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A 12-month survey of the gastro-intestinal helminths of antelopes, gazelles and giraffids kept at two zoos in Belgium

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Abstract

Faecal egg count patterns and clinical signs associated with gastro-intestinal (GI) nematodes of 107 zoo ruminants were monitored at fortnightly intervals for 1 year. The ruminants in this study were kept under different husbandry conditions at two sites of the Royal Zoological Society of Antwerp, the Antwerp Zoo and the Animal Park Planckendael. Artiodactylids involved were Arabian oryx (*Oryx leucoryx*), scimitar-horned oryx (*Oryx dammah*), bongos (*Tragelaphus euryceros isaaci*), sitatungas *(Tragelaphus spekii gratus*), common eland (*Taurotragus oryx*), impala (*Aepyceros melampus)*, slender-horned gazelles, (*Gazella leptoceros*), blue wildebeest (*Connochaetes taurinus taurinus*), Kordofan giraffes (*Giraffe camelopardalis antiquorum*) and okapi (*Okapia johnstoni*). Nematode eggs were recovered from 586 of 1606 (36.5%) individual faecal samples, using flotation techniques. Infection levels were distinctly low at Antwerp Zoo, probably due to zero grazing and daily dung removal. At Planckendael, the herds of Arabian oryx, scimitar-horned oryx and slender-horned gazelles showed markedly higher egg counts than the other herds, with more than 10% of the faecal egg counts having more than 100 eggs per gram (epg) and maximum faecal egg counts of 600, 750 and 1350 epg, respectively. Faecal egg counts increased during the mid-grazing season (July) and peaked at the end of the grazing season (October). No clinical signs, such as loss of faecal consistency, could be correlated with faecal egg counts ($P > 0.05$). With the exception of significantly more *Nematodirus* spp. eggs that were present in juvenile eland, no differences in faecal egg counts could be found between the sexes and different age groups. Abomasa and intestines of 17 animals that died during the survey were available for total worm counts. In one Arabian oryx, four slender-horned gazelles and one sitatunga low burdens ranging from 200 to 14,300 were found. Nematode species recovered were *Camelostrongylus mentulatus* from the abomasa and *Trichostrongylus retortaeformis, Nematodirus fillicollis*, *Capillaria* spp. and *Trichuris* spp. from the intestines. Our findings suggest different nematode infection levels between herds, which are mainly

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due to husbandry conditions but to a lesser extent to species- or individual susceptibility. Identification of ungulates that are highly infected and knowledge of the seasonal variation of their helminths can contribute greatly to a well-adjusted species-specific management and helminth control program.

Keywords: Antelope; *Camelostrongylus mentulatus*; Gastro-intestinal nematodes; Gazelles; *Trichostrongylus retortaeformis*; Zoo-ruminants

