingesting infected bovine flesh. Fayer et al. (1976) earlier the same year fed 16 cats *Sarcocystis*-infected musculature from bovines, but none of them became infected. Dubey and Streitl (1976c) suggested that separate species of *Sarcocystis* parasitize cattle in different areas of the United States, but they did not suggest a name for any of their *Sarcocystis* species.

SARCOCYSTIS SP. OF EDWARDS, FICKEN, LUTGEN, AND FREY, 1988

Definitive host: Unknown.

Intermediate host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Edwards et al. (1988) reported numerous cysts in a 1.5-year-old cat from College Station, Texas, USA. Sarcocysts were found in muscles of the heart, forelimbs, hind limbs, diaphragm, eyes, and intercostal spaces. Sarcocysts were (n=50): 48 (30–60) wide×1.5–2.2 long, had a thick wall, and septa subdivided the cyst into compartments, all with banana-shaped bradyzoites that were 7–10 long. TEM showed the primary cyst wall differed slightly from

those of sarcocysts found in cats by Kirkpatrick et al. (1986), and now thought to be identical with *S. felis* (Dubey et al., 1992b). Primary cyst walls seen by Edwards et al. (1988) had a Pvm with regularly-spaced, villus projections, which were round in cross-section and all about 1 long, whereas the villus projections of Kirkpatrick et al. (1986) and Dubey et al. (1992b) had shorter, irregularly-spaced projections. This led Edwards et al. (1988) to conclude that the form they saw may be a different species. No inflammatory response was associated with the sarcocysts in any of the muscles examined. This form must also be relegated to a *species inquirenda*.

SARCOCYSTIS SP. OF EINSTEIN AND INNES, 1956

Definitive host: Unknown.

Intermediate host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Levine and Ivens (1981) say that Einstein and Innes (1956) found sarcocysts in the striated muscles of a cat. We do not have, nor can we find a copy of, this reference.

SARCOCYSTIS SPP. OF EPE, ISING- VOLMER, AND STOYE, 1993

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Epe et al. (1993), in Germany, surveyed fecal samples from cats between 1984 and 1991 and found 3/1,147 (0.3%) to have sporocysts of *Sarcocystis*, which were not identified to species.

SARCOCYSTIS SP. OF FUNADA, PENA, SOARES, AMAKU, AND GENNARI, 2007

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Funada et al. (2007) examined fecal samples of domestic cats in São Paulo, Brazil. *Sarcocystis* sporocysts were detected in 6/327 (2%) samples, but no other information was given.

SARCOCYSTIS SPP. OF GENNARI, KASAI, PENNA, AND CORTEZ, 1999

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Gennari et al. (1999) examined fecal samples of domestic cats from São Paulo, Brazil. Sporocysts of *Sarcocystis* were found in 16/187 (9%) samples.

SARCOCYSTIS SP. OF HUBER, DA SILVA, BOMFIM, TEIXEIRA, AND BELLO, 2007

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Huber et al. (2007) surveyed fecal samples of cats (originally stray) from an animal shelter in Nova Iguaçu, Rio de Janeiro State, Brazil. Cat fecal samples were collected from the floor of the cat shelter; only 1/30 (3%) was positive for *Sarcocystis* sporocysts.

SARCOCYSTIS SPP. OF JANITSCHKE, PROTZ, AND WERNER, 1976

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: *Nanger granti* (Brooke, 1872) (syn. *Gazella granti*), Grant's Gazelle.

Remarks: Janitschke et al. (1976) found sarcocysts in Grant's gazelle in Tanzania, fed infected flesh to both cats and dogs, and reported finding sporocysts and sporulated oocysts in the feces of both. Sporocysts shed by the cat were L×W: 13×9 (11–16×8–12), L/W ratio, 1.4; the prepatent period

in cats was 20 days and patency lasted 44–48 days. Janitschke et al. (1976) thought they were dealing with two *Sarcocystis* species, but without further infection and/or molecular studies, it is not possible to tell which one was which. Therefore, these must remain *species inquirendae* until they can be differentiated and named. There are at least three *Sarcocystis* species that have been named from gazelles, but only from sarcocysts in their muscle tissues. All three, *S. gazellae* Balfour, 1913, *S. mongolica* Matschoulsky, 1947a,b, and *S. woodhousei* Dogel, 1916, are mentioned in Levine (1986) and in Dubey et al. (2015a), but the carnivore definitive host is not known for any of them. Clearly a lot of work still needs to be done just sorting out the various *Sarcocystis* species in gazelles.

SARCOCYSTIS SP. OF LUCIO-FORSTER AND BOWMAN, 2011

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Lucio-Forster and Bowman (2011) surveyed fecal samples of cats from two shelters (1,272 samples) and their affiliated foster homes (50 samples) in upstate New York, USA. *Sarcocystis* sporocysts were detected in 11/1,322 (<1%) samples. Determination was based on microscopy and morphology, and there was no attempt to identify to species.

SARCOCYSTIS SPP. OF MCKENNA AND CHARLESTON, 1980a

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: McKenna and Charleston (1980a) working on the North Island, New Zealand, examined fecal samples from domestic cats and identified sporocysts of *Sarcocystis* in 86/508 (17%) samples. There was no attempt to identify to species.

SARCOCYSTIS SP. MUNDAY, MASON, HARTLEY, PRESIDENTE, AND OBENDORF, 1978

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Munday et al. (1978) examined muscle samples from 1,497 Australian mammals including 3 red foxes (*Vulpes vulpes*) and 27 brown fur seals (*Arctocephalus pusillus* (syn. *S. doriferus*)), but all 30 were negative. They also examined intestinal mucosal scrapings or feces from 55 feral cats and found small numbers of sporocysts in 1, and these measured 13–14 × 8.5. They (1978) concluded the sporocysts were “typical of *Sarcocystis* or *Frenkelia*.”

SARCOCYSTIS SP. OF OGASSAWARA, BENASSI, LARSSON, AND HAGIWARA, 1986

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Ogassawara et al. (1986) examined fecal samples of domestic cats from different areas of São Paulo, Brazil and reported finding sporocysts of *Sarcocystis* in 18/215 (8%) fecal samples, mostly in animals 4–6-months-old (their Table 2).

SARCOCYSTIS SP. OF SERRA, UCHÔA, AND COIMBRA, 2003

Definitive host: *Felis catus* L., 1758, Domestic Cat.

Intermediate host: Unknown.

Remarks: Serra et al. (2003) examined fecal samples of 65 household and 66 stray cats in Rio de Janeiro, Brazil. *Sarcocystis* sporocysts were seen in 1/131 (<1%) cats, from one household.

SARCOCYSTIS SP. OF WALLACE, 1975

Definitive host: *Felis catus* L., 1758, Domestic Cat (?).

Intermediate host: *Mus musculus* L., 1758, House Mouse.

Remarks: Wallace (1975) looked at two morphologically different cysts in mouse skeletal muscles, which resulted when he inoculated them “with fecal material from a stray cat containing *Isospora*-type oocysts.” The most common cyst type turned out to belong to *T. gondii*, which he confirmed by feeding the cysts to lab cats that produced oocysts that were 13 × 11 and resembled those of *T. gondii*. The second type of cyst found in mouse skeletal muscles was “observed in only a few mice, contained bradyzoites resembling those of *Sarcocystis*, but the oocyst or sporocyst that gave rise to it was overlooked and apparently lost.”

TOXOPLASMA-LIKE OF EPE, COATI, AND SCHNIEDER, 2004

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Epe et al. (2004), in northern Germany, surveyed fecal samples of cats from 1998 to 2002 and found 3/441 (<1%) to pass *Toxoplasma*-like oocysts, which did not “fit” in any particular genus.

TOXOPLASMA-LIKE OF LUCIO-FORSTER AND BOWMAN, 2011

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Lucio-Forster and Bowman (2011) surveyed fecal samples of cats from two shelters (1,272 samples) and their affiliated foster homes (50 samples) in upstate New York, USA. “*Toxoplasma*-like” oocysts were detected in 11/1,322 (<1%) samples. Determination was based only on general morphology.

