Endoparasitism of carnivores kept at the Johannesburg Zoological Gardens

By

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SUMMARY

ENDOPARASITISM OF CARNIVORES KEPT AT THE JOHANNESBURG ZOOLOGICAL GARDENS

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This study was conducted to determine the occurrence of intestinal parasites found in captive wild carnivores at the Johannesburg Zoological Gardens. Faecal samples were collected from the enclosures of 22 different carnivore species from the families Canidae (*Canis adustus*, *Lycaon pictus, Vulpes zerda, Otocyon megalotis)*; Felidae (*Acinonyx jubatus, Caracal caracal, Felis silvestris lybica, Leopardus wiedii*, *Leptailurus serval*, *Panthera leo, Panthera tigris altaica, Puma concolor, Uncia uncial*); Hyaenidae (*Hyaena hyaena*); Mustelidae (*Lutra maculicollis, Mellivora capensis*); Procyonidae (*Nasua nasua*); *Ursidae* (*Tremarctos ornatus, Ursus arctos, Ursus martimus*) and Viverridae (*Civettictis civetta, Genetta genetta*). The samples were collected during routine cage cleaning. Faecal samples collected from 7 carnivore species, namely, cheetah (*Acinonyx jubatus*), caracal (*Caracal caracal*), African wild cat (*Felis silvestris lybica*), small spotted genet (*Genetta genetta*), margay (*Leopardus wiedii*), honey badger (*Mellivora capensis*) and fennec fox (*Vulpes zerda*), tested positive for cysts of *Giardia* sp. All infections were clinically inapparent. Two strobilar stages of a tapeworm recovered from a cheetah (*Acinonyx jubatus*) during necropsy at Johannesburg Zoological Gardens were identified as *Hydatigera taeniaeformis.*

Chapter 1
INTRODUCTION

As a result of a favourable host-parasite-balance that has developed through the evolutionary process, wild animals usually carry a heavy parasite burden without apparent clinical effects (Sachs & Sachs 1968). However, by reducing the ranges of wild animals, seen at its most extreme in zoological gardens, and by exposing them to stress conditions, the host-parasite balance is negatively influenced with parasites becoming clinically relevant (Sachs & Sachs 1968; Geraghty, Mooney & Pike 1982). Appropriate measures to control particularly gastrointestinal parasitic infections in zoo animals are therefore of utmost importance (Pérez Cordon, Hitos Prados, Romero, Sánchez Moreno, Pontes, Osuna & Rosales 2008). However, in contrast to the parasites commonly found in domestic animals, there is a lack of critical studies regarding the importance of parasites and particularly their pathogenicity in wild animals (Bauer & Stoye 1985). Some gastrointestinal parasites of zoo animals, especially mammalian carnivores, have zoonotic implications which require precautions to be taken by veterinarians and zoo personnel (Palmer, Soulsby & Simpson 1998).

Currently, there is little information available on the composition of the endoparasitic fauna of carnivores kept in zoological gardens in South Africa. In an attempt to remediate the lack of information, the aim of this project was to conduct a survey on the carnivores kept at the Johannesburg Zoological Gardens. The results of this survey would for the first time provide information on the occurrence of gastrointestinal parasites in captive wild carnivores in a zoological garden in South Africa which will assist in formulating appropriate control programmes.

Chapter 2
LITERATURE REVIEW OF ENDOPARASITIC INFECTIONS REPORTED FROM SELECTED CARNIVORES

A total of 22 different carnivore species are kept at the Johannesburg Zoological Gardens which are the subjects of this study. Published information on the endoparasite spectrum of helminths and protozoa that features in the gastrointestinal tract is summarized.

2.1 Canidae

2.1.1 Side-striped jackal (*Canis adustus*)

According to Round (1968), the side-striped jackal is known as a host for *Diphyllobothrium pretoriensis, Mesocestoides* sp., *Taenia brauni, Taenia* sp., *Ancylostoma braziliense, Ancylostoma caninum, Rictularia cahirensis* and *Trichinella spiralis. Dipylidium caninum* was reported from this jackal species in Kenya following necropsy (Nelson, Pester & Rickman 1965; East, Kurze, Wilhelm, Benhaiem & Hofer 2013).

2.1.2 Wild dog (*Lycaon pictus*)

According to Round (1968), the wild dog is known as a host for *Diphyllobothrium pretoriensis, Dipylidium caninum, Echinococcus granulosus, Echinococcus* sp., *Inermicapsifer sp., Taenia brauni, Taenia lyacontis, Taenia pisiformis, Taenia* sp. *Toxascaris leonina* and *Toxocara canis. Spirometra* sp. has later been reported from wild dogs in Luangwa National Park and Lupande Game Management Area, Zambia (Berentsen, Becker, Stockdale-Walden, Matandiko, McRobb & Dunbar 2012) based on faecal examination.

