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Patterns of parasitic infections in faecal samples from stray cat populations in Qatar

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Abstract

The parasite fauna of stray cat populations, comprising mainly helminth parasites, is described for the first time from the arid environment of the Qatar peninsula. During the winter and summer months of 2005, 824 faecal samples were examined from six sites in Qatar. Up to seven species of parasites were identified, six of which were nematodes – *Strongyloides stercoralis* as the most prevalent (18.4%), followed by *Aelurostrongylus abstrusus* (7.5%), *Toxocara cati* (6.1%), *Ancylostoma tubaeforme* (5.9%) and *Physaloptera* sp. (4.8%) and *Toxascaris leonina* (0.7%) – and one sporozoan species, *Isospora felis* (0.5%). Unidentified cestode eggs were also recovered from 10.7% of samples examined. The parasite species were found to be highly overdispersed in faecal samples from all sites, whereas the prevalence and intensity of infections were influenced by site and season. Infection levels tended to be higher during the winter season, especially in the case of *A. abstrusus* and *A. tubaeforme*, when conditions of temperature and humidity were more favourable for the development of egg and/or larval stages of parasites compared with the extremely hot and dry summer months. The results are discussed in relation to the distribution of the cat population in the vicinity of Doha and its outskirts and the potential threat of parasite transmission to human communities in Qatar.

Introduction

Unlike their canine counterparts, feline parasites, particularly helminths, have received less attention as potential sources of zoonotic infections (Fisher, 2003). The ecology and particularly the component community structure of helminth parasites in cats are based on data collected from the UK (Lewis, 1927; Hutchison, 1956; Woodruff *et al.*, 1964; Oldham, 1965; McColm & Hutchison, 1980; Nichol *et al.*, 1981) and Australia (Coman, 1972; Wilson-Hanson & Prescott, 1982; Shaw *et al.*, 1983; Thompson *et al.*, 1993; McGlade *et al.*, 2003). Knowledge of the intestinal parasites of cats in arid regions worldwide is remarkably limited and, despite extensive species lists and taxonomic studies undertaken in the Middle East regions (in Jordan, Morsy *et al.*, 1980; in Egypt, El-Shabrawy & Imam, 1978; Hasslinger *et al.*, 1988), there is relatively little comparable data on the ecology of parasite fauna of cats apart from Arafa *et al.* (1978) in Egypt.

In the State of Qatar, uncontrolled populations of stray and semi-domesticated cats exist in close proximity to human populations. Some less fortunate communities suffer from poor levels of hygiene, and a lack of veterinary care and, to a greater extent, zoonotic awareness, enhancing the risk of disease transmission. Cats, which were introduced to Qatar by explorers in the early 1960s for the biological control of rodent populations, have multiplied and colonized rapidly around food and water resources, mainly in urban but also in rural areas. The objective of the present paper, therefore, was to investigate for the first time the diversity and infection levels of intestinal parasites in faecal samples

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deposited by stray cat populations in urban sites of Doha and its outskirts in the State of Qatar.

Materials and methods

Study sites

Sampling of cat faeces was undertaken in three sites, namely Corniche, Al-Matar and Al-Sadd located in the capital city, Doha (longitude 51°31′60″E, latitude 25°17′12″N), and three sites on the outskirts of Doha, Abu-Hamour, Al-Rayyan and Al-Wakra. Corniche is a grassed public area lying on Doha Bay stretching over 7 km. Al-Matar and Al-Sadd are characterized by much socio-economic development contributing to a high population density. Al-Rayyan, which lies 10 km north of Doha (longitude 51°25′28″E, latitude 25°7′31″N), is considered to be the second most populated area, although there are still large uninhabited localities. Al-Wakra is a coastal small town, situated 15 km to the east of Doha (longitude 51°30′15″E, latitude 25°17′10″N), whereas Abu-Hamour lies to the south (longitude 51°29′44″E, latitude 25°14′8″N), as described previously by Abu-Madi *et al.* (2005).

