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Ectoparasites in urban stray cats in Jerusalem, Israel: differences in infestation patterns of fleas, ticks and permanent ectoparasites

H. SALANT[1], K. Y. MUMCUOGLU[1] and G. BANETH[2]

[1]Department of Microbiology and Molecular Genetics, Kuvin Centre for the Study of Infectious and Tropical Diseases, Hadassah Medical School, Hebrew University, Jerusalem, Israel and [2]School of Veterinary Medicine, Hebrew University of Jerusalem, Rehovot, Israel

Abstract. In a period cross-sectional study performed to examine ectoparasites on 340 stray cats in Jerusalem, Israel, 186 (54.7%) were infested with the cat flea, *Ctenocephalides felis* (Siphonaptera: Pulicidae), 49 (14.4%) with the cat louse, *Felicola subrostratus* (Phthiraptera: Trichodectidae), 41 (12.0%) with the ear mite, *Otodectes cynotis* (Astigmata: Psoroptidae), three (0.9%) with the fur mite, *Cheyletiella blakei* (Trobidiformes: Cheyletidae), two (0.6%) with the itch mite *Notoedres cati* (Astigmata: Sarcoptidae), and 25 (7.3%) with ticks of the species *Rhipicephalus sanguineus* sensu lato (Ixodida: Ixodidae), *Rhipicephalus turanicus* or *Haemaphysalis adleri* (Ixodida: Ixodidae). A higher number of flea infestations was observed in apparently sick cats ($P < 0.05$) and in cats aged < 6 months ($P < 0.05$). The proportion of flea-infested cats ($P < 0.01$), as well as the number of fleas per infested cat ($P < 0.01$), was higher in autumn than in other seasons. By contrast with findings in cats with flea infestations, rates of infestation with ticks were higher amongst cats with clinical signs ($P < 0.01$) and cats aged ≥ 6 months ($P < 0.05$). The high rates of ectoparasite infestation in the cats studied constitute a risk for the spread of vector-borne infections of zoonotic and veterinary importance.

Key words. Cats, ectoparasites, prevalence, Jerusalem.

Introduction

Infestations of ectoparasites can cause considerable discomfort to affected animals. In addition, arthropods, particularly insects and ticks, can serve as vectors of disease. Ectoparasites are capable of causing systemic disease that can lead to life-threatening conditions, such as anaemia in young or debilitated animals (Yeruham *et al.*, 1989), and flea bite allergies as well as flea infestations of people. The cat flea, *Ctenocephalides felis*, is one of the most important ectoparasites of cats and dogs worldwide (Rust & Dryden, 1997) and is a known vector for *Bartonella henselae* (Rhizobiales: Bartonellaceae), *Bartonella clarridgeiae* and *Rickettsia felis* (Rickettsiales: Rickettsiaceae), which in humans can cause cat scratch disease, endocarditis and cat flea typhus, respectively (Vobis *et al.*, 2003). Cat fleas are intermediate hosts of the cestode *Dipylidium caninum* (Cyclophyllidea: Dipylidiidae), which can be transmitted to pets and humans.

Numbers of feral cats are high in most urban and rural residential and industrial areas of Israel, probably as a result of a mild average annual temperature of 21.8 °C (range: 12–30 °C) (Israel Meteorological Services, 2013) and continuous access to an abundance of leftover food in garbage bins, as well as food deliberately fed to feral cats by cat enthusiasts; these conditions allow cats to propagate and maintain stable populations. For this reason, an attempt to

Correspondence: H. Salant, Department of Microbiology and Molecular Genetics, Kuvin Centre for the Study of Infectious and Tropical Diseases, Hadassah Medical School, Hebrew University, PO Box 12272, Jerusalem 91120, Israel. Tel.: +972 2 675 8080; Fax: +972 2 675 7425; E-mail: tsvis@ekmd.huji.ac.il

control feral cat populations by means of their capture, neutering and subsequent release, has been adopted by many municipalities.

