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Baylisascaris spp. in non-raccoon procyonid hosts and assessment of potential risk of human exposure

Max Carlin Parkanzky
Purdue University

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Kevin Kazacos

Joe Camp

George Moore

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BAYLISASCARIS SPP. IN NON-RACCOON PROCYONID HOSTS AND ASSESSMENT OF POTENTIAL RISK OF HUMAN EXPOSURE

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This thesis is dedicated to my family and friends, without whom I would not have made it this far.

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ABSTRACT

Parkanzky, Max Carlin. M.S., Purdue University, May 2015. Prevalence of *Baylisascaris* spp. in Non-Raccoon Procyonid Hosts and Assessment of Risk of Human Exposure. Major Professor: Kevin Kazacos.

Baylisascaris procyonis (Bp) is a large roundworm of the common raccoon (*Procyon lotor*) which serves as the definitive host. Bp is an important cause of clinical larva migrans, including severe neurological disease, across numerous taxa including humans. Other procyonids, as well as occasionally dogs, can act as definitive hosts for this or other *Baylisascaris* spp. Many of these animals are becoming more common as household pets, posing a risk to people who come in contact with these animals. We have investigated whether patent *Baylisascaris* spp. infection exists in captive non-raccoon procyonids and if humans who contact these animals are at risk of infection. Fecal samples from captive animals were examined using standard flotation methods in Sheather's sugar solution and examined for parasite eggs and oocysts. Fecal samples were provided by pet owners, breeding facilities, and zoos for examination. A standard dosage of fenbendazole was recommended when treatment advice was requested. An epidemiological survey was distributed to assess the risk of human exposure in cases where *Baylisascaris* eggs were seen. Findings suggest that many zoo facilities and pet owners are aggressive with routine fecal examination and preventive anthelmintic administration. Samples have been examined from 15 kinkajous, 30 coatis, and 23 captive raccoons. The prevalences of *Baylisascaris* spp. eggs present in the feces of captive coatis, raccoons, and kinkajous were 6.7%, 8.7%, and 13.3%, respectively. This confirms that *Baylisascaris* spp. infection occurs in captive procyonids other than raccoons. The study found significant evidence that the presence of raccoons is associated with a higher rate of *Baylisascaris* infection in other procyonids. The questionnaire found a large proportion of respondents had little knowledge of *Baylisascaris* even though they cared for procyonids which can serve as definitive hosts and that lapses in precautions in working with these animals, their habitats, or feces exist. In conclusion, this study shows that captive non-raccoon procyonids can serve as definitive hosts for *Baylisascaris* spp. and that a portion of the humans that work with these animals are at risk for exposure to *Baylisascaris* eggs. These findings call for better education of caretakers, pet owners, and veterinarians who work with non-raccoon procyonids.

CHAPTER 1. REVIEW OF LITERATURE

1.1 Introduction

The common raccoon (*Procyon lotor*) is the definitive host for *Baylisascaris procyonis*, the raccoon ascarid or large roundworm. This parasite has gained considerable importance as a cause of clinical larva migrans affecting a wide variety of birds and mammals, including humans, that represent paratenic hosts in the life cycle of the parasite. The parasite is well-recognized as a cause of clinical neurologic and ocular disease in humans and other paratenic hosts, who are most often exposed to infective eggs originating from infected raccoons.

Prevalence of *Baylisascaris procyonis* in wild raccoons has been estimated as high as 68-82%, the areas most impacted being the midwestern, northeastern and west coastal regions of the United States (Kazacos, 2001; Page et al., 2001a). Wild raccoons with patent *Baylisascaris procyonis* infections shed an average of 20,000-26,000 eggs per gram of feces with the highest rate of eggs shed by a raccoon reported at 256,700 eggs per gram of feces (Kazacos, 1982, 2001). The numbers of eggs shed per raccoon is due to the great capacity of adult female worms to produce eggs, at an estimated 115,000-179,000 eggs per worm per day, allowing even raccoons with relatively minor infections to shed large numbers of eggs in their feces (Kazacos, 2001). Eggs may then be ingested by paratenic host animals directly from raccoon feces or indirectly through grooming activities, resulting in the ingestion of eggs from their own, or their conspecific's, integument. Carnivorous animals can also become infected by consuming larvae that are present in the tissues of prey animals (paratenic hosts) which were previously infected through egg ingestion. Raccoons may become infected similarly, by ingesting infective eggs from the environment in the case of young raccoons, or ingesting larvae in paratenic hosts, in the case of older raccoons (Kazacos, 1983, 2001).

Raccoons commonly deposit feces in specific "toilet" areas known as latrines, which are typically found on horizontally oriented structures such as large rocks, stumps, logs, or in the crotches of trees (Kazacos, 2001; Page et al., 2001b). In the domestic environment, latrines have also been found on roofs, woodpiles, decks, and in barn lofts and garages (Kazacos, 2001). Because of this behavior, latrines can accumulate a large amount of feces and eggs over time and serve as a significant nidus for the spread of *Baylisascaris procyonis* to other raccoons as well as paratenic hosts (Page et al., 1999, 1998). In addition to the focal accumulation of *Baylisascaris procyonis* eggs at latrines in natural settings, raccoon feces-contaminated artificial habitats for captive animals are also known to act as potent sources of infection in the transmission of *Baylisascaris procyonis* to paratenic hosts, including humans (Kazacos, 2001, 2000, 1982). Two cases of human ocular disease were directly linked to the keeping of raccoons as pets, with subsequent infection of the owners with *Baylisascaris procyonis* (Kuchle et al., 1993; Raymond et al., 1978).

In humans and other paratenic hosts, *Baylisascaris procyonis* larvae aggressively migrate to the viscera, eyes, and central nervous system as part of their normal somatic migration. In doing so, they produce larval infection, the clinical and pathological designations of which are termed visceral (VLM), ocular (OLM), and neural larva migrans (NLM), respectively (Kazacos, 2001). *Baylisascaris procyonis* larvae grow considerably after beginning migration and reach a typical size of 1500 to 2000 µm; this, combined with other factors, is a significant contributor to the pathogenicity of the larvae (Kazacos, 2000). Ocular larva migrans (OLM) occurs as larvae invade the eye from the systemic circulation, producing serious eye damage and clinical disease (Kazacos and Boyce, 1989). Diffuse unilateral subacute neuroretinitis (DUSN) represents a special type of OLM in which the affected person has vision loss in the affected eye secondary to parasite-induced inflammatory effects on the retina including the optic nerve head and retinal vessels. *Baylisascaris procyonis* is a prominent cause of diffuse unilateral subacute neuroretinitis (DUSN) and is the leading cause of the large nematode variant in North America and Europe (Goldberg et al., 1993; Saffra et al., 2010).

Baylisascaris procyonis is the most common cause of clinical larva migrans in animals, specifically causing severe or fatal neurologic disease (NLM). Additionally, *Baylisascaris procyonis* is very nonspecific in the paratenic hosts it affects. This has led to devastating outbreaks of neurologic disease in domestic and wild animals, as well as zoological collections with rodents, rabbits, primates, and birds being the most commonly affected animal taxa (Kazacos, 2001).

Variety and severity of clinical signs in paratenic hosts are dependent on species and individual susceptibility as well as the number of larvae that migrate to sensitive organs, including the brain and eye. The severity of cerebrospinal disease is also negatively correlated with brain size making small granivores such as mice particularly susceptible (Kazacos, 2001). It is known that in mice and other small animals, a single larva migrating in the brain may be fatal (Tiner, 1953).

Typical neurologic signs in susceptible species at the onset of cerebrospinal larval migration include depression, lethargy, nervousness, rough hair coat, tremors, and head/body tilt. These signs can progress to more severe motor deficits, hypertonicity, recumbency, coma and death. Higher order mammals such as primates also exhibited loss of manual dexterity; psychomotor deficiencies with abnormal movements such as head bobbing, swaying and intention tremors; as well as narcolepsy and undirected/unsolicited vocalizations (Kazacos et al., 1981). Many of these clinical signs are similar to those seen in children infected with *Baylisascaris procyonis* (Kazacos, 2000, 2001).

Neurologic disease in humans presents with clinical signs similar to those in other mammals, the most common being progressive ataxia, irritability, lethargy and fever. The disease may quickly progress to more severe cognitive deficits, hypertonicity and hyperreflexia, coma, and death depending on the severity of infection. Peripheral eosinophilia, cerebrospinal fluid (CSF) eosinophilic pleocytosis, and deep white matter abnormalities are common findings by laboratory and MRI diagnostics (Kazacos et al., 2002; Rowley et al., 2000).

