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RESEARCH ARTICLE

Pavement parasites: a preliminary environmental survey of cat parasites in Klang Valley public housing areas

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ABSTRACT

Due to their proximity and association, cats play a dual role in humans' lives, serving as common companion animals as well as strays. However, they also serve as a significant reservoir for various parasites, including gastrointestinal (GI) parasites. The global prevalence of GI parasites in cats is relatively high, raising concerns about their potential transmission to humans and the risk of causing diseases. Cat droppings are frequently found contaminating the environment and, admittedly, more often in low-income housing areas, posing additional risks to this marginalised group. Therefore, this study aimed to survey the preliminary environmental prevalence of GI parasites in the faecal samples of cats collected from urban poor neighbourhoods in Klang Valley, Malaysia. A total of one hundred cat faecal samples were collected from 10 low-cost housing neighbourhoods across Klang Valley, Malaysia. The samples were then screened using direct smear, concentration techniques, and Harada-Mori to determine the parasitic prevalence. The overall prevalence was 73.0% (n=73), with at least one parasite species infecting the cats. A total of six GI parasites were recovered, including Hookworm (n=63, 63.0%), *Toxocara* spp. (n=26, 26.0%), *Cystoisospora* spp. (n=7, 7.0%), *Ascaris* spp. (n=2, 2.0%), *Balantidium coli* (n=1, 1.0%), and *Trichuris* spp. (n=1, 1.0%). Understanding the prevalence of these parasites is crucial, particularly in marginalised communities where poor environmental hygiene and overcrowding are prevalent, to ensure that appropriate preventive and control measures are implemented due to the zoonotic potential of these infections.

Keywords: Cats; gastrointestinal parasites; urban poor; PPR; Klang Valley.

INTRODUCTION

Cats are popular companion animals in Malaysia and are one of the most frequent stray species that come into direct contact with humans. Human beings were never meant to live without companionship, with dogs being the earliest animals domesticated around 20 000 years ago (Perri *et al*., 2021), while cats were domesticated around 12 000 years ago. Finding solace in these domesticated cats allows their owners to seek comfort in them, and due to their docile nature, cats are often the preferred animal for bonding with humans. As adorable as these furry creatures are, cats are excellent reservoirs for many parasites, including ticks, fleas, and gastrointestinal (GI) parasites (Rojekittikhun *et al*., 2014). Due to their proximity and close association with humans, cats can contaminate the environment by shedding parasitic eggs, larvae, cysts, or oocysts in their faecal discharges (Khademvatan *et al*., 2014). These can then be transmitted to humans either directly or indirectly via contaminated food, water, or surfaces.

In a study conducted in Peninsular Malaysia, the overall prevalence of GI parasitic infection in rural cats was found to be 89.3%, with at least one species detected (Ngui *et al*., 2014). These parasites included the helminths *Toxocara* spp., *Ancylostoma* spp., *Trichuris vulpis*, *Spirometra* spp., *Toxascaris leonina*, *Dipylidium caninum*, and *Ascaris* spp., while the protozoan parasites comprised *Entamoeba* spp., *Giardia duodenalis*, *Toxoplasma gondii*, *Cryptosporidium* spp., and *Isospora* spp. (Ngui *et al*., 2014). Some of these species are zoonotic and have zoonotic potential, which raises public health concerns. For instance, hookworm infections in humans transmitted by cats can result in clinical manifestations, including anaemia and protein deficiency. In children, the loss of protein and iron can lead to physical and mental retardation (CDC, 2019).

Over the past five decades, the urbanisation rate in Malaysia has tripled from 28.4% in 1970 to 78% in 2022, with an urban population growth rate of 4% per annum (Chew, 2018; World Bank, 2023). Klang Valley, comprising Wilayah Persekutuan Kuala Lumpur, Wilayah Persekutuan Putrajaya, and Selangor, is the most densely populated metropolis in Malaysia, with urban populations of 100%, 100%, and 95.8%, respectively. While one might argue that urbanisation has the potential for a positive transformation, the number of urban poor is still relatively high. This is attributed

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to the high migration of low-income groups into the big cities. Accelerated urban expansion over a short period of time may also exacerbate urban diseconomies, including environmental damage, pollution, poor sanitation services, misguided waste management, and population requirements that surpass service capacity (Trivedi *et al*., 2008).