TOXOPLASMA-LIKE OF NYAMBURA NJUGUNA, KAGIRA, MUTURI KARANJA, NGOTHO, MUTHARIA, AND WANGARI MAINA, 2017

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Nyambura Njuguna et al. (2017) examined fecal samples of household cats in the Thika region, Kiambu county, central Kenya. *Toxoplasma*-like oocysts of uncertain etiology were detected in 5/103 (5%) cats. However, these samples were *Toxoplasma*-negative by both mouse bioassay and PCR. Thus, it could have been *Hammondia* species.

HAMMONDIA–TOXOPLASMA OF BORKATAKI, KATOCH, GOSWAMI, GODARA, KHAJURIA, YADAV, AND KAUR 2013

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Borkataki et al. (2013) studied fecal samples from stray cats in Jammu, a humid subtropical zone in northwestern India. Oocysts of *Toxoplasma*/*Hammondia* (not distinguished) were detected in 88/100 (88%) samples.

HAMMONDIA–TOXOPLASMA OF CHRISTIE, DUBEY, AND PAPPAS, 1976

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Christie et al. (1976) surveyed intestinal parasites of cats, all >3-months-old, from a shelter in Columbus, Ohio, USA. “*Toxoplasma*-like” oocysts, 12 × 11, were detected in 9/1,000 (0.9%) cats. The oocysts were orally inoculated into mice, then the inoculated mice were fed to SPF cats; 1 SPF cat began to shed similar oocysts in its feces.

**GENUS LEOPARDUS
GRAY, 1842 (9 SPECIES)**

**CRYPTOSPORIDIUM SP. OF
HOLSBACK, CARDOSO, FAGNANI,
AND PATELLI, 2013**

Original host: *Leopardus tigrinus* (Schreber, 1775), Oncilla.

Remarks: Holsback et al. (2013) found oocysts of *Cryptosporidium* in fecal samples of two oncillas at the wild animal rehabilitation center in the state of São Paulo, Brazil, using flotation–centrifugation. No other information was given.

**HEPATOZOON SP. OF MERCER,
JONES, RAPPOLE, TWEDT, LAACK,
AND CRAIG, 1988**

Original host: *Leopardus pardalis* (L., 1758), Ocelot.

Remarks: Mercer et al. (1988) collected blood samples from ocelots trapped in Cameron and Willacy counties, Texas, USA; the authors found 6/13 (46%) samples infected with a *Hepatozoon* species. They made no attempt to name or identify the species.

**HEPATOZOON SP. OF METZGER,
DOS SANTOS PADUAN, RUBINI,
DE OLIVEIRA, PEREIRA, AND
O'DWYER, 2008**

Original hosts: *Leopardus pardalis* (L., 1758), Ocelot; *Leopardus tigrinus* (Schreber, 1775), Oncilla or Little Spotted Cat; *Leopardus wiedii* (Schinz, 1821) Margay.

Remarks: Metzger et al. (2008) collected blood samples from 29 non-domestic neotropical felids in northeastern Brazil and found an ocelot, a little spotted cat, and a margay

infected with an *Hepatozoon* species. They confirmed each infection by light microscopy and molecular analysis of partial sequences of the 18S rRNA gene of *Hepatozoon*, but no specific identification was attempted.

**ISOSPORA SP. OF PATTON,
RABINOWITZ, RANDOLPH,
AND JOHNSON, 1986**

Original host: *Leopardus pardalis* (L., 1758), Ocelot.

Remarks: Patton et al. (1986) did a coprological survey of parasites of wild neotropical Felidae from the Cockscomb Basin, Belize, Central America and said they found oocysts of an *Isospora* species in 3/8 (37.5%) fecal samples from ocelots. No other information was given.

**GENUS LEPTAILURUS
SEVERTZOV, 1858 (MONOTYPIC)**

**ISOSPORA FELIS OF MACKINNON
AND DIBB, 1938**

Original host: *Leptailurus serval* (Schreber, 1776) (syn. *Felis serval* Schreber, 1776), Serval.

Remarks: Mackinnon and Dibb (1938) looked at the feces of several serval at the London Zoo and reported oocysts they identified as those of *I. felis*. However, the oocysts they measured were 26–33 × 22–27, with sporocysts only 13 in mean length. They indicated the oocysts were partially sporulated when passed by their hosts. However, both the oocysts, and especially the sporocysts, are too small to be those of *I. felis* (now *C. felis*) and they are larger than those of *I. rivolta* (now *C. rivolta*). Levine and Ivens (1981) suggested these oocysts belong to a separate (unknown) species. We agree. It can only be relegated to a *species inquirenda*.

GENUS *LYNX* KERR, 1752 (4 SPECIES)

CRYPTOSPORIDIUM SPP. OF CARVER, SCORZA, BEVINS, RILEY, CROOKS, VANDEWOUDE, AND LAPPIN, 2012

Original host: *Lynx rufus* (Schreber, 1777), Bobcat.

Remarks: Carver et al. (2012) collected fecal samples from 141 bobcats in California (Ventura county) and Colorado (Front Range and Western Slope), USA. Samples were examined by flotation and direct immunofluorescence followed by PCR assays, but the authors did not specify what genes were amplified (!) and the PCR amplification failed. The authors said they detected *Cryptosporidium* across all studied sites but did not provide the number of positive animals nor the prevalence.

CRYPTOSPORIDIUM SPP. OF ZIEGLER, WADE, SCHAAF, STERN, NADARESKI, AND MOHAMMED, 2007

Original host: *Lynx rufus* (Schreber, 1777), Bobcat.

Remarks: Ziegler et al. (2007) examined fecal samples from bobcats in southeastern New York state, USA, by flotation and LM, and by polyclonal *Cryptosporidium* antigen-capture ELISA (considered positive based on an optical density ≥ 0.050). *Cryptosporidium* was found in 1/14 (7%) samples, but not identified to species.

EIMERIA LYNCSIS OF ANPILOGOVA AND SOKOV, 1973

Original host: *Lynx lynx isabellinus* (Blyth, 1847), Central Asian Lynx.

Remarks: Levine and Ivens (1981) listed this eimerian as having been described by Anpilogova and Sokov (1973) from Tadzhikistan (former USSR). They said the ellipsoidal oocysts measured 33×23 ($30-38 \times 19-27$) and had a bilayered wall with a M in the inner wall. However, neither pair of authors provided a line drawing or photomicrograph; thus, it can only be a *species inquirenda*.

EIMERIA SPP. OF ANPILOGOVA AND SOKOV, 1973

Original host: *Lynx lynx isabellinus* (Blyth, 1847), Central Asian Lynx.

Remarks: Levine and Ivens (1981) listed this eimerian as having been described by Anpilogova and Sokov (1973) from Tadzhikistan (former USSR). They said the elongate-ovoidal oocysts were truncated at the M and measured 40.5×27 , with sporocysts that were 13.5×11 , with no other information. Neither pair of authors provided a line drawing or a photomicrograph; thus, it can only be considered a *species inquirenda*.

EIMERIA TADZHIKISTANICA OF ANPILOGOVA AND SOKOV, 1973

Original host: *Lynx lynx isabellinus* (Blyth, 1847), Central Asian Lynx.

Remarks: Levine and Ivens (1981) listed this eimerian as having been described by Anpilogova and Sokov (1973) from Tadzhikistan (former USSR). They said the ovoidal oocysts measured $L \times W: 31.0 \times 23.5$ ($24-32 \times 19-27$), with a 2-layered wall and without a M, OR, PG. Neither pair of authors provided a line drawing or photomicrograph; thus, a *species inquirenda*.

HEPATOZOON SP. OF LANE AND KOCAN, 1983

Original host: *Lynx rufus* (Schreber, 1777), Bobcat.