1. Introduction

Due to declining free-ranging populations, wild ungulates kept at zoological collections have become increasingly important as stock for conservation, exhibition and study. Consequently, knowledge of their diseases needs to be gained, especially when bred for re-introduction in the wild (Kirkwood et al., 1987). A survey conducted in zoos in North America indicated that 91 out of the 99 parks experienced problems with internal parasites in their hoofed stock (Isaza et al., 1990). Despite extensive quarantine periods, repeated faecal examinations and anthelmintic treatment to prevent their introduction, gastro-intestinal (GI) nematodes remain a serious health problem in captive wild ruminants. Studies on and case reports of zoo animals reported prevalences of GI nematodes ranging from 65 to 100%, and mortality due to parasitic gastro-enteritis, ranging from 5 to 17% (Geraghty et al., 1982; Kaneene et al., 1985; Gorman et al., 1986; Meister et al., 1993). A few case studies described the occurrence in antelopes and gazelles of severe GI nematode infections, which were caused by *Camelostrongylus* spp., *Nematodirus* spp., *Haemonchus contortus, Ostertagia* spp., *Trichostrongylus* spp. and *Trichuris* spp. (Church, 1986; Kock, 1986; Flach and Sewell, 1987). In these cases, higher faecal nematode egg counts (FEC) appeared mainly in late winter and summer and were associated with loss of body condition, diarrhoea and death of individual animals. In comparison, wild or semi-wild gazelles, antelopes and giraffids are known to host a broad spectrum of GI nematodes. In these animals, seasonal variations and worm burdens differ markedly between hosts, climatic and environmental conditions, stocking density and feeding behaviour (Horak, 1981; Boomker et al., 1986; Boomker et al., 2000). Insufficient nutrition and to a lesser extent, inbreeding, seems to especially favor nematode infections (Anderson, 1983; Cassinello et al., 2001). While the above-mentioned references indicate the widespread occurrence of GI nematodes in zoo ruminants, substantial studies about the epidemiology, factorial influences (like housing) and host population impact are limited. Among the main reasons for the lack of in-depth studies are the wild and unapproachable nature of these animals and the small group sizes, which impede the traditional approaches used in parasitological research in domesticated ruminants. Physical contact without full sedation is seldom possible, and weight, condition and illness can only be estimated by observation from a distance, often accompanied by lack of individual identification. The tendency of zoological collections to keep animals in larger mixed species enclosures and the fact that in wild animals clinical signs only become perceptible at high-disease levels, does not facilitate the assessment of infections.

In this study, a survey of 1-year duration was instigated to firstly assess patterns of faecal egg counts of 107 exotic ungulates of the zoological gardens of Antwerp, Belgium, and which were kept at two different localities. Secondly, morbidity due to gastro-intestinal nematodes was studied, by carefully recording clinical signs (e.g. loss of faecal consistency) and worm counts of animals that died during the study. Thirdly, the influences of age, sex and housing on the faecal egg count were considered.

2. Material and methods

2.1. Localities

The localities where this study took place were the Zoo of Antwerp (Antwerp, Belgium) and the Animal Park Planckendael (Mechelen, Belgium), both owned by the Royal Zoological Society of Antwerp. The localities differ substantially in husbandry conditions.

The Zoo of Antwerp is an older, typical urban zoo of about 10 ha, where animals are accommodated in enclosures with sandy soil and dung is removed daily. At the newer Planckendael, about 40 ha in extent, animals are kept at lower stocking rates in large grassy enclosures, with less opportunity to remove dung. At both sites, animals were stabled when temperatures decreased below 10 °C (from October till February). The average monthly temperature was 10.9 °C from April 2002 till April 2003 and the total rainfall was 936.2 mm and this is considered more humid and warm compared with normal average values (9.5 °C, 807.1 mm) for this period in this temperate climate.

2.2. Animals and husbandry till April

In the Antwerp Zoo, Arabian oryx (*Oryx leucoryx*), bongos (*Tragelaphus euryceros isaaci*), Kordofan giraffes (*Giraffe camelopardalis antiquorum*) and okapi (*Okapia johnstoni*) were studied. Initially, 22 animals were examined but these were increased to a total of 28 (Table 1). No routine anthelmintic treatment was administered, because no helminthosis was suspected during the preceding 5 years.

In the Animal Park Planckendael, Arabian oryx (*Oryx leucoryx)*, scimitar-horned oryx (*Oryx dammah*), common eland (*Taurotragus oryx*), slender-horned gazelles (*Gazella leptoceros*), impala (*Aepyceros melampus)*, bongos (*Tragelaphus euryceros isaaci*), sitatungas (*Tragelaphus spekii gratus*) and blue wildebeest (*Connochaetes taurinus taurinus*) were studied. A total of 79 animals were sampled (initially 64 animals) (Table 1). At this locality clinical signs of gastro-enteritis, such as loss of faecal consistency, were observed regularly during the preceding 5 years and were often attributed to helminth infections. Routine helminth control consisted of the administration of fenbendazole (FBZ) (Panacur® 4%, Intervet, Belgium) in the feed to all ruminants, at a dosage rate of 7.5 mg/kg body mass for three consecutive days twice a year. In 2002, the animals were administered with FBZ on 1 April and 10 July. The herds of Arabian oryx, scimitar-horned oryx and gazelles received an additional 3-day FBZ treatment when stabled for the winter, since clinical helminthosis had been suspected during stabling in previous years. Results of previous studies indicated that lungworms, cestodes and trematodes were absent at the two localities; therefore only GI nematodes were considered here.