Approximately 3 million of Malaysia's 33.6 million population reside in governmental or private low-income housing complexes, with 1.76 million living in Klang Valley. This suggests that low-cost housing project tenants make up almost a quarter of the Klang Valley's population (The Edge, 2022; World Bank, 2023). Although public housing remains the best option for low-income earners, providing inexpensive rents and allowing individuals to improve their social mobility, recent investigations have raised concerns about its effectiveness since it has produced pockets of deprivation. The living conditions of such housing complexes are often plagued with the presence of stray animals, indiscriminate waste disposal, and poor infrastructure, which further exacerbate and promote the conditions for infectious diseases, including parasitic infections, to thrive (Abu Bakar *et al*., 2023). The consensus is that in urban settings, the role of stray animals as reservoirs for diseases has been underscored as a public health concern, unlike in rural settings (Traub *et al*., 2005).

Hence, given the current living circumstances of humans and cats, there is a need to determine the prevalence of GI parasites that these cats harbour in order to formulate control strategies, mitigate the risk of infections, and increase awareness of possible infections among local communities (Tun *et al*., 2015). Ergo, with this background, the current study sets out to investigate the current prevalence of gastrointestinal parasitic infection of urban cats in low-income housing areas in Klang Valley, Malaysia.

METHODOLOGY

Sample size determination

A total of 100 faecal samples were collected from cats living in selected PPRs (*Program Perumahan Rakyat*) and low-income housing areas throughout the Klang Valley, Malaysia. The sample size was initially determined based on logistical feasibility for a cross-sectional surveillance study. Post hoc calculations were conducted using the observed prevalence of 73% to estimate the required sample size for future studies. Using the standard formula for estimating proportions with a 95% confidence level and a 5% margin of error, the minimum required sample size was calculated to be approximately 303. Although the current sample size allows for a preliminary estimation of prevalence with an approximate ±7.4% margin of error, a larger sample size is recommended for improved precision and subgroup analyses. For exploratory or feasibility purposes, it is generally acceptable to use 10% - 30% of the estimated minimum sample size in pilot studies, which in this case supports the use of 100 samples as sufficient for a preliminary investigation (Johanson & Brooks, 2010).

Study sites and faecal sample collection

This study was conducted in 2022 across Klang Valley, Malaysia, specifically in two distinct districts: Lembah Pantai and Wangsa Maju (Figure 1). All samples were collected from lower-income housing areas, including PPRs (*Program Perumahan Rakyat*), apartments, and flats (Table 1). The two districts were selected because they are regarded as having some of the highest population densities within Klang Valley (DOSM, 2020). Site selection was further guided based on initial observations of