Cats can also be infested with ticks, as well as with mites such as *Notoedres cati*, *Cheyletiella blakei* and *Otodectes cynotis*, which, apart from causing direct damage to the infested animal, can also infest humans (Griffin *et al.*, 1993; Mumcuoglu *et al.*, 1993; Ihrke, 2006; Sréter-Lancz *et al.*, 2006; Souza *et al.*, 2007; Ferreira *et al.*, 2009).

The objective of this study was to investigate the prevalence of ectoparasite infestation in a stray cat population and to determine the effects of various demographic and environmental factors on the cats' risk for infestation.

Materials and methods

Animals

Stray cats brought to the cattery of the Jerusalem Municipality Veterinary Services during the period from March 2010 to April 2011 were included in the survey. As part of an ongoing municipal trap–neuter–release programme, cats brought into the cattery for sterilization were examined for ectoparasites. Cats were categorized as stray when no previous knowledge of their ownership and no physical clues such as collars, castration or ovariohysterectomy scars were available. Cat sex and age were recorded. Age was determined according to the animal's dental eruption (Merck Veterinary Manual, 1986), level of calculus (positively associated with increased age), and size (increasing until about 6 months of age). Demographic data, such as the region of capture within the city (north, west, central, east or south), neighbourhood ethnicity (mainly Muslim and Christian Arab, or Jewish), exact date of capture, and season (June–August, summer; September–November, autumn; December–February, winter; March–May, spring) were recorded. Wounds and clinical signs of disease were noted. Left ear pinna cropping was performed at the end of the sterilization procedure in order to avoid the recapture of previously neutered cats and thus avoid the same cats being sampled again for ectoparasites.

Ectoparasite collection

Cats were anaesthetized for surgery using a combination of ketamine hydrochloride (Ketalar™; 100 mg/mL; dosage: 10 mg/kg i.m.) and xylazine hydrochloride (Rompun™; 100 mg/mL; dosage: 1 mg/kg i.m.), observed for the presence of ectoparasites and then sampled. The total time allocated per cat for observation and sampling was consistently 15 min. Cats were examined for fleas by combing their fur for a period of 5 min (Zakson *et al.*, 1995) using a fine-toothed comb (Lochdan™; Regev Stainless Steel Industries Ltd, Ma'alot, Israel). All of the fleas recovered were placed into 70% ethanol for species identification and enumeration. The skin of the cat and the areas within the ear canal and between the toes were examined for the presence of ticks for an additional 5 min. The remaining time was used to apply three 10-cm bands of transparent adhesive tape (2 cm in width) to the dorsum and both flanks of the body; these were subsequently attached to a sheet of white paper and examined for lice, mites and flea faeces under a stereo microscope (×40). Deep scrapings of crusty skin lesions were also obtained, and material from the inside of both ears was sampled for the presence of ear mites. For this purpose, the end of a sterile cottonwool bud (Life®; Uzi Bat Yam Ltd, Bat Yam, Israel) was dipped in sterile olive oil and samples from the external ear canals were taken and placed into labelled tubes. The material on the cottonwool bud was transferred in the laboratory to a drop of Hoyer's solution on a microscope slide and examined under a light microscope. Fleas and ticks were preserved in 70% ethyl alcohol for species identification and the determination of life cycle stages. When crusts were visible on the skin of the cat, scrapings were taken with the aid of a scalpel and the material was later added to a drop of lactic acid and examined under a light microscope for the presence of mites such as *N. cati*.

Ectoparasite species classification

Ticks were classified according to their morphological characteristics based on the work of Walker *et al.* (2000) and Feldman-Muhsam (1951). Fleas were identified according to Hopkins & Rothschild (1953), lice according to Zlotorzycka *et al.* (1974) and parasitic mites according to McDaniel (1979).