Protozoal infections reported from wild dogs include infections with *Isospora* sp, *Sarcocystis* sp, *Toxoplasma gondii* and *Giardia* sp. Oocysts of *Isospora* sp and *Sarcocystis* sp were discovered in faecal samples obtained from wild dogs in Luangwa

National Park and the Lupande Game Management Area, Zambia (Berentsen *et al.* 2012). Wild dog populations in Zambia, Namibia and an Australian zoo were found to be infected with *Giardia* sp following microscopic faecal examination and PCR analysis (Ash, Lymbery, Lemon, Vitali & Thompson 2010). Wild dogs kept in various Slovak and Czech zoos tested positive for *Toxoplasma* antibodies (Sedlák & Bártová 2006).

2.1.3 Fennec fox (*Vulpes zerda*)

According to Round (1968), the fennec fox is known as a host of *Alaria alata, Joyeuxiella echinorhyncoides, Taenia crassiceps* metacestode, *Ancylostoma braziliense, Ancylostoma caninum, Ancylostoma duodenale, Cyathospirura seurati, Oxynema crassispiculum,* 'Oxyuroidea' species, *Physaloptera cesticillata, Physaloptera* sp., *Rictularia cahirensis, Spirocerca lupi, Sprirura rytipleuritis, Streptopharagus numidicus, Toxascaris sp, Toxocara masculior* and *Uncinaria stenocephala.*

Protozoal infections with *Isospora* sp, *Neospora caninum* and *T. gondii* have been reported from fennec foxes. Oocysts of *Isospora* sp were discovered in faecal samples of animals kept at the London Zoological Garden (Prasad 1961). Fennec foxes kept in various Slovak and Czech zoos tested positive for *T. gondii* and *N. caninum* based on serological examination for antibodies (Sedlák & Bártová 2005)

2.1.4 Bat-eared fox (*Otocyon megalotis*)

According to Round (1968), the bat-eared fox is known as a host for *Diphyllobothrium pretoriensis, Diplopylidium acanthotetra, Dipylidium caninum, Dipylidium otocyonis, Joyeuxiella* sp., *Ancylostoma caninum* and *Oxynema crassispiculum.* Based on PCR (polymerase chain reaction) analysis, larvae found in muscle samples collected from bat-eared foxes in the Serengeti, Tanzania, were identified as those of *Trichinella nelsoni* (Pozio, De Meneghi, Roelke-Parker & La Rosa 1997).

2.2 Felidae

2.2.1 Cheetah (*Acinonyx jubatus*)

According to Round (1968), the cheetah is known as a host for *Pharyngostomum cordatum, Taenia acinomyxi, Taenia hlosei, Taenia hydatigena, Ancylostoma braziliense, Ancylostoma caninum, Ancylostoma iperodontatum, Ancylostoma paraduodenale, Toxascaris leonina* and *Toxocara cati.* Infections with *Toxascaris leonina* in captive cheetah in zoological gardens have been reported (Geraghty *et al.* 1982). *Trichinella* larvae found in muscle samples collected from cheetah in the Serengeti National Park in Tanzania, were identified as those of *Trichinella nelsoni* by PCR (Pozio *et al.* 1997).

Protozoal infections reported from cheetahs include infections with *Cystoisospora rivolta, Cystoisospora felis, Toxoplasma gondii* and *Neospora caninum. Cystoisospora rivolta* and *C. felis* oocysts were discovered in faecal samples obtained from animals at the CCF in Namibia (Mény, Schmidt-Kűntzel &Marker 2012). Cheetahs kept at various zoos and breeding centres in the Midwestern United States, (De Camps, Dubey, & Saville 2008), Thailand (Thiangtum, Nimsuphun, Pinyopanuwat, Chimnoi, Tunwattana, Tongthainan, Jittapalapong, Rukkwamsuk & Maruyama 2006), Qatar (Dubey, Pas, Rajendran, Ferreira, Martins, Hebel, Hammer & Su 2010), Czech Republic and Slovenia (Sedlák & Bártová 2006) tested positive for *Toxoplasma* antibodies. *Neospora caninum* antibodies were detected in cheetahs kept in zoos in Czech Republic and Slovenia (Sedlák & Bártová 2006).

2.2.2 Caracal (*Caracal caracal*)

According to Round (1968), the caracal is known as a host for *Mesocestoides lineatus. Ancylostoma tubaeforme* and *Toxocara mystax* were recovered from a caracal in Somalia during necropsy (Iori & Lanfranchi 1996).

Toxoplasma gondii antibodies were detected in caracals kept in zoos in the Midwestern United States (De Camps *et al.* 2008) and breeding centres in the UAE and Qatar (Dubey *et al.* 2010).