Retinitis associated with *Baylisascaris procyonis* larval migration and ophthalmic gaze abnormalities such as strabismus have also been described in some cases of human neural larva migrans (Park et al., 2000; Rowley et al., 2000). There have been at least 24 cases of *Baylisascaris procyonis* associated cerebrospinal disease in humans described in the United States since 1981 with additional cases also known; others likely go unreported or misdiagnosed. Because damage to nervous tissue can occur before clinical symptoms develop, it is important to take precautions when working with objects contaminated by, or definitive hosts infected with, *Baylisascaris procyonis* (Kazacos et al., 2002). Low-level infection with subtle signs is known to occur in animals and likely also occurs in humans (Kazacos, 2001). Asymptomatic infection with seroconversion also takes place, related to very low infection and invasion of non-clinical organs.

The primary risk factors for human infection are exposure to raccoon latrines, and young age (<4 years) with pica/geophagia (Murray and Kazacos, 2004). Just as exposure to raccoon feces is a significant risk factor, exposure to feces of non-raccoon definitive hosts kept in captivity is similarly assumed to increase the risk of *Baylisascaris procyonis* infection in people. This would include exposure to non-raccoon procyonids kept as pets or in breeding facilities and zoos, as well as dogs that may be infected with *Baylisascaris procyonis*. As pets, all of these animals would have access to the domestic environment, thereby potentially putting people at risk of infection. Dogs are indiscriminate defecators, so they could potentially contaminate large areas of yards, exposing children and others to *Baylisascaris procyonis* eggs (Kazacos, 2006). Exposure to non-raccoon procyonids would also involve areas to which they have access, including cages or enclosures where they may be kept.

Although the prevalence of clinical *Baylisascaris procyonis* infection in humans is relatively low and mostly restricted to a specific subset of the population, recent developments in serological testing for *Baylisascaris procyonis* suggest that subclinical infections are common. In the past, using ELISA to test for the presence of antibodies to *Baylisascaris procyonis* excretory-secretory antigens (BPES) in a patient's serum or CSF has not been definitive in the diagnosis of baylisascariasis due to a one-way cross reactivity with *Toxocara* spp.; this resulted in a specificity of only 39.4% for the BPES ELISA (Dangoudoubiyam and Kazacos, 2009; Dangoudoubiyam et al., 2011). Western blotting of patient serum/CSF positive for anti-*Baylisascaris procyonis* antibodies demonstrates more diagnostic strength in conjunction with BPES ELISA, but cross reactivity remains a problem as well as the more involved nature of performing a western blot. Difficulties also arise when there are potential infections with multiple parasite species. There was at least one case of a likely dual-infection with *Baylisascaris procyonis* and *Toxocara* spp. based on ELISA and western blotting reported in a recent study (Dangoudoubiyam and Kazacos, 2009). Recently developed recombinant antigens have shown much greater sensitivity (88%) and specificity (98%) in the diagnosis of baylisascariasis (Dangoudoubiyam et al., 2010, 2011; Rascoe et al., 2013). Recombinant antigen serology demonstrated a seroprevalence of 11% in humans with unknown or suspected parasitic infection (Dangoudoubiyam et al., 2011). This coincides with the national seroprevalence of *Toxocara* spp. of 14%, a parasite with similar distribution and exposure levels in North America (Dangoudoubiyam et al., 2011; Won et al., 2008). These findings indicate that the prevalence of subclinical baylisascariasis is higher than the occurrence of clinical disease suggests.

1.2 Non-Raccoon Procyonids

Concerning non–raccoon procyonids as potential sources of *Baylisascaris procyonis* infection, several kinkajous (*Potos flavus*) that were being kept as pets were recently found to have patent *Baylisascaris* infections and were shedding infective eggs in the U.S. (Kazacos et al., 2011) and Japan (Taira et al., 2013). *Baylisascaris procyonis* had been described previously in a kinkajou from South America and an experimentally infected olingo (*Bassaricyon gabbii*) (Overstreet, 1970), so a precedent existed. It is suspected that in addition to kinkajous and olingos, other members of the Procyonidae family could also act as definitive hosts and pose a risk to owners and caretakers. There is anecdotal evidence of patent *Baylisascaris procyonis* infection in a coati in a wildlife sanctuary in the Netherlands (H. van Bolhuis, pers. comm. to K. R. Kazacos, 2012). A recent study by Tokiwa and colleagues has described a new species, *Baylisascaris potosis*, from wild kinkajous from the Cooperative Republic of Guyana (Tokiwa et al., 2014). It is unclear whether or not *B. procyonis*, *B. potosis*, or other species of *Baylisascaris* are prevalent in captive populations of non-raccoon procyonids, as well as the degree of their cross-infectivity.

The patent infections which were described in kinkajous and olingos support the indication that other new-world non-raccoon procyonids can also act as definitive hosts of *Baylisascaris* spp., and possibly *B. procyonis* (Kazacos et al., 2011; Overstreet, 1970). If this is true, *Baylisascaris* exposure is an important consideration for owners and handlers of these animals especially as members of this taxa become more popular as family pets. Children in families with procyonid pets are of particular concern as most young children engage in pica to some degree and cannot be trusted to follow appropriate hygiene procedures such as hand washing.

Beyond the scope of this study, it is also noted that the habitat range of ringtails and coatis overlap with the common raccoon making *Baylisascaris procyonis* a potential health risk throughout Central and South America if these animals can serve as definitive hosts for this parasite. In addition, the ability of coatis and ringtails to facilitate the spread of *Baylisascaris procyonis* is also likely significant as they share several distinct behavioral and dietary characteristics, namely that they are semi-terrestrial and omnivorous (Hass, 2002; Koepfli et al., 2007). Although vertebrate prey constitutes less than 10% of the natural diet of coatis (Whiteside, 2009), facultative consumption of small granivores, which are common paratenic hosts of *Baylisascaris procyonis* and are significant sources of the parasite in transmission to raccoons, is suspected. In contrast, kinkajous and olingos, which have been confirmed to carry *Baylisascaris* spp., are highly frugivorous and mostly arboreal which alters the scenarios in which they would be naturally exposed to *Baylisascaris* spp., although natural infections do occur (Koepfli et al., 2007; Overstreet, 1970). Kinkajous in captive breeding facilities were introduced infected from the wild in Guyana and then perpetuated the infection in their enclosures, from which it spread to other facilities (Kazacos et al., 2011); therefore they may have been infected with *B. potosis* (Tokiwa et al., 2014). It is possible that kinkajous could also acquire *Baylisascaris procyonis* from wild raccoons depositing feces near their outdoor enclosures, and vice-versa could lead to infection of local paratenic hosts and raccoons.

Prevalence of *Baylisascaris* spp. infection has not been determined in kinkajous, coatis (*Nasua* ssp.), olingos, or ringtails (*Bassariscus astutus*) either in the wild or kept in captivity. Nor has there been an assessment of risk of human exposure to *Baylisascaris* via these potential definitive hosts in scenarios where human contact is likely, such as zoos, breeding facilities and private collections. It is hoped that the research described in this proposal will help answer a number of these questions concerning *Baylisascaris* infection in non-raccoon procyonid hosts.

CHAPTER 2. METHODS

2.1 Fecal Examination

Fecal samples from kinkajous, coatis, ringtails, and olingos were requested from the following sources:

1. Zoological organizations
2. Breeding facilities
3. Private collections
4. Rescues and sanctuaries

They were submitted in sealed Ziploc bags or plastic containers. Precautions were taken to prevent human exposure to *Baylisascaris* from eggs, adult worms, or potentially contaminated feces. These included the use of protective disposable gloves, lab coats/aprons, restricted access of unauthorized personnel in work areas, and appropriate disposal and/or decontamination of all processing materials and instruments via autoclaving.