Faecal sampling

Sampling was conducted in the vicinity of public and private areas in the study sites during the winter (January–April) and the summer (May–October) seasons of 2005. The semi-dry winter endures scant and infrequent rainfall, ranging from 0.8 to 32.1 mm with mean temperatures of 17.1–27.1°C. The summer is hot, humid with no rainfall, and mean temperatures ranging from 29.5 to 36.1°C. Faecal samples were collected at 10 m intervals and the number of samples varied according to the size of the site and the abundance of cat droppings. Two grams of homogenized faeces were preserved in 10% formalin fixative vial (Para-Pak 10% formalin fixative) for at least 30 min at room temperature to ensure adequate fixation. The preserved sample was mixed vigorously by vortex and filtered through a macro-confiltration unit to remove bulky debris (Meridian Bioscience, Inc., Ohio, USA). After filtration, 10% formalin and ethyl acetate were added, the sample centrifuged for 10 min at 3000 rpm, and suspended into 1 ml. From each sample, three aliquots of 50 μl were examined microscopically for the identification and counting of eggs/larvae. The latter were expressed as either eggs/g faeces (EPG) or larvae/g faeces (LPG) and the means of EPG and LPG were calculated from all samples to represent the intensity of infection.

Statistical analysis

Statistical tests were performed using the SPSS 13.0 (Statistical Package for Social Sciences, SPSS Inc., Chicago, Illinois, USA). Chi-square and non-parametric tests (Kruskal–Wallis, Mann–Whitney), respectively, were performed to study the prevalence of infection and mean EPG or LPG relative to site and season. The frequency distribution of parasite eggs/larval stages from each site was tested for goodness of fit to the negative binomial distribution using a reformulated method of measuring the k parameter, as described previously by Pal & Lewis (2004).

Results

A total of 824 faecal samples were collected from six study sites from January to October, 2005 (table 1). The highest proportion of samples was collected from Corniche (23.3%) followed by Abu-Hamour (21%), Al-Matar (18.9%), Al-Wakra (13.1%), Al-Sadd (12.9%) and Al-Rayyan (10.8%). Apart from the Corniche, fewer samples were collected in the winter (39.2%) compared with the summer (60.8%).

Parasite species richness and dispersion

Six species of nematodes were recovered and 250 samples (30.3%) were found to be infected with at least one of these species. Of the nematode species found, *Strongyloides stercoralis* (18.4%) was the most prevalent, followed by *Aelurostrongylus abstrusus* (7.5%), *Toxocara cati* (6.1%), *Ancylostoma tubaeforme* (5.9%) and *Physaloptera* species (4.9%). In addition, six samples (three from Al-Sadd, two from Al-Rayyan and one from Al-Matar) were infected with *Toxoascaris leonina*, two samples (one from Al-Sadd and the other from Abu-Hamour) with the protozoan *Isospora felis,* and unidentified hexacanth eggs of cestodes likely to be the species of *Taenia, Dipylidium* and/or *Diplopylidium* were found in 10.7%. Hence, the latter species were not included in the statistical analysis. Faecal samples mainly comprised single infections (70%) with multiple infections being far less common (table 2). The highest proportion of multiple infections was recorded in Corniche (36%), followed by 17.3% in both Al-Sadd and Al-Matar, 10.6% in both Al-Rayyan and Abu-Hamour and 8% in Al-Wakra. Multiple infections of up to five species were found only in one sample from Corniche, whereas four samples, three from Corniche and one from Al-Matar harboured four species. In Abu-Hamour and Al-Wakra, no more than two parasite species were found in the samples examined.

All egg/larval stages of nematodes recovered from faecal samples in all sites were highly overdispersed, with k values ranging from 0.003–0.042 in *Physaloptera* sp., 0.005–0.023 in *A. abstrusus*, 0.005–0.029 in *A. tubaeforme*, 0.008–0.195 in *T. cati* and 0.02–0.04 in *S. stercoralis.*

Table 1. Number of faecal samples from six sites in Qatar during the winter and summer months of 2005.