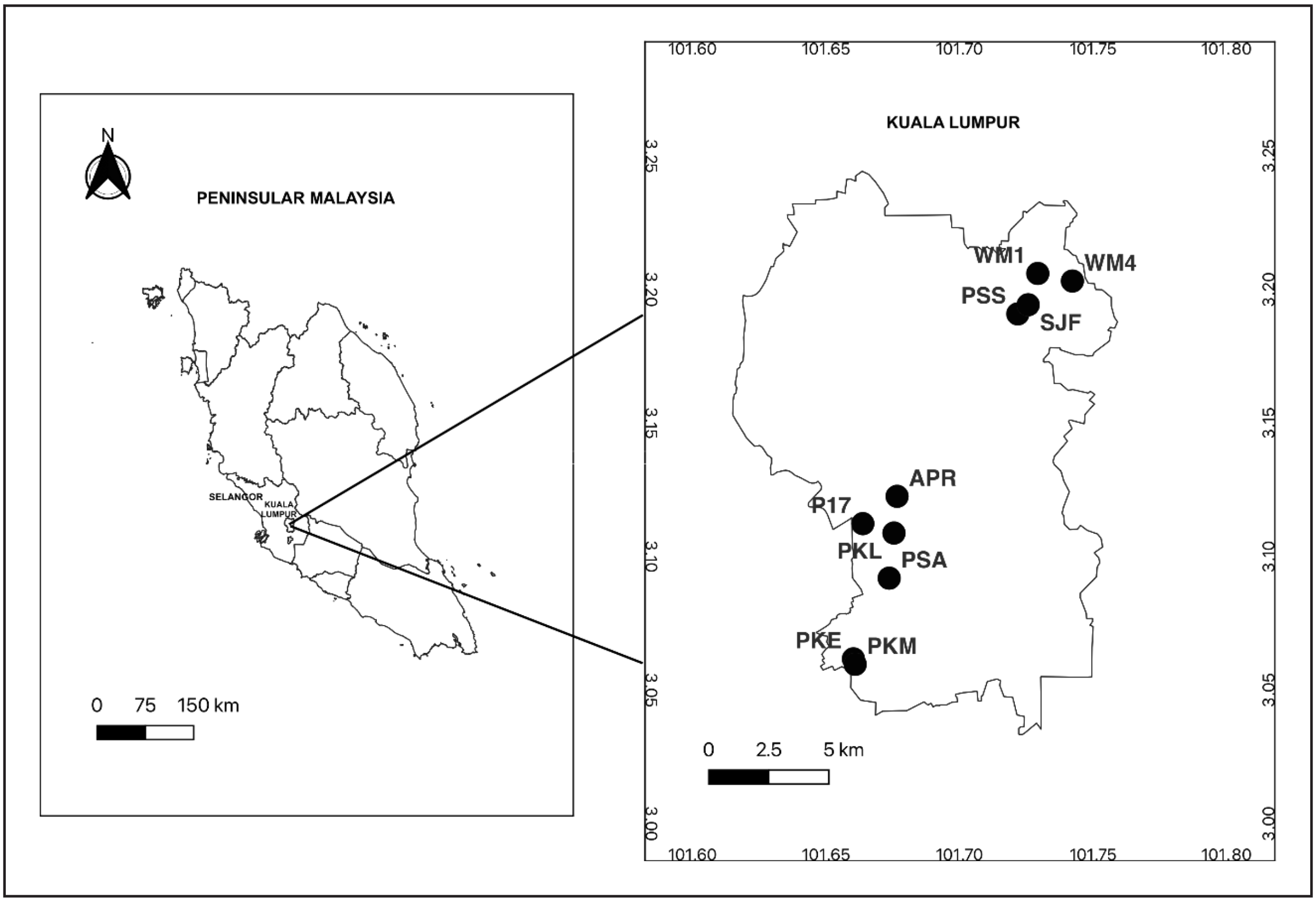

Figure 1. Location of study areas.

Table 1. Coordinates and districts of the study sites

Study site	Coordinate	District
WM1	3.2060° N, 101.7293° E	Wangsa Maju
WM4	3.2032° N, 101.7423° E	Wangsa Maju
PSS	3.1909° N, 101.7219° E	Wangsa Maju
SJF	3.1943° N, 101.7257° E	Wangsa Maju
P17	3.1124° N, 101.6638° E	Lembah Pantai
APR	3.1226° N, 101.6767° E	Lembah Pantai
PKL	3.1088° N, 101.6755° E	Lembah Pantai
PSA	3.0919° N, 101.6737° E	Lembah Pantai
PKE	3.0617° N, 101.6603° E	Lembah Pantai
PKM	3.0597° N, 101.6610° E	Lembah Pantai

stray cat activity and environmental conditions. The samples were collected from cats in the study sites via their discharged faeces, *i.e.,* the faecal samples were collected immediately after the cats had passed them and put into clean, wide-mouth screw-cap containers with proper labelling. The containers were then sealed in zip-lock bags and transported in an icebox back to the Parasitology Lab, Institute of Biological Sciences, Faculty of Science, Universiti Malaya. A small part of the faecal was then transferred into a separate screwcap container, labelled, and stored at -20°C until used. However, fresh faecal samples were used immediately for the Harada-Mori technique.

Parasitic screening of faecal samples

Upon collection, all samples were subjected to four different screening techniques: direct faecal smear, flotation and sedimentation techniques, as well as Harada-Mori, within 5 days. Briefly, the faecal samples were stained with both normal saline and iodine and examined for the presence of parasites using 10x and 40x magnification of light microscopy (Olympus CX23, USA).

Two concentration techniques were employed: simple flotation using concentrated sucrose solution (Horiuchi & Uga, 2016) and sedimentation using PBS-ether solution (Boondit *et al*., 2020). For the flotation technique, a small amount of the faecal sample was mixed with the concentrated sucrose solution before filtering it into an upright test tube. The tube was then topped up with the same sucrose solution until an inverted meniscus formed, and a coverslip was gently placed on top. After 15 minutes, the coverslip was transferred to a glass slide and examined under 10x and 40x magnification using light microscopy. For the sedimentation technique using PBS-ether solution, approximately 1-2g of sample was mixed with 7 ml of PBS and 3 ml of ethyl acetate before centrifuging for 5 minutes at 2 500 rpm. Afterwards, four distinct layers were observed, comprising ethyl acetate, faecal debris, PBS, and a pellet containing parasites. The pellet was then washed with PBS again and centrifuged at 3 000 rpm for 10 minutes. A drop of the pellet was taken, stained with Lugol's iodine on a clean slide, and examined under a light microscope at 10x and 40x magnifications for helminths and protozoa, respectively.

For the Harada-Mori technique, a faecal smear was prepared on a strip of filter paper with a tapered end and subsequently placed vertically inside a 15 mL Falcon tube. Approximately 4 mL of distilled water was added, ensuring the water level remained just below the smear. This setup allows the water to soak the filter paper, creating a moist environment that is favourable for ova to hatch and for larval development to occur. The tube was then incubated at 30°C for 10 days. During the incubation period, the water was examined daily for the presence of larvae by pipetting a small volume and observing it under a light microscope (Harada & Mori, 1955; Mbong Ngwese *et al*., 2020).

