A Survey of the Parasites of Coyotes (*Canis latrans)* in Western New York: Revealing High Coyote Parasite Loads & Parasites Novel to Coyotes in the Northeast US

by
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Abstract

Within the last 10-80 years, eastern coyotes (*Canis latrans*) have colonized most of New York State, as well as most of the northeastern United States. The ecological and pathogenic relationships between these carnivores and other animal populations, however, are not well understood. Coyotes are opportunistic hunters, and therefore could be bioaccumulators of the parasites present in their prey, thus serving as sentinel species for monitoring parasites in other wildlife populations. Additionally, coyote populations may act as a reservoir for parasites and diseases, including zoonotic ones. These have the potential to infect other, more fragile, native wildlife populations, as well as domestic animals, or even humans. Little research has been completed to date on coyote parasites in the Northeastern U.S.

The present study in western New York was conducted using established fecal flotation and light microscopy techniques to assess and quantify coyote endoparasite loads. Fecal samples were collected and identified based on size and content. Fecal flotation in Sheather sugar solution was performed. Parasite eggs and larvae were identified, classified, and quantified using digital light microscopy. Out of 15 specimens, 14 were positive for parasite infections. Twelve distinct species of parasites were identified, in addition to nematode, cestode, and trematode larvae. Six species of nematode were identified: *Trichuris vulpis, Eucoleus aerophilus, Eucoleus boehmi, Toxocara canis, Uncinaria stenocephala,* and *Ancylostoma spp.* Two species of cestode were distinguished: *Dypilidium caninum* and *Taenia spp,* and two species of protozoans were recognized: coccidia and *Eimeria spp.* Additionally, the trematode, *Alaria spp.*, and

the arthropod, *Mycoptes musculinus*, were identified. The number of parasite species per fecal sample ranged from 0-6, with a mean of 4.5. Three parasites were novel to coyotes—*Eucoleus boehmi*, *Eimeria spp.*, *Myocoptes musculinus*. *Trichuris vulpis*, *Dipylidium caninum,* and *Alaria spp.* had not been previously identified in coyotes in the Northeastern United States. As eastern coyote populations are steadily increasing and becoming more urbanized, potential for interactions with humans and subsequent zoonotic infections is increasing as well. Clinical knowledge of the parasites present in coyotes is crucial in understanding their possible impact on humans, their pets and livestock, and native wildlife.

Introduction

In 2002, Gompper completed a working paper on the ecology of northeastern coyotes, including current knowledge and priorities for further research. In this paper, he identified research on coyote parasites and diseases as a high priority in northeast coyote research because of the lack of in-depth understanding in this area, and the possibility of coyote populations acting as a reservoir for diseases that could impact other canid populations. Most of the previous studies on coyote parasites were conducted in the western or southern US, or Canada (Holmes, 1968; Morrison, 1979; Butler, et al., 1954; Erickson, 1944; Schitoskey, et al., 1980; Hirsch, et al., 1974; Bridger, et al., 2009; Conder, 1978; Foreyt, et al., 1982). In 1995, Bixel completed a small survey of coyote endoparasites in southern Pennsylvania. Gompper conducted a survey of coyote parasite infections in eastern New York in 2003. According to this author's best knowledge, no other survey studies of parasite loads of coyotes in the Northeastern U.S. have been completed. This study seeks to fill this gap in current and classical research on the parasites of eastern coyotes, with the goal of advancing our understanding of the possible ecological relationships between eastern coyotes, other wildlife populations, and humans, in the Northeastern U.S.

Coyotes are Nearctic canids, originally ranging across the grasslands and open country of the mid-western and western United States (Bekoff, 1977; Gompper, et al., 2002). Their range has been rapidly expanding in the last 80 years, until now it includes almost the entire Northeastern U.S. (Gompper, 2002). Three main hypotheses account for

this expansion—namely, that the extirpation of the wolf has allowed coyotes to colonize territories they were previously excluded from; that human populations have aided in the spread of coyotes through capture and release; and that human agricultural development and logging has altered the habitat to make it more favorable to coyotes (Gompper, 2002). Coyotes first colonized New York from the north in the 1940's (though some sightings were recorded as early as the 1920's), circumventing the Adirondack Park, and gradually expanding their range southward through New York, entering different portions of western New York in the period between 1975 and 2000 (Fener et al., 2005). Fener, et al. argue that it is not simply the increase in open habitat from logging that allowed coyote range expansion into New York, but the large area of farmland abandoned in the first half of the twentieth century—that provided an early successional habitat with high coyote prey density (2005). It also important to note that the last recorded wolves in New York were killed in the 1890's, thus making it unlikely that coyote range expansion contributed to their extirpation, although the converse is possible.

In part due to their foraging ecology, coyotes have the potential to be highly mobile, zoonotic vectors. They are opportunistic hunters, and have been recorded eating a wide variety of mammals, including, but not limited to, deer, elk, rodents, rabbits and livestock (Bekoff, 1977). They have also been known to eat ground-nesting birds, crustaceans, fish, insects, amphibians and reptiles, many fruits, and human refuse (Bekoff, 1977). In 2006, a study was completed on the prevalence and genotype of the parasites, *Giardia spp.* and *Cryptosporidium spp.,* in coyotes in northeastern Pennsylvania (Trout, et al., 2006). *Giardia spp.* and *Cryptosporidium spp.* are protist parasites that can infect a wide range of hosts, with varying symptomatic effects (Xiao, et

al., 2008). Coyotes in the Trout, et al. study were found to carry zoonotic *Cryptosporidium spp*., as well as multiple genotypes of *Giardia spp.*, including a zoonotic subspecies, as determined by molecular assemblages (Trout, et al., 2006). This study suggested that coyotes could acquire infections by ingestion of prey species. Thus coyotes' opportunistic hunting could contribute to their potential as zoonotic vectors. An additional study in California found that coyotes were carriers of *Bartonella spp.*, an emerging human pathogen with the potential of causing serious diseases (Chang, et al., 2000). Furthermore, *Bartonella spp.* infections in coyotes occurred with much greater frequency than in domestic dogs, suggesting the capacity of coyotes to act as a wildlife disease reservoir (Chang, et al., 2000). Coyotes are known to inhabit increasingly developed areas (Gehrt, 2009), thus making the possibility of parasite and disease transmission to humans and domestic animals more likely. Furthermore, because of their potential as bio-accumulators of disease, coyotes could be utilized as sentinels to monitor disease risk in other wildlife species (VerCauteren, 2008).

The current lack of knowledge regarding coyote parasite infections in the Northeastern U.S. necessitates further investigation in this area of coyote ecology. The present study seeks to contribute to this area of research, by utilizing fecal flotation technique to assess and quantify the endoparasite load carried by coyotes in western New York.

Materials and Methods

Coyote fecal samples were collected from September through November 2012, in northwestern Allegany County, NY, along walking and hiking trails, and primitive roads. The majority of the samples were in close proximity to fields, brushy areas, woodlands, or at a boundary between two habitats. Often the samples were found on a visible game trail that crossed the path or road that was being searched.

Fecal samples were photographed, collected, and placed in labeled 50 mL centrifuge tubes. The locations of the samples were logged in a Garmin™ Oregon 450t GPS unit, and the coordinates and marker number, as well as a description of the sample's location, contents and freshness, were recorded in a field notebook. The coordinates from the Garmin™ Oregon 450t GPS were used to create a map of the sample locations. To distinguish coyote feces from other possible canine feces, samples that were less than 1 inch in diameter, or did not contain hair, bones, apples or berries, were not utilized. Samples were brought back to the lab and stored at –20 °C for three to five months, until analysis.

Coyote parasite infection was assessed using fecal flotation technique under negative ventilation pressure, following established institutional research safety protocols. Sheather sugar solution was utilized for flotation (specific gravity = 1.27), made by dissolving 454 g sucrose in 355 mL distilled water, as detailed in Dryden, et al., 2005. Prior to flotation, fecal samples were thawed for 10-20 minutes. Between 3-8 g of feces were removed from the sample, weighed, and placed in 25 mLs of Sheather sugar solution. The sample was stirred with a glass rod until a relatively homogenous mixture

was formed, and allowed to rest for approximately three minutes. Following homogenization, the mixture was strained through a tea strainer into a beaker to remove hair, seeds and other large particles. The mixture was poured into a 15 mL centrifuge tube until a slight meniscus formed, and then a cover slip was placed on top. Following this, the tube was centrifuged at 524 x *g* (1500 rpm) in a rotating cup centrifuge for 5 minutes at 4 °C. The cover slip was removed and placed on a labeled microscope slide. A few drops of Sheather solution were poured into the top of the 15 mL tube until a second meniscus formed. A second cover slip was placed on the meniscus for approximately 1 minute and then transferred to a labeled slide, to ensure optimal collection of specimens. The top 1.5 mL of the supernatant was reserved.

The slides were scanned at 100X magnification using an Olympus BX60F microscope, and the specimens were identified to the nearest possible taxa based on morphology and size, and their abundance measured. If more than 25 eggs of a species were observed, then the total count was estimated based on the percentage of slide scanned. Photographs of the species observed were taken using a Q Imaging D10 BXTC camera and Windows Image-Pro Plus software, at 100X and 400X magnification. At least 50% of the second slide was scanned to ensure that all eggs and larvae were counted.

Microsoft Excel 2010© was used to analyze the abundance of eggs or larvae of each species over all the samples, and the abundance per gram of feces. The distribution of the number of parasites per sample, and the total number of samples infected with each species were also calculated using Microsoft Excel 2010©. Google Map Maker™ was used to create a map detailing fecal sample collection locations in Allegany County.

Results

A total of fifteen fecal samples were identified as coyote feces and collected in Allegany County, New York (Figure 1). The inset map in Figure 1 details the location of each of the sample collection sites in northwestern Allegany County. Samples were collected from within the townships of Caneadea, Centerville, Hume, Rushford and Granger, over an area of approximately 150 square kilometers. Thirteen of the samples were estimated to be 1-7 days old, and two were estimated to be at least several months old. Parasite eggs or larvae were identified in all but one of the 15 samples.

Eleven different species of parasite eggs and oocysts were identified based on morphological characteristics from the fecal flotations (Table 1). Six species from the class Nematoda (phylum Nemathelminthes) were identified: *Trichuris vulpis, Eucoleus aerophilus, Eucoleus boehmi, Toxocara canis, Uncinaria stenocephala,* and *Ancylostoma spp*. From the phylum Platyhelminthes, two species of class Cestoda (*Dypilidium caninum* and *Taenia spp.*) and one species of class Trematoda (*Alaria spp.)* were discovered. Two distinct protozoans were recognized. Some protozoans were identifiable as belonging to the genus Eimeria. Furthermore, the rest of the protozoans were classified as coccidia (Table 1).

In addition to the 11 different types of parasite eggs and oocysts distinguished, intact Nematode larvae, Cestode proglottid sections, Trematode larvae and a mite (*Myocoptes musculinus*) were identified. In Table 2, the frequency of each of the

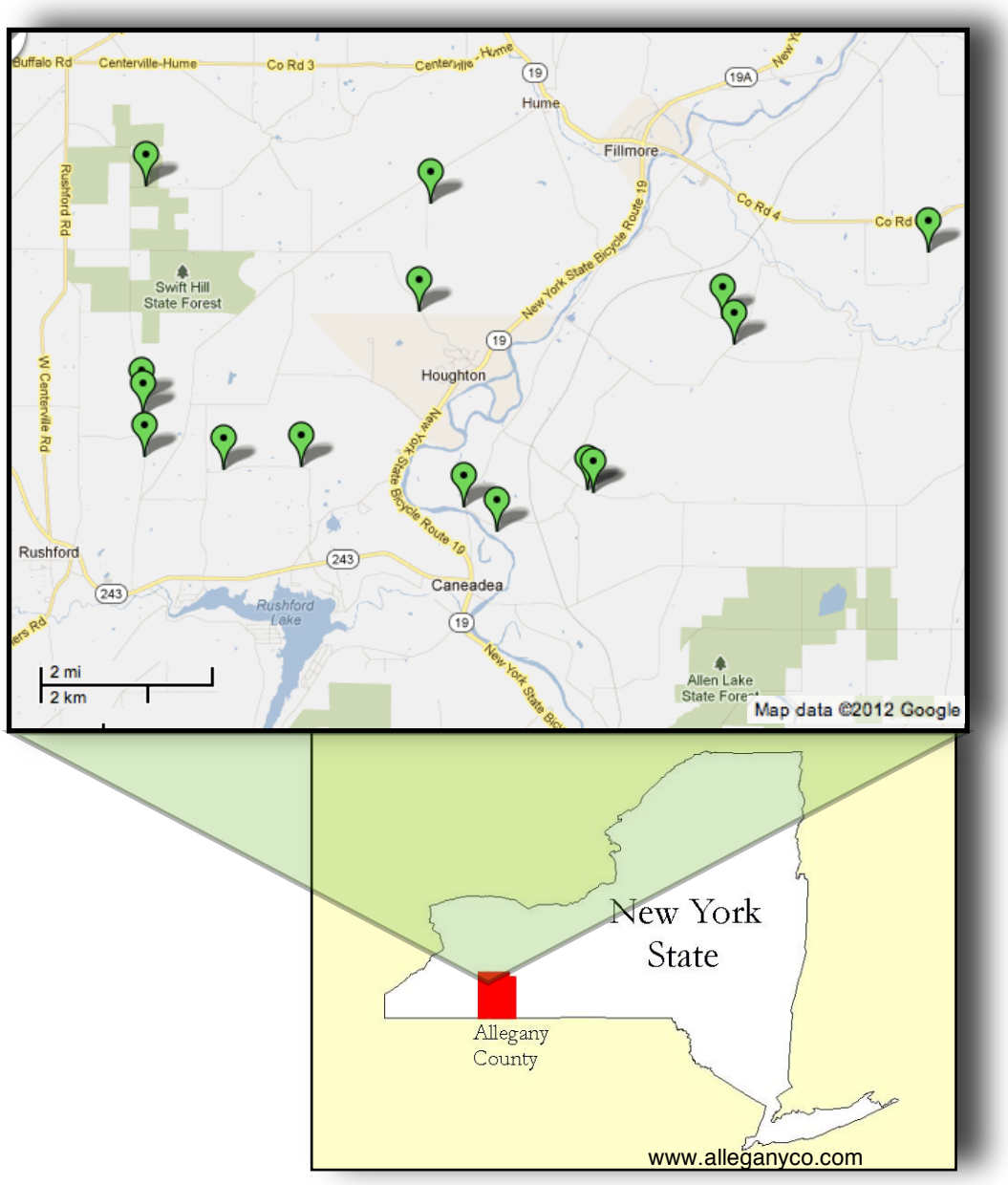

Figure 1. Map of coyote fecal sample collection sites in northwestern Allegany County, New York. The state map details the location of Allegany County in New York, and the inset reveals the location of the 15 sample collection sites within Allegany County. Samples were collected in the townships of Caneadea, Centerville, Hume, Rushford and Granger, September – November, 2011.