The fecal samples were examined via fecal flotation for the presence of *Baylisascaris* eggs using Sheather's sugar flotation solution at specific gravity 1.25-1.27, according to the following method:

1. Mix 1-2 grams of feces with Sheather's sugar solution in a fecal cup.

2. Strain feces through cheesecloth into a centrifuge tube, and then fill the tube to form a slight reverse meniscus on the top.
3. Carefully place the tube into the centrifuge; use a proper balance tube.
4. Apply a coverslip to the top of the tube and gently seat it in place. Centrifuge at 1200-1500 RPM for 5 minutes.
5. Gently remove the coverslip by pulling straight up; place it on a microscope slide. Examine with a 10x objective for parasite eggs, larvae, oocysts, etc. Use higher magnification to examine eggs and confirm identification.
6. Report the types of parasite eggs, larvae, oocysts, etc. seen and the amount (i.e. rare, few, moderate, many). If no parasites are seen, report as “no parasites seen”.

2.2 Questionnaire survey

A questionnaire was sent to the participating facilities to assess the general knowledge of *Baylisascaris procyonis* and the risks associated with working with definitive hosts and this parasite. Specific aims were to determine the level of risk handlers, caretakers, and owners of non-raccoon procyonid definitive hosts are being exposed to concerning *Baylisascaris* spp. and to determine if appropriate measures are being taken to prevent exposure and infection.

Upon conclusion of a facility’s participation, an informational pamphlet was provided to review the ideal methods of avoiding exposure and handling parasite contaminated objects or materials, as well as guidelines regarding routine parasite screening and prophylactic treatment of animals as a means to reduce the risk of human exposure to *Baylisascaris* spp.

2.3 Statistical Analysis

Statistical analysis was performed using the statistical software package Stata. A Fisher's exact test was used to assess the relationship between categorical variables. Statistical significance was assigned at a significance level $\alpha = 0.05$.

CHAPTER 3. RESULTS

3.1 Prevalence

Of one hundred seventy-one individual fecal samples which were received for examination, seventy-six were selected for statistical analysis. Samples from mammalian species present in inadequate numbers or which did not have paired questionnaire data were excluded from analysis. The three species of interest with adequate samples obtained were *Nasua* spp. (coati, n=30), *Procyon lotor* (raccoon, n=23), and *Potos flavus* (kinkajou, n=15). Fecal examination results are expressed as any of four categories: *Baylisascaris* sp. seen (Baylis+ or B+) (Figs. 3.1, 3.2), other helminth species seen (Helminths), protozoal species seen (Protozoa), and no parasites seen (NPS). Fecal samples were paired with premises which fell into one of six categories as follows: American Zoological Association (AZA) accredited zoological facility (n=24), non-AZA accredited zoological facility (n=18), animal rescue/wildlife sanctuary (n=14), animal entertainment business (n=7), personal pets (n=7), or other (n=3).

The prevalences of *Baylisascaris* sp. eggs present in the feces of captive coatis, raccoons, and kinkajous were 6.7%, 8.7%, and 13.3%, respectively. There was no statistically significant difference in prevalence of *Baylisascaris* spp. infection among the three species in captivity.

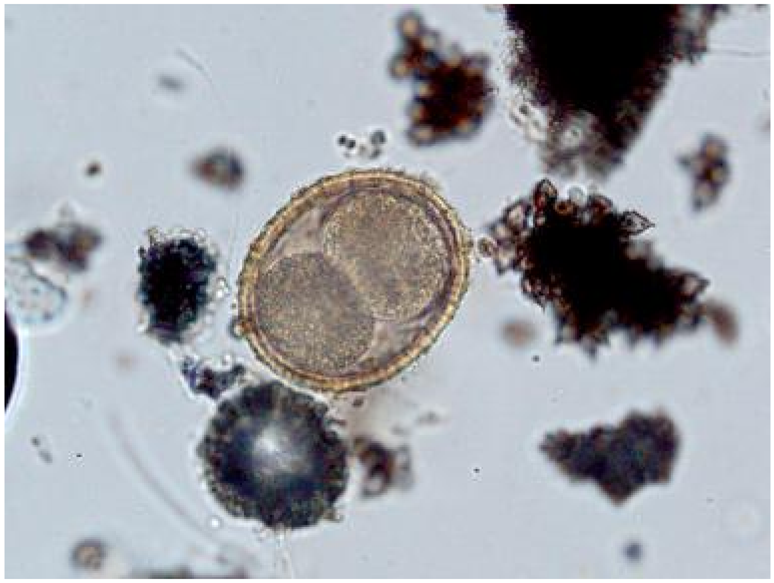

Figure 3.1 Sample 101 - *Baylisascaris procyonis* egg recovered from a captive raccoon that has begun to morulate. (x400).

Figure 3.2 Sample 68 - *Baylisascaris* sp. recovered from a captive kinkajou. Similar to figure 3.1, these eggs have begun to morulate and demonstrate morphologic characteristics very similar to known specimens of *Baylisascaris procyonis* such as the golden, coarse shell, sub-spherical to ovoid shape, and similar size. (x400).

There was no statistical significance found between *Baylisascaris* spp. positive fecal samples and the accreditation status of a premise, reported sightings of wild raccoons on the premises, the presence of protozoal parasites seen in feces, frequency of veterinary care, or housing animals at least part of the time outdoors.

Premises that housed captive raccoons were significantly more likely (p=0.004) to have other procyonids with Baylis+ feces compared to premises that did not house captive raccoons. The prevalence of Baylis+ in premises that housed captive raccoons versus those that did not house captive raccoons is 20.7% and 0%, respectively.

Samples from procyonids that had helminth eggs other than *Baylisascaris* spp. recovered from their feces were significantly more likely (p=0.037) to also be Baylis+ compared to animals for which there were no other helminth species eggs seen in the feces. The prevalence of Baylis+ in the feces of procyonids with fecal exams positive for other helminth species was 30.0% compared to the prevalence in feces without other helminths which was 5.2%

Procyonids which were reported to physically interact with other procyonids at least occasionally were significantly more likely (p=0.039) to have Baylis+ fecal examinations compared to procyonids which never interacted with other procyonids. The prevalence of Baylis+ in procyonids which had some degree of interaction was 15.0% compared to 0% in procyonids which never interacted with other procyonids.

A basic knowledge of *Baylisascaris procyonis* as well as a variety of human behaviors were investigated as potential risk factors for human exposure to *Baylisascaris procyonis* using an electronic survey program. Questionnaires were directed to individuals responsible for day to day care of the captive species of interest such as lead zoo keepers, owners, or rescue caretakers. Each response represents one premise housing captive procyonids. Of the respondents, 37% (n=14) had no prior knowledge of raccoon roundworm, 32% (n=12) did not know whether raccoon roundworm could be transmitted from raccoons to other species, 30% (n=11) did not know that raccoon roundworm could be transmitted to people, 11% (n=4) did not think and 43% (n=16) did not know that their captive animals may serve as hosts, 44% (n=16) did not and 3% (n=1) did not remember speaking with their veterinarian about raccoon roundworm, 19% (n=7) did not routinely wash hands after touching animals, 3% (n=1) did not wash hands after cleaning animal habitats, 22% (n=8) did not wash hands after handling food or water bowls, 3% (n=1) did not wash hands after removing feces, 8% (n=3) did not wash hands prior to eating, and 19% (n=7) reported that children regularly come in contact with captive animals.