Remarks: Lane and Kocan (1983) reported a *Hepatozoon* species infection in bobcats. No other information was given.

HEPATOZOON SP. OF MERCER, JONES, RAPPOLE, TWEDT, LAACK, AND CRAIG, 1988

Original host: *Lynx rufus* (Schreber, 1777), Bobcat.

Remarks: Mercer et al. (1988) collected blood samples from bobcats trapped in Aransa, LaSalle, Cameron, Starr, and Willacy counties, Texas, USA. They found that 3/20 (15%) were infected with a *Hepatozoon* species but made no attempt to name or identify the species.

ISOSPORA BIGEMINA LARGE FORM OF DUSZYNSKI AND SPEER, 1976

Original host: *Lynx rufus* (Schreber, 1777), Bobcat.

Remarks: In 1972, Dr. David Worley, Montana State University, Bozeman, Montana, USA collected feces from a bobcat and sent it to Duszynski, the University of New Mexico, Albuquerque, USA. Duszynski and Speer (1976) found oocysts they called *I. bigemina* large form and were among the first to use them to look at *in vitro* excystation of sporocysts that lack Stieda bodies. The oocysts and sporocysts were, of course, an unknown species of *Sarcocystis*. Although the species from the bobcat remains a *species inquirenda*, the interesting observation was that during excystation, the walls of the sporocyst collapsed, apparently along predetermined lines, allowing sporozoites to escape. As the sporocyst collapsed, the wall separated into two halves, each with two pieces attached together at a point corresponding to one pole of the original sporocyst.

ISOSPORA LYNCIS LEVINE AND IVENS, 1981

Synonym: *Isospora felis* (Wasielewski, 1904) Wenyon, 1923.

Original host: *Lynx* sp., Bobcat.

Remarks: Triffitt (1927) said she found oocysts of an *Isospora* in the rectal contents of a lynx that died in the Zoological Gardens, London, but did not specify the host species (*L. lynx* or *L. canadensis*). She did state that its oocysts were identical to those of *I. felis*, but that they had a M, which those of *I. felis* lack. Based on that difference, Levine and Ivens (1981) named the form partially described by Triffitt (1927) as *I. lyncis* because she also gave some mensural data. Triffitt (1927) said the oocysts were ovoidal, 40–47 × 28–37, and had an oocyst wall with 3-layers, ~0.75 thick, and a M, ~4–5 wide; ovoidal SP were 20–33 × 14–18, with a SR, and SZ measured 15 long, with a large RB at their more rounded end and a smaller one at their more pointed end. Triffitt (1927) said that sporulation was completed in 7–9 days at room temperature. However, neither Triffitt (1927) nor Levine and Ivens (1981) provided a line drawing or a photomicrograph. Thus, there is no evidence that this species actually exists, so the name only can be a *species inquirenda*.

SARCOCYSTIS SP. OF DUBEY, 1982b

Definitive host: *Lynx rufus* (Schreber, 1777), Bobcat.

Intermediate host: Unknown.

Remarks: Dubey (1982b) surveyed the feces for coccidians from a variety of wild carnivores from Montana, USA. He reported sporocysts of *Sarcocystis* in the feces of 2/61 (3%) bobcats. No attempt was made to identify the species beyond genus; thus, a *species inquirenda*.

GENUS PRIONAILURUS SEVERTZOV, 1858 (5 SPECIES)

SARCOCYSTIS SP. OF KUBO AND KUNIYOSHI, 2014

Definitive host: Unknown.

Intermediate host: *Prionailurus bengalensis*, Tsushima Leopard Cat.

Remarks: Kubo and Kuniyoshi (2014) examined tissues from wild Tsushima leopard cats in Japan; 5/36 (14%) had cysts presumed to be *Sarcocystis* in their muscles. Cysts were 33–745 × 17–65, cyst walls were 1.4–1.7 thick, and there were numerous finger-like protrusions. No attempt was made to identify the species beyond genus; thus, it must be considered a *species inquirenda*.

GENUS PUMA JARDINE, 1834 (2 SPECIES)

HEPATOZOOM SP. OF METZGER, DOS SANTOS PADUAN, RUBINI, DE OLIVEIRA, PEREIRA, AND O'DWYER, 2008

Original host: *Puma yagouaroundi* (É. Geoffroy Saint-Hilaire, 1803), Jaguarundi.

Remarks: Metzger et al. (2008) collected blood samples from 29 non-domestic neotropical felids in northeastern Brazil and found a jaguarundi infected with an *Hepatozoon* species. They confirmed this infection by light microscopy and molecular analysis of partial sequences of the 18S rRNA gene of *Hepatozoon*, but no specific identification was attempted.

SARCOCYSTIS SP. OF DUBEY, 1982b

Definitive host: *Puma* (syn. *Felis*) *concolor* (L., 1771), Puma, Cougar.

Intermediate host: Unknown.

Remarks: Dubey (1982b) surveyed feces for coccidians from a variety of wild carnivores in Montana, USA and reported sporocysts of *Sarcocystis* in 2/12 (17%) pumas. Sporocysts were 11.5–13.0 × 7.5–8.8. No attempt was made to identify the species beyond genus; thus, a *species inquirenda*.

SARCOCYSTIS SP. OF KLUGE, 1967

Definitive host: Unknown.

Intermediate host: *Puma* (syn. *Felis*) *concolor* (L., 1771), Puma, Cougar.

Remarks: Kluge (1967) found sarcocysts in the skeletal muscles of a 13-year-old puma that died in the National Zoological Park, Washington, D.C., USA. Sarcocysts, examined with LM, had a thin wall, composed of a single layer without septa projecting from the internal surface. The cyst contained numerous banana-shaped structures (bradyzoites?), "each of which had a round to oval subterminal nucleus and small basophilic granules within the cytoplasm." Kluge (1967) said these cysts "replaced approximately two-thirds of the sarcoplasm in the slightly swollen affected muscle bundles," but that no inflammatory reaction was seen. No other information and no measurements were given, but because he reported "no septa" to be present, it is unlikely that this form can be attributed to *S. felis*, so it must be considered a *species inquirenda*.

SUBFAMILY PANTHERINAE POCOCK, 1917

GENUS PANTHERA (L., 1758) (4 SPECIES)

APICOMPLEXAN PROTOZOA OF BJORK, AVERBECK, AND STROMBERG, 2000

Original host: *Panthera leo* (L., 1758) (syn. *Leo leo* Frisch, 1775), Lion.

Remarks: Bjork et al. (2000) published, "the first documentation of enteric parasites in a wild population of African lions in the Serengeti region" of northern Tanzania, Africa. They collected 33 freshly deposited fecal samples from wild lions, preserved them in 10% formalin, and examined both direct smears and fecal flotations for transmission stages. They said they found the following apicomplexans: *Eimeria* sp. in 1 lion, *Isospora felis* in 16, *I. rivolta* in 2, *Isospora* sp. in 1, *Sarcocystis* sp. in 15, and *Toxoplasma*-like oocysts in 4 samples. Unfortunately, they made these spurious identifications by measuring only one or a few oocysts, and all oocysts (except the oocysts/sporocysts of *Sarcocystis*) were unsporulated, which, of course, makes their identifications to genus completely unreliable, if not impossible.

APICOMPLEXAN PROTOZOA OF PATTON AND RABINOWITZ, 1994

Original hosts: *Panthera pardus* (L., 1758), Leopard; *Panthera tigris* (L., 1758), Tiger; *Panthera tigris bengalensis* (L., 1758), Bengal Tiger.

Remarks: Patton and Rabinowitz (1994) did a coprological survey of wild felids in Thailand and preserved the feces in 10% formalin, but made no mention that they took time to sporulate potential oocysts that may have been in their samples. Nonetheless, they reported finding *Isospora*-like oocysts that measured 40 × 32 in 2/54 (4%) *P. pardus* and in 1/3 (33%) *P. t. bengalensis*; *Isospora*-like oocysts that were 20 × 20 in 4/54 (7%) *P. pardus*; *Toxoplasma*-like oocysts in 1/54 (2%) *P. pardus*; *Sarcocystis* spp. oocysts/sporocysts in 11/54 (20%) *P. pardus* and 7/19 (37%) *P. tigris*. These generalist determinations to genus seem completely unreliable to us.