Parasite Taxon	Common name	Novel in NY
Nematoda:		
Ancylostoma spp.	Hookworm	
Eucoleus aerophilus	Fox lungworm	
Eucoleus boehmi		Yes
Toxocara canis	Roundworm	
Trichuris vulpis	Whipworm	Yes
Uncinaria stenocephala	Hookworm	
Cestoda:		
Dipylidium caninum	Double-pored or flea tapeworm	Yes
Taenia spp.		
Protozoa:		
Coccidia		
Eimeria spp.		Yes
Trematoda:		
Alaria spp.		Yes

Table 1. Parasite eggs and oocysts identified in coyote fecal samples. This table shows the taxa and taxonomic groups of the 11 parasite eggs and oocysts identified from the 15 coyote fecal samples collected. Common names included where applicable.

different types of parasite eggs, oocysts, and larvae for all the samples is presented. Furthermore, individual parasites expressed as parasite per gram of feces for all samples is shown. The number of each type of parasite infection across all observed samples ranged from 1-396. Three main species accounted for eighty-two percent of the parasites found. *Taenia spp.* eggs accounted for forty-eight percent of the parasites. It is important to note, however, that 395 of 396 *Taenia spp.* eggs were found in a single sample (Table 2). Twenty-one percent of the parasite infections were *Trichuris vulpis* eggs. Protozoan coccidians made up thirteen percent of the total number of observed parasites. The level of parasite infection ranged from 0.01 – 4.1 organisms per gram of feces.

Table 3 demonstrates the number of observed samples infected with each of the parasite species. Protozoan coccidia were found in 13 of the 15 samples; Nematode larvae and Cestode proglottid sections were each found in 10 of the samples (Table 3). Conversely, *Alaria spp.* eggs, *Dypilidium caninum* eggs, Trematode larvae, and *Myocoptes musculinus* adults were each only found in one sample respectively.

The distribution of the number of samples possessing a distinct number of different parasite infections is detailed in Figure 2. Samples were parasitized with zero to eight discrete infections. Only one sample was found with greater than six species of parasites. Indeed, one sample was negative for any type of parasite infection; however, this was most likely a result of the condition of the fecal sample at the time of collection (extreme desiccation). The mean number of discrete infections per sample was 4.5.

Parasite Taxon	Total taxa abundance across all samples	Percentage of taxa abundance across all samples	Taxa abundance across all samples / gram of feces
Nematoda:			
Ancylostoma spp. eggs	5	0.60	0.05
Eucoleus aerophilus eggs	9	1.1	0.09
Eucoleus boehmi eggs	8	0.96	0.08
Nematode larvae	29	3.5	0.30
Toxocara canis eggs	19	2.3	0.02
Trichuris vulpis eggs	173	21	1.8
Uncinaria stenocephala eggs	47	5.6	0.49
Cestoda:			
Cestode proglottid sections	25	3.0	0.26
Dipylidium caninum eggs	1	0.12	0.01
Taenia spp. eggs	396*	48	4.1
Protozoa:			
Coccidia oocysts	110	13	1.1
Eimeria spp. oocysts	5	0.60	0.05
Trematoda:			
Alaria spp. eggs	3	0.36	0.03
Trematode larvae	1	0.12	0.01
Arachnida:			
Myocoptes musculinus adults	1	0.12	0.01

Table 2. Parasite egg, oocyst and larvae frequency for all samples. This table indicates the abundance of each parasite (identified to the nearest taxon) across all the samples, as well as the percentage abundance. In addition, it reveals the number of species of parasite found per gram of feces for all the samples. This table includes Nematode and Trematode larvae, Cestode proglottids, and *Myocoptes musculinus* adults (fur mite), in addition to the parasite eggs and oocysts listed in Table 1.
*Note: 395 of these eggs occurred in one heavily parasitized sample.

Parasite Taxon	Total number of samples infected	Percentage of samples infected
Nematode:		
Ancylostoma spp. eggs	2	13
Eucoleus aerophilus eggs	3	20
Eucoleus boehmi eggs	2	13
Nematode larvae	10	67
Toxocara canis eggs	6	40
Trichuris vulpis eggs	8	54
Uncinaria stenocephala eggs	4	27
Cestode:		
Cestode proglottid sections	10	67
Dipylidium caninum eggs	1	6.7
Taenia spp. eggs	2	13
Protozoa:		
Coccidia eggs	13	87
Eimeria spp. eggs	3	20
Trematode:		
Alaria spp. eggs	1	6.7
Trematode larvae	1	6.7
Arthropod:		
Myocoptes musculinus adult	1	6.7

Table 3. The number of observed samples infected with each of the parasite species. This table indicates the frequency with which samples were infected with each of the different parasite species, including Nematode larvae, Trematode larvae, Cestode proglottid sections and *Myocoptes musculinus,* in addition to the parasite eggs listed in Table 1.

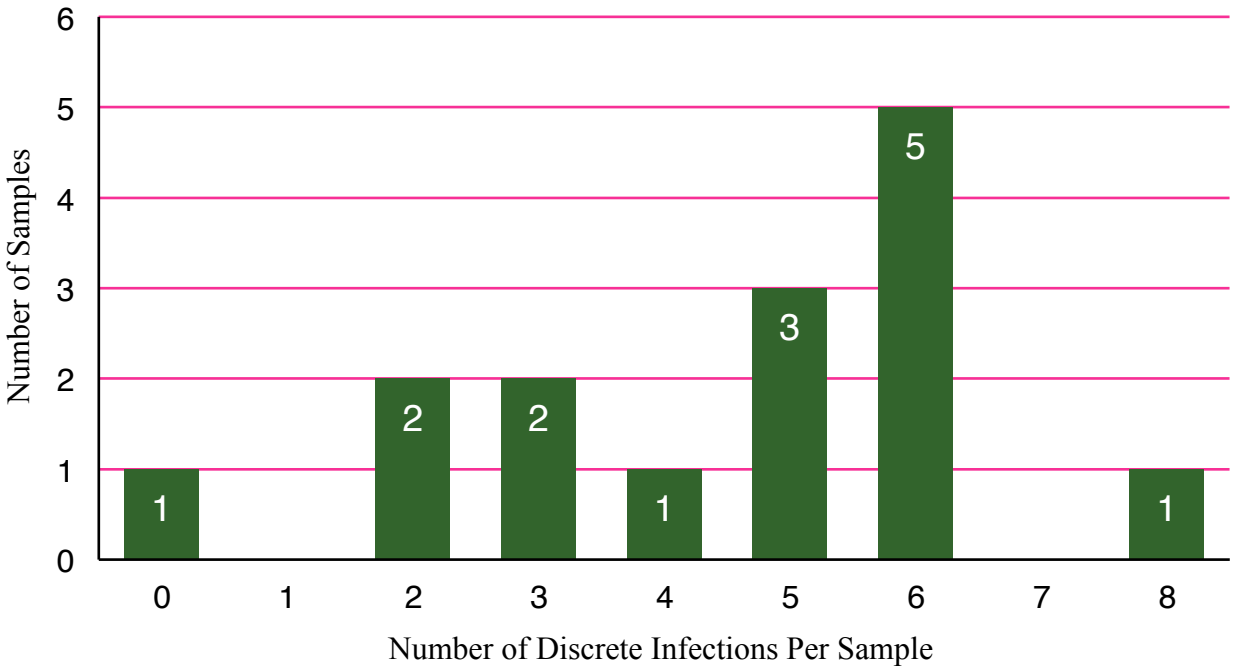

Figure 2. The distribution of the number of parasite infections in a discrete sample. This table shows the number of samples that possessed a certain number of discrete parasite infection types, ranging from zero to eight infections. The mean number of infections per sample was 4.5.

Discussion

Coyotes are highly mobile, opportunistic hunters and as such, serve as effective zoonotic vectors (Pappas, et al., 1985). Given the recent colonization of western New York by coyotes (1965-2000), a thorough knowledge of coyote populations and the parasite infections they carry is necessary to understand not only the health of the coyote populations, but also their potential impact on other wildlife, domestic animals, and even humans (Fener et al., 2005). The present study centered in western New York, specifically Allegany County, complements and builds upon the few other surveys of coyote endoparasite infections in the Northeastern U.S.—performed in eastern New York and southern Pennsylvania (Gompper, 2003; Bixel, 1995). In contrast to the forested sites, with varying levels of development, utilized in the eastern New York study (Gompper, 2003), the majority of the samples in this study were collected from locations in or near farmland. Thus, this study provides unique insight into comparing the potential effect of habitat on coyote parasite infection. Furthermore, it is the first study of its kind completed in western New York.

Allegany County is one of the most rural populations in NY, containing 47.6 persons per square mile (US Census Bureau, 2010). The portion of Allegany County, NY, in which samples were collected, encompassed approximately 150 square kilometers. Although the sample size was not large, it is important to note that coyote population density has been estimated to be 0.5 – 1.0/mi^2, or 1.9/mi^2 (Bekoff, 1977; Gehrt, 2009). Thus a study site encompassing 150 square kilometers could theoretically contain 30-120 coyotes. The large sample area decreases the likelihood of finding many

fecal samples. It is therefore unlikely that the samples came from only a few individuals, further supported by the different types and numbers of infections within the different samples collected.

As far as could be determined, of the 12 species identified in the present study, three were novel to coyotes—*Eucoleus boehmi*, *Eimeria spp.*, and *Myocoptes musculinus*. *Eucoleus boehmi* is a nasal nematode found in dogs (Schoning, et al, 1993). It is differentiated from *Eucoleus aerophilus* and *Trichuris vulpis* by an examination of the shell wall surface and the morula of the egg (Zajac, 2006). In most instances, *Eucoleus boehmi* is subclinical, but it can lead to sneezing and bloody nasal discharge (Zajac, 2006). *Eimeria spp.* is a parasite of ruminants and rabbits (Zajac, 2006; Kvičerová, et al., 2008). Although normally infection with *Eimeria spp.* is subclinical, it can lead to diarrhea in the host (Zajac, 2006). One instance of the arthropod, *Mycoptes musculinus,* was found in the samples collected. *Mycoptes musculinus* is a fur mite of rats and mice, and thus it is likely a spurious parasite (Zajac, 2006). Since the mite passed unharmed through the digestive tract of the coyote, however, it is possible that coyotes could act as a carrier in the spread of spurious parasites they ingest. *Mycoptes musculinus* can cause hair loss, skin thickening, reddening, and itchiness (Zajac, 2006).

Nine of the 12 species of parasites recognized in the present study were previously identified in coyotes in the US and Canada. Three of those nine were novel to coyotes in the Northeastern U.S. (Pennsylvania and New York)—*Trichuris vulpis, Dipylidium caninum*, and *Alaria spp.* (Bixel, 1995; Gompper, 2003). *Trichuris vulpis*, a common whipworm of domestic dogs (Hall, et al., 1956), has been infrequently identified in coyotes, with small concentrations of infections discovered in three states—Kansas,

Iowa, and Tennessee (Ameel, 1955; Franson, et al., 1978;Van Den Bussche, et al, 1987). Coyotes carrying *Dypilidium caninum* were previously identified in Utah, Kansas, Manitoba, and Florida (Butler, et al., 1954; Ameel, 1955; Samuel, 1978; Manning, 2007). The trematode, *Alaria spp.*, was discovered in coyotes in Alberta, Washington and Idaho, Oregon, and Florida (Holmes, 1968; Foreyt, et al., 1982; Dunbar, et al., 2003; Manning, 2007).

The six species of parasites previously recorded in the Northeastern U.S. were identified in the following states and Canadian provinces. *Ancylostoma spp*. was previously recorded in coyotes in Kansas, Utah, Pennsylvania, New York, Florida and South Carolina (Hirsch, 1974; Conder, 1978; Bixel, 1995; Gompper, 2003; Manning, 2007; Miller, 2009). Coyotes infected with *Eucoleus aerophilus*, fox lungworm, were found in Alberta, the Great Plains, the southwestern US, Pennsylvania, and New York (Holmes, 1968; Morrison, 1978; Morrison, 1979; Bixel, 1995; Gompper, 2003). Although *Uncinaria stenocephala* tends to have a more northerly range, it has previously been identified in Florida, as well as Alberta, Manitoba, South Dakota, Pennsylvania, New York, and Newfoundland (Manning, 2007; Holmes, 1968; Samuel, et al., 1978; Schitoskey, et al., 1980; Bixel, 1995; Gompper, 2003; Bridger, 2009). Coyotes carrying *Toxocara canis* were found in Minnesota, Utah, South Dakota, and New York (Erickson, 1944; Butler, et al., 1954; Schitoskey, et al., 1980; Gompper, 2003). Additionally, coyotes infected with *Taenia spp.* were recorded in Kansas, Utah, Washington and Idaho, New York, Florida, and Newfoundland (Hirsch, et al., 1974; Conder, 1978; Foreyt, et al., 1982; Gompper, 2003; Manning, 2007; Bridger, et al., 2009).