Site	Season: Winter	Season: Summer	Total
Corniche	110	82	192
Al-Matar	57	99	156
Al-Sadd	21	85	106
Abu-Hamour	74	99	173
Al-Rayyan	18	71	89
Al-Wakra	43	65	108
Total	323	501	824

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Table 2. Frequency distribution of nematode species occurring in faecal samples from six sites in Qatar during 2005; *N*, number of samples examined; %, proportion of samples infected.

No. of parasite species	Corniche		Al-Matar		Al-Sadd		Abu-Hamour		Al-Rayyan		Al-Wakra	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
0	105	54.7	117	75	78	73.6	130	75.1	58	65.2	86	79.6
1	60	31.3	26	16.7	15	14.2	35	20.2	23	25.8	16	14.8
2	16	8.3	10	6.4	8	7.5	8	4.6	5	5.6	6	5.6
3	7	3.6	2	1.3	5	4.7	0	0	3	3.4	0	0
4	3	1.6	1	0.6	0	0	0	0	0	0	0	0
5	1	0.5	0	0	0	0	0	0	0	0	0	0

Prevalence and intensity of infections

Strongyloides stercoralis

This rhabditoid nematode is a common human intestinal parasite worldwide, especially in tropical and subtropical countries (Gotuzzo *et al.*, 1999). Infection in humans is acquired by skin penetration of soil-transmitted larvae. However, dogs and cats can harbour strains of *S. stercoralis* (Robertson & Thompson, 2002) with zoonotic potential leading to chronic infections in immunocompromised individuals (Siddiqui & Brek, 2001). Eggs of *S. stercoralis* and *S. felis* are morphologically similar, but the identification of *S. stercoralis* was confirmed from the recovery of adult worms in cats following post-mortem examination.

Strongyloides stercoralis was the most dominant nematode recovered from all sites (table 3), with prevalence values of 23.4% in Corniche, 20.8% in Al-Sadd, 20.2% in Al-Rayyan, 15.6% in Abu-Hamour, 15.4% in Al-Matar and 14.3% in Al-Wakra, and no overall effect of site on prevalence ($P = 0.253$). The mean LPG ranged from 20.1 in Al-Matar to 37.2 in Corniche, but analysis of these intensities between sites (table 3) were not significant ($P = 0.346$). Relative to season, faeces infected with *S. stercoralis* showed higher prevalences in winter ($P = 0.014$) compared with the summer (table 4), especially in Al-Matar ($P = 0.001$) and Al-Sadd ($P = 0.001$). However, prevalences did vary significantly between sites in winter ($P = 0.02$), with a low value of 10.8% in Abu-Hamour and a high value of 47.6% in Al-Sadd. On the other hand, no site effects on prevalence values were observed in the summer ($P = 0.24$). In the case of intensity of infection, higher LPG were recorded in summer ($P = 0.025$) compared with winter (table 4).

Aelurostrongylus abstrusus

This metastrongylid nematode is a common feline lungworm occurring worldwide, for example in Europe (in Bulgaria, Stoichev *et al.*, 1982; in Germany, Barutzki & Schaper, 2003) and Australia (Wilson-Hanson & Prescott, 1982; McGlade *et al.*, 2003). First-stage larvae (L1) are coughed up the trachea of feline hosts, swallowed and passed through the alimentary tract ending up in soil via the faeces. L1 develop into third-stage larvae (L3) in slugs and snails which may be ingested by small rodents as paratenic hosts. The latter, on predation, are likely to be the route of transmission to cats, resulting in lungworm disease or aelurostrongyliasis in heavy infections.

The prevalence of *A. abstrusus* varied significantly across sites ($P = 0.004$), with the highest value of 13% being recorded in Corniche (table 3). This site effect clearly emerged in winter samples ($P < 0.001$), with the prevalence in Al-Sadd more than twice the values in other sites. There was also a significant seasonal effect ($P < 0.001$), with the prevalence of *A. abstrusus* ranging

Table 3. The prevalence (%) and mean eggs/g faeces or larvae/g faeces ± SEM of nematode species in faecal samples from six sites in Qatar during 2005.

