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Parasites of Stray Cats in Kuwait: Part I Cestodes, Nematodes

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Abstract: In spite of increasing numbers of stray cats in the streets of Kuwait, little is known about their parasites and the extent of risk they may pose to public health. A survey was conducted to study the endo and ecto-parasites of stray cats from different localities of Kuwait. External surface, blood and different internal organs including hearts, lungs, kidneys and gastrointestinal tracts of cats were examined for different parasites. Out of 240 cats examined, 207 (86.25%) were found to be infected with at least one parasite. Parasites identified included 4 cestodes*: Diplopylidium nolleri* (54.6%), *Diplopylidium acanthotetra* (45.4%), *Joyeuxiella pasquali* (38.3%) and *Taenia taeniaeformis* (0.8%), 7 nematodes: Ollulanus tricuspis (26.3%), *Physaloptera gemina* (4.2%), *Gnathostoma* sp. (0.4%), *Pterygodermatites cahirensis* (34.6%), *Ancylostoma tubaeforme* (1.3%), *Toxocara cati* (1.3%) and *Toxascaris leonina* (15%), 4 protozoa: *Isospora felis* (7.17%), *Isospora rivolta* (1.6%), *Sarcocystis* sp. (0.4%) and *Toxoplasma gondii* (2.12%) and 2 arthropods: *Otodectes cynotis* (ear mite) (3.3%) and an Ixodid nymph (hard tick) (0.4%). The effect of demographic factors (age, sex, site and season) on parasitism is discussed.

Key words: Cat, cestodes, nematodes, protozoa, arthropods, Kuwait

INTRODUCTION

Stray cats are a huge part of the growing pet over-population problem everywhere. There are 600 million cats worldwide, 75% of them are unowned (Margaret Mcluskey, World Society for Protection of Animals, personal communication). In 1998, the number of cats in the USA was estimated to be about 70 millions (Bowman *et al*., 2002). In Kuwait it is common to see stray cats roaming streets and lurking around garbage containers but there are no statistical data available on their numbers. Many appear to live throughout the country in multiple colonies in urban neighbourhoods on farms and near abattoirs and fish markets feeding on garbage, insects, small animals and meat and fish offal. This style of life facilitates the spread of disease agents and poses a threat to public health, livestock and domesticated pets.

Stray cats can harbor and transmit a variety of pathogens including parasites that can pose a risk to human-and animal health. In Kuwait, Toxoplasma antibodies were detected in pregnant women (Iqbal and Khalid, 2007). *Leishmania tropica* and *Dirofilaria repens* were recorded in Kuwaiti people (Al-Taqi and Behbehani, 1980; Hira *et al*., 1994). Three domestic cats were reported to be infected with *Trypanosoma evansi*, the camel hemoparasite (Tarello, 2005). No systematic study has been done to investigate these parasites in stray cats.

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In spite of increasing numbers of stray cats in Kuwait, little is known about their diseases and parasites and the extent of risk they may pose to public health. The only study of intestinal helminths of stray cats was conducted in a limited geographical area, around Kuwait city (Abdul-Salam and Baker, 1990). In many parts of the world parasitism of stray cats has been studied e.g., in Australia (McGlade *et al*., 2003), USA (Carleton and Tolbert, 2004), Brazil (Labarthe *et al*., 2004), Spain (Calvete *et al*., 1998), Egypt (Khalafalla, 2011) and in India (Borthakur and Mukharjee, 2011) as well as in the Gulf region e.g. in Iran (Changizi *et al*., 2007), Qatar (Abu-Madi *et al*., 2010), United Arab Emirates (Schuster *et al*., 2009) and Iraq (Al-Obaidi, 2012). Most of these studies point to the risk of stray cats passing diseases to man and other animals.

The present study was carried out to identify the endo-and ecto-parasites of stray cats in Kuwait, determine the prevalence of parasitism and ascertain if yearly prevalences were consistent over the period from July, 2011 to May, 2012. The effect of age, sex, habitat and type of diet on the prevalence and intensity of parasitism was studied. The main objective of this study is to evaluate the extent of the risk of stray cats may pose to public health, livestock and domestic pets. Because of the size of data obtained, the present paper covers cestodes, nematodes, protozoa and ectoparasites; data on trematodes will be published separately.

MATERIALS AND METHODS

Country description: Kuwait is a small country located in the desert geographical region. Because of the type of the climate and soil, vegetation is extremely sparse. The climate is continental characterized by its dry hot season (April-November) and mild cold wet season (December-March). Dust storms often occur during hot season and temperature sometimes reaches 50°C. Because this harsh climate and limited vegetation, mammalian life, including cats, tend to search for suitable habitats close to human dwellings with the associated risk of disease or parasite transmission.