In the studies reviewed above, two main methods were utilized for parasite identification—necropsy and digestive tract, lung and heart examination, and fecal flotation. Organ examination was by far the most common method, being used in the coyote parasite studies conducted in Utah, Minnesota, Kansas, Alberta, the Great Plains of the US, Manitoba, Iowa, the southwestern US, South Dakota, Washington and Idaho, Tennessee, and Newfoundland (Butler, et al., 1954; Erickson, 1954; Ameel, 1955; Holmes, et al., 1968; Morrison, 1978; Samuel, et al., 1978; Franson, et al., 1978; Morrison, 1979; Schitoskey, 1980; Foreyt, et al., 1982; Van Den Bussche, et al., 1987; Bridger, et al., 2009). The method of fecal flotation was utilized in studies in Oregon, New York, Florida, and South Carolina (Dunbar, et al., 2003; Gompper, 2003; Manning, 2007; Miller, et al., 2009). Fecal flotation should be considered as an efficient, humane, non-invasive alternative to necropsy and organ examination for parasite identification.

In the present study, the concentration of parasites ranged from 0.01 – 4.1 parasites per gram of feces. Four species were present in concentrations above 0.4—*Taenia spp., Trichuris vulpis*, Protozoan coccidia, and *Uncinaria stenocephela*—at 4.1, 1.8, 1.1, and 0.49 parasites per gram of feces, respectively. The concentration of *Taenia spp*. was due to its very high prevalence in one sample containing 395 eggs. Additionally, it is important to note the high concentration of *Trichuris vulpis* in the present study contrasted with the infrequency of its identification in coyote populations (Franson, et al., 1978). Since it is a common domestic dog parasite, this data suggests the possibility of increasing dog and coyote interactions with parasite transmission (Zajac, 2006). Furthermore, the coyote population's increase in the Northeastern U.S. and the decrease of unclaimed habitat elevate the likelihood of interactions between coyote

subpopulations, and thus more rapid transmission and higher levels of parasite infection (Gompper, 2002).

The frequency of each type of parasite infection across the observed samples varied widely from 6.7% to 87%. Coccida eggs, Nematode larvae, and Cestode proglottid sections occurred in greater than 65% of the samples each, with coccidians occurring in 87%. *Eucoleus boehmi*, *Eimeria spp.*, and *Myocoptes musculinus,* the three parasites discovered from the samples that were novel to coyotes, all occurred in less than 15% of the samples. Additionally, two of the three other coyote parasites identified in the present study novel to New York State, *Dipylidium caninum* and *Alaria spp.* were both present in less than 10% of the samples. These low levels of infection could indicate that these parasite species are emerging in western New York. The third parasite novel to New York State, *Trichuris vulpis,* was present in an unusually high number of the samples—54% (Franson, et al., 1978). Despite the small sample size, the large area of sample collection (~150 square kilometers) ensures that the present study is a good indicator of the frequency of parasite infections in coyotes of Allegany County.

The number of parasite infections in a discrete sample ranged from 0 – 8. Only one sample in the present study was found with greater than 6 parasite species, suggesting that mortality occurs after a certain number of parasite infections accumulate within an individual. Coyotes were heavily infected—each sample averaged 4.5 discrete infections. Furthermore, the sample that did not show any infection was extremely desiccated and produced a thick, dry film on the cover slip when centrifuged, even when the flotation technique was adjusted and repeated—making light microscopy analysis for that sample virtually impossible. Therefore, essentially none of the samples contained

fewer than 2 discrete infections. The general distribution of the number of infections per sample was somewhat exponential—increasing from one sample containing zero infections to 5 samples containing 6 infections. This contrasts sharply with the distribution reported in the previous coyote parasite study in eastern New York (Gompper, 2003), in which the distribution formed a negative slope, from most samples containing zero parasite infections to a very few samples containing 3-5 infections.

Many of the parasites discovered in the samples collected can cause serious health problems in their carriers, as well as potential for transmission to humans (Zajac, 2006). Many are transmitted through ingestion of infective larvae, infective eggs, sporulated oocysts or through transmammary or transplacental transmission (Zajac, 2006). Thus some pose a serious threat to domestic animals or children that may ingest the coyote feces. Protozoan coccidians can cause diarrhea, anemia, anorexia, weight loss, and abdominal pain in canids, and can have serious effects on pregnant women, or the immunosuppressed (Zajac, 2006). Infection with *Ancylostoma spp.* leads canids to develop severe anemia and death in young, and can cause humans to develop eosinophilic enteritis or cutaneous larva migrans (Zajac, 2006; Prociv, et al., 1990). *Trichuris vulpis*, a parasite novel to New York that can cause weight loss, ill-thrift and severe diarrhea in canids, has been known to infect humans (Zajac, 2006; Hall, et al., 1956). Finally, canid stillbirths, neonatal deaths and chronic ill-thrift can be caused by infection with *Toxocara spp.,* which also can infect children, leading to ocular and visceral larva migrans (Zajac, 2006).

As coyotes increase in range and population in the Northeastern U.S., so do their interactions with humans, domestic animals, and native wildlife (Gompper, 2003). The

coyotes' capacity as a highly mobile zoonotic vector necessitates a more thorough quantification of the parasite load it carries. The present study, one of only a few completed in the Northeastern U.S., identified 12 different species of parasites, including three never previously identified in coyotes, and three more novel to coyotes in the Northeastern U.S. High numbers of infections per sample suggest that the coyotes in western New York are heavily parasitized. Additional research utilizing DNA analysis to confirm parasite identification is needed, as well as research on the potential for coyote parasite transmission to domestic animals and humans. Furthermore, fecal flotation could serve as a future humane, rapid, efficient, and non-invasive method to quantify zoonotic parasite load within coyote populations.

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Photographic Atlas of Coyote Parasites in Allegany County, New York September – November 2011

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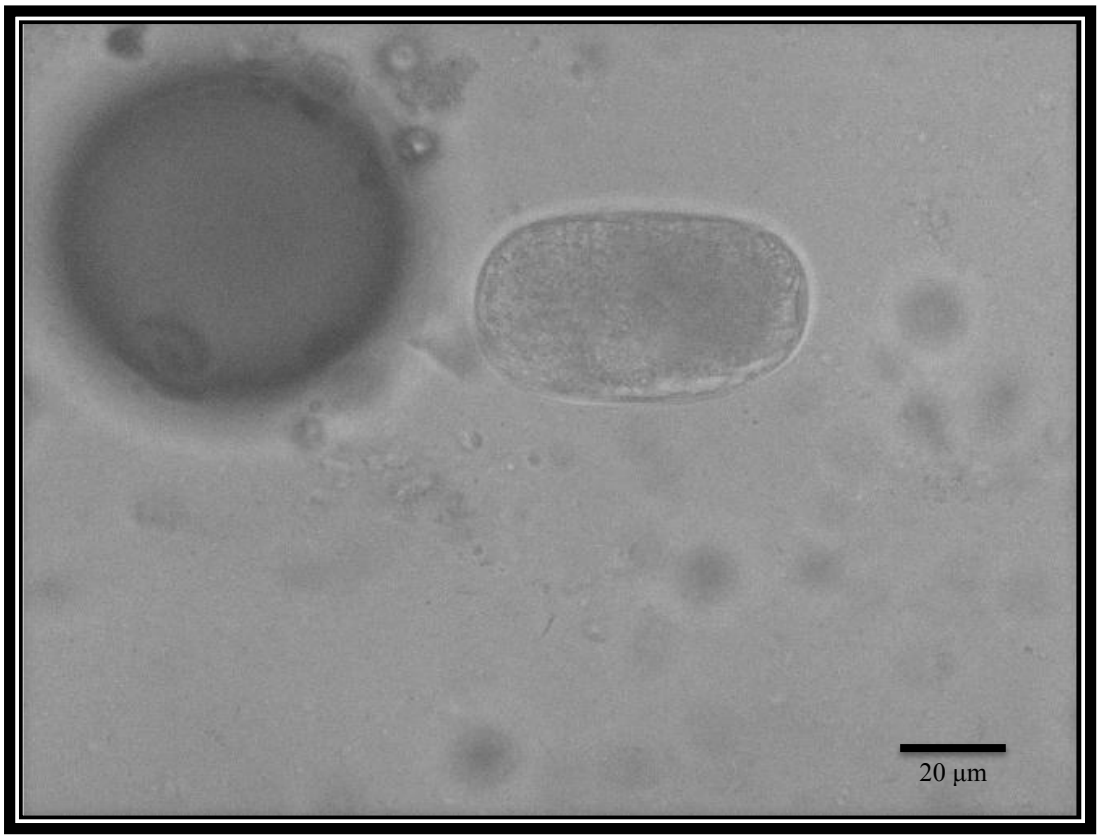