	Site						
	Corniche	Al-Matar	Al-Sadd	Abu-Hamour	Al-Rayyan	Al-Wakra	*P* value
Prevalence (%)							
S. stercoralis	23.4	15.4	20.8	15.6	20.2	14.3	0.253
A. abstrusus	13	5.1	11.3	4	6.7	3.7	0.004
T. cati	8.3	3.8	6.6	6.9	6.7	2.8	0.360
A. tubaeforme	8.9	11.5	4.7	1.7	3.4	2.8	0.001
Physaloptera sp.	14.1	0	0	1.2	10.1	1.9	<0.001
Larvae/g faeces							
S. stercoralis	37.2 ± 14.4	20.1 ± 7.2	24.1 ± 18.0	32.8 ± 15.4	47.1 ± 26.1	24.2 ± 11.0	0.346
A. abstrusus	22.8 ± 12.7	3.4 ± 2.8	4.4 ± 2.2	13.1 ± 12.4	2 ± 1.2	0.9 ± 0.5	0.004
Eggs/g faeces							
T. cati	1.5 ± 0.6	1.1 ± 0.8	0.6 ± 0.3	0.6 ± 0.2	0.5 ± 0.2	1.3 ± 1.2	0.359
A. tubaeforme	0.7 ± 0.2	1.6 ± 0.5	1.1 ± 0.7	0.2 ± 0.1	0.3 ± 0.2	1.6 ± 1.5	0.001
Physaloptera sp.	3.7 ± 0.9	0	0	0.1 ± 0.1	0.5 ± 0.2	0.1 ± 0.01	<0.001

Table 4. The prevalence (%) and mean eggs/g faeces (EPG) or larvae/g faeces (LPG) ± SEM of nematode species in faecal samples from six sites in Qatar during the winter and summer of 2005.

	Season					
	Winter		Summer		*P* value	
Nematode species	%	EPG or LPG	%	EPG or LPG	%	EPG or LPG
S. stercoralis	22.6	27 ± 9.8	15.3	33 ± 8.0	0.014	0.025
A. abstrusus	14.9	20.2 ± 9.6	2.8	2.8 ± 2.1	<0.001	<0.001
T. cati	9.9	1.1 ± 0.3	3.6	0.9 ± 0.4	<0.001	<0.001
A. tubaeforme	11.8	1.7 ± 0.6	2.2	0.4 ± 0.2	<0.001	<0.001
Physaloptera sp.	4.3	1.3 ± 0.4	5.2	0.7 ± 0.2	0.577	0.628

from 14.9% in winter compared with 2.8% in summer (table 4). This significant effect was particularly observed in Al-Sadd ($P < 0.001$), Corniche ($P = 0.001$) and Al-Matar ($P = 0.02$), with up to 52.4% of faecal samples from Al-Sadd infected during the winter. With reference to the intensity of infection, significantly higher LPG were recorded in Corniche and Abu-Hamour ($P = 0.004$) compared with the remaining sites (table 3) and a significantly higher number of LPG were found in winter ($P < 0.001$) than in summer (table 4).

Toxocara cati

This ascarid species is one of the largest intestinal nematodes occurring in feline hosts, which become infected through transmammary routes. Transmission also occurs via ingestion of eggs which are deposited by female *T. cati* into the soil via faeces (Dubey, 1966; Fisher, 2003). As in the case of *T. canis* in dogs, *T. cati* is capable of causing disease to humans by larval migration, following ingestion of the eggs, resulting in human toxocariasis which is a commonly reported zoonotic helminthiasis (Lewis & Maizels, 1993; Holland & Smith, 2006).

The prevalence of *T. cati* infection varied significantly with season ($P < 0.001$), increasing from 3.6% in summer to 9.9% in winter (table 4) but with no indication of site effect ($P = 0.36$). However, there was a significant difference in the prevalence of *T. cati* across sites during winter ($P = 0.005$), especially in Al-Sadd where 33.3% of faecal samples harboured *T. cati* in winter, compared with no infection in summer ($P < 0.001$). Analysis of EPG varied significantly with season ($P < 0.001$) with higher EPG in winter than summer (table 4) but intensities between sites (table 3) were not significant ($P = 0.359$).