Cat sampling and study sites: Stray cats were trapped from various districts to cover the six administrative Governorates (Al-Asema, Hawali, Farwanyiah, Mubarak Al-Kabeir, Al-Jahara and Al-Ahmadi) of Kuwait using special traps baited with fish. For analysis of data to compare between habitats of stray cats, the investigated districts were grouped into 2 main localities on the basis of the following criteria e.g., the standard of living of inhabitants, density of population, level of municipal services and accumulation of garbage. Locality 1 contained the districts which are inhabited by well-to do-Kuwaitis with good service levels and low population densities while Locality 2 contains the districts which are inhabited by expatriates with low service levels and high population densities. Some districts of Locality 2 which are inhabited by laborers, were characterized by accumulation of garbage and large numbers of cats.

Laboratory investigations: The captured cats were transferred to the laboratory where date of examination, site of trapping, gender, age and pregnancy and lactation status were recorded. The age of cats was assessed by dentition, the body size and maturation of genital organs. According to age the cats were grouped into adults (>6 months) and juveniles (≤6 months). After anesthetizing of cats using Rompun 2% intramuscular (1.5 mL 10 kg^{-1}), blood samples were collected in tubes with anticoagulant for detection of blood parasites and in tubes without anticoagulant to separate sera for detection of Toxoplasma antibodies. For necropsy, cats were humanely killed using intracardial T61 (1-4 mL according to age). This study was part of project designed to address many objectives including record of parasitic, viral, bacterial diseases and pathological lesions with thepermission from appropriate authorities from the Kuwaiti Public Authority of Agriculture and Fisheries, Kuwait Foundation for the Advancement of Sciences and approved by its animal ethics committee.

Parasitology procedures

External parasites: Skin was inspected for ecto-parasites or lesions caused by them by naked eye. Moreover, each cat was skinned and the skin was cut into small pieces which were soaked in 20% NaOH overnight. Then the skin pieces were removed and the sediment was examined under the stereo microscope. From ears, cerumen samples were taken, macerated in 10% NaOH and examined for ear mites microscopically.

Blood parasites: Blood films were prepared and stained with Giemsa and examined with oil immersion to detect haemoparasites.

Gastrointestinal helminthes: The stomach and intestine were removed from necropsied cats and placed in separate containers; the mucous membrane of each organ was scraped between the blades of a forceps. After that their contents were washed out over a 500 um sieve with tap water. The residues were systematically searched by eye for helminths which were transferred to 70% ethanol for preservation until identification. The residues were then thoroughly inspected under the stereo microscope to remove the minute parasites and scoleces of cestodes.

The worms were counted; the number of cestodes was based on the number of scoleces. For identification, nematodes were cleared and counted in polyvinyl

lactophenol and platyhelminths (cestodes and trematodes) were stained with a simple and rapid technique using Lactophenol Cotton Blue (LPCB) stain (Henedi and El-Azazy, 2013). Briefly, after the fixation of specimens in 70% ethanol, they were immersed in a suitable amount of lactophenol cotton blue (ready-for use; Merck, Germany) on clean slides. After 5 min the preparations were covered with cover slips and examined microscopically. For permanent preparations, the edges of cover slips were sealed with nail polish. In this method LPCB acts as a stain and mountant in the same time. Some specimens were stained with alum carmine, cleared in xylene and clove oil and mounted in Canada balsam or DPX.

Enteric protozoa: Faecal examination was performed using a direct method for detection of moving trophozoites of *Giardia* sp. or *Trichomonas* sp. as well as using concentration floatation technique for detection of oocysts or cysts of enteric protozoa. In the concentration method, 2 g of faeces were taken from rectum; sugar solution was used to float oocysts. McMaster slide was used to estimate the number of oocysts in a gram of faeces.

Tissue parasites: The diaphragm and skeletal muscles were examined using a trichinoscope and digestion technique for detection of *Trichinella* larvae (Nockler *et al*., 2000). *Toxoplasma* antibodies were detected by Indirect Haemagglutination test (IHAT) (Fumouze Diagnostics, France); the procedures were followed according to the manufacturer's instructions and the samples were classified positive at a titer of 1:80 or higher. The skin was examined for Leishmania lesions. Subcutaneous tissues and hearts were checked for adults and juveniles of *Dirofilaria repens* and *D. immitis*. For microfilaria detection, Giemsa stained blood films were examined and Knott's test was performed.

Parasite identification: The recovered parasites were identified according to the following keys and textbooks: Witenberg (1932), Soulsby (1982), Schmidt (1986) and Anderson *et al*. (2009). In addition, helminth specimens were sent to John M. Kinsella, Helm-West Laboratory, Missoula, Montana, USA for confirmation and voucher specimens were deposited in the US National Parasite Collection.