2.3. Experimental design

The 1-year observation period lasted from April 2002 to April 2003 and included a complete grazing and breeding season. At least 90 and 70% of the

Table 1
Animal species, population dynamics and husbandry conditions of antelopes, gazelles and giraffids, kept at Antwerp Zoo and Animal Park Planckendael

Animal species	Herd at beginning[a]	Births	Deaths	Import	Export	Stocking density (m^2)	Enclosures	Dung removal from pasture
Antwerp Zoo								
Arabian oryx	1.2.2	–	–	–	–	1/73	Sand ground	Daily
Bongo	1.3.1	1 August	–	–	0.0.1	1/166	Sand ground, little grass	Daily
Giraffe	1.3.2	1 June	1.1.0	–	0.0.1	1/133	Sand ground	Daily
Okapi	2.3.1	2 July–Oct	–	2.0.0	1.0 0	1/171	Sand ground	Daily
Planckendael								
Arabian oryx	1.3.0	–	–	–	–	1/504	Grassy pasture	Irregular
Scimitar-horned oryx	1.5.0	1 July	0.1.0	–	–	1/378	Pasture, low-quality grass	Irregular
Gazelle	5.8.1	4 Apr–June	2.3.2	–	1.0.0	1/63	Grassy pasture	Irregular
Impala	0.4.0	–	0.1.0	–	–	1/131	Sand ground	Irregular
Common eland	1.5.1	4 Aug-Oct	0.1.1	–	–	1/377	Sand ground, little grass	Daily
Bongo	1.1.0	–	–	–	–	1/750	Wooded muddy ground	Irregular
Sitatunga	2.14.6	8 July–March	0.2.10	–	1.3.0	1/27	Sand ground, stagnant water	Daily
Wildebeest	2.3.0	3 June–Aug	–	–	1.0.0	1/249	Pasture, low-quality grass	Daily

[a] Male.female.juvenile.

animals in Antwerp and Planckendael, respectively, were sampled at each occasion and a total of 1606 individual fresh faecal samples were examined. At the Antwerp Zoo, animals were sampled monthly, whereas at Planckendael, samples were taken at fortnightly intervals, owing to the suspicion that infections might be more important and a potential clinical problem.

On collecting a freshly dropped faecal sample a faecal consistence score was given: 1 for normal droppings, 2 for mushy sticky droppings and 3 for loose or fluid faeces. Faecal samples were transported in a cool box and either immediately processed or stored for a maximum of two days at 4 °C before examination. Clinical signs, other events and reproductive status were also noted at each sampling occasion. During the observation period, 31 ruminants (17 sub-adults/adults and 14 neonates) died. A necropsy was performed on each and the viscera of 17 animals were made available for worm counts and identification.

2.4. Parasitological techniques

Faecal egg counts were determined with a modified McMaster method, using a NaCl-solution (density 1.20 at 20 °C) (Thienpont et al., 1979), with a sensitivity of 50 eggs per gram faeces (epg). When samples contained eggs, 5–10g of each of these faecal samples were incubated in glass beakers at 28 °C for 10 days, with a beaker containing samples of all animals of the herd sampled at that occasion. Larvae from those cultures were identified to the genus level and genus composition was calculated in cultures where more than 50 third-stage larvae were present (Borgsteede and Hendriks, 1974). The abomasa and intestines of 17 adult and sub-adult ruminants were processed for helminth recovery, according to standard techniques (MAFF, 1986; Ritchie et al., 1966) and in total, 2% of the worm burden was counted. The abomasal mucosa of one Arabian oryx and one gazelle were digested according to the procedures given by MAFF (1986) and Ritchie et al. (1966).