Ancylostoma tubaeforme

Ancylostoma tubaeforme together with *Ancylostoma braziliense* and *Uncinaria stenocephala* are blood-feeding feline intestinal hookworms with a wide geographical distribution (Barutzki & Schaper, 2003; Coatin *et al.*, 2003; McGlade *et al.*, 2003). Adult worms pass eggs out with feline faeces then on to soil/vegetation where eggs ultimately produce L3 larvae. Human populations who have contact with L3-contaminated soil can acquire infection through skin penetration by L3, leading to pulmonary or intestinal symptoms of hookworm disease (Robertson & Thompson, 2002).

Up to 11.5 and 8.9% of faeces were infected with *A. tubaeforme* in Al-Matar and Corniche, respectively (table 3) with significantly more infected samples occurring in winter ($P = 0.001$) than in summer (table 4). The prevalence in winter was also significantly higher in Corniche and Al-Matar compared with other sites. Analysis of the EPG showed a significant site effect ($P = 0.001$) and seasonal effect ($P < 0.001$), higher values in winter (tables 3 and 4).

Physaloptera sp

Species of *Physaloptera*, for example *P. praeputialis* and *P. rara*, are commonly reported stomach nematodes of cats worldwide (Labarthe *et al.*, 2004). Embryonated eggs are passed out in faeces and when ingested by insect intermediate hosts, including cockroaches, beetles and crickets, develop into L3 larvae. Small rodents can act as paratenic hosts and, as in the case of *A. abstrusus*, the route of infection is likely to be predation by cats on mice. Occasionally human infection with *Physaloptera* species results from accidental ingestion of infected insects.

Physaloptera sp. was found in only four sites, with highest prevalences of 14.1% and 10.1% in Corniche and Al-Rayyan respectively (table 3). Differences in the prevalence of infection ($P < 0.001$) and EPG ($P < 0.001$) were highly significant between sites but there were no significant differences relative to season (tables 3 and 4).

Discussion

Previous studies on the helminth parasites of cats from the Middle East and north Africa by Morsy *et al.* (1980) in Jordan, El-Shabrawy & Imam (1978) and Hasslinger *et al.* (1988) in Egypt have been largely taxonomic, but Arafa *et al.* (1978) in Egypt reported site-specific, host age and gender effects on the prevalence of cat intestinal parasites. These studies, including those of Khalil *et al.* (1976), El-Shabrawy & Imam (1978) and Abo-Shady *et al.* (1983), have demonstrated the presence of a wide species diversity, primarily dominated by nematodes, cestodes and, to a lesser extent, trematodes. The present study is the first in the Arabian Gulf area, as a part of the Middle East, to provide an understanding of the ecology of stray cats inhabiting the harsh and arid environment in Qatar, where the trend, compared with previous studies, is somewhat different as no trematode and low levels of cestode infections were found. This is in contrast to the high level of infection of rats with the cestode *Hymenolepis diminuta* recorded by Abu-Madi *et al.* (2001, 2005) from similar sites in Qatar. The occurrence of the protozoan *I. felis* in only two faecal samples from all six sites in the present case suggests that desiccation inhibits oocyst development, especially as Morsy *et al.* (1980), following rectal examinations of cats, reported that up to 25.6% were infected with *I. felis*. Worldwide, more sensitive serological and molecular diagnostic tests (Morsy *et al.*, 1980; Bennett *et al.*, 1990; Yamagushi *et al.*, 1996; McGlade *et al.*, 2003) have been used to identify protozoan infections including *I. felis* in cats.