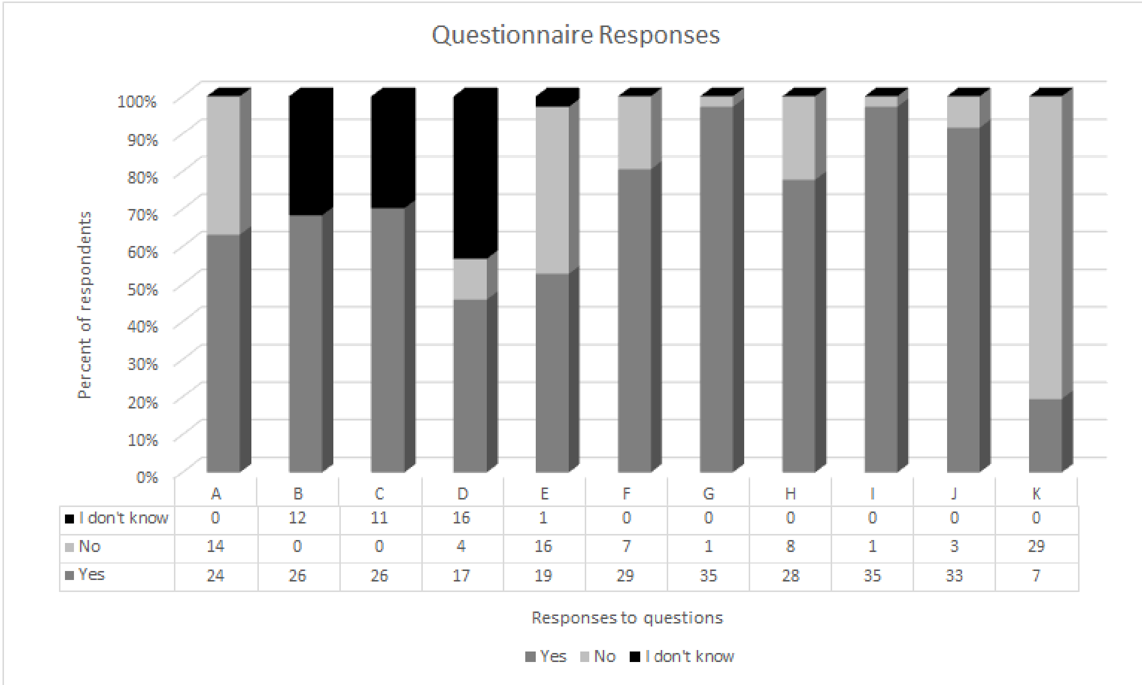

Figure 3.3 Responses for survey questions A-K. A: "Before speaking with me, had you ever heard of raccoon roundworm, *Baylisascaris procyonis*?" B: "To your knowledge, can raccoon roundworm be transmitted from raccoons to other species?" C: "To your knowledge, can raccoon roundworm be transmitted to people?" D: "Do you know if any animals you care for are able to carry raccoon roundworm?" E: "Has your veterinarian ever mentioned raccoon roundworm?" F: "Do you routinely wash your hands with soap and water after touching or holding any animals?" G: "Do you routinely wash your hands with soap and water after cleaning animal habitats or caging?" H: "Do you routinely wash your hands with soap and water after dandling any food or water bowls?" I: "Do you routinely wash your hands with soap and water after removing feces from the habitat or yard?" J: "Do you routinely wash your hands with soap and water before eating?" K: "Are there children which regularly come in contact with the animals in your care?"

Table 3.1 Summary of Results

Variables compared using Fisher's exact test	**P value**
Facilities that house raccoons vs. animals positive for *Baylisascaris* spp.	0.004
Animals that are positive for helminthes other than *Baylisascaris* spp. vs animals that are positive for *Baylisascaris* spp.	0.037
Wild raccoon sightings vs. animals positive for *Baylisascaris* spp.	0.562
AZA accreditation of a facility vs. animals positive for *Baylisascaris* spp.	0.658
Animals positive for protozoal spp. vs. animals positive for *Baylisascaris* spp.	1.000
Outdoor housing vs. animals positive for *Baylisascaris* spp.	0.078
Direct interaction between procyonids vs. animals positive for *Baylisascaris* spp.	0.039

CHAPTER 4. DISCUSSION

4.1 Prevalence

The results of the study indicate that, in addition to raccoons, coatis and kinkajous serve as important hosts for the intestinal helminth, *Baylisascaris* spp. The actual species involved, *B. procyonis*, *B. potosis*, or another *Baylisascaris* sp., was not determined, and molecular methods may be necessary for such identification. It is possible that, even if they have their own *Baylisascaris* species, cross-infectivity could occur, with non-raccoon hosts becoming infected with *B. procyonis*; but this has not been examined. Environmental factors such as being housed at a premise that also houses captive raccoons, being allowed direct interaction with other procyonids, and infection with other helminth species are associated with increased prevalence of patent baylisascariasis in these species. This study also confirms that kinkajous can serve as definitive host for a species of *Baylisascaris*, possibly either *B. procyonis* or *B. potosis*, as well as that coatis serve as host for at least one species of *Baylisascaris*.

Housing of captive raccoons was found to be a significant risk factor for infection with *Baylisascaris* which indicates that captive raccoons are likely an important source of *Baylisascaris procyonis* in captive animals. The absence of captive raccoons was perfectly predictive of no *Baylisascaris* being recovered on fecal examination of other procyonids. Many of the premises represented in the study consisted of zoological facilities and rescue organizations which often had numerous species present, including raccoons. Given the high prevalence of

Baylisascaris procyonis in wild raccoons and the high numbers of eggs shed by infected raccoons, it is likely that raccoons are serving as the source of infection. It is also notable that there was not a significant relationship between exposure to the outdoors and therefore potentially wild raccoons and an increased prevalence of *Baylisascaris* indicating that most of the infections in captive animals are likely coming from other captive animals and not a wild source. It is also possible that infections in non-raccoon procyonids were introduced previously in similar animals brought into the facilities, but this could not be examined. Although the results of the fecal examinations were not confirmed molecularly, the morphology of the eggs recovered was consistent with known samples of *Baylisascaris procyonis*. Recent findings by Tokiwa and colleagues (2014) show that there is a *Baylisascaris* specific to kinkajous, but the finding that infection is strongly associated with the presence of captive raccoons suggests that the parasite eggs found may be *Baylisascaris procyonis*. Further investigation is needed to molecularly identify the species of *Baylisascaris* found in captive non-raccoon procyonids.

The high rate of helminthic comorbidity in procyonids can be a result of several factors and may indicate inadequate anthelminthic therapy, frequent exposure to reservoir hosts, be reflective of the ability of many helminth eggs to persist in the environment, or suggests that infection with one helminth species predisposes a host to become infected with other species, perhaps using similar transmission methods. Variables such as deworming and veterinary care were not significant relative to the prevalence of *Baylisascaris* and may play less of a role than environmental factors in the control of the parasite. Due to the other factors discussed, frequent and repeated exposure, despite annual to biannual anthelminthic treatment, is likely the source of infection. This may be due to the persistence of helminth eggs in the environment or exposure to other animals patent with helminth parasites, or a combination thereof.

Procyonid-to-procyonid interaction is also a risk factor for developing baylisascariasis, and as discussed above, is likely a component of re-exposure which can result in persistently infected animals despite what is currently considered an adequate screening and treatment program. Animal interaction via grooming behavior is an important part of *Baylisascaris procyonis* transmission in the sylvatic cycle and is likely an equally important aspect of transmission in captive animals. If animal interaction consists of animal movement between captive habitats, the contamination of a clean habitat by feces from an infected animal is likely. Young raccoons have shown an increased tendency to become exposed by *Baylisascaris procyonis* contaminated environmental fomites. Most of the questionnaire findings suggest that when animals are housed together or are allowed to interact it is only within the same species. This indicates that while captive raccoons may a source of *Baylisascaris procyonis* for other captive procyonids, it is likely through an indirect route versus direct transmission. Possible routes include feces contaminated clothing, shoes, or hands, or improperly decontaminated environments which previously housed an infected animal such as a raccoon, or infected paratenic hosts to which they may have access.

The findings of this study highlight the difficulty of controlling helminth infections, particularly in habitats which may be difficult to decontaminate or when multiple animals are housed together or are allowed to interact. From a human health perspective, not only is preventive care and routine screening of captive procyonids important, it must also be coordinated with environmental control measures to reduce transmission of the parasite. Control of the parasite is secondary, however, to the education of animal caretakers about the risks of *Baylisascaris* infection.

A lack of awareness has been demonstrated by the responses to several questions. Many respondents had no knowledge of *Baylisascaris procyonis* prior to participation in this study (37%), of its transmissibility to other animals (32%), of its zoonotic potential (30%), or of the possibility that their captive animals may serve as hosts (47%). A possible knowledge gap in the veterinary medical community has also been identified by the large number of animal caretakers (47%) that have not spoken to their veterinarian about *Baylisascaris procyonis*. This suggests that veterinarians may not be aware of the possibility of some species to serve as hosts or have failed to adequately discuss the risks associated with caring for such animals. Many questionnaire responses also described lapses in basic precautions when dealing with infectious diseases. Lapses in hand hygiene (3-22% of respondents) are concerning due to well established fecal-oral transmission of *Baylisascaris procyonis*. Kinkajous, coatis, and raccoons are relatively more common in captivity and may be present in rescue facilities, zoological facilities, and as personal pets. Some of the animals represented in the study are also used for educational and interactive animal demonstrations, potentially putting the public at risk. 19% of respondents reported regular, direct contact between their captive animals and children which is of particular concern considering that young age (<4 years) has been previously demonstrated to be a risk factor for the development of neural larva migrans in children. Behaviors such as pica and geophagia common in developmentally immature children and which predispose children to exposure to wild *Baylisascaris procyonis* are likely of equal significance in the domestic setting with captive animals. Based on the husbandry practices represented by the data, it is likely that some people, including possibly children, are at risk for exposure to *Baylisascaris procyonis*.