COCCIDIA SP. OF MÜLLER-GRAF, 1995

Original host: *Panthera leo* (L., 1758) (syn. *Leo leo* Frisch, 1775), Lion.

Remarks: Müller-Graf (1995) conducted a coprological survey of intestinal parasites of wild *P. leo* in the Serengeti and the Ngorongoro Crater, Tanzania, East Africa. She examined feces from lions and found "Coccidia" in 59/112 (53%) samples. No other information was given on the oocysts she saw.

COCCIDIA SP. OF DUBEY AND JARDINE, 2008

Original host: *Panthera leo* (L., 1758) (syn. *Leo leo* Frisch, 1775), Lion.

Remarks: Dubey and Jardine (2008) examined formalin-fixed tissues of a <2-day-old captive-born lion cub, *P. leo*, from Pretoria, South Africa. Meronts, merozoites, gamonts, and unsporulated oocysts were found in epithelial cells of the cub's ileum and examined by LM and TEM. Endogenous stages did not stain with antibodies to *T. gondii* and/or *N. caninum* and the morphology and size of various tissue stages eliminated *I.* (syn. *C.*) *felis* and *I.* (syn. *C.*) *rivolta* as suspects. Stages also differed from those of *H. hammondi*, and *H. hammondi* is not known to be transmitted transplacentally, nor are felids suspected to be definitive hosts of *N. caninum*. The age of the cub and the advanced development of the parasite supported the assumption that it was acquired in utero but no identification was/could be made. This seems a great opportunity for a future research project but, until then, it must be considered a *species inquirenda*.

CRYPTOSPORIDIUM SP. OF KARANIS, PLUTZER, HALIM, IGORI, NAGASAWA, ONGERTH, AND LIQING, 2007

Original host: *Panthera pardus* (L., 1758), Leopard.

Remarks: Karanis et al. (2007) examined feces of *P. pardus* in the Xining Zoo, Qinghai province, China, using an immunofluorescence test, nested PCR, and sequencing of a partial 18S rRNA gene; they reported *Cryptosporidium* oocysts in *P. pardus* and said they were *C. parvum* mouse genotype. Neither the number of examined leopards nor their origin was given.

CRYPTOSPORIDIUM SP. OF LIM, NGUI, SHUKRI, ROHELA, AND NAIM, 2008

Original host: *Panthera tigris corbetti*, Indochinese Tiger.

Remarks: Lim et al. (2008) said they found oocysts of a *Cryptosporidium* sp. in the feces of 1/3 (33%) Indochinese tigers examined at Zoo Negara, Kuala Lumpur, Malaysia. No other information was given.

CRYPTOSPORIDIUM SP. OF LIM, NGUI, SHUKRI, ROHELA, AND NAIM, 2008

Original host: *Panthera tigris jacksoni*, Malayan Tiger.

Remarks: Lim et al. (2008) said they found oocysts of a *Cryptosporidium* sp. in the feces of 1/3 (33%) Malayan tigers examined at Zoo Negara, Kuala Lumpur, Malaysia. No other information was given.

CRYPTOSPORIDIUM SP. OF LIM, NGUI, SHUKRI, ROHELA, AND NAIM, 2008

Original host: *Panthera tigris sumatrae*, Sumatran Tiger.

Remarks: Lim et al. (2008) said they found oocysts of a *Cryptosporidium* sp. in the feces of 1/3 (33%) Sumatran tigers examined at Zoo

Negara, Kuala Lumpur, Malaysia. No other information was given.

CRYPTOSPORIDIUM SP. OF WANG AND LIEW, 1990

Original host: *Panthera* (?), identified only as "leopard."

Remarks: Wang and Liew (1990) reported oocysts of *Cryptosporidium* in a "leopard" from a bird park in Taiwan; the oocysts were detected in a fecal smear stained with modified Ziehl-Neelsen karbol-fuchsin. No other information was given.

EIMERIA NOVOWENYONI OF RASTÉGAÏEFF, 1929a

Original host: *Panthera tigris* (L., 1758), Tiger (?).

Remarks: Rastégaïeff (1929a) in a "note préliminaire" reported finding oocysts of this form in the feces of a tiger (species name not given) of the Zoological Gardens of Leningrad. She described the oocysts as spheroidal, 14–15 wide, without a M. She gave no other structural information other than it had four sporocysts. Rajasekariah et al. (1971) reported that they found this same "species" in a captured "panther" cub kept at the Dharmaram College, Bangalore, India and that it had spheroidal oocysts, 18–20 wide, with a 2-layered wall, ~2.0 thick, and without a M, OR, PG, SB, SR but that it had ellipsoidal SP, 10×6, with SZ that measured 8×4. They also reported another eimerian, *E. anekalensis*, which they described as new, also from this panther (see [Chapter 10](#), Felidae). It is questionable whether this poorly described form can be a parasite of both the tiger and the leopard. It is likely not a parasite of either, in our opinion.

HEPATOZOON SP. OF BROCKLESBY, 1971

Original host: *Panthera leo* (L., 1758), Lion.

Remarks: Brocklesby (1971) illustrated only a gamont/gametocyte in a granulocyte (PMN) of an east African lion; its size was given as 8.5 (8–10).

HEPATOZOON SP. OF KEYMER AND BROCKLESBY, 1971

Original host: *Panthera pardus* (L., 1758), Leopard.

Remarks: Keymer and Brocklesby (1971) described intraleukocytic gametocytes and extra-cellular forms of a *Hepatozoon* species in the blood, and two forms of meronts of a *Hepatozoon* in *P. pardus* from central Africa. Meronts were found, both in cardiac muscle and lungs. They said that the gametocytes were indistinguishable from *H. canis* of the dog, but unlike the *Hepatozoon* of the dog, no meronts were found in liver, bone marrow, spleen, or lymph nodes. This was the first description of *Hepatozoon* meronts from a leopard, but its actual identity remains a mystery.

HEPATOZOON SP. OF KRAMPITZ, SACHS, SCHALLER, AND SCHINDLER, 1968

Original host: *Panthera leo massaica* (Neumann, 1900), Massai Lion.

Remarks: Krampitz et al. (1968) said that about 28/56 (50%) Massai lions had “gametocytes in its monocytes, which differed from all other species described so far.”

ISOSPORA RIVOLTA-LIKE OF MANDAL AND CHOUDHURY, 1983

Original host: *Panthera pardus* (L., 1758), Leopard.

Remarks: Mandal and Choudhury (1983) collected feces from one *P. pardus*, in the Betla Forest Palamau Tiger Reserve, Bihar, India. They incubated the sample in 2%–2.5% potassium dichromate solution and concentrated oocysts via centrifugation. They found ovoidal isosporan oocysts with a 2-layered wall, ~0.9 thick,

that measured, L × W: 29.2 × 23.4 (26–31 × 22–24), L/W ratio: 1.2; M, OR, PG: all absent. Sporocysts were spheroidal, 15.3 (12–17); L/W ratio: 1.0; SB, SSB, PSB: all absent, but SR was present as a large, granular, spheroidal mass, 5.8 (5–7) wide; SZ were banana-shaped, 10.3 × 2.6 (7.5–10 × 2–3), with a prominent RB at the broad end. They chose only to identify the oocysts measured as *I. rivolta*-like. Its true identity is anyone’s guess.

ISOSPORA SP. OF CHAUHAN, BHATIA, ARORA, AGRAWAL, AND AHLUWALIA, 1973

Original hosts: *Panthera leo* (L., 1758), Lion; *Panthera tigris* (L., 1758), Tiger.