Data analysis

Statistical analysis was performed in Microsoft Excel (Version 16.8) and the Statistical Package for the Social Sciences (SPSS) software version 26 (IBM, Armonk, NY). Summary data are provided for the prevalence of infection plus 95% confidence limits (95% CL) calculated with bespoke software based on Rohlf and Sokal's (1995) statistical tables. Chi-square tests of independence were conducted to determine whether infection prevalence differed significantly between districts (Lembah Pantai and Wangsa Maju). A *p*-value of less than 0.05 was considered statistically significant. Effect sizes were reported using Phi.

RESULTS

Prevalence of cats gastrointestinal parasitic infections within the communities

A total of 100 faecal samples from cats were collected from 10 low-income housing areas in the Lembah Pantai and Wangsa Maju districts of Kuala Lumpur. Of these 100 samples, 73 were positive, resulting in an overall prevalence of 73.0% (95% CI = 63.6-81.1) (Table 2). The prevalence of protozoan species included *Cystoisospora* spp. with 7 samples (7.0%, 95% CI = 3.3-13.9) and *Balantidium coli* with 1 sample (1.0%, 95% CI = 0.1-5.3) (Figure 2). For helminth species, Hookworm was found in 63 samples (63.0%, 95% CI = 53.0-72.1), *Toxocara* spp. in 26 samples (26.0%, 95% CI = 18.1-35.5), *Ascaris* spp. in 2 samples (2.0%, 95% CI = 0.4-7.3), and *Trichuris* spp. in 1 sample (1.0%, 95% CI = 0.1-5.3) (Figure 2). Hookworm exhibited the highest prevalence, with 63 out of 73 positive samples, while *Balantidium coli* and *Trichuris* spp. had the lowest prevalence, with one sample each. Overall, helminth species demonstrated a higher prevalence than protozoan species. All helminth species were nematodes, primarily found in egg stages, except for hookworm, which was also presented as larvae.

Within the district level, Lembah Pantai had a higher prevalence of faecal parasite positivity than Wangsa Maju (85% vs 55%). Figure 3 explores the prevalence of cat faecal parasites according to the study sites within the districts. A Chi-square test of independence was conducted to assess whether infection status was associated with the district of the study sites. Upon scrutiny of the data, there was a significant association between the two factors ($\chi^2_1 = 10.959$, $p < 0.0001$) with a medium-sized effect (Phi = 0.331).

Table 2. Overall and species-specific prevalence of GI parasites in cats faecal samples

Parasite species identified	Number of positive samples (n)	Prevalence (%)	95% CI
Protozoa			
Balantidium coli	1	1.0	0.1–5.3
Cystoisospora spp.	7	7.0	3.3–13.9
Helminths			
Ascaris spp.	2	2.0	0.4–7.3
Hookworm	63	63.0	53.0–72.1
Trichuris spp.	1	1.0	0.1–5.3
Toxocara spp.	26	26.0	18.1–35.5
Total infected	73	73.0	63.6–81.1