Statistical analysis: Data were analyzed and statistical comparisons were performed using Statistix® analytical software (Version 8, Tallahassee, USA). Summary data for parasites intensity are expressed as arithmetic means±SEM. (Standard Error of Mean). This mean intensity of infection as defined by Bush *et al*. (1997) is an average of a particular parasite species among the infected members of a particular host species.. The prevalence and Confidence Intervals (CI) were calculated for as described by Sokal and Rohlf (2012). Prevalence is the proportion of infected hosts among all hosts examined while Confidence Intervals CI indicates the accuracy of the estimation using CI 95% is advisable.

RESULTS

Demographic data: Cat samples comprised 134 (55.8%) females and 106 (44.2%) males of which 95 and 65 were adults respectively. The overall number of young cats (≤6 months) was 80. Adult females were classified according to their reproductive status as pregnant (n = 36, 37.9%), lactating (n = 14, 14.7%) and barren (n = 45, 47.4%). The number of cats captured in the wet season was 129 of which 94 were adults while in the dry season 111 cats were trapped of which 66 were adults. From Locality 1, 117 cats were trapped, of which 75 were adults; while from Locality 2, 85 adults and 38 juveniles were trapped (Table 1 and 2).

Prevalence and intensity of parasite higher taxa and species: Out of 240 stray cats examined in one year (July 2011-May 2012) 207 (86.25%) were found to be infected with at least one parasite. The majority of cats (85.8%) had mixed infections with different parasites.

Tapeworms were the most frequently recovered parasites with overall prevalence 70.4%. Mainly cestodes occurred in mixed infections with a mean burden 134±19. Four species of cestodes were recorded representing 2 families, Dipylidiidae and Taeniidae. Among cestodes and even among all helminths, *Diplopylidium nolleri* was the most common (prevalence of 54.6% and mean burden 126±20), followed by *D. acanthotetra* (prevalence of 45.4% and mean burden 39±8). *Joyeuxiella pasqualei* was less in prevalence and abundance when compared with the two species of sDiplopylidium. *Taenia taeniaeformis* was the least in frequency among all cestodes and was only encountered in 2 cats (0.8%) with very low intensity (mean burden 1±0) (Table 3).

The prevalence of nematodes ranked the second (60.4%) among helminth higher taxa. Seven species of nematodes were recorded in this study with *Pterygodermatites cahirensis* was the most prevalent (34.6%) while the stomach worm, *O. tricuspis* was the most abundant (mean burden 116±17). Nine immature worms of *Gnathostoma* sp. were found in the stomach of a male adult cat. The 2 ascaridid species, *Toxascaris leonina* and *Toxocara cati*, were recorded but with differences of infection rate and abundance. The former worm was found in 15% of cats with a mean burden 17±5 (range 1-83) while the atter was recorded in 1.3% of cats with a mean burden 2±1. *Physaloptera gemina* and *Ancylostoma tubaeforme* were recorded in low prevalence rates 4.2 and 1.3%, respectively (Table 3).

Table 1: Demographic data (site, gende, age and season) of stray cats examined in Kuwait

	Season							
	Dry				Wet			
	Male		Female		Male		Female	
Locality	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile
1	14	9	19	7	21	13	21	13
2	20	9	41	10	10	10	14	9
Total	34	18	60	17	31	23	35	22

Table 2: Number of stray cats examined by age and reproductive status

	Age group		
Gender/reproductive status	Juvenile	Adult	Total
Male	41	65	106
Barren females	39	45	84
Pregnant	-	36	36
Lactating	-	14	14
Total	80	160	240

Table 3: Prevalence and mean intensity of different parasites recorded in stray cats from Kuwait relative to gender and age

	All cats (240)			Female (134)			Male (106)		
Parasite species	Prevalence (%)	Intensity±SEM	Range	Prevalence (%)	Intensity±SEM	Range	Prevalence (%)	Intensity±SEM	Range
D. nolleri	54.6	126±20	1-4383	59.7	98±12	1-857	48.1	170±25	1-4383
D. acanthotetra	45.4	39±8	1-327	50	41±7	1-303	39.6	36±7	1-327
J. pasqualei	38.3	21±6	1-191	39.5	23±6	1-191	36.8	17±5	1-120
T. taeniaeformis	0.8	1±0	1	0.7	1±0	1	0.9	1±0	1
O. tricuspis	26.3	116±17	1-1838	26.9	105±18	1-1838	25.5	132±15	1-1068
P. gemina	4.2	7±3	1-27	5.9	7±3	1-27	1.9	10±3	1-18
Gnathostoma sp	0.4	9±0	9	-	-		-	0.9	9±09
P. cahirensis	34.6	7±3	1-77	34.3	9±4	1-77	34.9	6±3	1-25
A. tubaeforme	1.3	4±2	2-7	1.5	5±2	2-7	0.9	2±-	2
T. cati	1.3	2±1	1-3	0.7	3±-	3	1.9	2±1	1-2
T. leonina	15	17±5	1-83	11.9	19±8	2-71	11.9	15±5	1-83
I. felis	7.17	2576	200-19400	5.2	829	200-1400	9.4	3800	
I. revolata	1.6	350	200-400	0.7	200	200	2.8	400	400
Sarcocystis	0.4	200	200	-	-		-	0.9	200200
T. gondii	2.12	19840	200-93600	1.5	47000	400-936002.8	1733	200-4000	