Remarks: Chauhan et al. (1973) did a “preliminary survey” of parasitic infections among mammals and birds at the Lucknow Zoological Garden, India and reported finding *Isospora* sp. oocysts in the feces of *P. leo* and *P. tigris*, but the number of lions and tigers examined was not stated.

ISOSPORA SP. OF HOU, HUA, LIU, ZENG, CHAI, SUN, LIU, AND XIA, 2008

Original host: *Panthera tigris altaica* Temminck, 1844, Tiger.

Remarks: Hou et al. (2008) found coccidian oocysts in a naturally-infected tiger in China; based on morphology, sporulation, and phylogenetic analysis, they concluded the coccidian from their tiger was *Isospora*. No other information was given.

ISOSPORA SP. OF PANDE, BHATIA, CHAUHAN, AND GARG, 1970

Original host: *Panthera leo* (L., 1758), Lion.

Remarks: Pande et al. (1970) examined feces of 23 mammal species in the Zoological Gardens, Lucknow, India for coccidian oocysts, including

four samples from zoo lions, two of which had isosporan oocysts in them. Ovoidal oocysts were $L \times W$ ($n=30$): 26×22 ($23-33 \times 20-28$), L/W ratio: 1.2 (1.1-1.4); the oocyst wall was 2-layered, ~ 1.3 thick, and lacked M, OR, PG. Sporocysts were ellipsoidal, 17×12 ($16-18 \times 11-13$), L/W ratio: 1.4; SB, SSB, PSB: all absent, but SR was present and SZ were banana-shaped, 13×4 ($12-15 \times 3-9$), with a central N and a prominent RB at the broad end. Pande et al. (1970) compared their sporulated oocysts to those of *I. felis*, *I. laidlawi*, and *I. leonine* and thought theirs was sufficiently different. Nonetheless, they wrote, "It is not possible to assign present material categorically to any of these" and, "pending the availability of more material, these oocysts are, therefore described under an unnamed species, *Isospora* sp." Levine and Ivens (1981) questioned whether or not this is a true parasite of the lion, and so do we. This morphotype has not been seen or described since its original discovery, but if it is found again and, indeed, is a true parasite of the lion, it must be placed in the *Cystoisospora*.

ISOSPORA SP. OF PATTON, RABINOWITZ, RANDOLPH, AND JOHNSON, 1986

Original host: *Panthera pardus* (L., 1758), Leopard.

Remarks: Patton et al. (1986) did a coprological survey of neotropical felids in Belize; they found oocysts of an *Isospora* species in the feces of 2/25 (8%) jaguars from the Cockscomb Basin of Belize, Central America. No other information was presented.

ISOSPORA SP. OF RAVINDRAN, KUMAR, AND GAFOOR, 2011

Original host: *Panthera pardus* (L., 1758), Leopard.

Remarks: Ravindran et al. (2011) said they found oocysts of an *Isospora* sp. in the fecal sample from 1/1 *P. pardus*. No other information was given.

ISOSPORA SPP. OF SINGH, GUPTA, SINGLA, SINGH, AND SHARMA, 2006

Original host: *Panthera leo* (L., 1758) (syn. *Leo leo* Frisch, 1775), Lion.

Remarks: Singh et al. (2006) said they found *Isospora* spp. in 4/50 (9%) fecal samples from lions in Mahendra Choudhury Zoological Park, Punjab, India. No other information was given.

ISOSPORA SPP. OF SINGH, GUPTA, SINGLA, SINGH, AND SHARMA, 2006

Original host: *Panthera tigris* (L., 1758), Tiger.

Remarks: Singh et al. (2006) said they found *Isospora* spp. in 5/50 (11%) fecal samples from tigers, Mahendra Choudhury Zoological Park, Punjab, India. No other information was given.

SARCOCYSTIS SP. OF BERENTSEN, BECKER, STOCKDALE-WALDEN, MATANDIKO, MCROBB, AND DUNBAR, 2012

Definitive host: *Panthera leo* (L., 1758) (syn. *Leo leo* Frisch, 1775), Lion.

Intermediate host: Unknown.

Remarks: Berentsen et al. (2012) surveyed African lions and other carnivore species from the Luangwa Valley, Zambia, and reported sporocysts of a *Sarcocystis* species in 1/15 (7%) *P. leo* but gave no other information about this parasite.

SARCOCYSTIS SP. OF BHATAVDEKAR AND PUROHIT, 1963

Definitive host: Unknown.

Intermediate host: *Panthera leo* (L., 1758) (syn. *Leo leo* Frisch, 1775), Lion.

Remarks: Bhatavdekar and Purohit (1963) may have been the first to document sarcocysts in the muscles of felids. They said they found, "a very thin hyaline capsule and the cavity was filled

with numerous crescentic bodies" in sections of heart muscle from two zoo lions (presumably *P. leo*) that had died in India. The sarcocysts, examined only under LM, were, 12.3 × 2.4, did not have "discernable" septa, and they were found in both striated and cardiac muscle fibers and in the cells of Purkinje fibers. Because of the small size and lack of septa (?), it is unlikely that this form can be attributed to *S. felis*, so it must be considered a *species inquirenda*. Bhatvdekar and Purohit (1963) said they fed sarcocysts in muscle tissue to mice and injected "the spores" (bradyzoites?) intramuscularly into mice and that "typical sarcocysts developed within four to seven weeks after feeding the infective stages." This remains to be confirmed.

SARCOCYSTIS SP. OF BWANGAMOI, ROTTCHER, AND WEKESA, 1990

Definitive host: Unknown.

Intermediate host: *Panthera leo* (L., 1758) (syn. *Leo leo* Frisch, 1775), Lion.

Remarks: Bwangamoi et al. (1990) found numerous sarcocysts measuring 730–760 × 113–114 in the skeletal muscles of a 7-year-old lioness from Nairobi National Park, Africa. No other information was given, thus, a *species inquirenda*.

SARCOCYSTIS SP. OF JOG, MARATHE, GOEL, RANADE, KUNTE, AND WATVE, 2003

Definitive host: *Panthera tigris* (L., 1758), Tiger.

Intermediate host: Unknown.

Remarks: Jog et al. (2003) surveyed the feces of 69 tigers from Tadoba National Park, Maharashtra, India, and found 3/69 (4%) passed sporocysts of a *Sarcocystis* species, and 2/36 (5.5%) tigers from Mudumalai National Park and Wildlife Sanctuary passed similar sporocysts in their feces. No attempt was made to further characterize the species, but Jog et al. (2003) also mentioned that 0/28 leopards, presumably *Panthera pardus* (L., 1758), were never found to have sporocysts in their feces when examined.

SARCOCYSTIS SP. OF MÜLLER-GRAF, 1995

Definitive host: *Panthera leo* (L., 1758) (syn. *Leo leo* Frisch, 1775), Lion.

Intermediate host: Unknown.

Remarks: Müller-Graf (1995) did a coprological survey of wild *P. leo* in the Serengeti and the Ngorongoro Crater, Tanzania, East Africa. She examined feces from lions and found "Coccidia" in 59/112 (53%) samples. She also reported finding sporocysts representing a *Sarcocystis* species in 16/112 (28%) samples. No other information was given on these samples.

SARCOCYSTIS SP. OF PATTON AND RABINOWITZ, 1994

Definitive host: *Panthera pardus* (L., 1758), Leopard.

Intermediate host: Unknown.

Remarks: Patton and Rabinowitz (1994) did a coprological survey of wild felids in Thailand and found *Sarcocystis* sporocysts in the feces of 11/54 (20%) samples examined. No other information was presented; thus, another *species inquirenda*.

SARCOCYSTIS SP. OF PATTON AND RABINOWITZ, 1994

Definitive host: *Panthera tigris* (L., 1758), Tiger.

Intermediate host: Unknown.

Remarks: Patton and Rabinowitz (1994) did a coprological survey of wild felids in Thailand and found *Sarcocystis* sporocysts in the feces of 7/19 (37%) samples examined. No other information was presented, thus another *species inquirenda*.