2.2.3 African wild cat (*Felis silvestris lybica*)

According to Round (1968), the African wild cat is known as a host for *Diphyllobothrium theileri, Diplopylidium acanthotetra, Dipylidium sexcoronatum, Joyeuxiella fuhrmanni, Mesocestoides lineatus, Mesocestoides longistriatus, Mesocestoides* sp., *Taenia laticollis, Taenia selousi, Ancylostoma braziliense, Ancylostoma caninum, Ancylostoma paraduodenale, Cyathospirura chevreuxi, Cylicospirura feline, Habronema* sp., *Physaloptera brevispiculum, Physaloptera praeputialis, Protospirura numidica, Spirocerca lupi* and *Toxascaris leonina.*

2.2.4 Margay (*Leopardus wiedii*)

According to a checklist of helminths on threatened vertebrate species from Brazil, margays are mentioned as hosts for *Ancylostoma pluridentatum* and *Diphyllobothrium latum* (Vieira, Luque & Muniz-Pereira 2009).

2.2.5 Serval (*Leptailurus serval*)

According to Round (1968), the serval is known as a host for *Opisthorchis starkovi, Schistosoma rodhaini, Diphyllobothrium decipiens, Diphyllobothrium theileri, Diphyllobothrium* sp., *Hymenolepis diminuta, Joyeuxiella fuhrmanni, Joyeuxiella pasqualei, Mesocestoides* sp., *Sparganum* sp., *Ancylostoma braziliense, Ancylostoma paraduodenale, Physaloptera praeputialis, Spirocerca lupi, Toxocara cati, Toxocara* sp., *Trichinella spiralis* and *Vogeloides servalis.*

Servals kept in various zoos in Czech Republic and Slovenia tested positive for *Toxoplasma* antibodies (Sedlák & Bártová 2006).

2.2.6 Lion (*Panthera leo*)

According to Round (1968), the lion is known as a host for *Pharyngostomum cordatum, Diphyllobothrium theileri, Dipylidium* sp., *Echinococcus granulosus, Mesocestoides* sp., *Taenia gonyamai, Taenia hydatigena, Taenia regis, Taenia taeniaeformis, Taenia* sp., *Ancylostoma paraduodenale, Ancylostoma tubaeforme, Cylicospirura subaequalis, Galoncus perniciosus, Gnathostoma spinigerum, Gnathostoma* sp., *Lagochilascaris*

major, Ollulanus tricuspis, Physaloptera praeputialis, Toxocara canis, Toxocara cati, Toxascaris leonina and *Trichinella spiralis. Taenia simbae* recovered from lions in East Africa was described as a new species by Dinnik & Sachs (1972). *Trichinella* larvae found in muscle samples from lions in the Serengeti National Park, Tanzania, were identified as *Trichinella nelsoni* by PCR analysis (Pozio *et al.* 1997).

Infection with *Toxascaris leonina* and *Toxocara cati* have also been diagnosed in captive lions in zoological gardens based on faecal examination (Gurler, Beyhan, Acici, Bolukbas & Umur 2010; Lim, Ngui, Shukri, Rohela & Mat Naim 2008).

Protozoal infections reported from lions include infections with *Toxolasma gondii* and *Sarcocystis* sp. Lions kept at various zoological gardens in the Midwestern United States (De Camps *et al.* 2008) and Thailand (Thiangtum *et al*. 2006) tested positive for *Toxoplasma* antibodies. *Sarcocystis* sp. oocysts were discovered in faecal samples obtained from animals in the Luangwa Valley in Zambia (Berentsen *et al.* 2012).

2.2.7 Siberian tiger (*Panthera tigris altaica*)

Following faecal examination, the trematode *Platynosomum fastosum* was found in Siberian tigers in the Lazovsky Nature Preserve, Russia (González, Carbonell, Urios & Rozhnov 2007).

Based on faecal examination there is evidence of nematode infections with *Toxascaris leonina, Toxocara cati, Ancylostoma* sp and *Strongyloides* sp. Animals infected with *T. leonina* and *T. cati* were reported from zoological gardens in Ireland and India (Geraghty *et al.* 1982; Acharjyo 2004) and from Lazovsky Nature Reserve in Russia (Gonzáles *et al.* 2007). Infections with ancylostomatids and *Strongyloides* sp were reported from Lazovsky Nature Reserve in Russia (Gonzáles *et al.* 2007).

Siberian tigers kept at various zoological gardens in Czech Republic, Thailand and the USA tested positive for toxoplasmosis based on serological examination for antibodies (Sedlák & Bártová 2006; De Camps *et al.* 2008; Thiangtum *et al.* 2006).

2.2.8 Puma (*Puma concolor*)

Echinococcus oligarthrus was isolated from puma in Brazil during necropsy (Tappe, Stich & Frosch 2008).

There is evidence of infection with hookworms and ascarids based on faecal examination. Infections with *Ancylostoma braziliense, Toxocara mystax* and *Toxascaris leonina* were reported by Noronha, Vicente & Pinto (2002) in Brazil. *Toxascaris leonina* and *Uncinaria stenocephala* were identified in captive puma from the Samsun Zoological Garden in Turkey (Gurler *et al.* 2010). Based on faecal examination, pumas kept at the Negara zoo in Malaysia were found to be infected with *T. cati, Spirometra* sp. and hookworm (Lim *et al.* 2008).