2.5. Data processing

The prevalences mentioned are annual ones where individual animals that excreted eggs during the 1-year study period are posed against the total number of animals. The variation in seasonal egg counts were calculated using the geometric mean after transformation of the individual counts to ln (count + 1). These geometric means were compared between herds by means of ANOVA (Scheffe's multiple comparisons adjustment) with period and herd as fixed effects and a *P*-value of <0.05 indicating significance (S-Plus® 6.0, Insightful Corp., Seattle, USA). The clinical importance of parasite infections was assessed by calculating the odds ratio between appearance of loss of faecal consistency (scores 2 and 3) and level of faecal egg counts (categorical 0–100, 101–300, >301). For this purpose, the Woolf procedure for point and interval estimation between category data in cross-sectional studies was used, with *P*-value <0.05 (Thrusfield, 1995) (Winepiscope© 2.0, Clive, Edinburgh, UK). To assess risk factors such as age, sex and housing in relation to egg counts, odds ratios were again calculated ($P < 0.05$).

3. Results

3.1. Faecal egg count pattern

In the Antwerp Zoo, the herd of the Arabian oryx showed the highest prevalence of nematode eggs (Table 2). However, also in species such as okapi and giraffes, which were presumed to be free of helminths, nematode eggs were found. In all the ruminants sampled at the Antwerp Zoo, the faecal egg count remained very low (<100 epg) during the whole observation period and no seasonal fluctuations were evident. The third-stage larvae recovered from faecal cultures were all *Ostertagia*-like.

In Planckendael, all animals of the herds of Arabian oryx, scimitar-horned oryx and slender-horned gazelles had strongyle-type eggs in their faeces. *Nematodirus* spp. was the dominant nematode (80.0%) in common eland and *Capillaria* spp. in sitatunga (20.8%) (Table 2). Coproculture revealed *Ostertagia*-like and *Trichostrongylus*-like third-stage larvae. The herds with the highest FEC's were the Arabian oryx, scimitar-horned oryx and slender-horned gazelles. For these herds, the geometric means over the 1-year period were 53, 24 and 24 epg, respectively. Maximum individual FEC's for these

Table 2
Percentage of individual ruminants in Antwerp Zoo and Animal Park Planckendael that were found to pass strongyle-type eggs with their faeces during the 1-year survey (annual prevalence)

Animal species	N	No. of samples	Annual prevalence (%)			
			Strongyle-type	*Nematodirus* spp.	*Capillaria* spp.	*Trichuris* spp.
Antwerp Zoo						
Arabian oryx	5	55	80.0	–	80.0	–
Bongo	6	63	–	–	66.7	16.7
Giraffe	7	70	14.3	–	–	–
Okapi	10	87	10.0	–	20.0	–
Planckendael						
Arabian oryx	4	141	100.0	50.0	50.0	–
Scimitar-horned oryx	7	193	100.0	14.3	–	–
Gazelle	20	411	100.0	–	–	40.0
Impala	4	49	–	–	–	–
Common eland	10	160	30.0	80.0	40.0	20.0
Bongo	2	50	–	–	–	–
Sitatunga	24	171	16.7	12.5	20.8	–
Wildebeest	8	136	12.5	–	12.5	–

three herds were 600, 750 and 1350 epg, respectively, and individual FEC's of >100 epg per total number of samples were encountered in 34 of 141 (24%), 18 of 177 (10%) and 71 of 411 (17%) samples, respectively. In eland, sitatunga and wildebeest, total geometric means were <1, and the maximum individual FEC's recorded remained below 100 strongyle-type eggs per gram. No eggs were recovered from faecal samples of impala and bongos.