	Adult (160)			Juvenile (80)		
	Prevalence (%)	Intensity±SEM	Range	Prevalence (%)	Intensity±SEM	Range
D. nolleri	63.1	141±21	1-4383	37.5	77±13	1-962
D. acanthotetra	57.5	43±8	1-327	21.3	22±5	1-84
J. pasqualei	46.9	24±6	1-191	21.3	6±2	1-116
T. taeniaeformis	1.3	1±0	1		- -	-
O. tricuspis	27.5	65±13	1-1068	23.8	235±211	-1838
P. gemina	5.6	8±3	1-27	1.3	1±01	1
Gnathostoma sp	-		-	-	1.3	9±09
P. cahirensis	33.8	8±4	1-77	36.3	7±3	1-33
A. tubaeforme	1.9	4±2	2-7	-	- -	
T. cati	1.3	3±1	2-3	1.3	1±-	1
T. leonina	*19.3*	18±5	1-83	6.3	6±3	1-22
I. felis	2.5	650-	400-800	16.3	3170	200-19400
I. revolata	0.6	400	400	3.8	333	200-400
Sarcocystis	-		-	-	-	1.3200200
T. gondii	0.6	1000	1000	0.5	24550	200-93600

The prevalence of protozoan infection as detected by fecal examination was 9.2%. Four species were recovered, of which *I. felis* was the most prevalent, while *Toxoplasma gondii* was the most abundant (Table 3). The overall prevalence of *T. gondii* IG as detected by serological examination (IHAT) was 19.6%. No microfilariae, blood parasites, *Trichinella* larvae, lesions of Leishmania or *Dirofilaria* worms were detected.

Out of 240 cats examined only 8 (3.3%) were found to be infected with the ear mite, *Otodectes cynotis*. Only one cat from Al-wafra district (agriculture area) had one tick, an ixodid nymph on its body.

Effect of demographic factors on parasitism: The overall infection rate with parasites was slightly higher ($p>0.05$) in females (94.3%) than in males (86.5%). However, the overall prevalence was significantly higher ($p = 0.01$) prevalence in adults (91.8%) than in juveniles (73.7%). The infection rate was also significantly higher ($p = 0.02$) in the wet season than in the dry season. However, no significant difference was observed between the prevalence rate of parasites in cats trapped in Locality 1 and 2, respectively.

Adults had significant higher intensity and infection rate with cestodes ($p = 0.00$) than juveniles. No significant

Table 4: Prevalence and 95% confidence intervals (C.I) of parasites in 240 cats of different age groups. Sexes and seasons

		Nematodes (95% CI)			Cestodes(95% CI)			Protozoa (95% CI)	
Parameters	Prev.	Low	High	Prev.	Low	High	Prev.	Low	High
Sex									
Male	57.7	47.56	67.1	64.2	54.2	73.2	12.3	6.7	20.1
Female	62.7	53.91	70.89	75.4	67.18	82.4	6.7	3.1	12.4
Age									
Adult	63.7	55.78	71.2	81.9*	75.01	87.52	3.8	1.3	7.9
Young	53.8	42.24	64.92	47.5	36.21	62.29	20*	11.8	30.4
Season									
Wet	70.5*	61.9	78.2	73.6	65.2	81.0	3.9	1.2	8.8
Dry	48.6	39.0	58.3	66.6	57.1	75.3	15.3*	9.2	23.4
Locality									
1	52.9	43.5	62.3	76.1	67.3	83.5	8.5	4.2	15.1
2	67.5*	58.4	75.6	65.0	55.9	73.4	9.8	5.1	16.4
Total	60.4	53.9	66.6	70.4	64.2	76.1	9.2	5.8	13.6

($p>0.05$) effect of cat age on infection with nematodes was observed; however, their intensity and prevalence were significantly higher ($p = 0.00$) in the wet season than in the dry season. On the other hand, the prevalence of cestode infections was not influenced by season. The gender of cats had no effect on the prevalence of each group of helminths. The infection rates with cestodes and nematodes were higher in females than males but this was not significant. On the other hand, the prevalence of helminths was affected by the reproductive status of females. Pregnant and lactating females had significantly higher ($p = 0.02$) infection rate (96%) than barren females (82.1%). Nematodes showed significantly higher ($p = 0.00$) infection rates in cats captured in Locality 2 than Locality 1. While the prevalence of cestodes was not affected by the origin of cats.