Statistical analysis

Statistical analysis was performed using Pearson's exact chi-squared test or Fisher's exact test (StatXact Version 10; Cytal, Inc., Cambridge, MA, U.S.A.). Significance was measured using a two-tailed test whereby differences with a P-value of < 0.05 were considered statistically significant. All analyses included in the present Results section were performed using Fisher's exact test except for the analysis of flea infestation according to region of capture, which was determined using an exact chi-squared test.

Results

During the study period, 340 cats were examined, of which 153 were male and 187 were female. Thirty-two of the females were pregnant. A total of 112 cats were aged ≤ 6 months. Of the 340 cats, 103 were sampled in summer, 64 in winter, 121 in spring and 52 in autumn. Cats collected included 78 from northern, 103 from western, 41 from eastern, 20 from southern and 98 from central areas of Jerusalem. Clinical signs defined as any evidence of disease or previous trauma to one of the body systems were observed in 48 (14.1%) of the 340 sampled cats.

At least one species of ectoparasite was recovered from 68.8% of the 340 cats. Overall, adults of the cat flea, *C. felis*, were recovered from 186 (54.7%) cats, the cat louse, *Felicola subrostratus*, from 49 (14.4%) cats, the ear mite, *O. cynotis*,

from 41 (12.0%) cats, the fur mite, *C. blakei*, from three (0.9%) cats, the itch mite, *N. cati*, from two (0.6%) cats, and adult ticks of *Rhipicephalus sanguineus* sensu lato (three cats, 0.9%), *Rhipicephalus turanicus* (19 cats, 5.6%) and *Haemaphysalis adleri* (three cats, 0.9%) from 25 (7.4%) cats. No cats were co-infested with more than one species of tick. Table 1 shows cat infestation rates according to various physical and demographic parameters.

Fleas were recovered from cats in each month of the year. A significantly higher number of flea infestations was observed among sick cats ($P < 0.05$) and in cats aged < 6 months ($P < 0.05$). The health status of cats was not confounded by age. The proportion of flea-infested cats ($P < 0.01$), as well as the numbers of fleas per infested cat ($P < 0.01$), was significantly higher in autumn than in other seasons (Fig. 1). There was a significant association between the presence of fleas and flea faeces ($P < 0.01$). The number of female fleas collected from cats ($n = 510$) was much higher than the number of male fleas collected ($n = 111$). No significant differences in flea infestation were observed amongst cats according to area of capture ($P > 0.05$, exact chi-squared test) or neighbourhood ethnicity ($P > 0.05$).

Otodectes cynotis infestation was significantly higher in male than in female cats ($P < 0.05$). Infestations with permanent parasites such as *O. cynotis*, *C. blakei*, *N. cati* and *F. subrostratus* were significantly higher in autumn than in other seasons ($P < 0.05$).

Most *R. sanguineus* s.l. and *R. turanicus* ticks were recovered from cats in summer (11/25, 44.0%) and spring (10/25, 40.0%), respectively. Two of the three (66.7%) *H. adleri* ticks were recovered from cats in winter. There were significantly higher rates of tick infestation amongst cats with clinical signs ($P < 0.05$) and cats aged > 6 months ($P < 0.05$) (Table 1).

These data did not support the hypothesis that infestation with any one of the ectoparasites observed in this study significantly increased the likelihood of co-infestation with any other ectoparasite. Furthermore, no significant differences in infestation rates were observed according to cat gender or cat pregnancy status (Table 1).

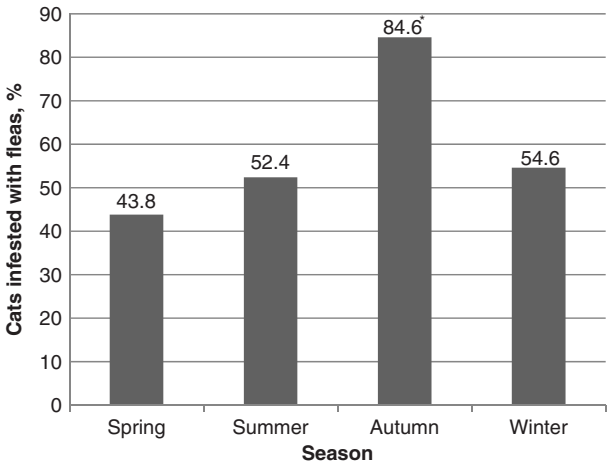

Fig. 1. Percentages of stray cats collected in Jerusalem ($n = 340$) found to be infested with fleas according to season. *Percentage significantly greater than in other seasons ($P < 0.05$).