SARCOCYSTIS SP. OF SOMVANSHI, KOUL, AND BISWAS, 1987

Definitive host: Unknown.

Intermediate host: *Panthera pardus* (L., 1758), Leopard.

Remarks: Somvanshi et al. (1987) examined the carcass of a young leopard that was shot in Ramgarh, Uttarakhand, India, in the foothills of the Himalayas. Numerous elongated sarcocysts were found in the myocardium; the sarcocyst wall was thin, with numerous trophozoites. In spite of the large number of sarcocysts seen, the authors reported no inflammatory reaction. No other information was presented; thus, another *species inquirenda*.

FAMILY HERPESTIDAE BONAPARTE, 1845

GENUS CYNICITIS OGILBY, 1833 (MONOTYPIC)

ISOSPORA SP. OF MARKUS, 1972

Original host: *Cynictis penicillata* (G. [Baron] Cuvier, 1829), Yellow Mongoose.

Remarks: Markus (1972) reported isosporan-like oocysts from the yellow mongoose in South Africa, but no measurements were given.

GENUS HELOGALE GRAY, 1862 (2 SPECIES)

SARCOCYSTIS SP. OF VILJOEN, 1921

Definitive host: Unknown.

Intermediate host: *Helogale parvula* (Sundevall, 1847), Common Dwarf Mongoose.

Remarks: According to Levine and Ivens (1981), Viljoen (1921) found sarcocysts in the striated muscles of *H. parvula* in South Africa, but they did not see that actual paper, and got the citation from Nietz (1965). Levine (1986) did not list this species, and Dubey et al. (2015a) listed neither the Viljoen nor Nietz references and made no mention of a *Sarcocystis* species in *H. parvula*. Viljoen (1921) does not come up in Google Scholar and we were unable to obtain a copy of the Nietz paper.

GENUS HERPESTES ILLIGER, 1811 (10 SPECIES)

ISOSPORA ICHNEUMONIS OF LEVINE, IVENS, AND HEALY, 1975

Original host: *Herpestes ichneumon* (L., 1758), Egyptian Mongoose.

Remarks: Balozet (1933) found oocysts in fecal matter of two *H. ichneumon* from the Zaghouan region, Tunisia. He measured 100 sporulated oocysts and offered a very superficial description saying the subspheroidal oocysts were L×W: 22×19 (19–26×16–20), with a transparent, 2-layered wall and a poorly visible M. He said oocysts sporulated in 4 days when fecal material was placed on filter paper impregnated with potassium dichromate. Balozet (1933) fed sporulated oocysts in fecal material to a 4-day-old puppy and 9 days later, reinfected it with more oocysts. Four days after the second inoculation, oocysts were “extremely numerous” in the dog’s feces, and the pup was described as having dysentery; after the fourth day of patency, oocysts became rare in the feces and the pup was sacrificed 30 days after the first inoculation. Balozet (1933) found no visible intestinal lesions and concluded that he had found *Isospora rivolta* (Grassi, 1879) Wenyon, 1923, saying, “...which appears to be a rather ubiquitous species capable of parasitizing several species of carnivorous species.” In spite of this very modest description, and the lack of line drawing or photomicrograph, Levine et al. (1975) named the form seen by Balozet (1933) a new species, *I. ichneumonis*, when they should have relegated it, as we are here, to a *species inquirenda*.

GENUS MUNGOS É. GEOFFROY SAINT-HILAIRE, AND F.G. CUVIER, 1795 (2 SPECIES)

SARCOCYSTIS SP. OF VILJOEN, 1921

Definitive host: Unknown.

Intermediate host: *Mungos mungo* (Gmelin, 1788), Banded Mongoose.

Remarks: According to Levine and Ivens (1981), Viljoen (1921) found sarcocysts in the striated muscles of *M. mungo* in South Africa, but they did not see Viljoen's paper and got the citation from Nietz (1965). Levine (1986) did not list this species, and Dubey et al. (2015a) listed neither the Viljoen nor Nietz references and made no mention of a *Sarcocystis* species in *M. mungo*. Viljoen (1921) does not come up in Google Scholar and we were unable to obtain a copy of the Nietz paper.

GENUS SURICATA DESMAREST, 1804 (MONOTYPIC)

ISOSPORA SP. OF USHIGOME, YOSHINO, SUZUKI, KAWAJIRI, MASAKI, ENDO, AND ASAKAWA, 2011

Original host: *Suricata suricatta* (Schreber, 1776), Meerkat.

Remarks: Ushigome et al. (2011) examined fecal materials of 53 species of captive animals in Kawasaki Yumemigasaki Zoological Park, Japan, and found some *Isoospora* sp. oocysts in meerkats. Not much to go on, but certainly an area that could bear fruitful research.

FAMILY HYAENIDAE GRAY, 1821

GENUS CROCUTA KAUP, 1828 (MONOTYPIC)

CYSTOISOSPORA SP. OF FERREIRA, 2015

Original host: *Crocota crocuta* (Erxleben, 1777), Spotted Hyaena.

Intermediate host: Unknown.

Remarks: Ferreira (2015) collected 164 fecal samples from 104 known spotted hyaena juveniles

(*C. crocuta*), ages 36- to 726-days-old, from March, 2010 to August, 2011 and examined them for parasite eggs and oocysts. She also extracted parasite DNA from the feces of two spotted hyaenas to obtain 18S rRNA gene fragments of 556 and 803bp (minus primers), using the template *Cystoisospora felis* (of Carreno et al., 1998, GenBank accession #L76471.1). Her fecal samples showed two *Cystoisospora* forms, type 1 (small form, ~14µm) in 33/104 (32%) hyaenas and *Cystoisospora* type 2 (large form, 31µm) in 44/104 (42%) hyaenas. Her type 1 isolate (hyaena #I550) was closely related to *B. besnoiti*, *H. triffittae*, *T. gondii*, and *N. caninum*, indicating that it does not belong to *Cystoisospora*, whereas her type 2 isolate (hyaena #M661) aligned with the *Isoospora/Cystoisospora* clade.

HEPATOZOON SP. OF KRAMPITZ, SACHS, SCHALLER, AND SCHINDLER, 1968

Original host: *Crocota crocuta* (Erxleben, 1777), Spotted Hyaena.

Remarks: Krampitz et al. (1968) said that about 4/9 (44%) spotted hyaenas in the Serengeti National Park, Tanzania had gametocytes of a *Hepatozoon* species in their monocytes and neutrophils.

ISOSPORA SP. OF BERENTSEN, BECKER, STOCKDALE-WALDEN, MATANDIKO, MCROBB, AND DUNBAR, 2012

Original host: *Crocota crocuta* (Erxleben, 1777), Spotted Hyaena.

Remarks: Berentsen et al. (2012) surveyed hyaenas and other African carnivore species from the Luangwa Valley, Zambia for gastrointestinal parasites; they reported *Isoospora* species in 3/9 (33%) *C. crocuta* but gave no other information about this parasite.

**ISOSPORA SP. OF ENGH, NELSON,
PEEBLES, HERNANDEZ, HUBBARD,
AND HOLEKAMP, 2003**

Original host: *Crocuta crocuta* (Erxleben, 1777), Spotted Hyaena.

Remarks: Engh et al. (2003) collected fecal samples from *C. crocuta* in the Masai Mara National Reserve, Kenya, and found oocysts of an *Isospora* sp. in 18/70 (26%) hyaenas. The size of the oocysts, ~35.3 µm, was intermediate between that of *I. (=C.) felis* and *I. (=C.) leonina*, two species recorded in African lions, but not in hyaenas.

FAMILY VIVERRIDAE GRAY, 1821

**SUBFAMILY PARADOXURINAE
GRAY, 1865**

**GENUS PARADOXURUS F.G.
CUVIER, 1821 (3 SPECIES)**

**COCCIDIA, CYCLOSPORA, EIMERIA
SPP. OF CHAKRABORTY, TIWARI,
REDDY, AND UMAPATHY, 2016**

Original hosts: *Paradoxurus hermaphroditus* (Pallas, 1777), Asian Palm Civet; *Paradoxurus jerdoni* Blanford, 1885, Jerdon's Palm Civet.