Sources of bias in this study include response bias noting that breeding facilities are underrepresented in the study and may be a significant source of *Baylisascaris* infection in captive non-raccoon procyonids. This is suggested by recent reports of *Baylisascaris* infection in pet kinkajous by Kazacos and colleagues (2011) and Taira and colleagues (2013).

In summary, this study has demonstrated that kinkajous and coatis can serve as actively shedding hosts of *Baylisascaris* spp. eggs. Infection of captive procyonids is associated with captive raccoons being housed on the same premises, direct interaction with other procyonids, and concurrent infection with another helminth species. Re-exposure is also the most likely cause of parasitism in the animals investigated as regular screening or treatment was not significantly associated with infection or infection-free animals. These findings indicate that coordinated environmental decontamination for *Baylisascaris* spp. eggs, isolation of new or suspect animals, and preventive screening and therapeutics are important for minimizing the presence of *Baylisascaris* in the domestic environment, and therefore minimizing human exposure. Educational materials should also be distributed to owners and caretakers of all procyonid species, not only raccoons, about the dangers of *Baylisascaris* infection and the appropriate ways to prevent exposure and control this parasite

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APPENDICES

Appendix A Photomicrographs

Figure A 1 Sample 65 *Procyon lotor* – Unknown *Capillaria* sp. egg

Figure A 2 Sample 71 *Potos flavus* – *Baylisascaris* sp. egg

Figure A 3 Sample 78 *Procyon lotor* – two coccidian oocysts

Figure A 4 Sample 78 *Procyon lotor* – *Strongyloides procyonis* egg

Figure A 5 Sample 82 *Procyon lotor* – Coccidian oocyst

Figure A 6 Sample 83 *Procyon lotor* – many coccidian oocysts

Figure A 7 Sample 111 *Nasua nasua* – *Baylisascaris* sp. egg (morulated)

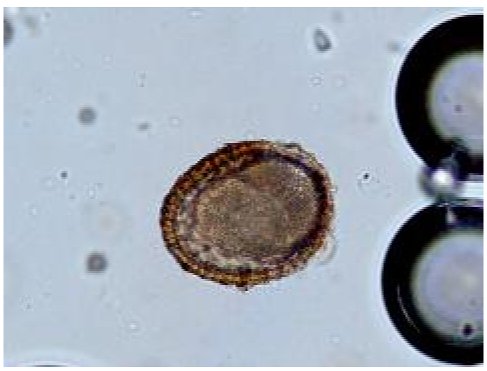

Figure A 8 Sample 112 *Nasua nasua* – *Baylisascaris* sp. egg (morulated)

Figure A 9 Sample 121 *Procyon lotor* – Unkown *Capillaria* sp. egg

Figure A 10 Sample 121 *Procyon lotor* – two coccidian oocysts

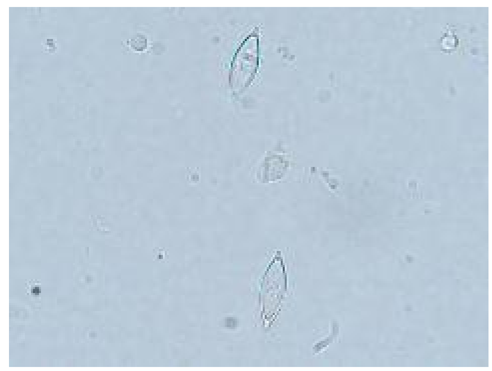

Figure A 11 Sample 161 *Procyon lotor* – *Monocystis* sp. sporocysts

Figure A 12 Sample 163 *Nasua nasua* – Coccidian oocyst with micropyle

Appendix B Fecal Samples

Table B 1 Fecal Samples

Sample#	Species	Result	Zip code	City, State	Type of Facility
4	*Potos flavus*	NPS	32909	Palm Bay, FL	Personal pets
8	*Potos flavus*	NPS	07097	Jersey City, NJ	Animal entertainment business
9	*Potos flavus*	NPS	78201	San Antonio, TX	Personal pets
10	*Procyon lotor*	NPS	79605	Abilene, TX	Zoo facility - AZA accredited
11	*Potos flavus*	NPS	88130	Portales, NM	Zoo facility - AZA accredited
12	*Nasua* sp.	NPS	88130	Portales, NM	Zoo facility - AZA accredited
16	*Nasua* sp.	NPS	72203	Little Rock, AR	Zoo facility - AZA accredited
17	*Nasua* sp.	NPS	72203	Little Rock, AR	Zoo facility - AZA accredited
21	*Procyon lotor*	NPS	98108	Tukwila, WA	Zoo facility - non-AZA accredited
22	*Procyon lotor*	NPS	98108	Tukwila, WA	Zoo facility - non-AZA accredited
23	*Procyon lotor*	NPS	98108	Tukwila, WA	Zoo facility - non-AZA accredited
24	*Procyon lotor*	NPS	98108	Tukwila, WA	Zoo facility - non-AZA accredited
25	*Procyon lotor*	*Baylisascaris* sp., helminth	98108	Tukwila, WA	Zoo facility - non-AZA accredited
32	*Procyon lotor*	NPS	78701	Austin, TX	Zoo facility - non-AZA accredited
33	*Nasua* sp.	NPS	78701	Austin, TX	Zoo facility - non-AZA accredited
34	*Procyon lotor*	NPS	14450	Fairport, NY	Zoo facility - non-AZA accredited
35	*Nasua* sp.	NPS	02121	Boston, MA	Animal entertainment business
36	*Nasua* sp.	NPS	02121	Boston, MA	Animal entertainment business
37	*Nasua* sp.	NPS	02121	Boston, MA	Animal entertainment business
38	*Nasua* sp.	NPS	02121	Boston, MA	Animal entertainment business
41	*Nasua* sp.	NPS	80841	Air Force Academy, CO	Zoo facility - AZA accredited

Table 2.2 continued

42	*Procyon lotor*	Protozoa, helminth	21201	Baltimore, MD	Zoo facility - AZA accredited
47	*Nasua* sp.	NPS	28201	Charlotte, NC	Zoo facility - AZA accredited
48	*Nasua* sp.	NPS	28201	Charlotte, NC	Zoo facility - AZA accredited
49	*Nasua* sp.	NPS	28201	Charlotte, NC	Zoo facility - AZA accredited
53	*Procyon lotor*	NPS	94401	San Mateo, CA	Zoo facility - AZA accredited
60	*Potos flavus*	NPS	78201	San Antonio, TX	Zoo facility - non-AZA accredited
61	*Potos flavus*	NPS	78201	San Antonio, TX	Zoo facility - non-AZA accredited
62	*Nasua* sp.	NPS	78201	San Antonio, TX	Zoo facility - non-AZA accredited
63	*Nasua* sp.	NPS	78201	San Antonio, TX	Zoo facility - non-AZA accredited
65	*Procyon lotor*	Helminth	53562	Madison, WI	Zoo facility - non-AZA accredited
67	*Nasua* sp.	Helminth	91335	Raseda, CA	Zoo facility - non-AZA accredited
68	*Potos flavus*	*Baylisascaris* sp.	91335	Raseda, CA	Zoo facility - non-AZA accredited
69	*Nasua* sp.	NPS	91335	Raseda, CA	Zoo facility - non-AZA accredited
70	*Procyon lotor*	NPS	91335	Raseda, CA	Zoo facility - non-AZA accredited
71	*Potos flavus*	*Baylisascaris* sp., helminth	91335	Raseda, CA	Zoo facility - non-AZA accredited
73	*Nasua* sp.	NPS	60290	Chicago, IL	Zoo facility - AZA accredited
76	*Nasua* sp.	NPS	58501	Bismark, ND	Zoo facility - AZA accredited
78	*Procyon lotor*	Protozoa, helminth	58501	Bismark, ND	Zoo facility - AZA accredited
79	*Procyon lotor*	NPS	58501	Bismark, ND	Zoo facility - AZA accredited
85	*Procyon lotor*	Protozoa	91775	San Gabriel, CA	Animal rescue/wildlife sanctuary
86	*Nasua* sp.	Helminth	32011	Nassau Village-Ratliff, FL	Animal rescue/wildlife sanctuary
87	*Nasua* sp.	NPS	32011	Nassau Village-Ratliff, FL	Animal rescue/wildlife sanctuary