The seasonal egg count patterns of the herds of Arabian oryx, scimitar-horned oryx and gazelle are presented in Fig. 1. A first rise in egg counts was observed at the beginning of July, approximately 90 days following the first routine fenbendazole (FBZ) treatment (given at 2 April). Mean FEC's in July were 119 epg (range: 0–450 epg) for the Arabian oryx, 10 epg (range: 0–200 epg) for scimitar-horned oryx and 8 epg (range: 0–1350 epg) for gazelle. Almost all individual FEC's in these species decreased to 0 following routine FBZ treatment in July. A second, more important rise in FEC's was noted in October, at the end of the grazing season, approximately 105 days following the last treatment (given at 7 July). Geometric mean FEC's in October were 228 epg (range: 0–600 epg) for the Arabian oryx, 161 epg (range: 0–750 epg) for scimitar-horned oryx and 341 epg (range: 0–950 epg) for gazelle. FEC's decreased again to nearly 0 following the routine treatment at stabling. A third small rise in egg counts was seen in February. No evidence of a peri-parturient rise in antelopes and gazelles was noted. *Nematodirus* spp. eggs appeared in November (mainly in eland, range: 0–150 epg), *Capillaria* spp. eggs were recovered in February (mainly in sitatunga, range: 0–150 epg) and *Trichuris* spp. eggs were recovered in gazelle in October (range: 0–200 epg).

3.2. Morbidity assessment

In the Antwerp Zoo, morbidity could not be assessed due to very low to absent parasite infection. In Planckendael, loss of faecal consistency was markedly present in the gazelles: 231 (56.2%) of the 411 samples collected had scores 2 and 3 and sample size was large enough to significantly ($P < 0.05$) correlate loss of faecal consistency with faecal egg counts above 100 epg (odds ratio 7.18, interval 3.84–13.42). The herd of common eland showed a loss of faecal consistency in 36 (22.5%) of 160 samples. This could, however, not be correlated with egg counts of >100 per gram ($P > 0.05$). Too few samples with an epg of >100 were counted to allow correlation with the presence of loose faeces in sitatungas, wildebeest, impala and bongos. Nearly no loose faeces were noted in Arabian and scimitar-horned oryx. No other clinical signs, such as poor body condition, were observed.