Figure 1. *Ancylostoma spp.* egg

Nematoda

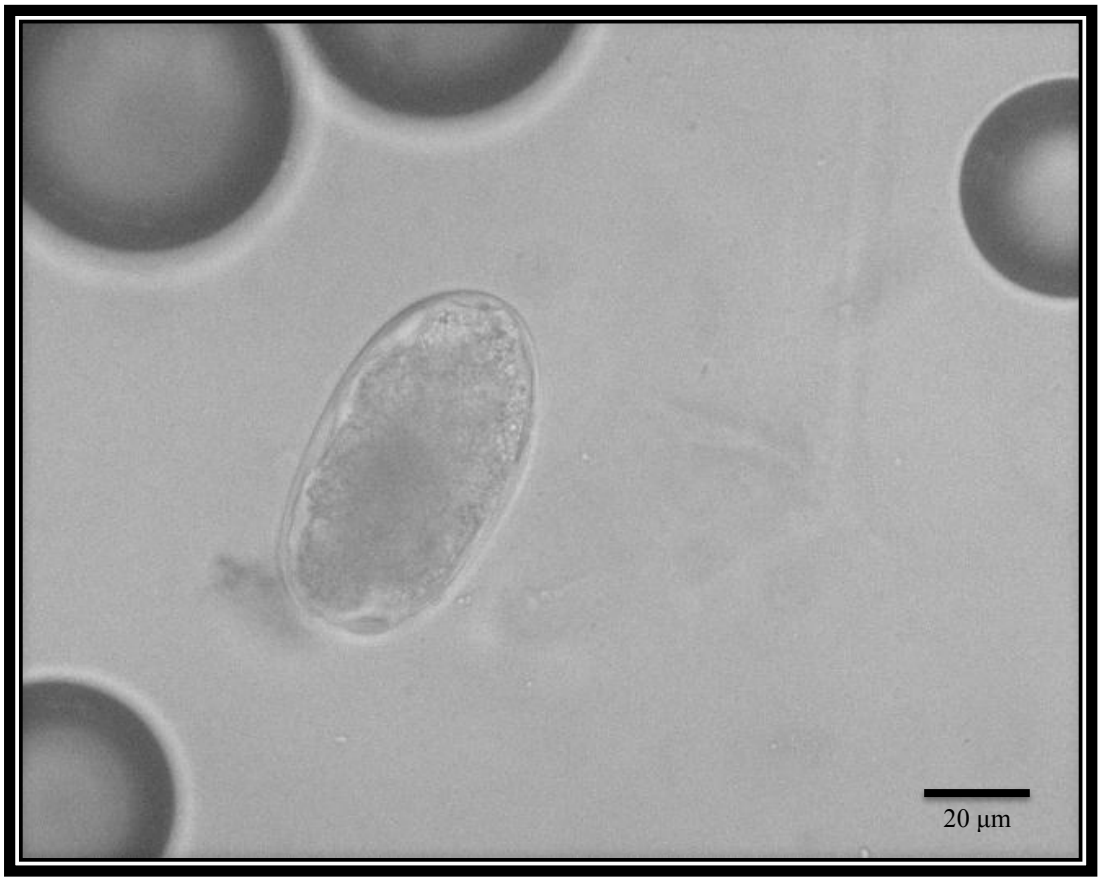

Figure 2. *Uncinaria stenocephala* egg

Nematoda

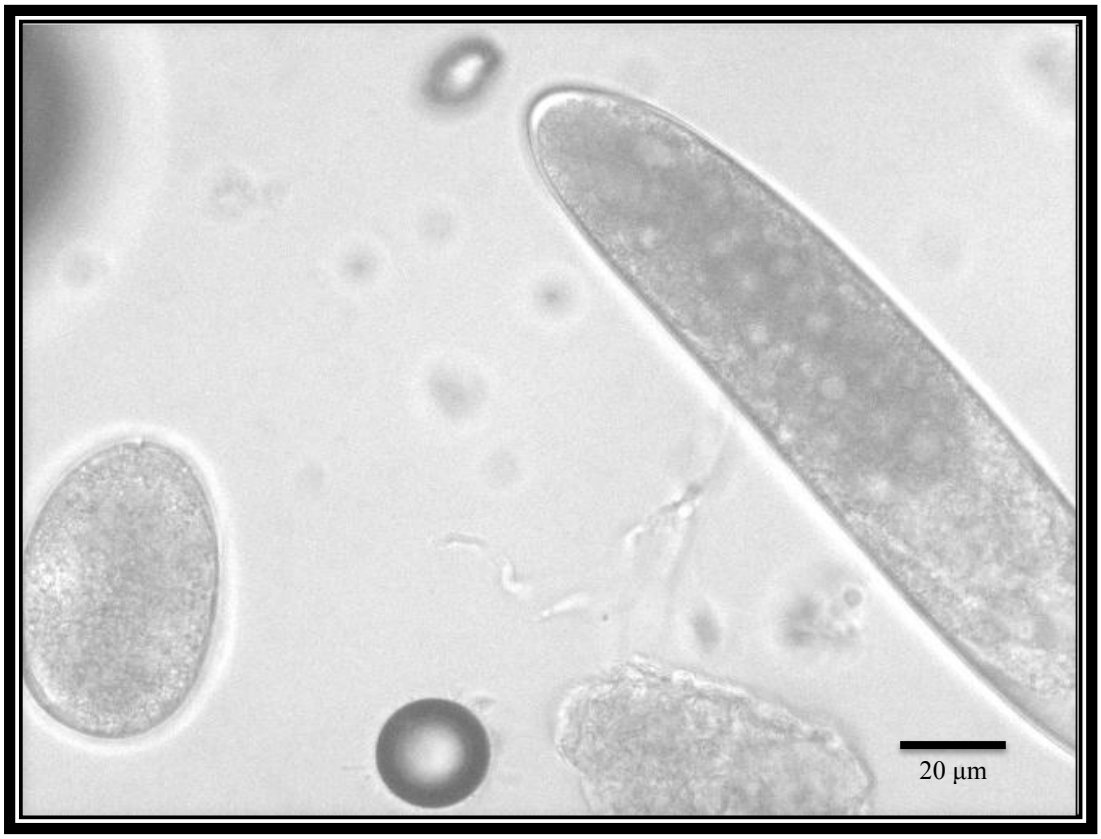

Figure 3. *Uncinaria stenocephala* egg & free-living nematode

Nematoda

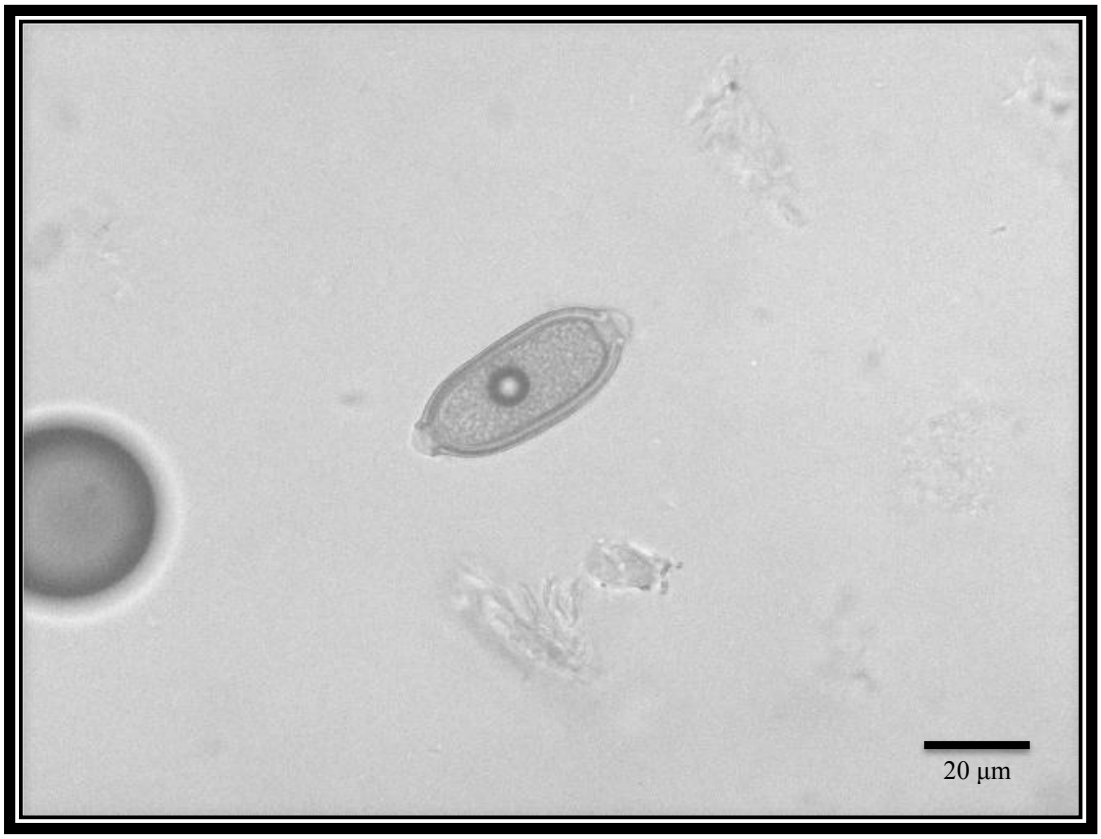

Figure 4. *Eucoleus aerophilus* egg

Nematoda

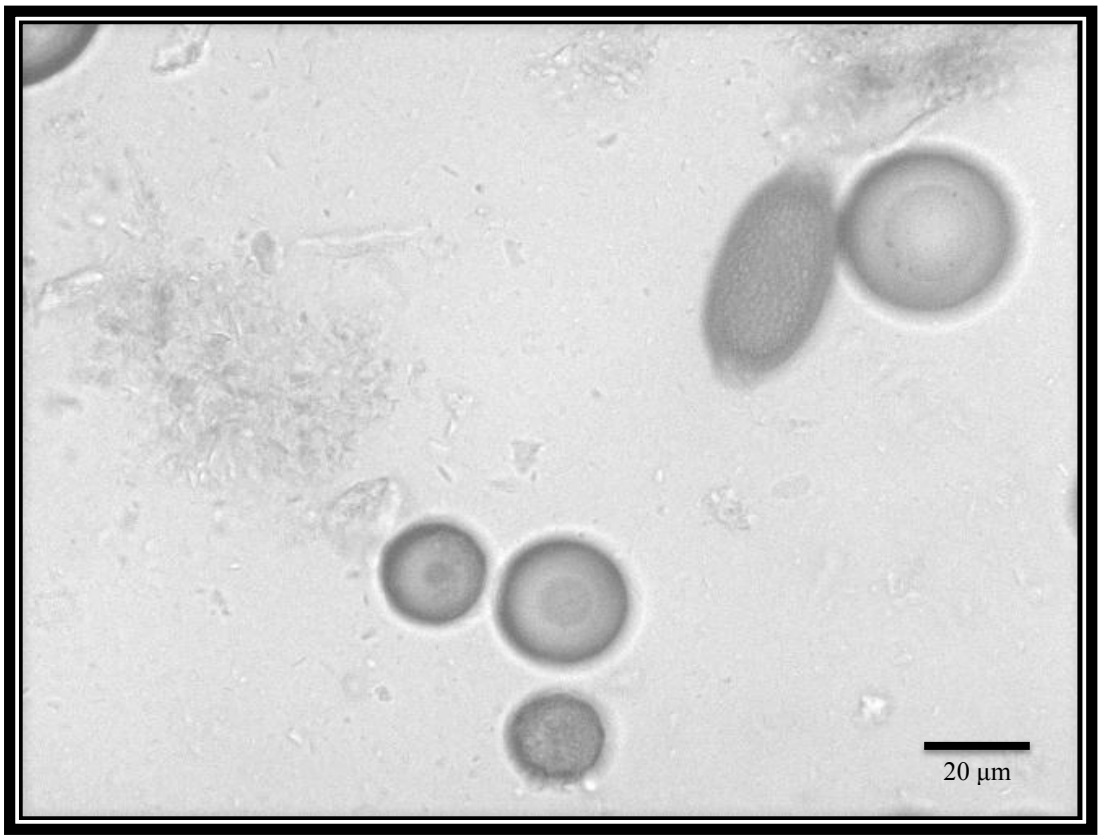

Figure 5. *Eucoleus aerophilus* egg surface

Nematoda

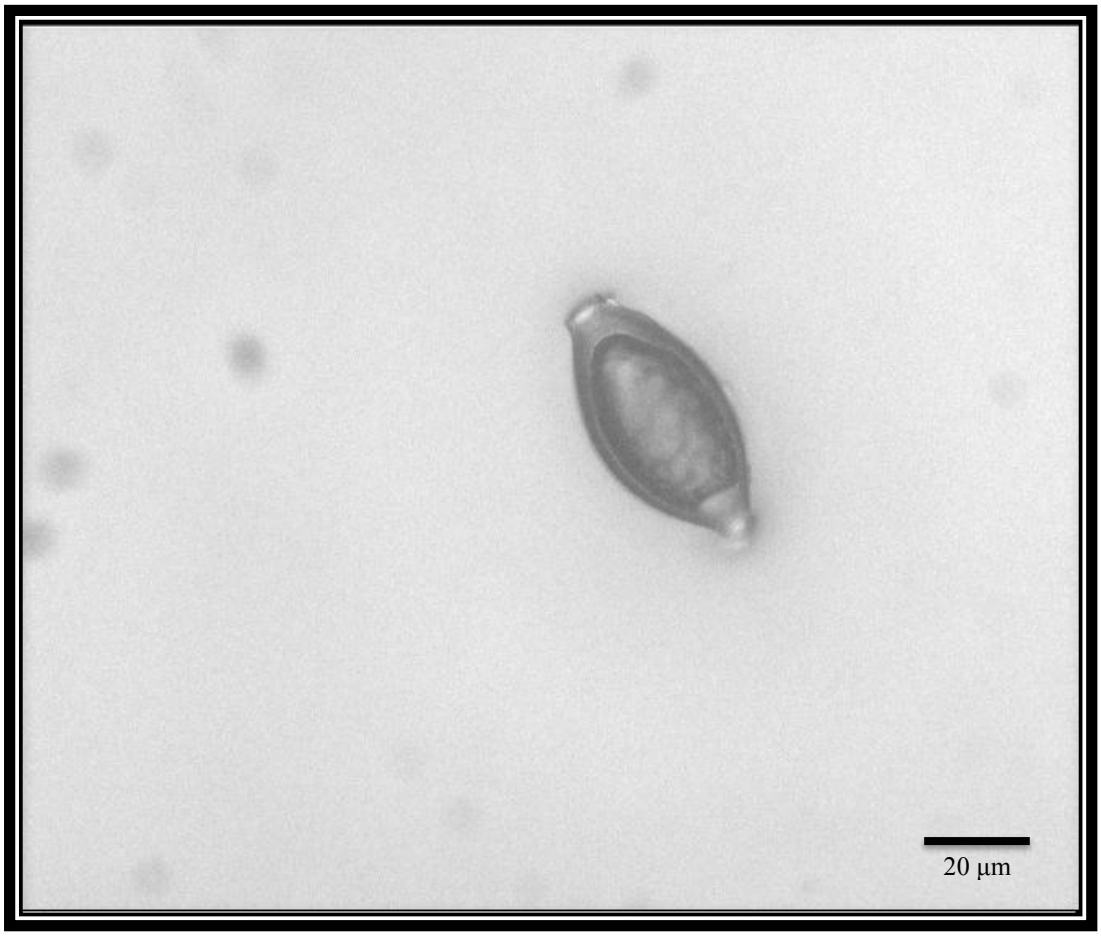