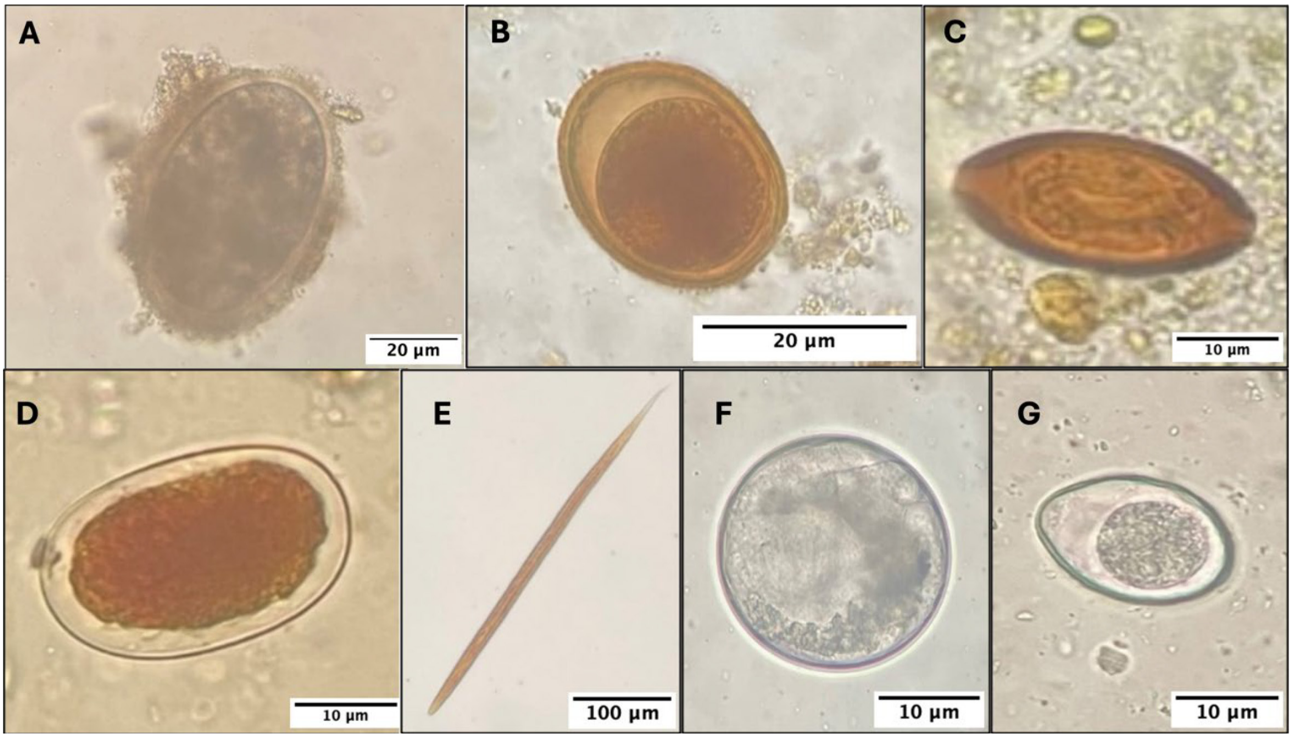

Figure 2. Photomicrographs of (A) *Ascaris* sp. egg, (B) *Toxocara* spp. egg, (C) *Trichuris* spp. egg, (D) Hookworm egg, (E) Hookworm larvae, (F) *Balantidium coli* cyst, (G) *Cystoisospora* spp. cyst.