Discussion

The present study documented for the first time a high rate of ectoparasite infestation in stray cats in Jerusalem: 54.7% of the cats examined were found to harbour *C. felis*. Fleas were found on cats throughout the year, as previously reported elsewhere (Bond *et al.*, 2007), probably because the region has a mild climate.

Similar findings of higher proportions of flea-infested animals, as well as higher numbers of fleas per affected animal in autumn than in other seasons have been reported in calves, lambs and kids in Israel (Yeruham *et al.*, 1989).

Table 1. Infestation rates amongst 340 urban stray cats captured in Jerusalem according to various physical and demographic parameters.

Parameter	Variable	*Ctenocephalides felis*, *n* (%)	> 50 *C. felis*/cat, *n* (%)	Tick infestation, *n* (%)	Permanent parasites‡, *n* (%)	*Otodectes cynotis*, *n* (%)
Cat sex	Males§	88/153 (57.5%)	24/153 (15.7%)	14/153 (9.1%)	45/153 (29.4%)	26/153 (17.0%)*
	Female§	98/187 (52.4%)	18/187 (9.6%)	11/187 (5.9%)	42/187 (22.5%)	15/187 (8.0%)
Age	≤ 6 months§	70/112 (62.5%)*	24/112 (21.4%)	4/112 (3.5%)	26/112 (23.2%)	16/112 (14.3%)
	> 6 months§	116/228 (50.9%)	18/228 (7.9%)	21/228 (9.2%)*	61/228 (26.8%)	25/228 (11.0%)
Health status	Clinical signs§	30/48 (62.5%)	7/48 (14.6%)	9/48 (18.8%)†	13/48 (27.1%)	5/48 (10.4%)
	No clinical signs§	156/292 (53.4%)*	35/292 (12.0%)	16/292 (5.4%)	74/292 (25.3%)	36/292 (12.3%)
Season	Autumn§	44/52 (84.6%)†	14/52 (26.9%)†	1/52 (1.9%)	15/52 (28.8%)*	ND
	Other seasons§	142/288 (49.3%)	28/288 (9.7%)	24/288 (8.3%)	72/288 (25.0%)	ND
Cat pregnancy status	Pregnant§	14/32 (43.7%)	2/32 (6.3%)	1/32 (3.1%)	10/32 (31.2%)	1/32 (3.1%)
	Non-pregnant§	83/155 (53.5%)	16/155 (10.3%)	8/155 (5.2%)	23/155 (14.8%)	14/155 (9.0%)

*$P < 0.05$; †$P < 0.01$.
‡*Notoedres cati*, *Felicola subrostratus*, *Cheyletiella blakei*, *Otodectes cynotis*.
§Each cell was analysed as a two-by-two contingency table using Fisher's exact test.
ND, not done.

The higher recovery of fleas from sick cats may be related to their decreased movement and socialization, whereas higher flea numbers in cats aged < 6 months may reflect the decreased elimination of fleas as a result of less self-grooming, as has been described previously in other species (Yeruham *et al.*, 1989). Therefore, young and apparently healthy cats appear to be a good source of flea-transmitted pathogens. Young cats have been found to harbour higher levels of bacteraemia with *B. henselae* compared with older cats and are likely to acquire infection in their first year of life (Chomel *et al.*, 1995).