Table 2.2 continued

88	*Potos flavus*	NPS	37201	Nashville, TN	Zoo facility - AZA accredited
90	*Procyon lotor*	NPS	84663	Springville, UT	Animal entertainment business
101	*Procyon lotor*	*Baylisascaris* sp.	80840	Colorado Springs, CO	Zoo facility - AZA accredited
102	*Potos flavus*	NPS	77001	Houston, TX	Animal entertainment business
109	*Procyon lotor*	NPS	91701	Rancho Cucamonga, CA	Other
111	*Nasua* sp.	*Baylisascaris* sp.	85345	Peoria, AZ	Animal rescue/wildlife sanctuary
112	*Nasua* sp.	*Baylisascaris* sp., helminth	85345	Peoria, AZ	Animal rescue/wildlife sanctuary
118	*Procyon lotor*	NPS	48601	Saginaw, MI	Personal pets
122	*Potos flavus*	NPS	61085	Stockton, IL	Animal rescue/wildlife sanctuary
123	*Potos flavus*	NPS	61085	Stockton, IL	Animal rescue/wildlife sanctuary
127	*Potos flavus*	Helminth	06901	Stamford, CT	Other
128	*Potos flavus*	NPS	06901	Stamford, CT	Other
131	*Nasua* sp.	NPS	11953	Middle Island, NY	Animal rescue/wildlife sanctuary
132	*Potos flavus*	Helminth	11953	Middle Island, NY	Animal rescue/wildlife sanctuary
140	*Nasua* sp.	NPS	76856	Mason, TX	Personal pets
141	*Nasua* sp.	NPS	76856	Mason, TX	Personal pets
142	*Nasua* sp.	NPS	76856	Mason, TX	Personal pets
143	*Nasua* sp.	NPS	76856	Mason, TX	Personal pets
144	*Procyon lotor*	NPS	85001	Phoenix, AZ	Animal rescue/wildlife sanctuary
145	*Nasua* sp.	Protozoa	83401	Idaho Falls, ID	Zoo facility - AZA accredited
146	*Nasua* sp.	NPS	83401	Idaho Falls, ID	Zoo facility - AZA accredited
147	*Nasua* sp.	NPS	83401	Idaho Falls, ID	Zoo facility - AZA accredited
158	*Procyon lotor*	NPS	78347	Chapman Ranch, TX	No Response
159	*Nasua* sp.	Protozoa	78347	Chapman Ranch, TX	No Response
160	*Nasua* sp.	NPS	78347	Chapman Ranch, TX	No Response

Table 2.2 continued

161	*Procyon lotor*	NPS	52641	Mount Pleasant, IA	Animal rescue/wildlife sanctuary
162	*Procyon lotor*	NPS	52641	Mount Pleasant, IA	Animal rescue/wildlife sanctuary
163	*Nasua* sp.	Protozoa	92260	Palm Desert, CA	Zoo facility - AZA accredited
164	*Nasua* sp.	Protozoa	92260	Palm Desert, CA	Zoo facility - AZA accredited
167	*Procyon lotor*	Protozoa	65801	Springfield, MO	Zoo facility - AZA accredited
168	*Potos flavus*	NPS	27344	Siler City, NC	Animal rescue/wildlife sanctuary
169	*Potos flavus*	NPS	27344	Siler City, NC	Animal rescue/wildlife sanctuary

Appendix C Questionnaire Survey

What is your first and last name? This will be used strictly for record keeping and no personal information will be made public or sold/given to any agencies or organizations.

Are you representing a zoo facility, animal sanctuary/rescue, breeding facility, or similar? Or are the animals personal pets?

- ❍ Zoo facility - AZA accredited
- ❍ Zoo facility - non-AZA accredited
- ❍ Animal rescue/wildlife sanctuary
- ❍ Animal entertainment business - such as interactive animal shows or animal actors
- ❍ Breeding facility
- ❍ Personal pets
- ❍ Other ____________________

What is the name of the facility you represent?

Please select all of the animal species that you own or care for.

- ❑ Kinkajou
- ❑ Coati (coatimundi)
- ❑ Olingo
- ❑ Ring tail cat (cacomistle)
- ❑ Dog
- ❑ Cat
- ❑ Raccoon
- ❑ Possum
- ❑ Skunk
- ❑ Badger
- ❑ Domestic farm animals (e.g. horse, chicken, cow)
- ❑ Bird species
- ❑ Small mammals (e.g. rodents, rabbits)
- ❑ Primate species (e.g. capuchin monkey, marmoset)

How many kinkajous do you own or care for?

- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5
- ❍ 6
- ❍ 7
- ❍ 8
- ❍ 9
- ❍ 10
- ❍ >10

Please enter a name or identifier for all of the kinkajous in your care. If you care for more than 10, enter 10 of them below and we will contact you for the rest of the information at a later date.

Name of kinkajou 1?

Name of kinkajou 2?

Name of kinkajou 3?

Name of kinkajou 4?

Name of kinkajou 5?

Name of kinkajou 6?

Name of kinkajou 7?

Name of kinkajou 8?

Name of kinkajou 9?

Name of kinkajou 10?

How many coatis do you own or care for?

❍ 1
❍ 2
❍ 3
❍ 4
❍ 5
❍ 6
❍ 7
❍ 8
❍ 9
❍ 10
❍ >10

Please enter a name or identifier for all of the coatis in your care. If you care for more than 10, enter 10 of them below and we will contact you for the rest of the information at a later date.

Name of coati 1?

Name of coati 2?

Name of coati 3?

Name of coati 4?

Name of coati 5?

Name of coati 6?

Name of coati 7?

Name of coati 8?

Name of coati 9?

Name of coati 10?

How many olingos do you own or care for?

- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5
- ❍ 6
- ❍ 7
- ❍ 8
- ❍ 9
- ❍ 10
- ❍ >10

Please enter a name or identifier for all of the olingos in your care. If you care for more than 10, enter 10 of them below and we will contact you for the rest of the information at a later date.

Name of olingo 1?

Name of olingo 2?

Name of olingo 3?

Name of olingo 4?

Name of olingo 5?

Name of olingo 6?

Name of olingo 7?

Name of olingo 8?

Name of olingo 9?

Name of olingo 10?

How many ringtails (cacomistles) do you own or care for?

- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5
- ❍ 6
- ❍ 7
- ❍ 8
- ❍ 9
- ❍ 10
- ❍ >10

Please enter a name or identifier for all of the ringtails (cacomistles) in your care. If you care for more than 10, enter 10 of them below and we will contact you for the rest of the information at a later date.

Name of ringtail 1?

Name of ringtail 2?

Name of ringtail 3?

Name of ringtail 4?

Name of ringtail 5?

Name of ringtail 6?

Name of ringtail 7?

Name of ringtail 8?

Name of ringtail 9?

Name of ringtail 10?

Before speaking with me, had you ever heard of raccoon roundworm, Baylisascaris procyonis?

- ❍ Yes
- ❍ No

To your knowledge, can raccoon roundworm be transmitted from raccoons to other species?

- ❍ Yes
- ❍ No
- ❍ I don't know

To your knowledge, can raccoon roundworm be transmitted to people?

- ❍ Yes
- ❍ No
- ❍ I don't know

Please describe, in general terms, how raccoon roundworm is transmitted to people.

To your knowledge, what disease does it cause in people?

Do you know if any animals you care for are able to carry raccoon roundworm?

- ❍ Yes
- ❍ No
- ❍ I don't know

Has your veterinarian ever mentioned raccoon roundworm?

- ❍ yes
- ❍ No
- ❍ I don't remember

Do you routinely wash your hands with soap and water:

- ❑ After touching or holding any animals?
- ❑ After cleaning animal habitats or caging?
- ❑ After handling any food or water bowls?
- ❑ After removing feces from the habitat or yard?
- ❑ Before eating?

Are there children which regularly come in contact with the animals in your care?

- ❍ Yes
- ❍ No

Have you ever seen raccoons on the property or on the facility grounds?

- ❍ Yes
- ❍ No

Are you familiar with what raccoon latrines look like?