Remarks: Chakraborty et al. (2016) did a field survey of civets in the Anamalai Tiger Reserve (10° 12–35'N, 76° 49'–77° 24'E) and adjoining Valparai plateau, southern Western Ghats, India. They collected fecal samples of 108 civets from December, 2014 to March, 2015; samples were taken from 10 "forest fragments" that ranged from 8–2,000 ha. All samples were collected in 10% formalin, and they (2016) could not identify to which of the three endemic civets each fecal sample belonged. Samples thought to be infected with a *Cyclospora* sp. were found in two forest fragments, those infected with *Eimeria* species

were found in four forest fragments and those identified only as *Coccidia* species were found in seven forest fragments. It is not clear how they defined "Coccidia" species nor how they were able to distinguish oocysts of *Cyclospora* and *Eimeria* species, given that feces were collected in 10% formalin and, apparently, not placed into thin layers in Petri dishes to allow sporulation.

**EIMERIA SP. OF COLÓN
AND PATTON, 2012**

Original host: *Paradoxurus hermaphroditus* (Pallas, 1777), Asian Palm Civet.

Remarks: Colón and Patton (2012) did a coprological survey of civets in Sabah, Borneo, and feces from a road-killed *P. hermaphroditus* was reported to have oocysts of an *Eimeria* species in its feces. No other information was given.

**SUBFAMILY VIVERRINAE
GRAY, 1821**

**GENUS GENETTA F.G. COUVIER,
1816 (14 SPECIES)**

**CRYPTOSPORIDIUM SP. OF MATEO,
DE MINGO, DE LUCIO, MORALES,
BALSEIRO, ESPÍ, BARRAL, LIMA-
BARBERO, HABELA, FERNÁNDEZ-
GARCÍA, BERNAL, KÖSTER,
CARDONA, AND CARMENA, 2017**

Original host: *Genetta genetta* (L., 1758), Common Genet.

Remarks: Mateo et al. (2017) examined fecal samples of genets, from three autonomous regions of Spain (Basque Country, Castile-La Mancha, Extremadura) and examined them by nested PCR targeting the 18S rRNA gene, followed by genotyping based on the gp60 gene. *Cryptosporidium* was detected in 1/6 (17%) samples, the one from Extremadura.

**EIMERIA GENETTAE OF
AGOSTINUCCI AND BRONZINI,
1953**

Original host: *Genetta dongolana* (L., 1758) (syn. *Genetta dongolana* Hemprich and Ehrenberg, 1832), Common Genet.

Remarks: Agostinucci and Bronzini (1953) examined the intestinal contents of one *G. dongolana* that died in the Zoological Garden of Rome, Italy, a few days after it arrived from Somalia (East coast of Africa) and found unsporulated oocysts. They kept the fecal material in 3% potassium dichromate solution at ~18°C and said, "the oocysts reached full maturity in ~7–8 days." Sporulated oocysts were slightly ellipsoidal and "featured a micropyle in each of the poles, with rather thin-walled, smooth, and seemingly double outline." The oocysts were L×W: 25.4×19.9 (20–30×12.5–25), L/W ratio: 1.3; OR, PG: both absent. Sporocysts were reported to be "pear-shaped pods," 8.4×6.0 (6–12.5×5–7.5); SR: absent. There was no mention of presence or absence of SB, SSB, PSB, and there was no line drawing or photomicrograph, presented as a type, to support this inadequate description. No one in the literature has referred to this species since its original description. Therefore, it must be relegated to a *species inquirenda*.

**HEPATOZOON SP. OF
KEYMER AND
BROCKLESBY, 1971**

Original hosts: *Genetta genet* (L., 1758), Common Genet; *Genetta thierryi* Matschie, 1902 (syn. *Genetta rubiginosa* Pucheran, 1855), Haussa Genet; *Genetta tigrine* (Schreber, 1776), Cape Genet.

Remarks: Keymer and Brocklesby (1971) studied and described intraleukocytic and extracellular stages of a *Hepatozoon* sp. they found in the blood of *G. rubiginosa* and *G. tigrina*, and meronts in the liver and cardiac muscle of *G. rubiginosa*. They found two forms of meronts in the heart, and both differed from meronts found in the

liver. This was the first time *Hepatozoon* meronts have been described in *Genetta* spp.

**GENUS VIVERRA L., 1758
(4 SPECIES)**

**EIMERIA, ISOSPORA, AND
SARCOCYSTIS SPP. OF COLÓN AND
PATTON, 2012**

Original host: *Viverra tangalunga* (Gray, 1832), Malayan Civet.

Remarks: Colón and Patton (2012) did a coprological survey of civets in Sabah, Borneo, and a female *V. tangalunga* was reported to have *Eimeria* and *Isospora* oocysts and sporocysts of a *Sarcocystis* sp. in her feces. But no other information was given.

NOMENA NUDA (2)

Some authors, especially in some of the very old literature, gave new names to organisms they saw, but for which they presented no other substantive information. Such a name is called a "nude name" or *nomen nudum* (pl. *nomena nuda*). These names become preoccupied and unavailable names; however, the same name may be made available at a later time for the same or a different concept, but in such case, it would take authorship and date from the act of establishment, not from the earlier publication as a *nomen nudum*.

GENUS FELIS L., 1758

**ISOSPORA
NOVOCATI OF
PELLÉRDY, 1974b**

Original host: *Felis catus* L., 1758, Domestic Cat.

Remarks: Pellérdy (1974b) proposed this name for *I. rivolta* from the cat because he believed *I. rivolta* was first discovered and named from the dog. However, Wenyon (1923) reviewed all of the literature on the coccidia known to that date from dogs and cats and convinced most colleagues that *I. rivolta* was first discovered in the cat. Thus, as concluded by Dubey (1975c), and we agree, this renders *I. novocati* to be rendered a nomen nudum.

GENUS MARTES PINEL, 1792

ISOSPORA MUSTELAE OF GALLI-VALERIO, 1932

Original host: *Martes martes* (L., 1758), European Pine Marten.

Remarks: Galli-Valerio (1932) said he saw an ovoidal coccidium that was, 7×2.25 with a flattened micropyle in the feces of the European pine marten and that it developed two sporocysts each with four sporozoites. We know of no oocysts in any apicomplexan family that has oocysts this small. No other structural data were given nor did he include a line drawing. Therefore, this name must be considered a nomen nudum.

DISCUSSION

In the Caniformia, there are no casual, common-name-only, or genus-name-only references in these family and genera: **Canidae:** *Atelocynus* Cabrera, 1940 (monotypic); *Cerdocyon* C.E.H. Smith, 1839 (monotypic); *Dusicyon* C.E.H. Smith, 1839 (monotypic); *Otocyon* Müller, 1836 (monotypic); *Speothos* Lund, 1836 (monotypic); *Urocyon* Baird, 1857 (2 species); **Mephitidae:** *Conepatus* Gray, 1837 (4 species); *Mydaus* F.G. Cuvier, 1821 (2 species); **Mustelidae:** *Aonyx* Lesson 1827 (2 species); *Hydrictis* Pocock, 1921 (monotypic); *Lutrogale* Gray, 1865 (monotypic); *Pteronura* Gray, 1837 (monotypic); *Arctonyx* F.G.