Figure 6. *Eucoleus boehmi* egg

Nematoda

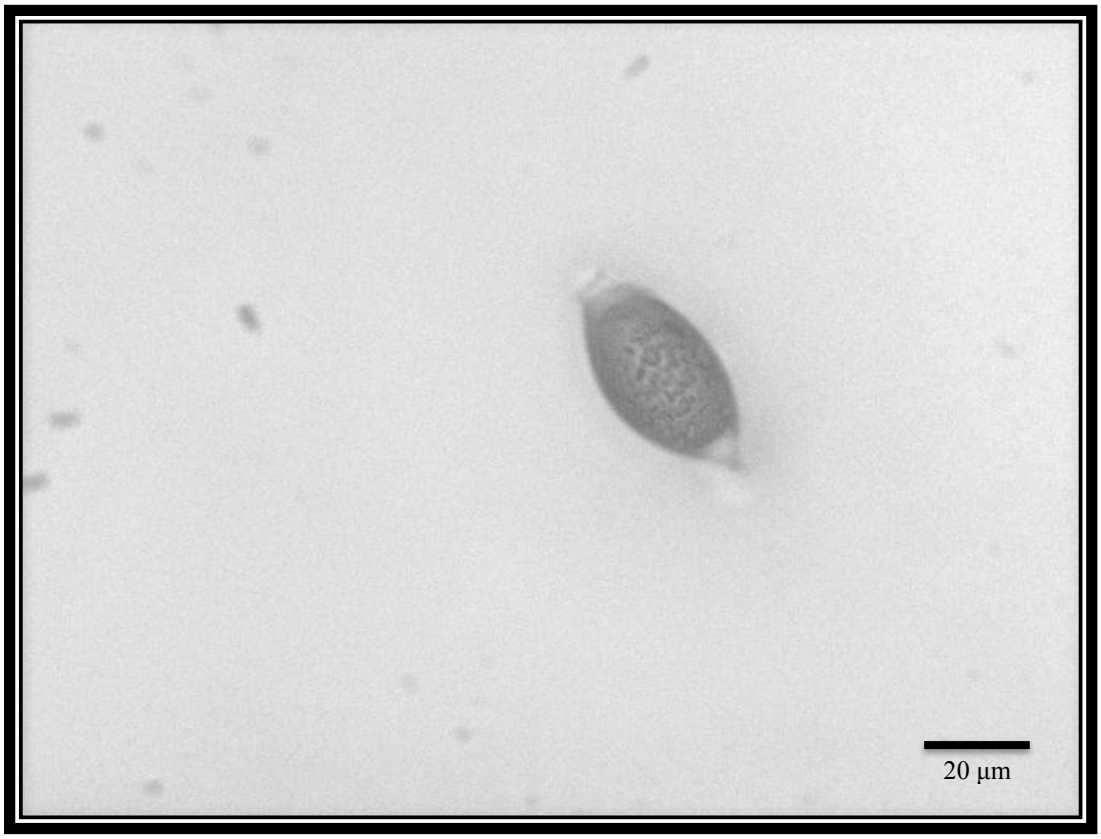

Figure 7. *Eucoleus boehmi* egg surface

Nematoda

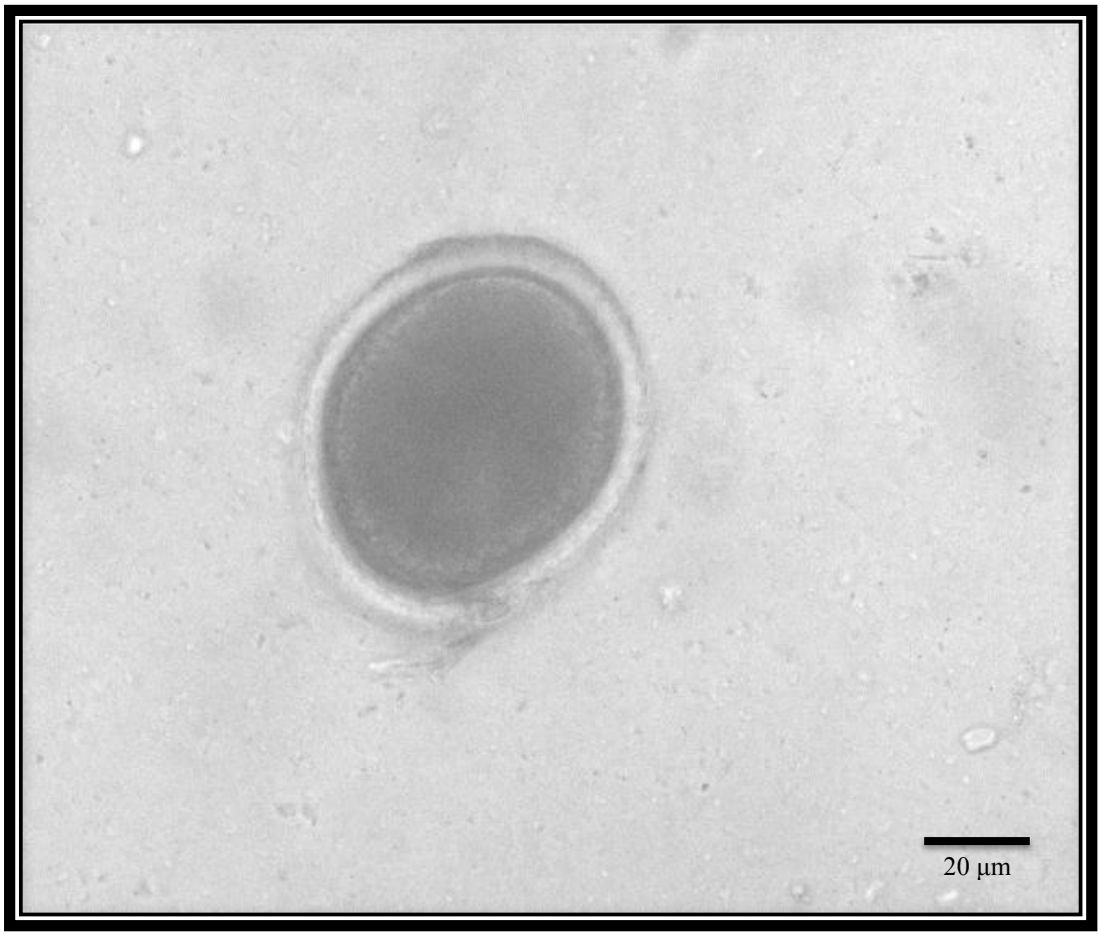

Figure 8. *Toxocara canis* egg

Nematoda

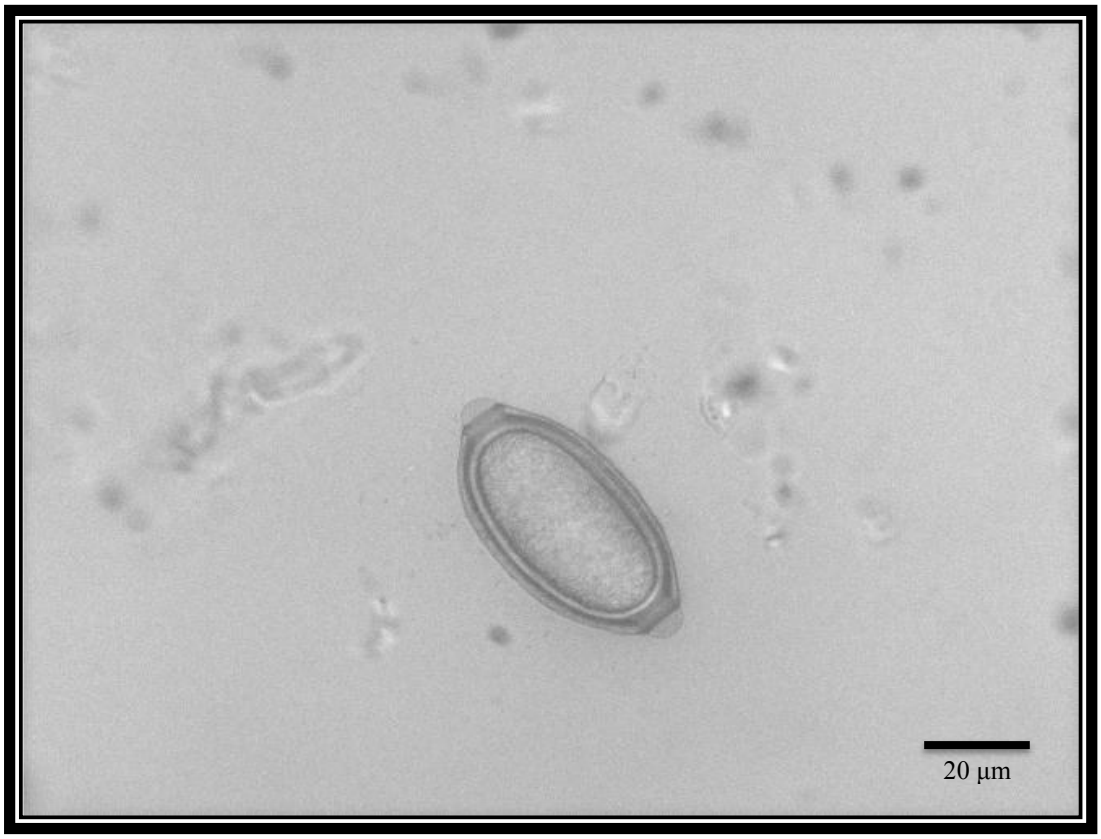

Figure 9. *Trichuris vulpis* egg

Nematoda

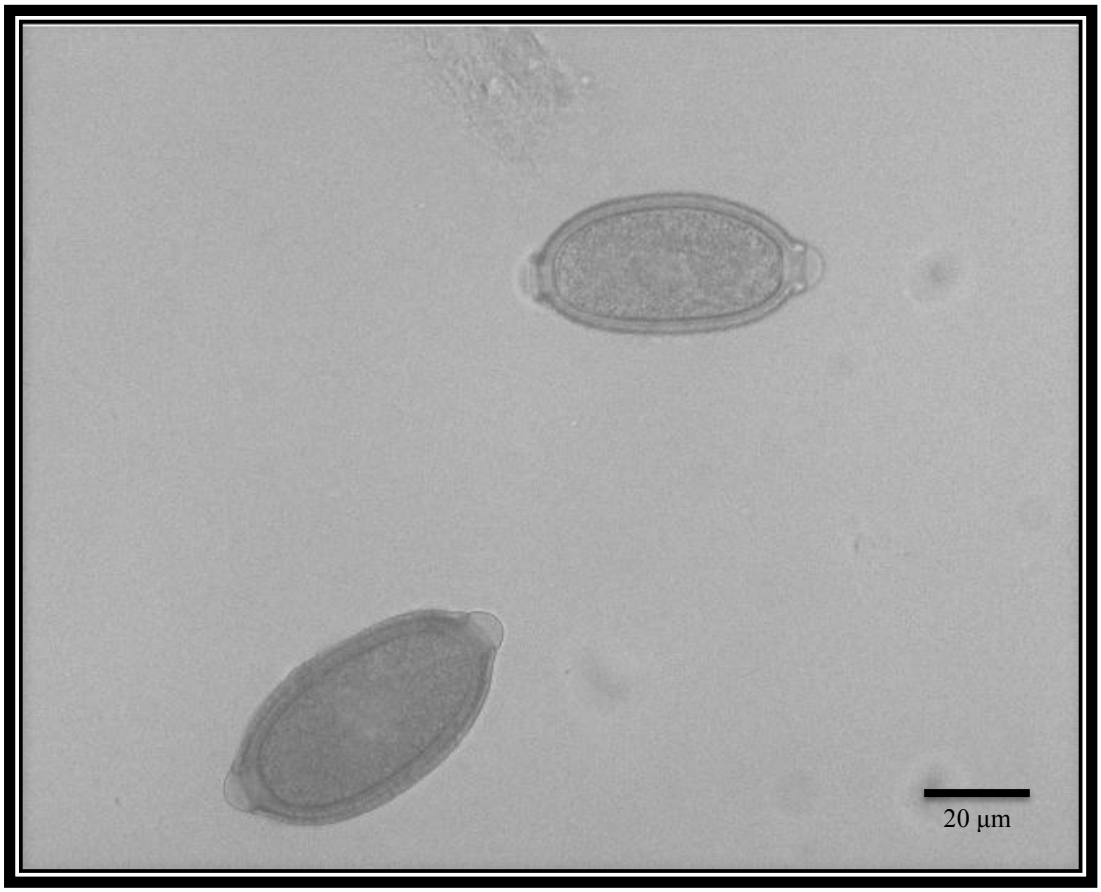

Figure 10. Multiple *Trichuris vulpis* eggs

Nematoda

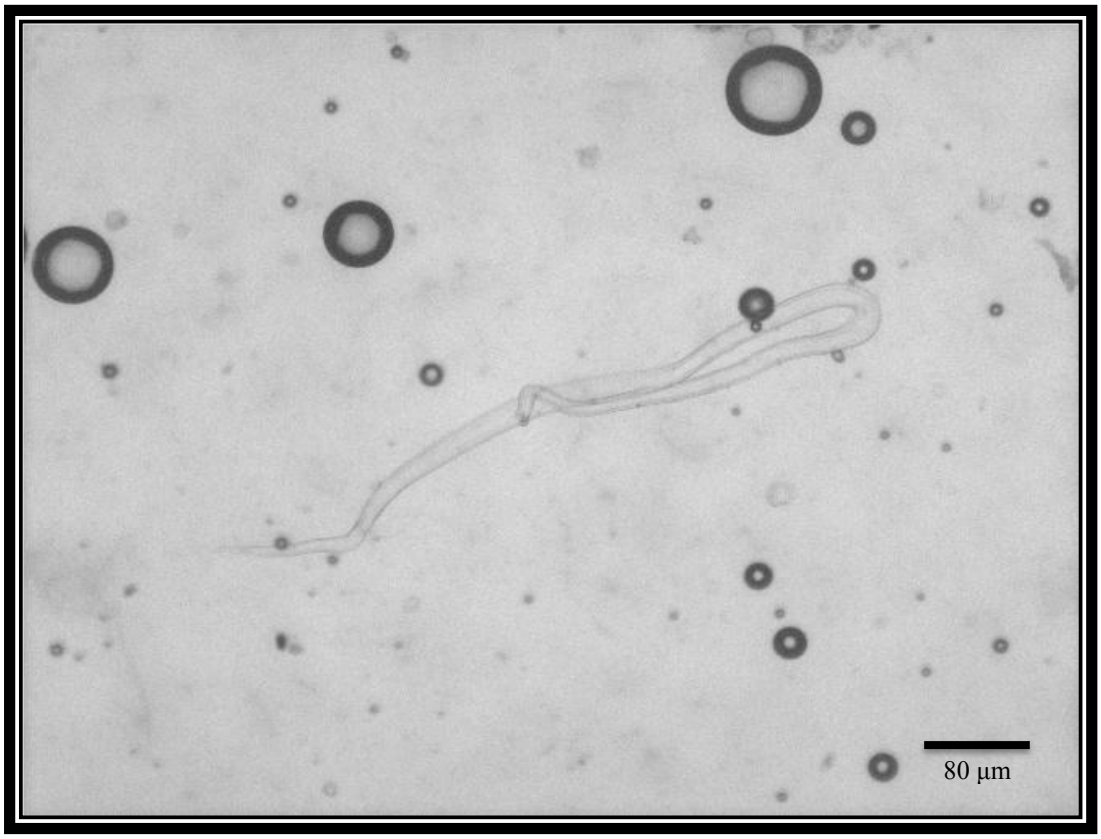