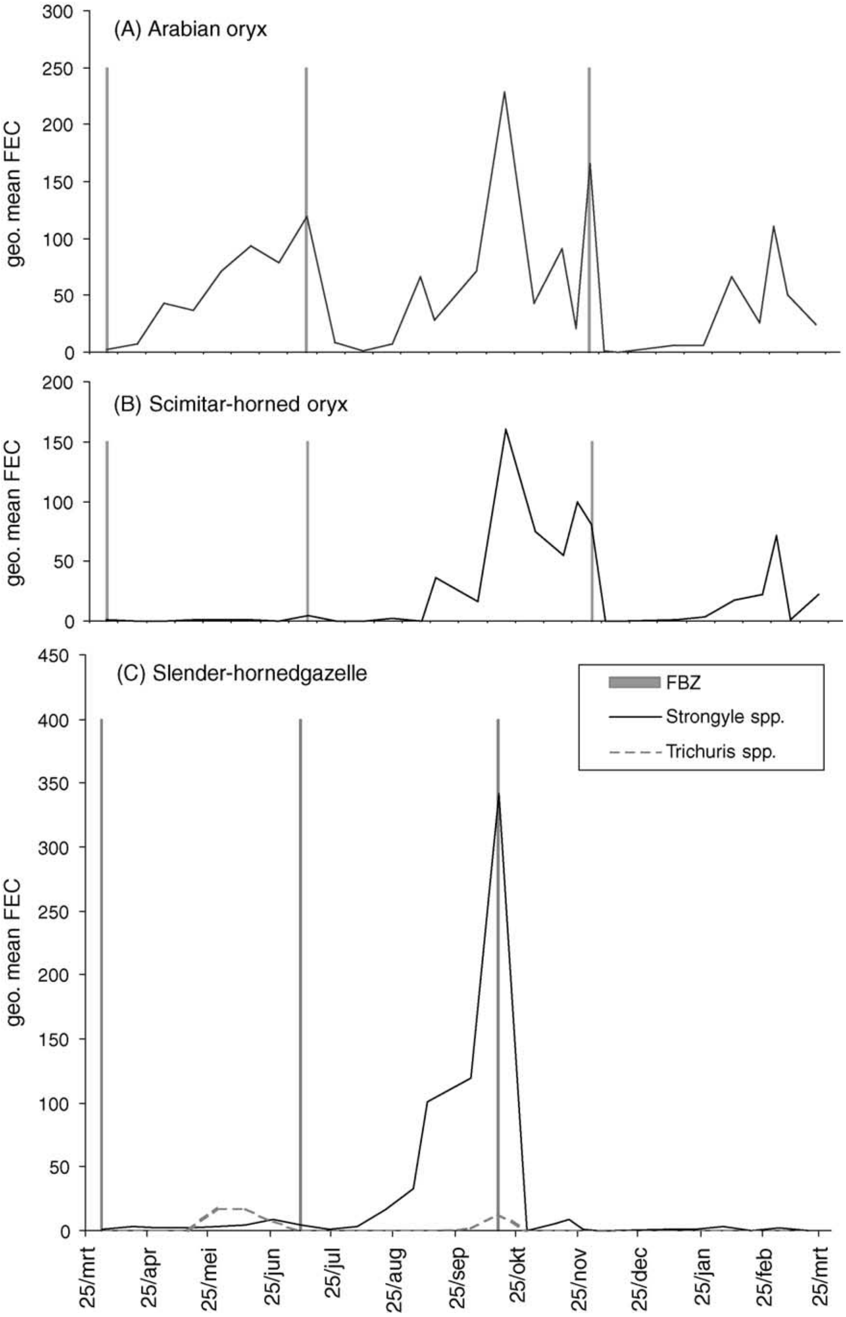

Fig. 1. Seasonal fluctuations in geometric mean faecal strongyle egg count in Arabian oryx (A), scimitar-horned oryx (B) and slender-horned gazelle (C), kept at Animal Park Planckendael (Vertical bars point a 3-day in-feed treatment with fenbendazole).

3.3. Risk factors assessment

No effect of sex on FEC was evident, but very few males were infected with helminths. No age–egg count correlation could be found in case of strongyle infections, although juvenile eland showed statistically higher *Nematodirus* spp. egg counts ($P < 0.05$, odds ratio 5.29 (1.10–25.48)). Successful breeding herds (gazelles, scimitar-horned oryx, sitatungas, common eland, wildebeest) did not have higher FEC's than non-breeding herds ($P > 0.05$) (Arabian oryx, impala, bongos). Animals given the opportunity to graze all the year round (Arabian oryx, scimitar-horned oryx, gazelle) harbored significantly ($P < 0.05$) more nematodes than herds on very limited or zero-grazing (sitatungas, bongos, common eland, impala, wildebeest).

3.4. Worm counts and identification

In Antwerp Zoo (Table 3), no adult helminths were recovered from the intestinal washings of an adult okapi and two adult giraffes. In Planckendael, a moderate burden (9500 adults and 4800 fourth-stage larvae) was present in a male Arabian oryx that was culled in November 2002 (Table 3). Low burdens were present in the gazelles with a maximum of 4300 adults and 250 fourth-stage larvae occurring in an adult

Table 3
Causes of death and total worm burdens of antelopes, gazelles and giraffids, kept at Antwerp Zoo and Animal Park Planckendael. These animals died during the 1-year survey (14 neonates not included)