2.2.9 Snow leopard (*Uncia uncia*)

Captive snow leopards in the Padmaja Naidu Himalayan Zoological Park were found to be infected with *Toxocara* sp and *Toxascaris leonina* (Pradhan, Sharma, Subba & Chettri 2011). Also Geraghty *et al.* (1982) reported eggs of *Toxascaris* sp. in faecal samples from snow leopards kept at the Dublin zoological gardens.

Thiangtum *et al.* (2006) detected antibodies against *T. gondii* in snow leopards kept at various zoological gardens in Thailand. Similarly, there are also records from animals at zoological gardens in the USA (De Camps *et al.* 2008).

2.3 Hyaenidae

2.3.1 Striped hyaena (*Hyaena hyaena*)

According to Round (1968), the striped hyaena is known as a host for *Taenia* sp. and *Trichinella spiralis. Taenia crocutae* (Graber, Trancy & Thal 1973), *Taenia dinniki* (Jones & Khalil 1984), *Taenia hyaenae* (Loos-Frank 2000), *Taenia multiceps* (Kuntz & Myers 1968), Oocysts of *Isospora levinei* are noted in striped hyaenas from India (Levine & Ivens 1981). *Toxoplasma gondii* antibodies were detected in striped hyaenas kept at the Breeding Centre for Endangered Arabian Wildilfe in the United Arab Emirates (UAE) (Dubey *et al*. 2010).

2.4 Mustelidae

2.4.1 Spotted neck otter (*Lutra maculicollis*)

According to Round (1968), the spotted neck otter is known as a host for *Baschkirovitrema incrassatum, Cynodiplostomum namrui* and *Prudhoella rhodesiensis Cloeascaris spinicollis* was recovered from a spotted neck otter in Tanganyika (= Tanzania) (Baylis 1923).

2.4.2 Honey badger (*Mellivora capensis*)

According to Round (1968), the honey badger is known as a host for *Mesocestoides caestus, Physaloptera* sp. and *Uncinaria parvibursata.*

Based on faecal examination, honey badgers kept in a zoological garden in Bangladesh were found to be infected with the trematode *Artyfechinostomum sufratyfex*, *Toxocara* sp. and *Strongyloides* sp. (Ahasan, Iqbal & Ul-Azam 2010). The Honey badger is also listed as a host for *Ancylostoma* sp. and *Physaloptera brevispiculum* in the review by Acharjyo (2004).

2.5 Procyonidae

2.5.1 South American coati (*Nasua nasua*)

Oocysts of *Eimeria nasuae* were found in faecal samples in coati from Brazil (Levine & Ivens 1981). Trophozoites of *Giardia* sp were identified in faecal samples from coati in Brazil (Holsback, Cardoso, Fagani & Patelli 2013).

2.6 Ursidae

2.6.1 Spectacled bear (*Tremarctos ornatus*)

The spectacled bear is listed as a host for *Baylisascaris transfuga* (Schaul 2006).

2.6.2 Brown bear (*Ursus arctos*)

Cestodes of the genus *Diphyllobothrium* were recovered from brown bears in Alaska during necropsy (Rausch 1954).

Baylisascaris transfuga was reported from wild brown bears in Europe, the USA and Canada (Rogers & Rogers 1976; De Ambrogi, Aghazadeh, Hermosilla, Huber, Majnaric, Reljic & Elson-Riggins 2011). *Trichinella* sp. infection were reported from wild brown bears in Alaska, Western USA, California, Northwestern Canada, Russia, Azerbaijan and Germany (Rogers & Rogers 1976; Schaul 2006; Choquette, Gibson & Pearson 1969). Diagnosis was based on the detection of antibodies (Schaul 2006) or by demonstration of larvae in muscle samples (Choquette *et al.* 1969). *Uncinaria stenocephala* was reported in animals from the shores of the Caspian sea (Rogers & Rogers 1976; Schaul 2006).

2.6.3 Polar bear (*Ursus maritimus*)

Infection with *Diphyllobothrium latum* was reported in a captive polar bear from the USA (Schaul 2006; Rogers & Rogers 1976).

Eggs of *Baylisascaris transfuga* were identified in both captive and wild populations of bears in faecal samples (Schaul 2006).

Trichinella spiralis has been recovered from captive polar bears in Germany, USA and UK (Schaul 2006). *Trichinella harma* has been reported from captive polar bears in zoological gardens from the USA and Mexico (Schaul 2006). Based on serology, a not further identified *Trichinella* species were reported in wild bears from Alaska (Jenkins, Castrodale, De Rosemond, Dixon, Elmore, Gesy, Hoberg, Polley, Schurer, Simard & Thompson 2013), Canada, Greenland, (Larsen & Kjos-Hanssen 1983) and the Barents Sea Islands (Naidenko, Ivanov, Mordvintsev, Platonov, Ershov & Rozhnov 2013).