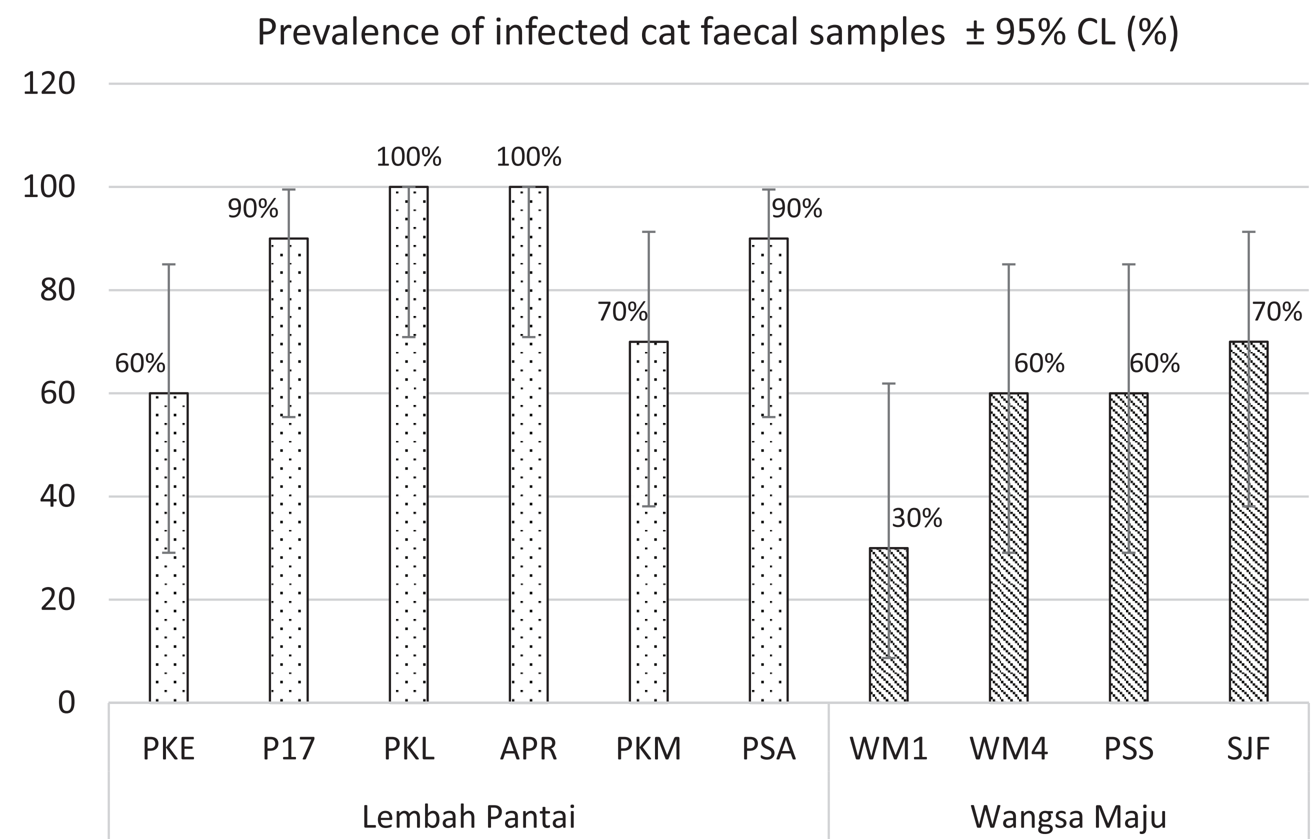

Figure 3. Prevalence of infected cat faecal samples with parasites according to study sites.

Prevalence of parasitic co-infection

From Table 3, monoparasitism (where one sample is affected by only one species of parasite) had a higher prevalence than polyparasitism (where a sample contains more than one species of parasite). Monoparasitism had a prevalence of 47 samples (47.0%, 95% CI = 37.4-57.0), followed by biparasitism with 25 samples (25.0%, 95% CI = 17.4-34.4), and triparasitism with 1 sample (1.0%, 95% CI = 0.1-5.3). Table 3 also illustrates the identified biparasitism co-infections: Hookworm/*Toxocara* spp. (17.0%), Hookworm/*Cystoisospora* spp. (5.0%), Hookworm/*Ascaris* spp. (2.0%), and Hookworm/*Trichuris* spp. (1.0%). Only one triparasitism co-infection was identified, which was Hookworm/*Toxocara* spp./*Cystoisospora* spp. (1.0%).

Prevalence of parasites based on techniques

Four techniques were used altogether: direct faecal smear using saline and iodine, flotation, sedimentation, and Harada-Mori. All techniques showed positive results (Table 4). Among these, the flotation technique produced the most positive results (62 samples) with five species of parasites identified, followed by the sedimentation technique (51 samples), also with five species of parasites identified. The Harada-Mori technique identified one parasite species from 27 samples, while the direct faecal smear using iodine had 18 samples, and the direct faecal smear using saline had the least, with 8 samples. Both saline and iodine direct faecal smears identified two different species of parasites. The Harada-Mori technique had the lowest number of parasite species identified, as this method is used specifically to detect the larvae of Hookworm and *Strongyloides* spp.

Table 3. Distribution of parasitic co-infection in cat faecal samples

Parasitic status	Number of positive samples (n)	Prevalence (%)	95% CI
Monoparasitism	47	47.0	37.4–57.0
Polyparasitism			
Biparasitism	25	25.0	17.4–34.4
Hookworm + *Toxocara* spp.	17	17.0	10.7–25.9
Hookworm + *Cystoisospora* spp.	5	5.0	2.0–11.3
Hookworm + *Trichuris* spp.	1	1.0	0.1–5.3
Hookworm + *Ascaris* spp.	2	2.0	0.4–7.3
Triparisitism	1	1.0	0.01–0.30
Hookworm + *Toxocara* spp. + *Cystoisospora* spp.	1	1.0	0.01-0.30

Table 4. Detection of parasitic infections using diagnostic techniques in cats' faecal samples

Techniques used	Number of positive samples (n)	Parasites identified
Direct Faecal Smear (Saline)	8	Hookworm *Toxocara* spp.
Direct Faecal Smear (Iodine)	18	Hookworm *Toxocara* spp.
Flotation	62	*Ascaris* spp. *Balantidium coli* Hookworm *Cystoisospora* spp. *Toxocara* spp.
Sedimentation	51	*Ascaris* spp. Hookworm *Cystoisospora* spp. *Toxocara* spp. *Trichuris* spp.
Harada-Mori	27	Hookworm

DISCUSSION

The Klang Valley area was selected for this study as it is the most developed and densely populated region in Malaysia, with a high concentration of cats coexisting within human habitats. Both Wangsa Maju and Lembah Pantai were chosen because they are considered to have among the highest population densities in Klang Valley, with densities of 13 475/km² and 7 405/km² (DOSM, 2020). High population density is known to have a correlation with increased environmental contamination, poor sanitation management, and more human-animal interactions (Jarquin *et al*., 2016). These cats frequently roam residential areas and public places such as parks, night markets, and open eateries (Tun *et al*., 2015). Kuala Lumpur, the Federal Territory within Klang Valley, was the primary focus due to its high population density, rising from 1 297 500 residents in 2000 to 8 420 000 in 2022 (Abdul Rashid & Ghani, 2009; Macrotrends, 2022). Interestingly, a large number of faecal samples collected in this study tested positive for at least one species of gastrointestinal (GI) parasite, indicating widespread environmental contamination.