In contrast to helminths, Juvenile cats had significantly higher ($p = 0.00$) infection rate with protozoa than adults and significantly higher ($p = 0.00$) prevalence of protozoan infection was observed during the dry season. However, no significant effect of gender and site on the prevalence of protozoa was detected (Table 4). Sero-positivity of *Toxoplasma* was significantly higher ($p = 0.00$) in adults (89.4%) than in juveniles (10.6%). No detection of *Toxoplasma* antibodies was observed in kittens younger than 3 months and shedding oocysts in their feces.

Analysis of *Diplopylidium* sp. and *Joyeuxiella* sp. infection generated comparable results which is likely due to similar biology. The prevalence of these cestode species was higher in adult cats than in juveniles; but no effect was observed relative to sex, season and site.

The frequency of *O. tricuspis* was affected by season and site where it was highly significant ($p = 0.01$) in the wet season and Locality 2 but no significant difference in prevalence was reported relative to gender and age. *T. leonina* had the same trend as *O. tricuspis* as its prevalence was significantly higher ($p = 0.00$) in the wet season and Locality 2; in addition it was also affected by age; *T. leonina* was significantly higher ($p = 0.00$) in adults than in juveniles. With respect to the prevalence of *P. cahirensis*, no significant differences were observed between males and females, adults and juveniles, wet season and dry season and Locality 1 and Locality 2. However, analysis of data regarding the frequency of *P. cahirensis* and dipylidiid cestodes which ranked the first most common among nematodes and cestodes, respectively revealed that there was a positive highly significant ($p = 0.00$) correlation between them in terms of occurrence. The prevalences of helminth species of <5% were too low to merit detailed analysis.

DISCUSSION

In the only study on feline parasitism in Kuwait, Abdul-Salam and Baker (1990) examined 103 stray cats collected from districts around Kuwait city and found 76 (73.8%) of them were infected with five helminths (2 cestodes, 2 nematodes and one trematode). The higher infection rate (86.25%) with 25 helminth species (4 cestodes, 7 nematodes and 14 trematodes) recorded in this study is attributed to the higher number of cats examined in different localities of Kuwait state.

The results of this study are comparable to other reports from the Gulf region in that the prevalence rates of parasitism in stray cats were high, 90% in Iran (Changizi *et al*., 2007), 87% in United Arab Emirates (U.A.E.) (Schuster *et al*., 2009), 83.2% in Qater (Abu-Madi *et al*., 2010) and 90.9 in Iraq (Al-Obaidi, 2012). Similar results were obtained in studies conducted in the other parts of the world e.g. Spain (Calvete *et al*., 1998), Brazil (Labarthe *et al*., 2004), Egypt (Khalafalla, 2011), Nigeria (Sowemimo, 2012) where the overall prevalence of feline parasitic infection was 90, 90, 91 and 85.5%, respectively. This high infection rate of parasitic infections in stray cats was expected as they are scavengers feeding on garbage, insects, small animals and fish and meat offal.

The present study also agrees with most of these studies in the Gulf region that the vast majority of worms were cestodes but they differ in which species of tapeworms was common in each country. *D. nolleri* was the most prevalent cestode in this study and in that of Changizi *et al*. (2007) in Iran. However, *Joyeuxiella* spp. and *T. taeniaeformis* were the most frequent tapeworms recorded in UAE (Schuster *et al*., 2009) and in Qatar (Abu-Madi *et al*., 2010), respectively.

Probably, these differences in the prevalence rates of cestode species among the Gulf countries are attributed to variations in the infection rates of metacestodes in intermediate hosts as well as to the abundance and availability of these intermediate hosts to stray cats in each country. Delahay *et al*. (1998) stated that differences in parasite species or their prevalence and abundance may vary among host populations as a result of variations in some factors including diet.

Very little has been described relative to the biology of Diplopylidium and *Joyeuxiella.* The cysticercoids of these cestodes have been found in lizards, snakes, toads and small mammals (Witenberg, 1932). It has been believed 2 intermediate hosts are required for Diplylidiinae of which the primary ones are coprophagous insects and the secondary ones, reptiles or occasionally amphibian or small mammals; but this has never actually been proved for any member of dipterous insects. Witenberg (1932) failed to infect the maggots of common fly, meal-worms and cockroaches with the gravid segments of these cestodes. Similarly, Ortlepp (1933) was unable to infect dung beetles fed the gravid proglottids of *J. fuhrmanni*.

The method by which the reptiles become infected is obscure, although the cysticercoids of these dipylidiid cestodes have been recorded from lizards in many countries including Turkey (Mimioglu and Sayin, 1963), Russia (former USSR) (Matevosjan, 1963), India (Agrawal and Pande, 1979), Tanzania (Simonsen and Sarda, 1985), South Africa (Schuster *et al*., 2004) and Iraq (Al-Barwari and Saeed, 2007).