Toxoplasma gondii antibodies were detected in animals kept at zoological gardens in Slovakia and the Czech Republic (Sedlák & Bártová 2006)

Fatal sarcocystosis caused by a not identified species of *Sarcocystis* was reported in two polar bears kept at a zoological garden in Alaska (Garner, Barr, Packham, Marsh, Burek-Huntington & Wilson 1997).

2.7 Viverridae

2.7.1 African civet (*Civettictis civetta*)

According to Round (1968), the African civet is known as a host for *Ancylostoma ceylanicum, Ancylostoma duodenale* and *Contracaecum microcephalum.*

The species is incriminated as a definitive host for *Paragonimus uterobilateralis* based on the recovery of eggs in faecal samples (Pan American Health Organization 2003). Based on faecal examination, captive African civets were found to be infected with *Ancylostoma* sp., *Trichuris* sp. and not further identified cestodes in Ethiopia (Tolosa & Regassa 2007). *Trichinella britovi* was identified in muscle samples of African civets by means of PCR analysis and trichinoscopy (Pozio, Pagani, Marucci, Zarlenga, Hoberg, Meneghi, La Rosa & Rossi 2005).

Wild African civets in Sierra Leone were identified as hosts of *Isospora viverrae* following post mortem examination (Levine & Ivens 1981).

2.7.2 Small-spotted genet (*Genetta genetta*)

According to Round (1968), the small-spotted neck otter is known as a host for *Diplopylidium acanthotetra, Diplopylidium genetta, Diplopylidium monoophorum, Joyeuxiella gervaisi, Joyeuxiella dongolensis, Joyeuxiella pasqualei, Mesocestoides ambiguous, Sparganum* sp., *Taenia laticollis, Taenia* sp., *Ancylostoma caninum, Cyathospirura nouveli, Molineus genettae, Protospirura numidica, Physaloptera praeputialis, Rictularia cahirensis, Rictularia leiperi, Rictularia macdonaldi* and *Trichinella spiralis.*

Several parasites were recovered during necropsy of small spotted genets from the Iberian Peninsula, namely *Metorchis albidus, Taenia parva, Mesocestoides* sp, *Joyeuxiella pasqualei, Trichinella* sp., *Ancylostoma* sp., *Toxocara* sp., *Cyatospirura seurati* and *Neospora caninum* (Casanova, Feliu, Miguel, Torres & Špakulová 2000).

Taenia parva was recovered from wild small spotted genets in Spain (Ribas, Feliu & Casanova 2009). *Ancylostoma tubaeforme* was recovered from the intestine of small spotted genets in Somalia (Iori & Lanfranchi 1996). Larvae identified by PCR analysis as those of *Trichinella britovi*, were detected in muscle samples of small spotted genets from Guinea (Pozio *et al.* 2005).

Genets from Spain tested positive for antibodies against *Neospora caninum* (Sobrino, Dubey, Pabón, Linarez, Kwok, Millán, Arnal, Luco, López-Gatius, Thulliez, Gortázar & Almería 2008).

Chapter 3
MATERIALS AND METHODS

3.1 Survey location

The survey was conducted at Johannesburg Zoological Gardens in Johannesburg, Gauteng Province.

3.2 Study animals

The survey was carried out on a total of 58 animals belonging to 22 carnivore species kept at the Johannesburg Zoological Gardens (Table 3.1). Carnivores of the same species were housed together.

3.3 Sample collection

A single faecal sample from each of the 58 animals was collected from the enclosures during the period of July 2013 to September 2013.

Fresh faecal samples (± 10 g) were transferred into 30 ml screw cap sample containers filled with SAF fixative (**S**odium acetate, **A**cetic acid, **F**ormaldehyde) from the ground of the confined areas where animals were kept (Price 1994). The samples were stored in a refrigerator at 5-10 ^{o}C until processed. None of the animals had received anthelmintic treatment for over 2 months when samples were collected. Also none of the animals showed any clinical signs related to parasitic infections at the time samples were collected.

3.4 Diagnostic procedures

SAF-preserved faecal samples were processed by the formalin-ethyl acetate sedimentation technique (Ash & Orihel 1987) and microscopically examined for the presence of protozoan cysts, oocysts, trophozoites and helminth eggs. Protozoan developmental stages and helminth eggs were identified according to published morphological criteria (Ash & Orihel 1987; Beugnet, Polack & Dang 2008).

During necropsy of a male cheetah (*Acinonyx jubatus*) that had died of kidney failure at the Johannesburg Zoological Gardens, two strobilar stages of a cestode were recovered from the small intestine and made available for identification. The hook-bearing rostellum was cut off the scolex, mounted on a slide in a drop of Berlese's fluid and a cover slip was added. Gentle pressure was exerted on the cover slip to disrupt the rostellum and to allow the hooks to lie in profile. Small and large hooks were counted and the length measured respectively. Final identification was based on published morphological criteria of the rostellar hooks (Verster 1969).