- ❍ Yes
- ❍ No
- ❍ I don't know

Have you ever seen raccoon latrines on the property or facility grounds?

- ❍ Yes
- ❍ No

How old is ${lm://Field/1}?

- ❍ Less than 1 year old
- ❍ 1 year old
- ❍ 2 years old
- ❍ 3 years old
- ❍ 4 years old
- ❍ 5 years old
- ❍ 6 years old
- ❍ 7 years old
- ❍ 8 years old
- ❍ 9 years old
- ❍ 10 years old
- ❍ Older than 10 years

How long have you owned ${lm://Field/1} or how long has ${lm://Field/1} been at your facility?

- ❍ Less than 1 year
- ❍ 1 year
- ❍ 2 years
- ❍ 3 years
- ❍ 4 years
- ❍ 5 years
- ❍ 6 years
- ❍ 7 years
- ❍ 8 years
- ❍ 9 years
- ❍ 10 years
- ❍ Longer than 10 years

What ${lm://Field/1}'s gender?

- ❍ Male
- ❍ Female

Is ${lm://Field/1} altered? (Neutered, castrated, spayed)

- ❍ Yes
- ❍ No

Approximately when was the last time ${lm://Field/1} saw a veterinarian familiar with ${lm://Field/1}'s species?

- ❍ Within the past 6 months
- ❍ Between 6 months and 1 year ago
- ❍ Between 1 and 2 years ago
- ❍ Longer than 2 years ago
- ❍ I don't know

How frequently is ${lm://Field/1} screened for parasites?

- ❍ Twice yearly
- ❍ Yearly
- ❍ About every two years
- ❍ Less often than every two years
- ❍ Never
- ❍ I don't know

Approximately when was the last time ${lm://Field/1} was screened for parasites?

- ❍ Within the past 6 months
- ❍ Between 6 months and 1 year ago
- ❍ Between 1 and 2 years ago
- ❍ Longer than 2 years ago
- ❍ Never
- ❍ I don't know

What was the result of the most recent fecal exam?

- ❍ There were no parasites seen
- ❍ There were parasites seen. Please list as many of the parasites as you can: ____________________

Does ${lm://Field/1} receive regular deworming medication?

- ❍ No
- ❍ If yes, what dewormer was used? List multiple dewormers if more than one was used. ____________________

Was ${lm://Field/1} captive bred or wild caught?

- ❍ Captive bred
- ❍ Wild caught
- ❍ I don't know

Does ${lm://Field/1} come in contact with other kinkajous? Select all that apply

- ❑ It is housed with other kinkajous
- ❑ It occasionally interacts with other kinkajous owned by you or your facility
- ❑ It occasionally interacts with other kinkajous owned by others
- ❑ It never comes in contact with other kinkajous

Is ${lm://Field/1} housed indoors or outdoors?

- ❍ It is housed outdoors
- ❍ It is housed indoors
- ❍ It is sometimes housed outdoors and sometimes housed indoors

Is ${lm://Field/1} a pet (lives at least part time in the home such as in a bedroom or living room) or does ${lm://Field/1} live exclusively separated from the domestic environment (e.g. in an out building such as with breeding animals or in an enclosed habitat such as at a zoo.)

- ❍ Lives in the home
- ❍ Lives in an area/building separated from people

To your knowledge, has ${lm://Field/1} ever had contact with any wildlife?

- ❍ Yes
- ❍ No

Have you seen any wild raccoons, possums, or skunks near ${lm://Field/1}'s housing?

- ❍ Yes
- ❍ No

How old is ${lm://Field/1}?

- Less than 1 year old
- 1 year old
- 2 years old
- 3 years old
- 4 years old
- 5 years old
- 6 years old
- 7 years old
- 8 years old
- 9 years old
- 10 years old
- Older than 10 years

How long have you owned ${lm://Field/1} or how long has ${lm://Field/1} been at your facility?

- Less than 1 year
- 1 year
- 2 years
- 3 years
- 4 years
- 5 years
- 6 years
- 7 years
- 8 years
- 9 years
- 10 years
- Longer than 10 years

What ${lm://Field/1}'s gender?

- Male
- Female

Is ${lm://Field/1} altered? (Neutered, castrated, spayed)

- Yes
- No

Approximately when was the last time ${lm://Field/1} saw a veterinarian familiar with ${lm://Field/1}'s species?

- Within the past 6 months
- Between 6 months and 1 year ago
- Between 1 and 2 years ago
- Longer than 2 years ago
- I don't know

How frequently is ${lm://Field/1} screened for parasites?

- Twice yearly
- Yearly
- About every two years
- Less often than every two years
- Never
- I don't know

Approximately when was the last time ${lm://Field/1} was screened for parasites?

- Within the past 6 months
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- Between 1 and 2 years ago
- Longer than 2 years ago
- Never
- I don't know

What was the result of the most recent fecal exam?

- ❍ There were no parasites seen
- ❍ There were parasites seen. Please list as many of the parasites as you can: ____________________

Does ${lm://Field/1} receive regular deworming medication?

- ❍ No
- ❍ If yes, what dewormer was used? List multiple dewormers if more than one was used. ____________________

Was ${lm://Field/1} captive bred or wild caught?

- ❍ Captive bred
- ❍ Wild caught
- ❍ I don't know

Does ${lm://Field/1} come in contact with other coatis? Select all that apply

- ❑ It is housed with other kinkajous
- ❑ It occasionally interacts with other kinkajous owned by you or your facility
- ❑ It occasionally interacts with other kinkajous owned by others
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- ❍ Lives in the home
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To your knowledge, has ${lm://Field/1} ever had contact with any wildlife?

- ❍ Yes
- ❍ No

Have you seen any wild raccoons, possums, or skunks

near ${lm://Field/1}'s housing?

- ❍ Yes
- ❍ No

How old is ${lm://Field/1}?

- ❍ Less than 1 year old
- ❍ 1 year old
- ❍ 2 years old
- ❍ 3 years old
- ❍ 4 years old
- ❍ 5 years old
- ❍ 6 years old
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- ❍ 8 years old
- ❍ 9 years old
- ❍ 10 years old
- ❍ Older than 10 years

How long have you owned ${lm://Field/1} or how long has ${lm://Field/1} been at your facility?

- Less than 1 year
- 1 year
- 2 years
- 3 years
- 4 years
- 5 years
- 6 years
- 7 years
- 8 years
- 9 years
- 10 years
- Longer than 10 years

What ${lm://Field/1}'s gender?

- Male
- Female

Is ${lm://Field/1} altered? (Neutered, castrated, spayed)

- Yes
- No

Approximately when was the last time ${lm://Field/1} saw a veterinarian familiar with ${lm://Field/1}'s species?

- Within the past 6 months
- Between 6 months and 1 year ago
- Between 1 and 2 years ago
- Longer than 2 years ago
- I don't know

How frequently is ${lm://Field/1} screened for parasites?

- ❍ Twice yearly
- ❍ Yearly
- ❍ About every two years
- ❍ Less often than every two years
- ❍ Never
- ❍ I don't know

Approximately when was the last time ${lm://Field/1} was screened for parasites?

- ❍ Within the past 6 months
- ❍ Between 6 months and 1 year ago
- ❍ Between 1 and 2 years ago
- ❍ Longer than 2 years ago
- ❍ Never
- ❍ I don't know

What was the result of the most recent fecal exam?

- ❍ There were no parasites seen
- ❍ There were parasites seen. Please list as many of the parasites as you can: ____________________

Does ${lm://Field/1} receive regular deworming medication?

- ❍ No
- ❍ If yes, what dewormer was used? List multiple dewormers if more than one was used. ____________________

Was ${lm://Field/1} captive bred or wild caught?

- ❍ Captive bred
- ❍ Wild caught
- ❍ I don't know

Does ${lm://Field/1} come in contact with other olingos? Select all that apply

- ❑ It is housed with other kinkajous
- ❑ It occasionally interacts with other kinkajous owned by you or your facility
- ❑ It occasionally interacts with other kinkajous owned by others
- ❑ It never comes in contact with other kinkajous

Is ${lm://Field/1} housed indoors or outdoors?

- ❍ It is housed outdoors
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- ❍ It is sometimes housed outdoors and sometimes housed indoors

Is ${lm://Field/1} a pet (lives at least part time in the home such as in a bedroom or living room) or does ${lm://Field/1} live exclusively separated from the domestic environment (e.g. in an out building such as with breeding animals or in an enclosed habitat such as at a zoo.)