Consistent with the present findings, the nematode species *A. tubaeforme, A. abstrusus, Physaloptera* sp. and *T. cati* have generally been found to be dominant members of the endoparasite communities of cats (Barutzki & Schaper, 2003; Coatin *et al.*, 2003; Labarthe *et al.*, 2004), although in the present study *A. abstrusus* has been recorded for the first time in the Middle East. The occurrence of *S. stercoralis* with a relatively high prevalence of 18.5% is also the first record of a feline *Strongyloides* species emerging in the Middle East. Other species of *Strongyloides*, such as *S. felis*, have been reported exclusively from Australian cats (Speare & Tinsley, 1987) with a level of infection up to 33.5%, but the limited reporting of *Strongyloides* sp. worldwide is likely to be due to low levels of infections in the definitive host, together with misdiagnoses (Speare & Tinsley, 1987). The identification of cestode species in faecal samples also poses difficulties, especially in a harsh and arid environment where proglottids rapidly disintegrate in the faecal material to liberate eggs with hexacanth embryos. In the present study up to 10.7% of faecal samples were positive for unidentified cestode eggs, which are likely to belong to species of *Taenia*, *Diplopylidium*, *Dipylidium* and/or *Mesocestoides* (El-Shabrawy & Imam, 1978; Calvete *et al.*, 1998).

The frequency distribution of nematode species recovered in this study was typically overdispersed, consistent with previous studies (Engbaek *et al.*, 1984; Delahay *et al.*, 1998). Such aggregation is likely to be correlated with heterogeneity in host behaviour, immunity and the clumped distribution of infective stages in the faeces (Anderson & Gordon, 1982; Wakelin, 1987).

Extrinsic factors such as variation in site and season have been shown to be significant in determining prevalence and intensity levels. Climatic conditions encountered during the winter months in Qatar, with comparatively low temperatures and higher degrees of humidity compared with the summer period (personal communication with the Department of Meteorology), may be responsible for the maintenance and enhancement of parasite infectivity (Calvete *et al.*, 1998). Seasonal fluctuations in the prevalence of infections were compounded by differences between sites, especially with higher prevalences in the case of *Physaloptera* sp., *A. tubaeforme* and *A. abstrusus*. Significant differences between sites were also shown by *Physaloptera* sp. and *A. abstrusus* in EPG/LPG levels, with Corniche being a focus of infection for the majority of parasites recovered, suggesting a higher density of stray cats in this urban site. In addition, unlike other habitats examined, Corniche is an irrigation site comprising many grassed areas, which would tend to retain moisture levels thereby enhancing the survival and development of eggs and larval stages of nematodes.

Site-specific variations in prevalences and intensities can be influenced by a combination of factors, including the distribution of the host population, variation in the ingestion and/or penetration rates of infective stages. Exceptionally, *T. cati* infection seems to be independent of habitat type, where no significant differences in the prevalence and intensity were registered between sites. This is similar to other studies on *T. cati* infection (Arafa *et al.*, 1978; Engbaek *et al.*, 1984; Hasslinger *et al.*, 1988) and is likely to be related to the transmammary transmission of *T. cati* (Engbaek *et al.*, 1984). However, the effects of seasonal changes are far more striking in determining the compositions and levels of infection of parasite species in the faecal samples from most sites examined. Prevalence and LPG/EPG values of *S. stercoralis*, *A. abstrusus*, *T. cati* and *A. tubaeforme* were significantly higher in the winter than in the summer. This suggests that higher temperatures with no humidity in the hot and dry summer months reduce the survival and viability of free-living infective stages in the soil and faecal material, together with the availability of intermediate hosts (snails and rodents in the case of *A. abstrusus*), thereby reducing parasite transmission.

In conclusion, the composition and infection levels of the intestinal parasites of cats are clearly influenced by the extrinsic factors of site and season in such a hot and arid country such as Qatar. Faecal examination has been shown to be a non-invasive method for quantifying the prevalence and intensity of infection, but further studies using necropsy of stray cat populations are needed for more accurate identification to be made of infective stages, especially the cestodes. In addition, the role of intrinsic factors, including host age and gender, needs to be assessed in structuring these parasite communities. The zoonotic potential of parasites such as *T. cati*, *S. stercoralis*, *A. tubaeforme* and *I. felis*, underscores the role of stray cats in Qatar as reservoir hosts for zoonotic diseases. Infective stages are disseminated with faecal material and are likely to contaminate the soil of public and private areas in urban, suburban and rural sites, hence an improvement in the awareness of the potential health risk to the human population needs to be addressed.

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