Table 3.1: Carnivore species kept at the Johannesburg Zoological Gardens

Scientific name	Common name	Total number kept	Gender composition ♂:♀
Acinonyx jubatus	Cheetah	3	1/2
Canis adustus	Side striped jackal	2	0/2
Caracal caracal	Caracal	2	1/1
Civettictis civetta	African civet	3	1/2
Felis silvestris lybica	African wild cat	2	1/1
Genetta genetta	Small spotted genet	3	2/1
Hyaena hyaena	Striped hyaena	2	1/1
Leopardus wiedil	Margay	2	1/1
Leptailurus serval	Serval	1	0/1
Lutra maculicollis	Spotted neck otter	1	1/0
Lycaon pictus	Wilddog	1	0/1
Mellivora capensis	Honey badger	3	2/1
Nasua nasua	South American coati	7	0/7
Otocyon megalotis	Bat eared fox	1	0/1
Panthera leo	Lion	10	3/7
Panthera tigris altaica	Siberian tiger	4	1/3
Puma concolor	Puma	2	1/1
Tremarctos ornatus	Spectacled bear	2	1/1
Ursus arctos	Brown bear	2	1/1
Ursus maritimus	Polar bear	2	1/1
Uncia uncia	Snow leopard	1	0/1
Vulpes zerda	Fennec fox	2	1/1

Chapter 4
RESULTS

A total of 17 faecal samples obtained from 7 carnivore species, tested positive for cysts of *Giardia* sp. The carnivore species found infected were cheetah (*Acinonyx jubatus*), caracal (*Caracal caracal*), African wild cat (*Felis silvestris lybica*), small spotted genet (*Genetta genetta*), margay (*Leopardus wiedii*), honey badger (*Mellivora capensis*) and the fennec fox (*Vulpes zerda*). The cysts presented with the distinctive features of the genus. They were oval and measured 7-11 µm in length and 5-9 µm in width and had a well-defined wall. Some cysts displayed the typical bilateral symmetry of the trophozoite.

The strobilar stages recovered from a male cheetah were identified as those of *Hydatigera taeniaeformis* (syn. *Taenia taeniaeformis*). A total of 26 rostellar hooks arranged in two crowns were counted of which 11 were large and 15 small. The large hooks measured 397.7 to 418.4 (mean 411.6 µm) and the small hooks 249.6 to 264.8 µm (mean 258.6 µm) in length. These findings are in accordance to published data summarized by Hall (1919), Verster (1969) and Loos-Frank (2000) for *H. taeniaeformis*.

There was no evidence of gastrointestinal helminth and protozoal infection in the other 15 species kept at the Johannesburg Zoological Gardens.

Figure 4.1: *Giardia* sp cysts in a faecal sample of an African wildcat (x200)

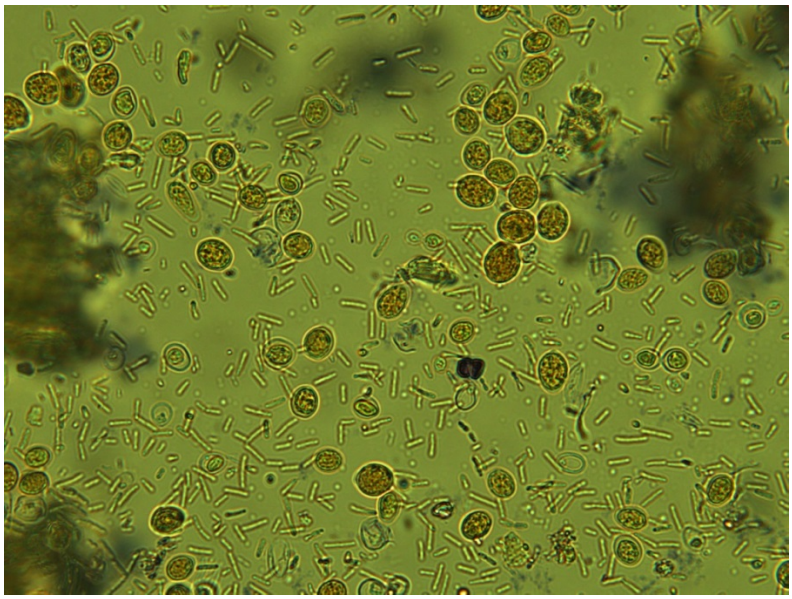


Figure: 4.2: *Giardia* sp. cysts in a faecal sample of a margay (x100)