- ❍ Lives in the home
- ❍ Lives in an area/building separated from people

To your knowledge, has ${lm://Field/1} ever had contact with any wildlife?

- ❍ Yes
- ❍ No

Have you seen any wild raccoons, possums, or skunks

near ${lm://Field/1}'s housing?

- ❍ Yes
- ❍ No

How old is ${lm://Field/1}?

- ❍ Less than 1 year old
- ❍ 1 year old
- ❍ 2 years old
- ❍ 3 years old
- ❍ 4 years old
- ❍ 5 years old
- ❍ 6 years old
- ❍ 7 years old
- ❍ 8 years old
- ❍ 9 years old
- ❍ 10 years old
- ❍ Older than 10 years

How long have you owned ${lm://Field/1} or how long has ${lm://Field/1} been at your facility?

- ❍ Less than 1 year
- ❍ 1 year
- ❍ 2 years
- ❍ 3 years
- ❍ 4 years
- ❍ 5 years
- ❍ 6 years
- ❍ 7 years
- ❍ 8 years
- ❍ 9 years
- ❍ 10 years
- ❍ Longer than 10 years

What ${lm://Field/1}'s gender?

- ❍ Male
- ❍ Female

Is ${lm://Field/1} altered? (Neutered, castrated, spayed)

- Yes
- No

Approximately when was the last time ${lm://Field/1} saw a veterinarian familiar with ${lm://Field/1}'s species?

- Within the past 6 months
- Between 6 months and 1 year ago
- Between 1 and 2 years ago
- Longer than 2 years ago
- I don't know

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- Twice yearly
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- About every two years
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What was the result of the most recent fecal exam?

- ❍ There were no parasites seen
- ❍ There were parasites seen. Please list as many of the parasites as you can: ____________________

Does ${lm://Field/1} receive regular deworming medication?

- ❍ No
- ❍ If yes, what dewormer was used? List multiple dewormers if more than one was used. ____________________

Was ${lm://Field/1} captive bred or wild caught?

- ❍ Captive bred
- ❍ Wild caught
- ❍ I don't know

Does ${lm://Field/1} come in contact with other ringtails? Select all that apply

- ❑ It is housed with other kinkajous
- ❑ It occasionally interacts with other kinkajous owned by you or your facility
- ❑ It occasionally interacts with other kinkajous owned by others
- ❑ It never comes in contact with other kinkajous

Is ${lm://Field/1} housed indoors or outdoors?

- ❍ It is housed outdoors
- ❍ It is housed indoors
- ❍ It is sometimes housed outdoors and sometimes housed indoors

Is ${lm://Field/1} a pet (lives at least part time in the home such as in a bedroom or living room) or does ${lm://Field/1} live exclusively separated from the domestic environment (e.g. in an out building such as with breeding animals or in an enclosed habitat such as at a zoo.)

❍ Lives in the home
❍ Lives in an area/building separated from people

To your knowledge, has ${lm://Field/1} ever had contact with any wildlife?

❍ Yes
❍ No

Have you seen any wild raccoons, possums, or skunks near ${lm://Field/1}'s housing?

❍ Yes
❍ No

Which of the following species that you care for have veterinary care and parasite screening at least yearly?

❑ Dog
❑ Cat
❑ Raccoon
❑ Possum
❑ Skunk
❑ Farm animals
❑ Birds
❑ Small mammals
❑ Primates
❑ I don't know

Which of the following species that you care for have contact with other procyonids (kinkajou, coati, ring tail, olingo) that you care for?

- ❑ Dog
- ❑ Cat
- ❑ Raccoon
- ❑ Possum
- ❑ Skunk
- ❑ Farm animals
- ❑ Birds
- ❑ Small mammals
- ❑ Primates
- ❑ None

To your knowledge, raccoon roundworm poses a health risk to which of the following species that you care for?

- ❑ Dog
- ❑ Cat
- ❑ Raccoon
- ❑ Possum
- ❑ Skunk
- ❑ Farm animals
- ❑ Birds
- ❑ Small mammals
- ❑ Primates
- ❑ None
- ❑ I don't know

Have any of the following species that you care for ever been diagnosed with a raccoon roundworm infection?

- ❑ Dog
- ❑ Cat
- ❑ Raccoon
- ❑ Possum
- ❑ Skunk
- ❑ Farm animals
- ❑ Birds
- ❑ Small mammals
- ❑ Primates
- ❑ None

VITA

VITA

Education

Purdue University College of Veterinary Medicine — West Lafayette, Indiana
D.V.M. expected May 2015 — August 2011 - present

Purdue University College of Veterinary Medicine — West Lafayette, Indiana
Department of Comparative Pathobiology — May 2011 - present
M.S., Veterinary Parasitology expected May 2015

Michigan State University — East Lansing, Michigan
B.S., Animal Science, December 2009 — August 2006 – December 2009

Research Experience

Master's thesis involving literature review, project design, data collection — West Lafayette, Indiana, May 2012 - present
Prevalence of *Baylisascaris procyonis* in non-raccoon procyonids hosts and assessment of risk of human exposure.
Faculty advisor: Kevin Kazacos, DVM, PhD, DACVM (parasitology)

Assisted with data collection involving volume calculation of internal organs using CT/MRI images and 3D rendering software for several studies. — East Lansing, Michigan, April 2007 – July 2011

International Education

Small Animal Internal Medicine Clinical Externship — Switzerland and Germany, August 2014

Food, Agriculture and Natural Resource Systems in South Africa and Swaziland — South Africa, Swaziland, May 2007
Joint Animal Science and College of Veterinary Medicine Program

Specialty Practice Experience

Animal Medical Center, Interventional and Renal Medicine — New York, New York
Veterinary Intern — July 2014

Michigan State University Veterinary Teaching Hospital, Diagnostic Imaging — East Lansing, Michigan, April 2007 – July 2011
Research Assistant, Undergraduate Departmental Aide

General Practice Experience

Almost Home Humane Society — Lafayette, Indiana
Volunteer Student Surgeon — November 2013 - present

Chelsea Animal Hospital — Chelsea, Michigan
Veterinary Assistant — June 2002 – October 2010

Awards and Honors

- Purdue University College of Veterinary Medicine Dean's List — December 2011, May 2012; December 2012, May 2013; December 2013, May 2014
- Purdue University College of Veterinary Medicine Semester Honors — December 2011, May 2012; December 2012
- Michigan State University Dean's List — May 2008
- CEF Whitetails Unlimited Scholarship for Outstanding Leadership — June 2006
- Michigan Competitive Scholarship — June 2006
- Michigan Merit Award — June 2006

Continuing Education

- Merial-NIH Veterinary Scholars Symposium — July 2012
- Phi Zeta Day, Omicron Chapter — April 2012
- Student American Veterinary Medical Association Symposium — March 2012, April 2013
- Fish Anesthesia Wet Lab — February 2012

Professional Organizations and Leadership Roles

- Purdue Veterinary Medicine Open House PACUC Chair — October 2013 – May 2014
- Purdue Graduate Student Government Senator – Student Affairs Committee — January 2013 – May 2014
- Tutor – Second Year Veterinary Parasitology — August 2013 – May 2014
- Tutor – First Year Veterinary Physiology — August 2012 – May 2013
- Student Chapter of the American College of Veterinary Internal Medicine (SCACVIM) **President and Founder** — May 2012 – May 2014
- Purdue Exotic Animal Club — September 2011 – May 2013
- Student Chapter of the American Veterinary Medical Association (SCAVMA) — September 2011 – present
- Veterinary Business Management Association (VBMA) — September 2011 – present
- Student Veterinary Emergency and Critical Care Society (SVECCS) — September 2011 – May 2013
- Michigan State University Alumni Association — December 2009 – presen

Special Projects

Dive for Dogs — Tecumseh, Michigan
The American Society for the Prevention of Cruelty to Animals Fundraiser — October 2009
Founder and Organizer

Healthy Pet Surgical Suite — Okemos, Michigan
Michigan Veterinary Medical Association Summer Fair Exhibit Volunteer — June – August 2008

Chelsea Animal Hospital Spay and Neuter Program — Chelsea, Michigan
Volunteer — 2002 - 2006

Extracurricular Activities

Skydiving Coach — Tecumseh, MI
United States Parachute Associate (USPA) Licensed — June 2009 – June 2010

References

Available upon request.