The high prevalence and abundance of *Diplopylidium* and *Joyeuxiella* in stray cats from different localities of Kuwait indicate that reptiles constitute the main part of their diet. It is strongly suggested that the source of infection to cats is Hemidactylus geckos which are widespread in the residential areas of Kuwait and also distributed in other Gulf countries (Gholamifard and Rastegar-Pouyani, 2011).

Mimioglu and Sayin (1963) observed that *Hemidactylus turcicus* was the preferred prey of cats. It would be worthwhile to study the complete life cycles of *Diplopylidium* and *Joyeuxiella* in the Gulf region. *T. taeniaeformis*, the rodent borne cestode was found rarely (0.8%) in contrast with much higher prevalence rates in Qatar (73.6%; Abu-Madi *et al*., 2010), UAE. (16.7%; Schuster *et al*., 2009) and Egypt (30.3%; El-Shabrawy and Imam, 1978). The low prevalence could indicate that rodents do not play a substantial role in the diet of stray cats in Kuwait, perhaps because of low densities of these preys in localities where stray cats occur.

Abdul-Salam and Baker (1990) justified the absence of this tapeworm in their survey that rodents were scarce due to the active rodent control campaign conducted by Ministry of Health in Kuwait. On the other hand, the low prevalence of *Strobilocercus* (*Cysticercus*) *fasciolaris*, the larval stage of *T. taeniaeformis*, among rodents could be another reason for the low prevalence of this cestode in cats. Al-Mahi (2008) reported a low infection rate (4.23%) of *T. taeniaeformis* in wild cats in Egypt as a reflection of the scarcity of *S. fasciolaris*in rodents; only *Rattus norvigacus*, among other rodents examined was found to be infected with a low prevalence rate (5.77%) and a mean abundance (0.06).

The absence of *D. caninum* in this study was expected as no fleas were found on examined cats. Also, this cestode was not found in stray cats in the study of Schuster *et al*. (2009) in UAE although flea infestation was detected but in very low prevalence, probably related to the low humidity.

P. cahirensis is the most prevalent nematode with prevalence rate 34.6% but of low intensity (mean burden = 7). The same finding was recorded by Schuster *et al*. (2009) in UAE with comparable infection rate (35.6%) and Intensity (mean burden = 6). Higher infection rate (52.2%) was recorded in Iran (Arbabi and Hooshyar, 2009). In Iraq, this nematode was found in stray cats by Daoud *et al*. (1988) but in a recent survey in Mosul city Al-Obaidi (2012) did not report it; similarly, *P. cahirensis* was absent in the study of Abu-Madi *et al*. (2010) in Qatar.

The larvae of *P. cahirensis* were found in beetles (Quentin *et al*., 1976) and in geckoes (Gupta and Pande, 1970). The common utilization of intermediate and paratenic hosts between this spirurid nematode and dipylidiid cestodes and the significant positive association in terms of frequency of occurrence between them may explain their high prevalence among the parasites in this study and that of Schuster *et al*. (2009) in UAE. However, the infection rate and intensity of *P. cahirensis* were considerably lower than that of dipylidiid cestodes; perhaps because of differences in the prevalence and abundance of their larval stages in insects and reptiles.

O. tricuspis ranked the second after *P. cahirensis* but was the most abundant among nematodes. This seems in contradiction with other reports from the Gulf region;

apart from Schuster *et al*. (2009) it has not been reported; it is easily missed during examination of stomach ingesta because of its small size. The high intensity (one cat harbored 1836 worms) is not uncommon and may be due to the cat-to-cat transmission by consumption of infected vomitus or even through autoinfection (Wittmann, 1982; Bowman *et al*., 2002).

Although, *T. cati* is a common parasite of felidae in this study only 1.3% of the examined cats were infected with low intensity (mean burden = 2), similar to other studies in the region (Schuster *et al*., 2009; Abu-Madi *et al*., 2010); this may be low tolerance of its eggs to high temperatures and desiccation. In contrast, it seems that *T. leonina* has a greater tolerance to high temperatures and low humidity (Okoshi and Usui, 1968); therefore it was reported at higher prevalence (15%) and a mean burden (7).

P. gemina is recorded for the first time in cats in Kuwait and even in the Gulf region. *Physaloptera praeputialis* is the more common species of Physalopteridae, reported from the Gulf region (Changizi *et al*., 2007; Abu-Madi *et al*., 2010; Schuster *et al*., 2009; Al-Obaidi, 2012). The spicules of *A. gemina* as measured in the present study are longer than that reported for *P. praeputialis* (Morgan, 1944; Mohamadain and Ammar, 2012). Our specimens differ from that of *A. kuwaitensis* which was recovered from the stomach of rodents in Kuwait (Khalil *et al*., 1979) in the length of the body of the female and male as well as in the length and shape of the spicules.