Figure 11. Nematode larva

Nematoda

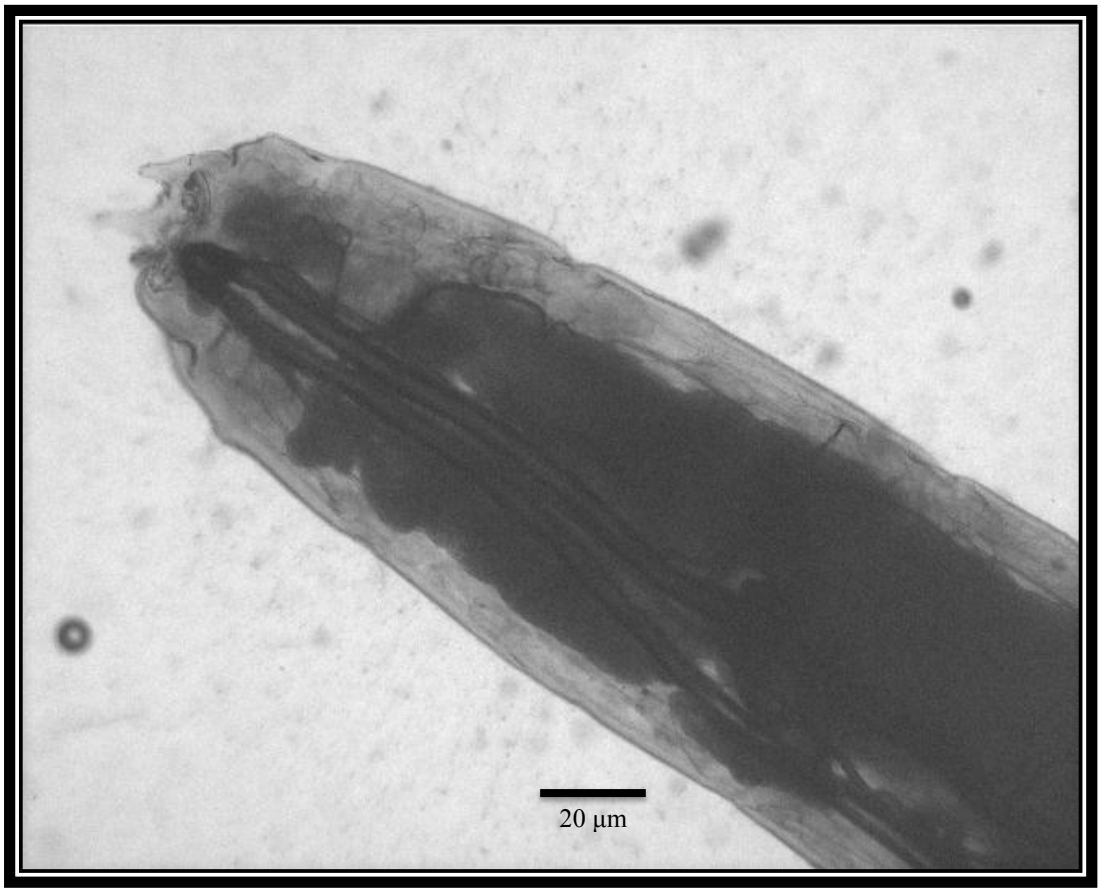

Figure 12. Close-up of free-living nematode

Nematoda

Figure 13. Close-up of free-living nematode larvae

Nematoda

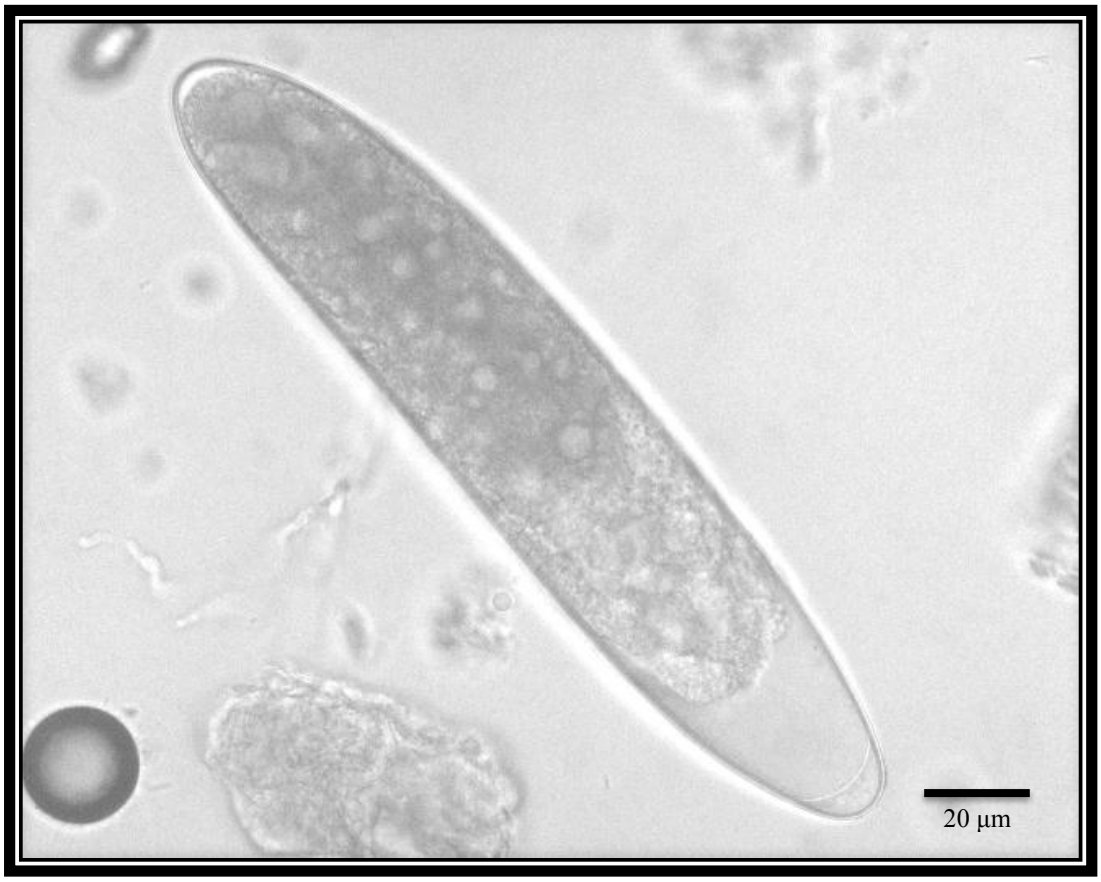

Figure 14. Free-living nematode

Cestoda

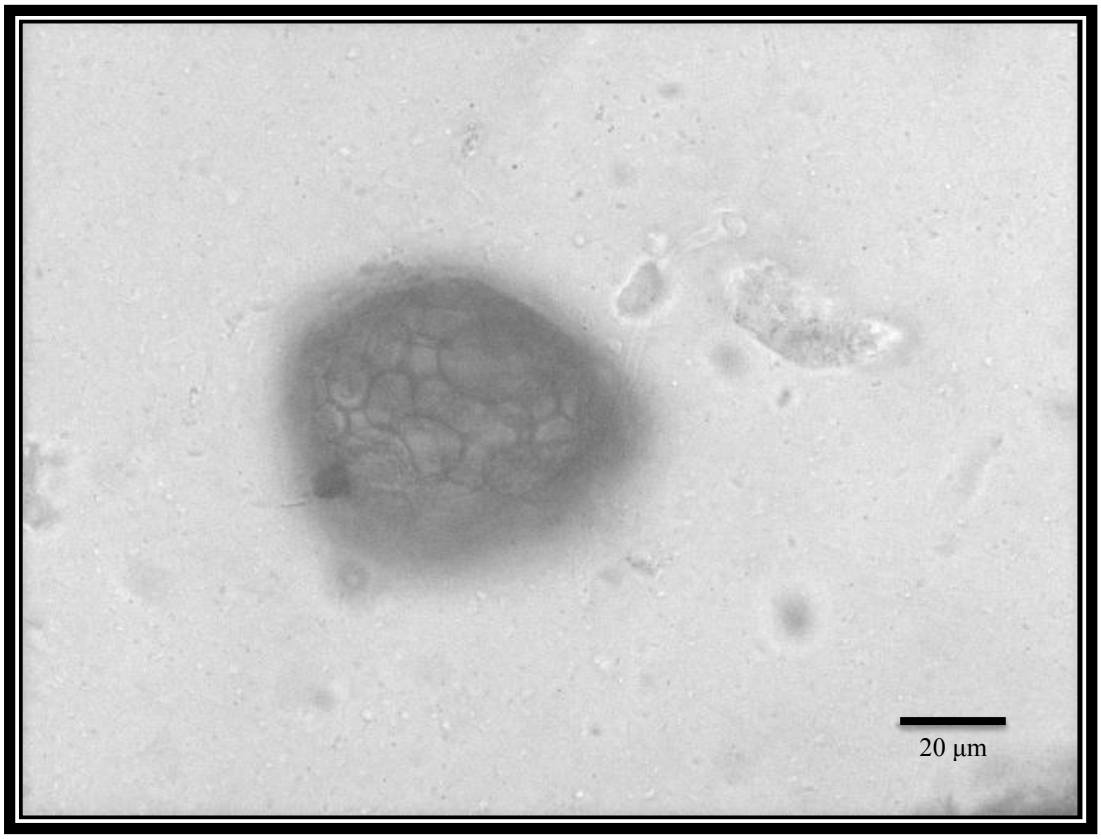

Figure 15. *Dipylidium caninum* egg

Cestoda

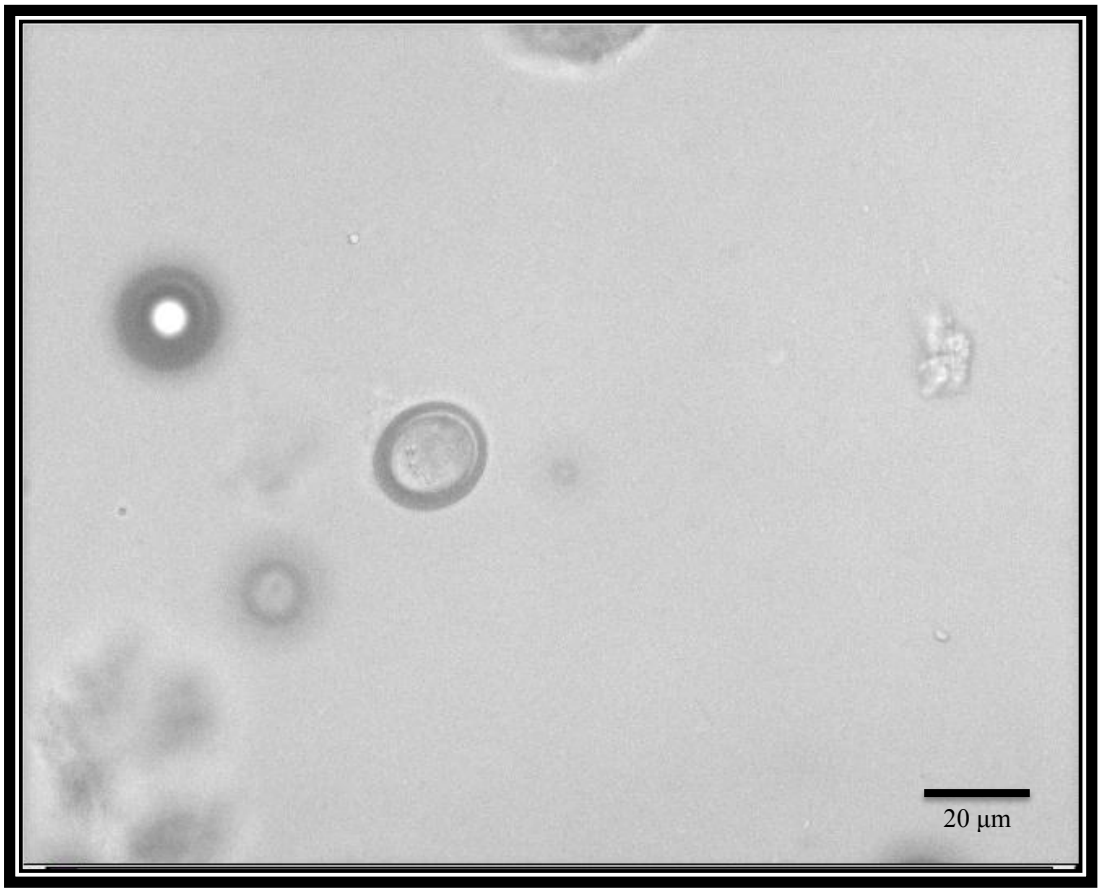

Figure 16. *Taenia spp*. egg; note hooks in embryo.

