Stray animal and human defecation as sources of soil-transmitted helminth eggs in playgrounds of Peninsular Malaysia

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Abstract

Soil contaminated with helminth eggs and protozoan cysts is a potential source of infection and poses a threat to the public, especially to young children frequenting playgrounds. The present study determines the levels of infection of helminth eggs in soil samples from urban and suburban playgrounds in five states in Peninsular Malaysia and identifies one source of contamination via faecal screening from stray animals. Three hundred soil samples from 60 playgrounds in five states in Peninsular Malaysia were screened using the centrifugal flotation technique to identify and determine egg/cyst counts per gram (EPG) for each parasite. All playgrounds, especially those in Penang, were found to be contaminated with eggs from four nematode genera, with Toxocara eggs (95.7%) the highest, followed by Ascaris (93.3%), Ancylostoma (88.3%) and Trichuris (77.0%). In addition, faeces from animal shelters were found to contain both helminth eggs and protozoan cysts, with overall infection rates being 54% and 57% for feline and canine samples, respectively. The most frequently occurring parasite in feline samples was Toxocara cati (37%; EPG, 42.47 ± 156.08), while in dog faeces it was Ancylostoma sp. (54%; EPG, 197.16 ± 383.28). Infection levels also tended to be influenced by season, type of park/playground and the texture of soil/faeces. The occurrence of Toxocara, Ancylostoma and Trichuris eggs in soil samples highlights the risk of transmission to the human population, especially children, while the presence of Ascaris eggs suggests a human source of contamination and raises the issue of hygiene standards and public health risks at sites under investigation.

Introduction

Soil-transmitted helminths (STH) are listed as one of the world’s neglected parasites in tropical regions (Molyneux et al., 2005). Soil contaminated with helminth eggs is a potential source of infection that poses a threat to the public, especially young children, to Toxocara, Ascaris, Ancylostoma and Trichuris eggs. Children are at risk when playing in sandpits in playgrounds and parks contaminated with infective eggs or larvae of parasites (Glickman & Schantz, 1981; Duwel, 1984) and mainly acquire infection after ingestion of eggs embedded under unwashed fingernails.

Many worldwide reports have highlighted the importance of STH to children, especially in developing countries, where reduced physical activity, impaired learning ability and poor growth have been reported (Stephenson et al., 1990; Nokes et al., 1992; Adams et al., 1994; Koroma et al., 1996). However, most studies have focused on soil contaminated with Toxocara eggs, especially in industrialized countries, with prevalences...
ranging from 1.2% in Brazil (Chieffi & Muller, 1976), 2.7% in Argentina (Sommerfelt et al., 1992), 15.5% in Iraq (Mahdi & Ali, 1993), 20.6% in Kansas (Dada & Lindquist, 1979), 24% in urban areas in Italy (Habluetzel et al., 2003) and up to 67.7% in Kobe, Japan (Zibaei & Uga, 2008) and 97.5% in Greece (Himonas et al., 1992). Only a small number of studies has highlighted soil contamination with other helminths, including eggs of *Ascaris*, *Ancylostoma* and *Trichuris* (Ajala & Asaolu, 1995; Blaszewska et al., 2011).

To date, there are only a few studies on helminth contamination of public playgrounds in Malaysia, although Loh & Israf (1998) reported high prevalences of over 50% of *Toxocara* in soil from public playgrounds in Serdang and Petaling Jaya. In addition, Noor Azian et al. (2008) reported on contamination of 182 soil samples examined from urban (Setapak, Kuala Lumpur) and rural residential parks (Kuala Lipis, Pahang); 12.1% were contaminated with *Toxocara* eggs, followed by *Ascaris* (7.4%), hookworm (4.9%) and *Trichuris* (1.6%).

Helminth and protozoan infections are also common in Malaysian schoolchildren. Rajeswari et al. (1994) reported that faecal samples from 456 schoolchildren in Gombak, Malaysia showed an overall prevalence of 62.9%, mainly comprising *Trichuris trichiura* (47.1%), *Giardia intestinalis* (14.7%), *Entamoeba coli* (11.4%), *Entamoeba histolytica* (9.9%) and *Ascaris lumbricoides* (7.9%). Bundy et al. (1988) found that 66% of 1574 children living in a slum area of Kuala Lumpur, Malaysia, were infected with *T. trichiura*, 49.6% with *A. lumbricoides* and 5.3% with hookworm. Moreover, Rahman (1998) showed that intestinal infections in schoolchildren from an urban area in Penang were dominated by *Trichuris* (100%), *Ascaris* (37.9%) and hookworm (18.7%).