In the present study, 7.4% of the cats examined were found to be infested with ticks and more tick-infested cats were seen in the spring and summer months (22/25, 88.0%). This is likely to reflect the warmer conditions under which adult stages of tick species propagate. Tick infestation rates in cats vary among regions and have been reported to be 52.4% in a study from Hungary, and as low as 1.4% in a study from Brazil (Mendes-de-Almeida *et al.*, 2011; Capári *et al.*, 2013).

Felicola subrostratus is the only louse that affects cats (Grant, 1989). This louse is a species-specific, non-blood-sucking parasite that is usually spread by direct contact between animals. In heavy infestations, it may cause scaling, papules, a dull coat and pruritus. In Brazil, rates of infestation varied between 4% and 39% in feline populations (Mendes-de-Almeida *et al.*, 2007; Ferreira *et al.*, 2009), whereas in Hungary the rate of infestation was only 0.4% (Capári *et al.*, 2013), which is substantially lower than the 14.4% found in Jerusalem in the present study.

Ticks including *H. adleri*, *R. turanicus* and *R. sanguineus* have been reported to harbour rickettsial pathogens in Israel (Harrus *et al.*, 2011; Keysary *et al.*, 2011). To the best of our knowledge, *H. adleri* has been found only in Israel and was first found on golden jackals [*Canis aureus* (Carnivora: Canidae)] and described as a new species of tick (Feldman-Muhsam, 1951). Later, it was also found on the marbled polecat, *Vormela peregusna* (Carnivora: Mustelidae), the red fox, *Vulpes vulpes* (Carnivora: Canidae), the jungle cat, *Felis chaus* (Carnivora: Felidae) and the African wild cat, *Felis libyca* (Theodor & Costa, 1967), and the Steppe cat or Pallas's cat, *Otocolobus manul* (Carnivora: Canidae) (Hoogstraal & Kim, 1985). This is the first report of domestic cat infestation with *H. adleri*.

Rhipicephalus sanguineus s.l. was found in 0.9% of cats in the Jerusalem area, which reflected a lower infestation rate than found in Brazil and Dubai, where 1.6% and 4.2%, respectively, of cats were found to be infested with *R. sanguineus* (Ferreira *et al.*, 2009; Schuster *et al.*, 2009).

By contrast with the findings in flea-infested cats, in which fleas were found more often in young cats with no apparent clinical signs, tick infestation rates were higher amongst cats with clinical signs and those aged > 6 months. This may be because sick cats are less mobile and do not get rid of ticks as well as healthy cats.

The ear mite, *O. cynotis*, is found in cats worldwide and is the most common cause of feline otitis externa (Ihrke, 2006). No previous studies have reported differences between the sexes in rates of *O. cynotis* infestation in cats, as observed in this study. The higher infestation of male cats with *O. cynotis* may be explained by their social behaviour, which brings them into contact with greater numbers of other cats (Souza *et al.*, 2007).

The causative agents of feline mange, *N. cati* and *C. blakei*, both of which can opportunistically infest other animals and humans (Griffin *et al.*, 1993; Sousa, 1995), were detected in 0.6% and 0.9%, respectively, of the Jerusalem cats. This is the first report of these parasites in Israel. *Notoedres cati* infestation was found in 2.1% of cats in a Brazilian study (Ferreira *et al.*, 2009) and *C. blakei* infestation was reported in 1.9% of cats in a study from Iran (Borji *et al.*, 2011).

The limitations of the present study include the length of the examination period and the limited number of adhesive tapes used per cat. A longer study spanning greater time might have shown fluctuations in infestation rates among years, and the use of more adhesive tapes per cat might have yielded higher infestation rates for some ectoparasites.

In conclusion, a mild climate and accessible food resources represent favourable conditions for the proliferation of stray cats in Jerusalem, as well as for the ectoparasites that inhabit them. This increases the likelihood that ectoparasites will affect domestic cats and the local human population. The risk for ectoparasite exposure should cause concern because of the veterinary and zoonotic implications of infections transmitted by cat ectoparasites.

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