Cestoda

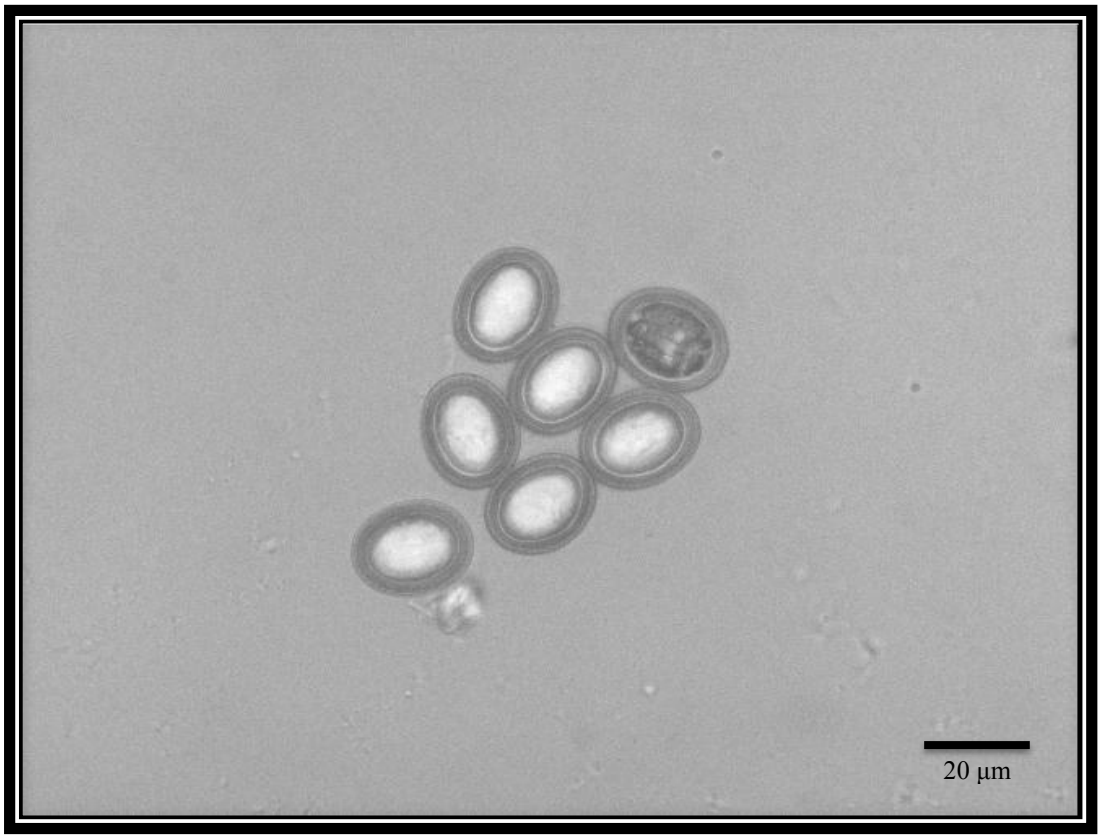

Figure 17. Group of *Taenia spp.* eggs

Cestoda

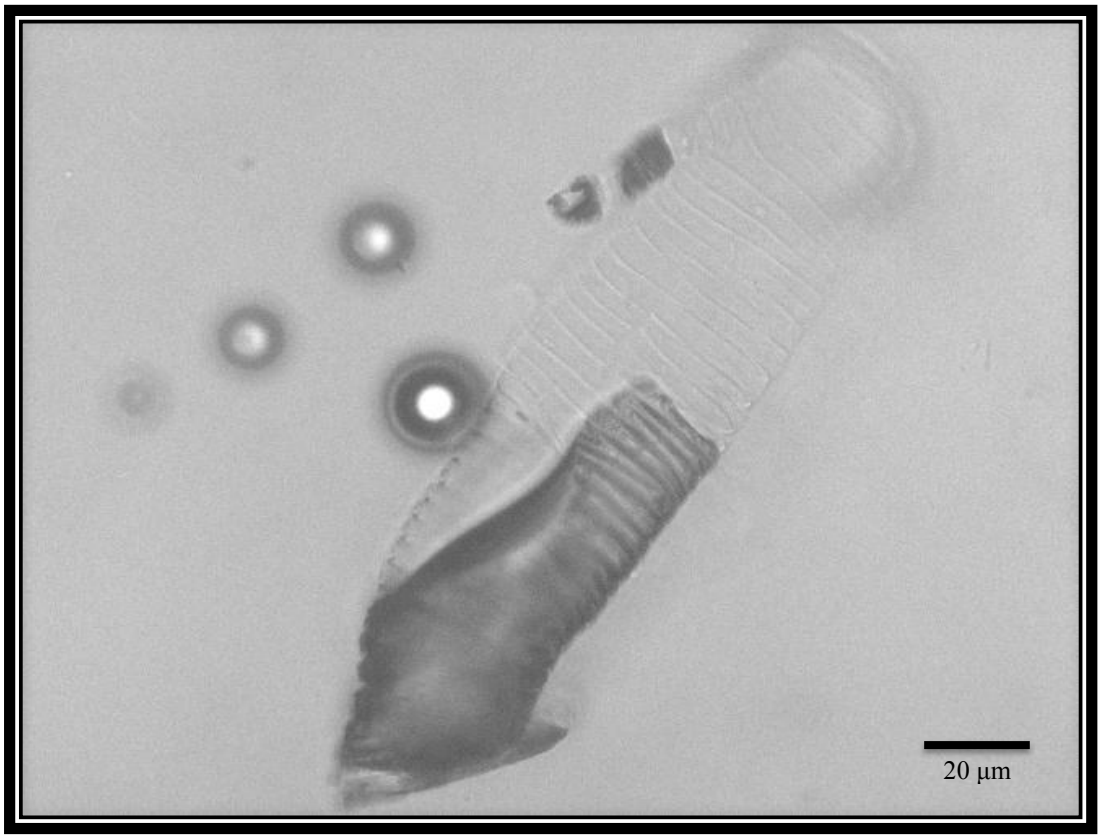

Figure 18. Cestode proglottid section

Cestoda

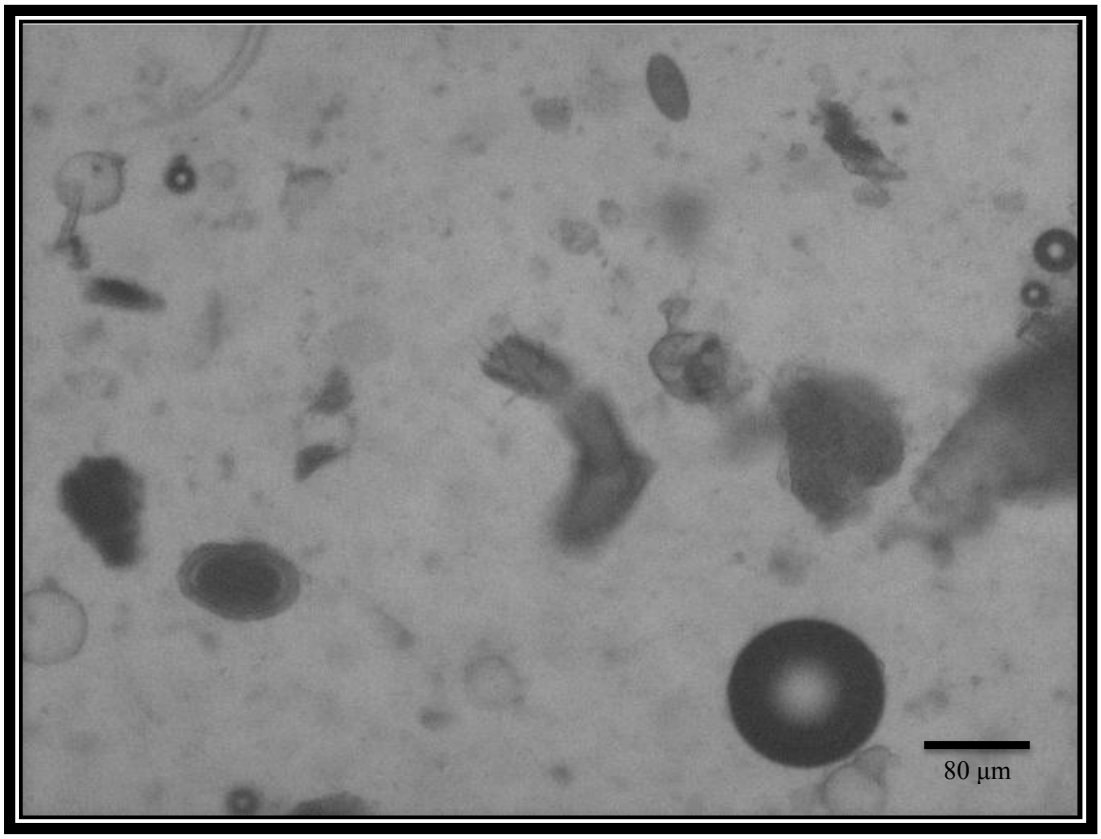

Figure 19. Cestode proglottid section

Protozoa

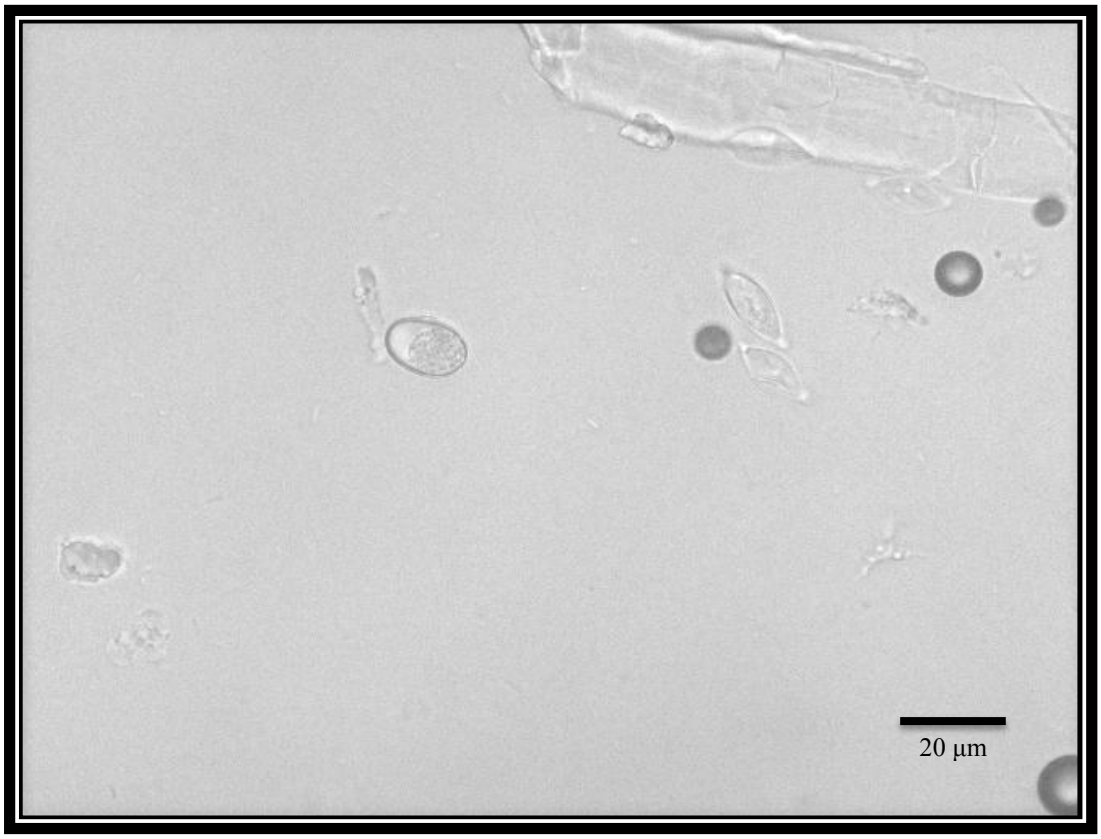

Figure 20. Coccidia oocyst

Protozoa

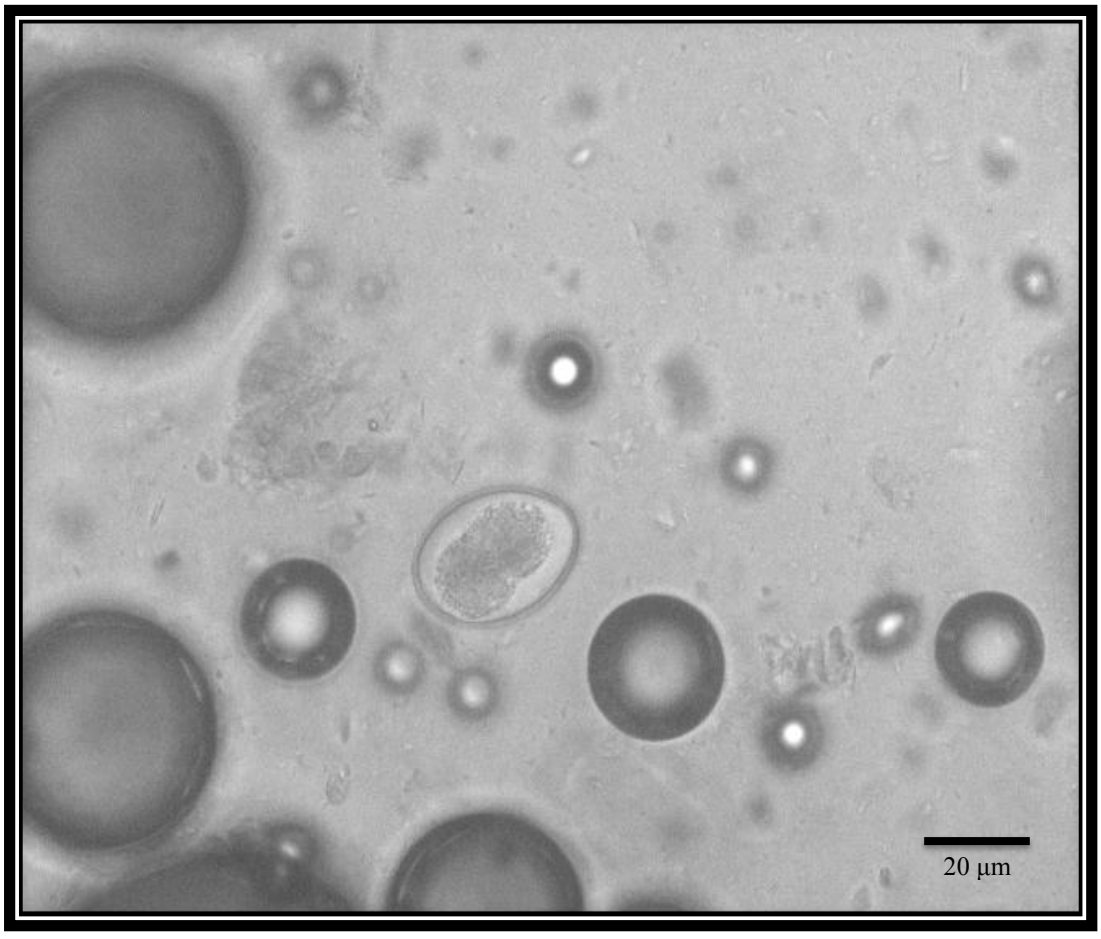

Figure 21. 2-Cell stage coccidia oocyst