Animal species	Sex	Age	Cause of death	FEC	Abomasum	Small intestines	Large intestines
Antwerp Zoo							
Okapi	f	14 years	Necrotic colitis	0	–	–	–
Giraffe	f	20 years	Liver pathology	0	–	–	–
Giraffe	m	13 years	Intestinal obstruction	0	–	–	–
Planckendael							
Arabian oryx	m	1 year	Culled	1700	*Camelostrongylus mentulatus* 8650 (55% EL4) *Trichostrongylus retortaeformis* 150	*Trichostrongylus retortaeformis* 1100 *Nematodirus fillicollis* 1900 *Capillaria* spp. 1550	*Trichuris* spp. 950
Scimitar-horned oryx	f	14 years	Kidney failure	50	–	–	–
Gazelle	f	7 years	Liver pathology	0	–	–	–
Gazelle	f	5 months	Traumatic injury[a]	350	*Camelostrongylus mentulatus* 1150	*Trichostrongylus retortaeformis* 750	–
Gazelle	m	5 years	Traumatic injury	0	–	–	–
Gazelle	f	7 years	Traumatic injury[a]	500	*Camelostronylus mentulatus* 2550 (10% EL4) *Trichostrongylus retortaeformis* 200	*Trichostrongylus retortaeformis* 1000	*Trichuris* spp. 800
Gazelle	m	6 years	Traumatic injury[a]	50	*Camelostrongylus mentulatus* 100	*Trichostrongylus retortaeformis* 350	–
Gazelle	f	8 years	Traumatic injury[a]	100	*Camelostrongylus mentulatus* 50	*Trichostrongylus retortaeformis* 400	*Trichuris* spp. 50
Impala	f	9 years	Unknown	0	–	–	–
Common eland	f	10 years	Traumatic injury[a]	0	–	–	–
Sitatunga	v	5 years	Uterusprolapse	0	–	–	–
Sitatunga	v	4 years	Liver pathology	25	–	*Capillaria* spp. 200	–
Sitatunga	v	5 months	Pneumonia	0	–	–	–
Sitatunga	f	46 days	Pneumonia	0	–	–	–

[a] Injuries caused by territorial fighting.

female. *Camelostrongylus mentulatus* was the dominant abomasal species. *Trichostrongylus retortaeformis* was dominant (50%) in the small intestines, followed by *Nematodirus fillicollis* (26%) and *Capillaria* spp. (24%). No macroscopic lesions that could have been caused by GI nematodes were seen.

4. Discussion

In the Antwerp Zoo, nematode eggs were recovered in all herds, although they appeared rather infrequently and the intensity of infection was low. Therefore, we can conclude that GI nematodes are not a cause of morbidity at this locality. The zero-grazing system and the daily dung removal sufficiently reduced the uptake of infective eggs or larvae, in spite of the high-stocking density.

In Planckendael, a marked distinction could be made between herds with high FEC's (Arabian oryx, scimitar-horned oryx and gazelles), herds with low FEC's (eland, sitatungas and wildebeest) and no-shedding herds (impala and bongos). In this study, the individual, male-female and age-related differences in FEC's (within herds) were negligible compared to the differences between the species (between herds). The difference between herds could be explained by husbandry-dependent factors and secondly, by species-dependent factors.

Husbandry-dependent factors are housing, feeding behavior and density-related stress. The problem herds, Arabian oryx, scimitar-horned oryx and gazelles, are all kept on large pastures of low-quality grass, where dung is removed on an irregular basis. Therefore, the availability of third-stage larvae to these herds may be expected to be higher, and may explain the higher burdens. In contrast, the herds of eland, sitatungas, wildebeest, bongos and impala have less grazing opportunity and for eland, wildebeest and impala dung is removed at least weekly. Nutritional (Anderson, 1983) and inter-male stress (Flach and Sewell, 1987), both density-related factors were also shown to favor nematode infection. However, these factors were absent at this study site, with exception of territorial fighting between the female gazelles.

Species-dependent factors that may favor higher nematode burdens are lower genetic resistance, due to evolution or inbreeding. In other zoo-related studies and under different husbandry conditions, *Hippotraginae* and *Antilopinae* were found to be more affected by GI nematodes (Boyce et al., 1991). Roberts and Fernando (1990) observed a lower level of resistance to GI nematodes in ruminant species that were challenged to a lesser extent with nematodes in their natural environment. In the current study, the high-shedding herds were all desert species that under natural conditions are minimally exposed to infection. Cassinello et al. (2001) have demonstrated that inbreeding has a serious impact on the susceptibility of gazelles to infection with nematodes.

Nematodes were reported as cause of significant morbidity and mortality in antelopes and gazelles of Planckendael over the last 5 years and consequently anthelmintics had been used on a regular base, either for curative or preventive purposes. In this study, however, FEC's and worm burdens were usually low to moderate.