A. tubaeforme was found only in 2 cats (1.3%) with mean intensity of 4. Which seems low when compared to other studies. Again this variation may be attributed to differences in environmental conditions. The life cycle of this hookworm is direct, and therefore the larvae are affected by ambient temperatures and humidity (Matthews, 1985). The hookworm of carnivores recorded previously from Kuwait was *A. caninum*, found in dogs (Abdul-Salam, 1986) and cats (Abdul-Salam and Baker, 1990) with a low prevalence rate of 2.9% and 0.48%, respectively. Although low-level *A. caninum* infections may occur in cats, they are easily confused with *A. tubaeforme*.

Gnathostoma spp. are mainly encountered in Southeast Asia and South America where these spirurid parasites use small copepod crustaceans as first intermediate hosts while freshwater fish and other animals, e.g., frogs, snakes and small mammals act as second intermediate/paratenic hosts. Final hosts, including Cats, become infected by eating one of second intermediate/paratenic hosts containing the infective stage (third larval stage) (Rojekittikhun, 2002). Given this complex life cycle it is unlikely that this parasite is endemic in Kuwait but the infection could be acquired from imported fish. In this study, the one infected cat was trapped around the Kuwait fish market. Kuwait imports fish from many countries where *Gnathostoma* has been reported, e.g., Egypt (Arafa *et al*., 1978), India (Tiwari *et al*., 2009) and Southeast Asia (Nawa and Nakamura-Uchiyama, 2004). The advanced third larval stages of *Gnathostoma* in fish tissues are killed in 48 h by freezing and by refrigeration after 30 days (Alvarez-Guerrero and Alba-Hurtado, 2011).

On the other hand it is likely that local fish could be the source of infection. Some fish e.g. *Tenuatosa ilish*a (known locally as sabour) and *Pampus argen*teus (Known locally as zobaidy) are anadromous migrating upstream to the Shatt Al-Arab River for spawning and nursery in March, then returning back to Kuwait's waters in the Gulf for feeding and wintering (Al-Hassan, 1999; Al-Husaini, 2003). Sabour and zobaidy could be infested in fresh waters of Iraq where *Gnathostoma* was recorded in 24% of examined stray cats (Al-Obaidi, 2012). However, this needs more investigation. Copepods have been reported from the Shatt Al-Arab River (Khalaf, 2008) and they have been found to be the main dietary component of zobaidy caught from Kuwait's waters (Dadzic *et al*., 2000).

Differentiation between the oocysts of coccidian species was based on the size and morphological features. It was easy to recognize *Sarcocystis* oocysts as they were passed already sporulated in the faeces. Differences in size between the oocysts of *I. felis*, *I. revolta* and *T. gondii/Hammondia* sp. rendered differential identification possible. However, differentiation between the oocysts of *Toxoplasma* and *Hammondia*, which have the same size, was not possible. Researchers considered the smallest sized oocysts belonging to *Toxoplasma* as sero-positive cats had *Toxoplasma* antibodies in this survey.

Only two arthropods were reported in the present study with very low prevalence, probably because of the harsh environmental conditions in Kuwait. The absence of fleas on stray cats which live outdoors is a reflection of the hot and dry weather in the country. Temperature and humidity are the two important factors which influence the survival, development and reproduction of cat fleas (Koutinas *et al*., 1995).

This study showed that variations in demographic factors play a significant role in determining the prevalence and intensity of different parasite higher taxa and species. No significant differences between the sexes were observed. However, pregnant and lactating cats had significantly higher prevalence rates of helminths than

barren females. These differences may be related to relaxation of immunity (Soulsby, 1982) or to behavioral changes and increased food intake (Burt *et al*., 1980; Engback *et al*., 1984).

Significant higher prevalence of overall helminths as well as of cestodes was detected in the adult-than juvenile group. This indicates that the risk of exposure to helminth infection increased with age and coincides with other studies (Schuster *et al*., 2009; Abu-Madi *et al*., 2010). On the other hand, the age o f cats was not a significant determinant for infection with nematodes, probably a reflection of the comparable prevalence rates of *O. tricuspis* and *P. caharensis*, which were the most prevalent nematodes, in different age groups.