Protozoa

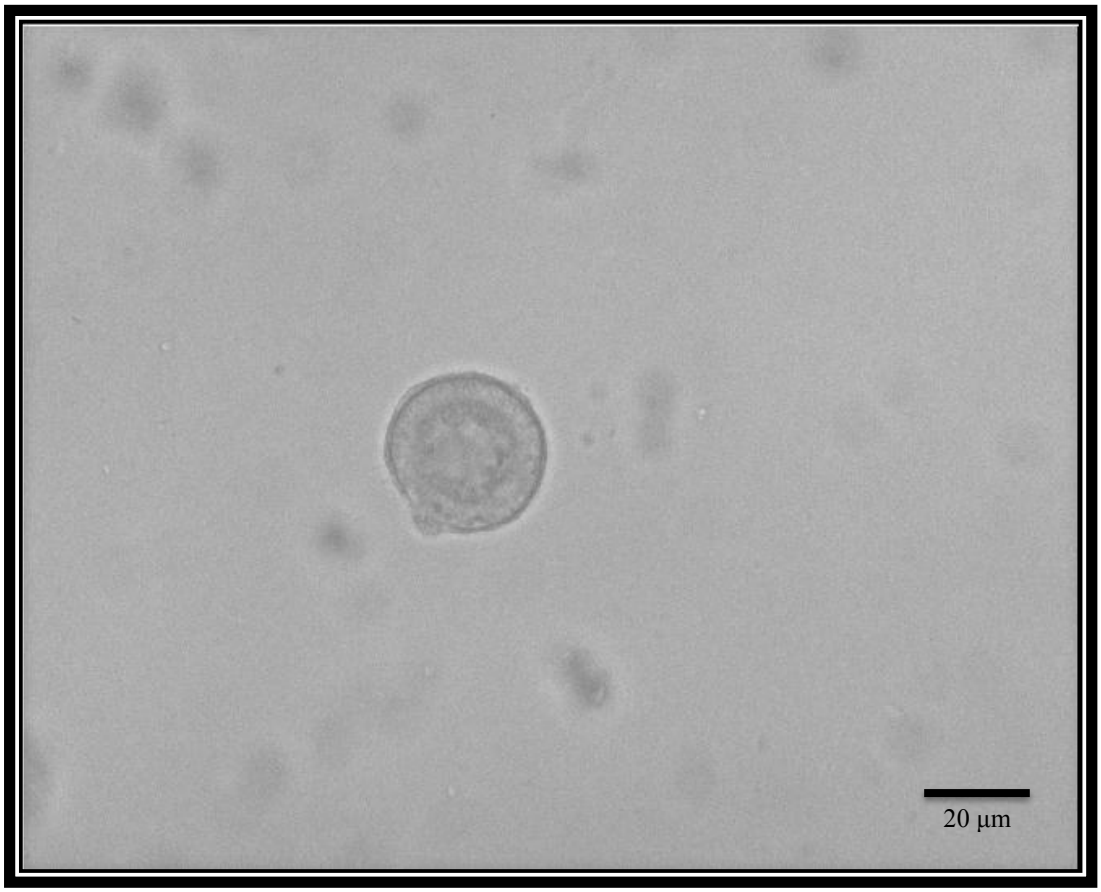

Figure 22. *Eimeria spp.* oocyst

Protozoa

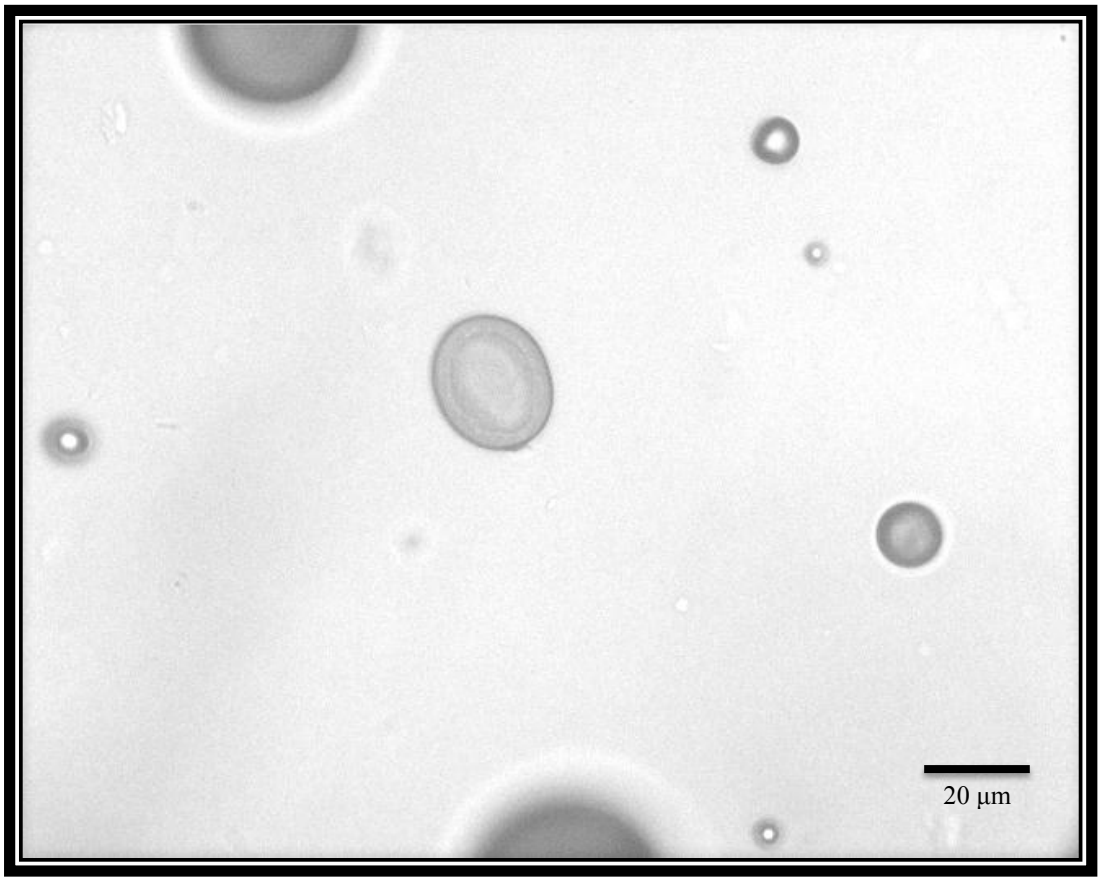

Figure 23. *Eimeria spp.* oocyst

Trematoda

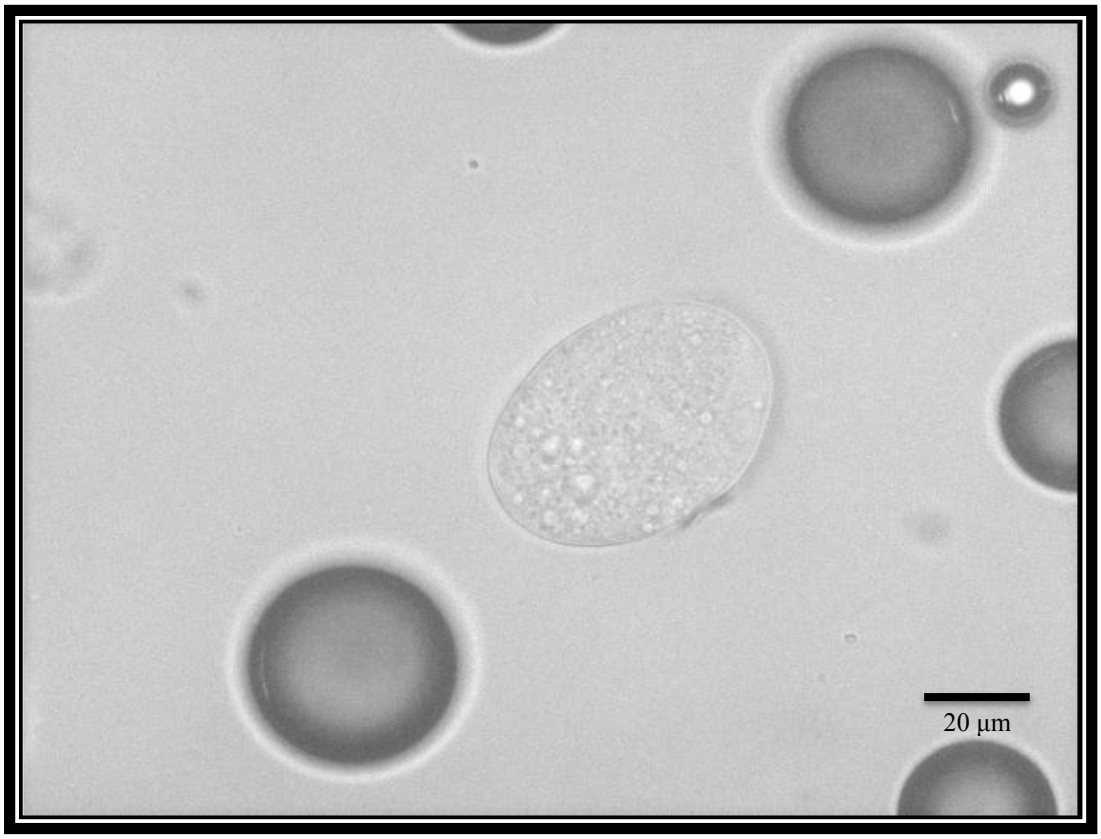

Figure 24. *Alaria spp.* egg

Arachnida:

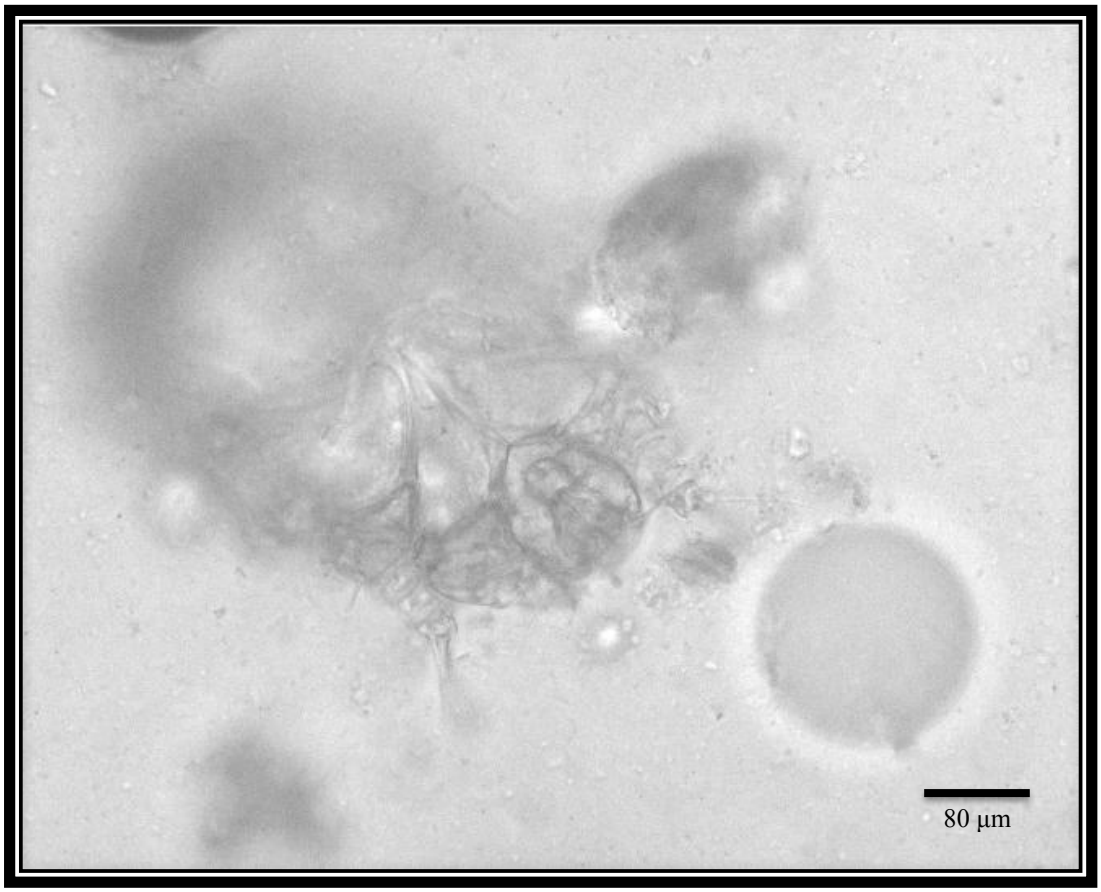

Figure 25. *Myocoptes musculinus* adult

Pseudoparasite

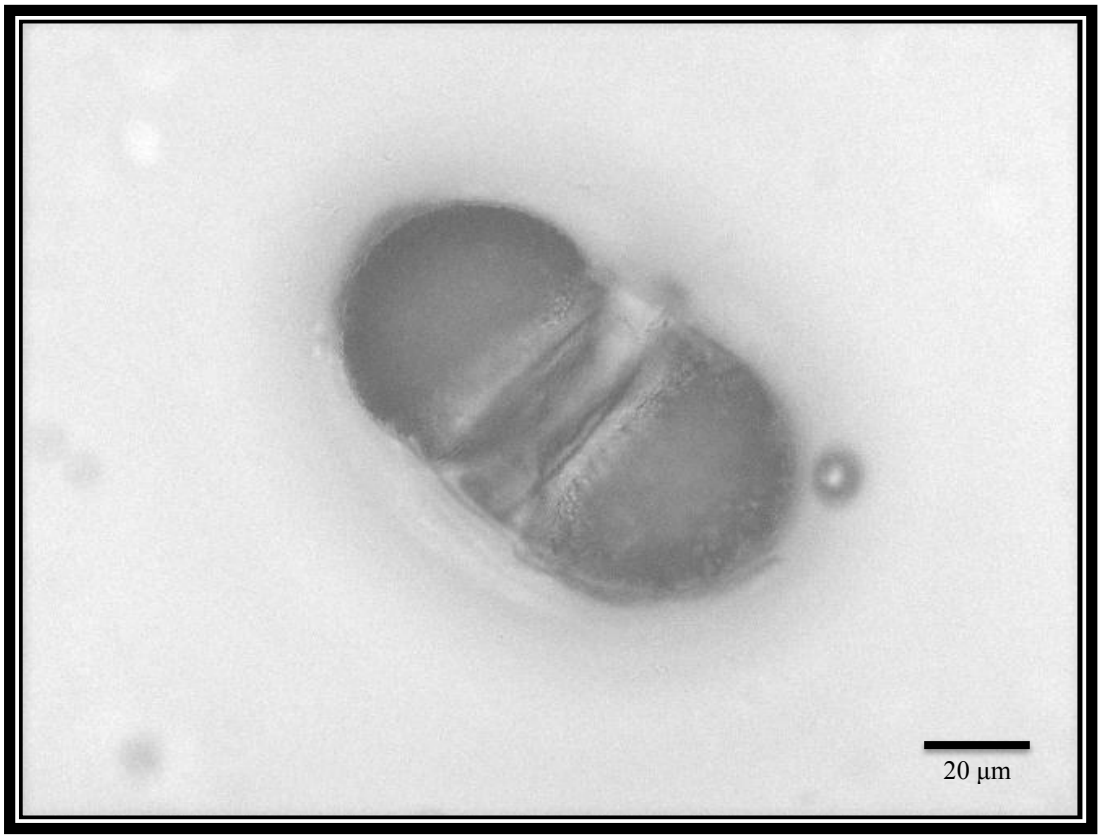

Figure 26. Pine pollen