The first rise of FEC's in July, in the middle of the grazing season, and the second rise in October, at the end of the grazing season, were most likely caused by infective larvae acquired from the pastures. The routine anthelmintic treatment, administered twice (or thrice) a year, partly eliminated the infection, as post-treatment FEC's approximately were 0. However, rapid re-infections occurred, as indicated by the rapid increase in the egg counts. These increases in FEC's are an indication that the used anthelmintic control program needs improvement and that a program that targets the larvae on the pastures could be more appropriate. If the highly infected herds and the seasonal pattern in FEC's are known, recommendations can be made. Contamination and accumulation of larvae on pastures can be reduced by removing dung more frequently from the enclosures or by reducing grazing opportunities. However, ethically and economically, zoos desire more natural, larger pastures with less animals and mixed species, with a minimum of human interference. Therefore, reducing larval availability by well-adjusted anthelmintic use, such as an early season anthelmintic treatment, seems more realistic. The latter has implications in that, over time, anthelmintic resistance could develop, so a minimal number of anthelmintic treatments should be administered and the efficacy resulting from those treatments should be evaluated. The low abundance of nematodes in Antwerp Zoo and some herds at Planckendael may justify the lack of a helminth control program but all involved herds should be continuously monitored by faecal egg counts on at least two or three occasions per year and especially when stress situations occur. This means before and after translocation, during rut and parturition or other factors leading to physiological stress.

Another conclusion is that it is essential to assess management practices by criteria other than clinical observations only. In gazelles, the loss of faecal consistency appeared to be correlated with trichostrongylid infections, but confounding factors could be the concurrent infections with *Trichuris* spp. and *Eimeria* spp. Little is known about the pathogenicity of these two parasites. The loss of faecal consistency in gazelles was never seen combined with changes of diet or increased intake of lush or green fodder. However, generally, the appearance of mushy droppings in all herds could not be consistently correlated with high FEC's, therefore attributing loose faeces to trichostrongylid infection could lead to over use of anthelmintics.

The burdens of *Camelostrongylus mentulatus* in the Arabian oryx and gazelles of Planckendael are relatively moderate (max 8650) compared with those of approximately 20,000, associated with abomasitis, found in wild and captive antelopes and gazelles in Europe, North Africa and the USA (Eslami et al., 1980; Kock, 1986; Flach and Sewell, 1987; Wisser et al., 2001; Ortiz et al., 2001). *Trichostrongylus retortaeformis* has previously been described in blackbuck (*Antilope cervicapra*), squirrels (*Sciurus carolinensis*) and hedgehogs (*Erinaceus europaeus*) in England (Sloan, 1951), grass vole (*Microtus montebelli*) in Japan (Asakawa and Uchikawa, 1991), goats in Turkey (Akkaya, 1998) and Spain (Garcia Romero et al., 1998), captive maras (*Dolichotis patagonum*) in the UK (Porteous and Pankhurst, 1998) and brushtail opossum (*Trichosurus vulpecula*) in New Zealand (Cowan et al., 2002). In Europe, this trichostrongylid is endemic in the lagomorph population and since numerous rabbits abound on the pastures of Planckendael, the occurrence of *T. retortaeformis* in the ruminants is not surprising. Sharing of the same parasite species by different wild animals has also been recorded by Round (1968) and Boomker et al. (1997).

5. Conclusion

This study has indicated that quantitative FEC's are indispensable for monitoring levels of parasitic infestations and pinpointing problem herds. The nematode species recorded in this study are known to be of pathogenic importance. To fully prevent morbidity and mortality, more husbandry-related options, such as late turn out and offering less grazing opportunity, should be explored. However, a well-adjusted anthelmintic program, such as early season treatments to prevent pasture contamination, seems indispensable and needs more research. For the future, the tendency of zoological collections to keep animals on large densely populated exhibition areas, with mixed species, could result in more nematode-related problems.

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