No significant difference was noted in the overall prevalence of helminths between cats which were captured in Locality 1 and those were trapped from Locality 2. This trend was also demonstrated when the results of cestode infection was analyzed. No regional as well as seasonal differences in the prevalence of cestodes were found. This observation is likely to be related to the comparable levels of regional and seasonal abundance of intermediate and paratenic hosts. On the other hand, nematodes showed higher infection rates in Locality 2 than Locality 1. In Locality 2, comparatively higher densities of stray cats were observed; the situation which facilitates the transmition of nematodes, thus they are less likely to be exposed to harsh environmental conditions prevailing in Kuwait. It has been known that overstocking of farm animals may enhance the transmission of parasites. El-Azazy (1995) found that in Saudi Arabia, higher prevalence of abomasal nematodes in small ruminants was unexpectedly recorded in summer because animals are overstocked on limited pasture areas during a period of drought. Likewise for ecological factors, higher prevalence of nematodes, particularly *O.tricuspis* and *T. leonina*, was recorded in wet season when climatic conditions are favorable for the thriving of preparasitic stages.

Unexpectedly, the prevalence of coccidian protozoa in cats was significantly higher in the dry season. High temperatures (above 45ºC) stop the sporulation of oocysts (Bowman *et al*., 2002). It seems that the feline coccidians in Kuwait is linked with the age and breeding season of cats rather than the environmental conditions. It was noted that the highest number of 3-month-old cats, the most susceptible age to infection with coccidia, particularly *T. gondii* (Davis and Dubey, 1995; Bowman *et al*., 2002) were trapped in the dry season as the breeding season of cats in Kuwait is almost through wet/cold season, nearly the same breeding season of stray cats in Qatar (Abu-Madi *et al*., 2010). Subsequently, kittens prevail in the next (dry) season; in cat colonies, these vulnerable kittens acquire infection from their dams and other cats.

Shedding of oocysts at high intensity was observed in juveniles, particularly under 3 months of age which were noted not to have *Toxoplasma* antibodies in their sera. The epidemiological studies on toxoplasmosis have shown that cats in wild become infected soon after weaning and excrete large numbers (millions) of oocysts for short period (2 weeks) after primary infection (Dubey, 1994). Mainly, these cats stop shedding oocysts in the rest of their lives; however, some do shed-albeit fewer-oocysts for short periods after re-infection (Dubey, 1994). Dubey and Beattie (1988) stated that during oocyst shedding period, cats may not develop antibodies.

Cats and other felines have been reported as reservoir hosts of many parasites of zoonotic importance. This study reported some zoonotic parasitic infections which may threaten the public health. The most common feline helminths known to have zoonotic potentialare *T. cati* and *A. tubaeforme*, the causative agents of visceral larva migrans (human toxocariasis) and cutaneous larva migrans (creeping eruption), respectively. Because of the low prevalence of these parasites as shown in the present study, they are unlikely a major public health threat in Kuwait and indeed human toxocariasis and creeping eruption have not been reported in this country.

Cats are a corner-stone in the life cycle of *T. gondii* as a final host and they play an important role in the epidemiology of toxoplasmosis which is a zoonotic disease. *T. gondii* which was recorded by fecal and serological examinations in cats in this study, is an important causative agent of abortion and stillbirth in humans and animals (Dubey 1994). In Kuwait, 2 studies detected antibodies to *Toxoplasma* in human population and pregnant women (Behbehani and Al-Karmi, 1980; Iqbal and Khalid, 2007). Also, *Toxoplasma* antibodies were detected by IHAT during our routine examination of serum of aborted sheep and goats in the Veterinary Laboratories (unpublished data).

Gnathostoma infection is not known to be endemic in the Middle East including the Gulf region but *Gnathostoma* larval migrans has been reported in a visitor in Israel (Nagler *et al*., 1983) and in a guest worker in Kuwait (Hira *et al*., 1989). Reporting of *Gnathostoma* in this study and that of Al-Obaidi (2012) in Iraq may initiate the need to study the endemic status of *Gnathostoma* in Kuwait and other Gulf countries and the risk which may be posed by seafood consumption by investigating the dietary habits of people as well as examining imported and local fish.

CONCLUSION

This study reveals in general that stray cats-as scavengers In a given area-can act asindicators of pathogens prevailing in the environment. Cats in Kuwait were found to be infected with soil-borne-(e.g. *Toxocara*),

insect-borne- (e.g., *Physaloptera*), reptile-borne-(e.g., *Diplopylidium*; *Joxeuiella*; *Pterygodermatites*), fish-borne (e.g., *Gnathostoma*), rodent-borne (e.g., *Toxascaris*; *Taenia taeniaeformis*) and meat-borne parasites (e.g., *Toxoplasma*) all obtained orally. Although, some of these parasites are of public health importance, there is little evidence that stray cats and their parasites posed a major public health risk.

Parasites with indirect life cycles (using intermediate hosts) and as such less exposed to the harsh environment, appear able to survive well in the hot and dry Kuwait climate. Demographic factors appear to have effect on feline parasitism. The prevalence of cestodes and protozoa was affected by the age of cats while location and season played a role in the prevalence of nematodes. The results point to a need for further study of the biology of dipylidiid cestodes and of the epidemiology of *Gnathostoma* and other seafood-borne parasites in the upper Gulf region.

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