The overall prevalence of GI parasites in cats was 73.0%, with helminth infections being more prevalent than protozoan infections. The identified helminths included *Ascaris* spp. (2.0%), Hookworm species (63.0%), *Trichuris* spp. (1.0%), and *Toxocara* spp. (26.0%). The protozoa observed were *Balantidium coli* (1.0%) and *Cystoisospora* spp. (7.0%). The most common parasites were hookworms and *Toxocara* spp., both recognised for their zoonotic potential.

Similar trends were observed in other studies. A local study in Klang Valley reported a 57.9% prevalence (55/152) of GI parasites in cats, identifying similar species: hookworm (36.2%), *Toxocara* spp. (9.9%), *Trichuris* spp. (2.0%), *Ascaris* spp. (0.7%), and *Spirometra* spp. (9.2%) (Tun *et al*., 2015). An overseas study in Oran, Algeria, found a 60.8% prevalence (62/102), with *Toxocara cati* (43.1%) and several protozoa, including *Cystoisospora* spp. and *Giardia duodenalis* (Slimane *et al*., 2022). These findings underscore the consistent global burden of GI parasites in cats, particularly hookworm and *Toxocara* spp.

Polyparasitism, or infection with multiple parasites, has also been documented in various studies. In the present study, monoparasitism was more prevalent. However, a similar study conducted in Selangor and Pahang, showed higher rates of polyparasitism (46.7%) compared to monoparasitism (38.1%). Dual infections, especially with hookworm and *Toxocara* spp., were common (Ngui *et al*., 2014). These findings suggest that co-infections may be underreported and warrant closer surveillance.

The present study also highlights the significant association between cats' GI parasite positivity and the district of the low-cost apartments. Lembah Pantai had a higher prevalence than Wangsa Maju, which could be attributed to both socioeconomic and environmental factors. Lembah Pantai has a higher Gini coefficient (0.4) compared to Wangsa Maju (0.3) (DOSM, 2020), indicating greater income disparity and economic inequality. Higher income inequality has often been associated with poorer living conditions, indiscriminate waste disposal, and poor management of waste collection facilities (AbuBakar *et* *al*., 2025), all of which could facilitate the risk of environmental contamination and transmission of infectious diseases (Pickett & Wilkinson, 2015), including intestinal parasites. This fosters a conducive environment for parasite transmission, as faecal contamination and unmanaged waste create reservoirs for the strays and pests.

Cats often scavenge for food, preying on rodents, birds, or insects, or drinking contaminated water sources that increase their exposure to parasites (Toenjes, 2014; CDC, 2022). Rodents, for instance, frequently harbour intestinal parasites, making them a significant source of food for cats that consume them raw. Infected cats may exhibit symptoms such as vomiting, diarrhoea, anorexia, weight loss, or even anaemia. While adult cats may be asymptomatic carriers, kittens and immunocompromised animals are more vulnerable to clinical disease (CDC, 2022).

All parasites identified in this study are zoonotic and pose potential health risks to humans. *Toxocara* spp., for instance, can cause toxocariasis, while hookworm larvae may result in cutaneous larva migrans (Khademvatan *et al*., 2014; Weir & Ward, 2022). Other parasites, such as *Ascaris* spp., *Trichuris* spp., *Balantidium coli*, and *Cystoisospora* spp., also have established zoonotic profiles (CDC, 2022). Transmission generally occurs through the accidental ingestion of infective eggs or cysts via contact with contaminated soil, cat litter, or surfaces (Khademvatan *et al*., 2014). Although the risk of transmission to healthy individuals is usually low, vulnerable populations, including infants, pregnant women, the elderly, and immunocompromised individuals, are at greater risk (Cornell Feline Health Center, 2017). For example, cat hookworm infection in humans, although typically limited to the skin, can still result in discomfort and inflammation (Rabbani *et al*., 2020).

Preventive measures for cats include regular deworming, appropriate feeding practices, and limiting their exposure to contaminated environments. Kittens should adhere to a structured deworming schedule, while adult cats should undergo routine deworming at least four times a year (GoodVets, 2021). Similarly, maintaining environmental and personal hygiene, such as daily litter box cleaning, proper waste disposal, and handwashing after handling soil or pets, is critical for reducing human exposure. A comparative study in Indonesia revealed that stray cats had a significantly higher prevalence (88.3%) of GI parasites compared to owned cats (48.33%), likely due to differences in veterinary care and dietary quality (Rabbani *et al*., 2020). This emphasises the importance of regular medical attention in lowering the parasite burden in cat populations.