Cuvier, 1825 (monotypic); *Eira* C.E.H. Smith, 1842 (monotypic); *Galictis* Bell, 1826 (2 species); *Gulo* Pallas, 1780 (monotypic); *Ictonyx* Kaup, 1835 (2 species); *Lycodon* Gervais, 1845 (monotypic); *Poecilogale* Thomas, 1883 (monotypic); *Taxidea* Waterhouse, 1839 (monotypic); *Vormela* Blasius, 1884 (monotypic); **Odobenidae:** *Odobenus* Brisson, 1762 (monotypic); **Otariidae:** *Arctocephalus* É. Geoffroy Saint-Hilaire, and F.G. Cuvier, 1826 (8 species); *Eumetopias* Gill, 1866 (monotypic); *Neophoca* Gray, 1866 (monotypic); *Phocartos* Peters, 1866 (monotypic); **Phocidae:** *Halichoerus* Nilsson, 1820 (monotypic); *Histriophoca* Gill, 1873 (monotypic); *Hydrurga* Gistel, 1848 (monotypic); *Monachus* Fleming, 1822 (3 species); *Ommatophoca* Gray, 1844 (monotypic); **Procyonidae:** *Bassaricyon* J.A. Allen, 1876 (5 species); *Bassariscus* Coues, 1887 (2 species); *Nasua* Storr, 1780 (2 species); *Nasuella* Hollister, 1915 (monotypic); and **Ursidae:** *Melursus* Meyer, 1793 (monotypic); and *Tremarctos* Gervais, 1855 (monotypic). In total, there is no record that 37/72 (51%) Caniformia genera, and their 60 species (above), have any abbreviated coccidian identifications associated to them. And, in the 35 genera that have been surveyed, only 52/105 (49.5%) species in those genera have been looked at sufficiently to have various coccidian forms known from them.

In the Feliformia, we found no casual, common-name-only, or genus-name-only references in these family and genera: **Eupleridae:** *Cryptoprocta* Bennett, 1833 (monotypic); *Eupleres* Doyère, 1835 (monotypic); *Fossa* Gray, 1865 (monotypic); *Galidia* I. Geoffroy Saint-Hilaire, 1837 (monotypic); *Galidictis* I. Geoffroy Saint-Hilaire, 1839 (2 species); *Mungotictis* Pocock, 1915 (monotypic); *Salanoia* Gray, 1865 (monotypic); **Felidae:** *Caracal* Gray, 1843 (monotypic); *Catopuma* Severtzov, 1858 (2 species); *Pardofelis* Severtzov, 1858 (monotypic); *Profelis* Severtzov, 1858 (monotypic); *Neofelis* Gray, 1867 (monotypic); *Uncia* Gray, 1854 (monotypic); **Herpestidae:** *Atilax* F.G. Cuvier, 1826 (monotypic); *Bdeogale* Peters, 1850 (3 species); *Crossarchus* F.G. Cuvier, 1825 (4 species); *Dologale*

Thomas, 1926 (monotypic); *Galerella* Gray, 1865 (4 species); *Ichneumia* I. Geoffroy Saint-Hilaire, 1837 (monotypic); *Liberiictis* Hayman, 1958 (monotypic); *Paracynictis* Pocock, 1916 (monotypic); *Rhynchogale* Thomas, 1894 (monotypic); **Hyaenidae**: *Hyaena* Brisson, 1762 (2 species); *Proteles* I. Geoffroy Saint-Hilaire, 1824 (monotypic); **Nandiniidae**: *Nandinia* Gray, 1843 (monotypic); **Viverridae**: *Arctictis* Temminck, 1824 (monotypic); *Arctogalidia* Merriam, 1897 (monotypic); *Macrogalidia* Schwarz, 1910 (monotypic); *Paguma* Gray, 1831 (monotypic); *Chrotogale* Thomas, 1912 (monotypic); *Cynogale* Gray, 1837 (monotypic); *Diplogale* Thomas, 1912 (monotypic); *Hemigalus* Jourdan, 1837 (monotypic); *Prionodon* Horsfield, 1822 (2 species); *Civettictis* Pocock, 1915 (monotypic); *Poiana* Gray, 1865 (2 species); and *Viverricula* Hodgson, 1838 (monotypic). In total, there is no record that 37/54 (68.5%) Feliformia genera, and their 50 species (above), have any abbreviated coccidian identifications associated to them. And, in the 17 genera that have been surveyed, only 27/71 (38%) species in those genera have been looked at sufficiently to have various coccidian forms known from them.

In total, we found 483 apicomplexans that have been mentioned in the literature and placed into 17 genera or generic categories, but that either have not been described sufficiently or there was so little information provided by the author(s), that their validity, and sometimes even their identity was in question. These include: 2 "Apicomplexa protozoa," 1 *Besnoitia* sp., 34 Coccidia-like or Coccidia spp., 135 *Cryptosporidium* spp., 2 *Cyclospora* spp., 26 *Cystoisospora* spp., 36 *Eimeria* spp., 3 *Hammondia*-like forms; 7 *Hammondia*-*Neospora*-like forms; 7 *Hammondia*-*Toxoplasma*-like forms; 14 *Hepatozoon* spp., 1 *Hoareosporidium* sp., 72 *Isospora* spp., 1 *Klossia* sp., 1 "oocysts," 135 *Sarcocystis* spp., and 3 *Toxoplasma*-like forms. All are considered *species inquirendae*. In addition, two names, *Isospora novocati* of Pellérdy, 1974b, and *Isospora mustelae*

of Galli-Valerio, 1932, are considered *nomen nudum*, by definition.

If one takes time to look into any of the individual entries cited above in this chapter, you might imagine each as the beginning of a short story that may wet your appetite for more information, but the story ends and leaves you wanting to know more. Even though many of these citations may seem trivial on first examination, they all present some modest baseline data, and virtually any one of these efforts could be expanded on by the right person(s). From the above numbers, two things may be obvious; (1) most carnivore populations have been poorly surveyed for apicomplexan parasites; and (2) there are a plethora of apicomplexan genera and species to be discovered, studied in much more detail, and be defined in many different ways.

We are just now beginning to have a basic understanding of most of the apicomplexan genera mentioned in this chapter and we now know where and how to look for them. For example, *Besnoitia* species are often overlooked or misidentified as sarcocysts of *Sarcocystis* when carcasses are examined. It is still worthwhile and useful to study the oocysts of *Eimeria*, *Isospora*, *Caryospora*, and *Cystoisospora* species, but they must be carefully defined by measurements, photomicrographs, and line drawings. Sporocysts of *Isospora* species must be examined carefully to determine the presence or absence of a Stieda body. If a Stieda body is present, cross-transmission and feeding experiments will be needed to determine if sporulated oocysts can infect the host species in which they were discovered, or their nearest relatives, or the original oocysts may belong to a prey item and simply be passing through the gut of the original host from environmental contamination. If the sporocysts of larger isosporan-like oocysts do not have a Stieda body, it is most likely they are a species of *Cystoisospora* and lab mice should be infected to determine if they can act as intermediate/transport hosts for some asexual stage(s).

Lots of surveys look at certain muscles of potential host species for the presence of sarcocysts and if there are none present (or none are “seen”) in the specific muscles examined, the animal necropsied is considered negative for *Sarcocystis*. However, those doing surveys should understand that some sarcocysts are not visible to the naked eye, especially if they are very young, some are very small even when mature and can best be found by pepsin digestion versus gross inspection, and many species have their highest densities in different tissues; to some, this may seem reminiscent of how *Eimeria* species seem to divide up the intestinal tract, each destined to live in its own site-specific location. To illustrate the point we are making, Mohammed (2000) and Mohammed et al. (2000) looked for *Sarcocystis* infections in different gazelle species at the

King Khalid Wildlife Research Centre in Saudi Arabia. They detected no macroscopic sarcocysts by fibre optic examination, a 40% infection rate was detected by histological examination, and an overall prevalence of infection of 67% was reached when they used pepsin digestion of muscle. In addition, the esophagus, diaphragm, heart, tongue, and skeletal muscles had different rates of infection dependent on the host gazelle species that was examined. They also reported that *Sarcocystis* infection was significantly higher in free-ranging gazelles kept in a main enclosure than in gazelles kept in breeding pens and higher in adult versus juvenile gazelles. Thus, there are lots of ways to examine every problem and, with the plethora of inquiries presented in this chapter, there are lots of problems awaiting future study.