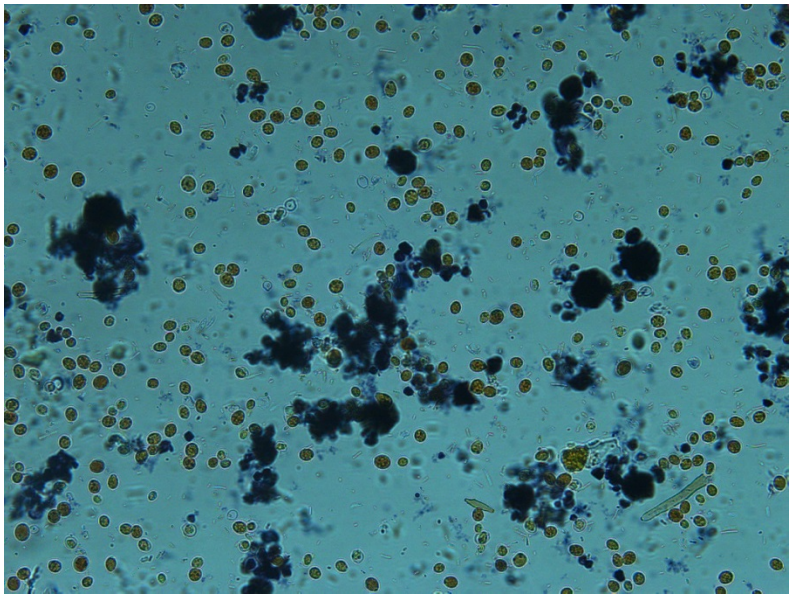


Figure 4.3: *Giardia* sp. cysts in a faecal sample of a honey badger (x200)

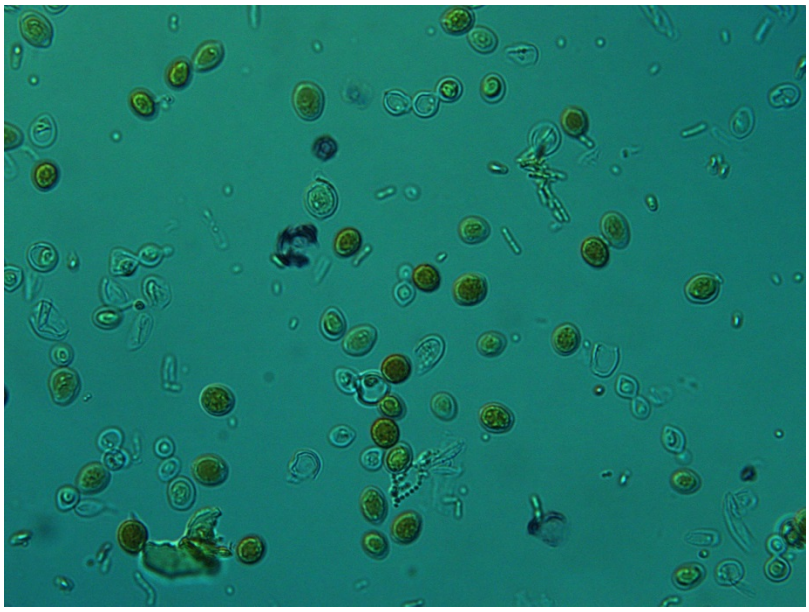
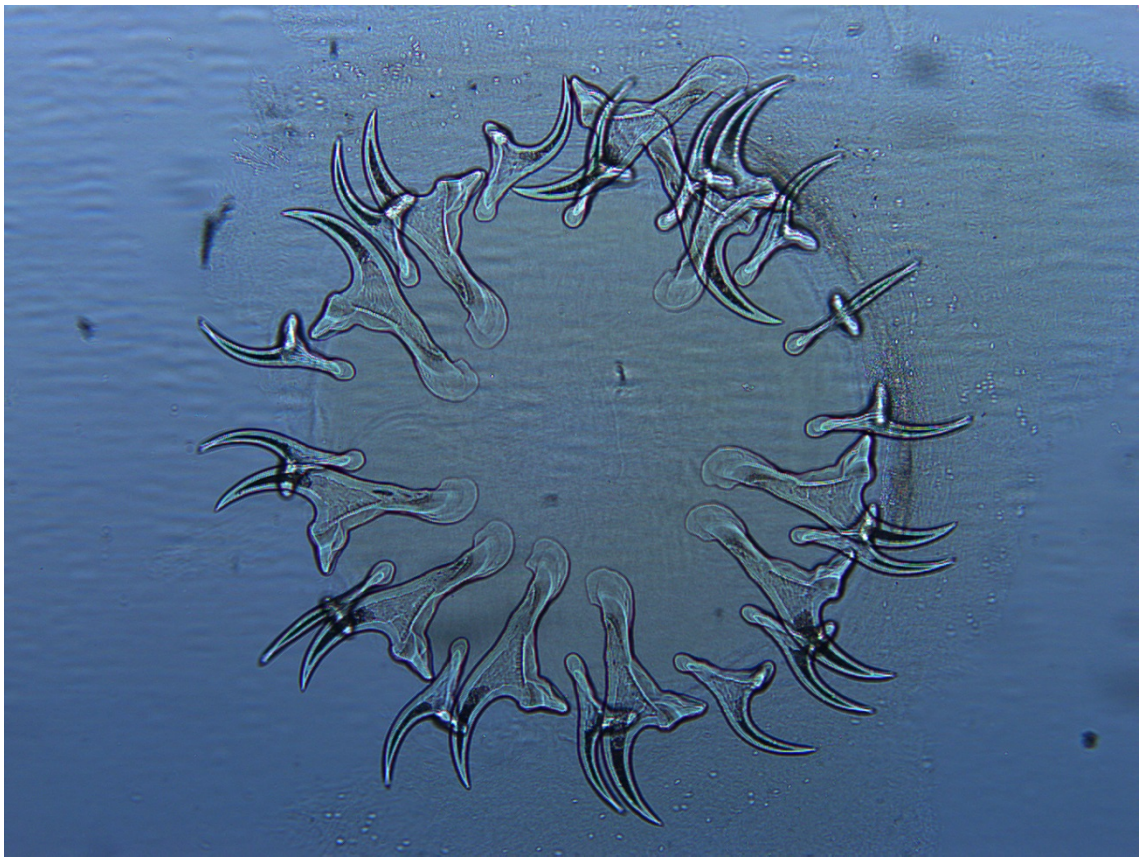