From a public health perspective, the findings of this study raise significant concerns. In densely populated, low-income urban settings like PPR communities in Klang Valley, environmental contamination from cat faeces poses a tangible risk of zoonotic transmission. These communities often experience limited access to veterinary services, sanitation infrastructure, and awareness campaigns that can exacerbate disease transmission. Although parasites such as *Toxocara* spp. and hookworm may be part of the natural intestinal flora in cats, their high prevalence, especially in areas with poor environmental hygiene, raises concerns regarding potential spill-over events, particularly among populations with high exposure risks. Children playing in shared outdoor spaces, individuals walking barefoot, or residents handling waste without protective gear, are particularly susceptible to infections such as toxocariasis or cutaneous larva migrans (Kidane *et al*., 2014; CDC, 2022).

Although this study did not quantify direct human or environmental exposure, its findings offer a crucial basis for further research. Subsequent studies should incorporate environmental sampling and human prevalence surveys to better understand zoonotic risk and assess actual infection rates among exposed communities. These efforts would strengthen causal links between cat infections and human health outcomes. Therefore, this study underscores the urgent need for targeted One Health interventions (Figure 4), including stray animal control, deworming programs, community education, and environmental sanitation to alleviate the burden of zoonotic GI parasites in urban poor areas. Integrating veterinary, environmental, and public health strategies is crucial for protecting both human and animal health.

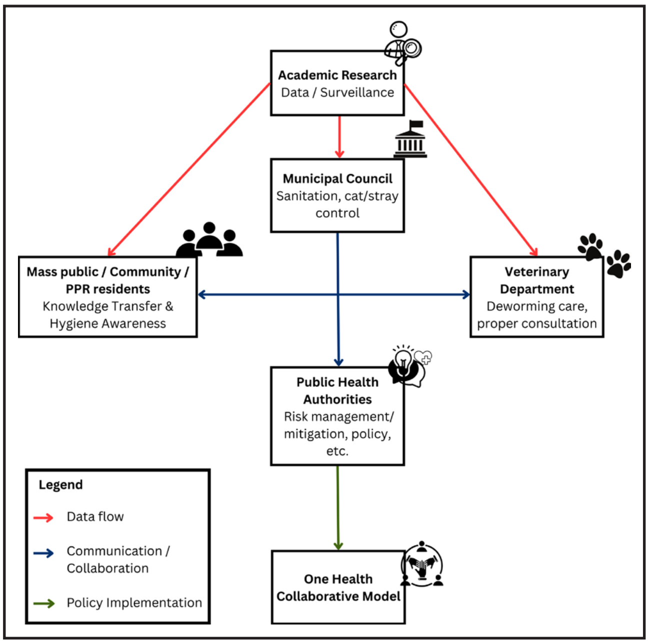

Figure 4. Interconnection of stakeholders responsible for mitigating GI parasites in cats within the urban poor population. This framework emphasises a One Health approach, integrating animal, human, and environmental health efforts.

To err is human; accordingly, this study is implicated by several limitations alongside its strengths. Firstly, the sample size is relatively small; however, it is sufficient as a preliminary survey to reflect the status of GI parasitic infections in cats within the urban poor communities of Klang Valley. Secondly, the collection of faecal samples was done via fresh excreta, which introduces the risk of contamination with the soil microbiome. However, this is mitigated by promptly collecting the faecal samples after defecation and selecting portions that did not come into contact with the soil. Future studies should also include comparative studies of non-public housing areas to assert better the widespread prevalence of intestinal parasites in urban cat populations.

Nevertheless, this study finds strength in the novelty of the target cohort. To the best of our knowledge, this study is the first to outline the current status of GI parasitic infection in cats in urban poor residential areas, an area often overlooked and underrepresented. It also provides valuable baseline data for appropriate public health risk mitigation and interventions. Microscopical methods remain the gold standard for parasitological diagnosis. As such, this study utilised three microscopic techniques that are widely used, rapid, easy-to-replicate, and reliable in providing results. While no particular technique is considered comprehensive, taken together, these three techniques complement each other.

CONCLUSION

This preliminary study highlights a high prevalence (73.0%) of gastrointestinal parasites among cats in urban low-cost housing areas across Klang Valley, Malaysia. The findings underscore the potential health risks posed by environmental contamination with cat faeces in densely populated and underserved communities, where close human-animal interaction and limited sanitation increase the likelihood of parasite transmission. Given the zoonotic potential of these parasites and the vulnerability of certain population groups, this issue warrants greater attention from public health authorities. Integrated, community-based control strategies that combine stray animal management, environmental hygiene, routine deworming, and public awareness initiatives are essential to mitigate the risk of parasitic infections and safeguard the health of marginalised urban populations.

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Conflict of Interests

The authors declare no conflict of interest.

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