Figure 4.4: Rostellar hooks of *Taenia taeniaeformis* in profile (x200)



Chapter 5
DISCUSSION

Infections with gastrointestinal parasites, which are usually clinically inapparent in free-ranging game, can cause serious disease in captive animals due to stress and massive build-up of infective stages as a result of confined space (Pérez Cordón *et al.* 2008). Stress has a detrimental effect on the host's immune system which results in increased susceptibility to parasitic infections (Martínez, Troiano, Añasco, Rearte & Jara 2002). Several parasites of particularly carnivores have zoonotic implications, posing a health threat to both, animal keepers and the public (Warwick, Arena, Steedman & Jessop 2012; Chethan Kumar, Lokesha, Madhavaprasad, Shilpa, Karabasanavar & Kumar 2013). Control programmes are therefore critical, taking into consideration that the complete absence of parasites is an elusive goal and regular treatment of the entire collection is not only an expensive exercise, but also promotes the selection and establishment of drug resistant parasite strains (Mény *et al.* 2012).

There is currently little information available on the composition of the endoparasitic fauna of carnivores kept in zoological gardens in South Africa. In an attempt to remediate this lack of information, a survey was conducted on the carnivores kept at the Johannesburg Zoological Gardens during 2013. At the Johannesburg Zoological Gardens, gastrointestinal parasite infections are monitored by examining faecal samples every three months by means of flotation. Carnivores presenting with positive faecal flotation results are treated with combination dewormers containing praziquantel and pyrantel. Injectable formulations containing ivermectin are administered during routine immobilizations for the treatment of endoparasites and ectoparasites. Faecal samples obtained from seven carnivore species at the Johannesburg Zoological Gardens, namely, cheetah (*Acinonyx jubatus*), caracal (*Caracal caracal*), African wild cat (*Felis silvestris lybica*), small spotted genet (*Genetta genetta*), margay (*Leopardus wiedii*), honey badger (*Mellivora capensis*) and fennec fox (*Vulpes zerda*), tested positive for cysts of *Giardia* sp. All infections were clinically inapparent. Clinical giardiosis commonly presents with chronic diarrhoea (Tangtronsup & Scorza 2010). *Giardia* sp. cysts can remain infectious for up to 3 months in water

(Olson, O'Handley, Ralston & McAllister 2004). Possible sources of infection at the Johannesburg Zoological Gardens are the municipal water supply, the large colony of feral cats that has access to the premises and rodents which remain difficult to control (Janeczko & Griffin 2010). According to the records of Johannesburg Zoological Gardens which extend back till 2006, *Giardia* infections had not been diagnosed so far. Metronidazole and fenbendazole are considered options for treatment.

The strobilar stages recovered from a cheetah during necropsy were identified as those of *Hydatigera taeniaeformis.* Abuladze (1964) lists the cheetah as a definitive host for *H. taeniaeformis*, however, he is not providing any geographical location or reference. This is in contrast to the information provided in a check list of helminth parasites of African mammals (Round 1968) which does not mention the cheetah as a definitive host. It therefore appears that this is the first confirmed record of cheetahs acting as definitive hosts for *H. taeniaeformis*. Intermediate hosts are, amongst others, rodents which are abundant at the premises of the Johannesburg Zoological Gardens (Loos-Frank 2000). Taeniid species recorded from cheetah so far are *Taenia acinonyxi, Taenia hlosei* and *Taenia hydatigena* (Round 1968). According to the zoological garden's records, a not further specified infection with tapeworm was diagnosed in a serval in 2011.

The results of this survey indicate that the programme adopted by the Johannesburg Zoological Gardens for the control of gastrointestinal parasitic infections is appropriate. However, further studies should be conducted to investigate the source of the *Giardia* infections in the carnivore species affected.

Chapter 6
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