Therefore the present study was undertaken to provide a comprehensive update on soil contaminated primarily with helminths in public playgrounds in Peninsular Malaysia. The determination of sources of contamination and confounding factors such as season, together with differences in soil types in both urban and suburban areas, are also considered.

**Materials and methods**

**Study sites**

Soil samples were collected from playgrounds in urban and suburban areas from five states in Peninsular Malaysia (table 1). These included Kuala Lumpur, the capital city of Malaysia, together with Petaling Jaya, Klang and Shah Alam districts in Selangor representing the west, the town of Kuantan in the state of Pahang representing the east, Georgetown (Penang) representing the north, and Malacca city representing the south state of Peninsular Malaysia (table 1). Kuala Lumpur is the largest city, with a population of 1.6 million, and is an enclave within the state of Selangor, in the central west coast Peninsular Malaysia. Petaling Jaya, Klang and Shah Alam districts are located in the state of Selangor, neighbouring Kuala Lumpur and comprising mostly residential and some industrial areas. The coastal city of Malacca, located approximately 130 km south of Kuala Lumpur, has a population of 788,706. Georgetown is the capital of Penang Island and located on the north-west coast of Peninsular Malaysia on the Straits of Malacca. Finally Kuantan, which is another coastal city in the state capital of Pahang, is situated along the east coast of Peninsular Malaysia, near the mouth of the Kuantan River and faces the South China Sea.

Malaysia features a tropical rainforest climate which is hot and humid throughout the year, along with abundant rainfall. Generally, the wet season occurs from April to May and October to December, with the dry season occurring between January to March and June to September. Temperatures remain constant, with maximum temperatures ranging between 31 and 37.2°C

<table>
<thead>
<tr>
<th>Region</th>
<th>Cities/District</th>
<th>No. of playgrounds</th>
<th>No. of samples</th>
<th>Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>West</td>
<td>Federal territory of Kuala Lumpur</td>
<td>12</td>
<td>60</td>
<td>3°8’51”N 101°41’36”E</td>
</tr>
<tr>
<td></td>
<td>Kuala Lumpur City</td>
<td>3</td>
<td>15</td>
<td>3°10’32”N 101°44’21”E</td>
</tr>
<tr>
<td></td>
<td>Keramat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Selangor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Petaling Jaya</td>
<td>5</td>
<td>25</td>
<td>3°05’N 101°39”E</td>
</tr>
<tr>
<td></td>
<td>Shah Alam</td>
<td>5</td>
<td>25</td>
<td>3°54’00”N 101°32’00”E</td>
</tr>
<tr>
<td></td>
<td>Klang</td>
<td>5</td>
<td>25</td>
<td>3°02’N 101°27”E</td>
</tr>
<tr>
<td>East</td>
<td>Penang Island</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kuantan City</td>
<td>5</td>
<td>25</td>
<td>3°49’00”N 103°20’00”E</td>
</tr>
<tr>
<td></td>
<td>Indera Mahkota</td>
<td>4</td>
<td>20</td>
<td>3°49’19”N 103°18’17”E</td>
</tr>
<tr>
<td></td>
<td>Teluk Chempedak</td>
<td>1</td>
<td>5</td>
<td>3°48’48”N 103°21’55”E</td>
</tr>
<tr>
<td>North</td>
<td>Penang Island</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Georgetown City</td>
<td>5</td>
<td>25</td>
<td>5°24’37”N 100°18’57”E</td>
</tr>
<tr>
<td></td>
<td>USM Campus</td>
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<td>5</td>
<td>5°21’26”N 100°17’58”E</td>
</tr>
<tr>
<td></td>
<td>Jelutong</td>
<td>2</td>
<td>10</td>
<td>5°23’15”N 100°18’57”E</td>
</tr>
<tr>
<td></td>
<td>Butterworth</td>
<td>2</td>
<td>10</td>
<td>5°25’10”N 100°19’46”E</td>
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<tr>
<td>South</td>
<td>Malacca</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malacca City</td>
<td>4</td>
<td>20</td>
<td>2°11’20”N 102°23’4”E</td>
</tr>
<tr>
<td></td>
<td>Batu Berendam</td>
<td>4</td>
<td>20</td>
<td>2°15’27”N 102°15’13”E</td>
</tr>
<tr>
<td></td>
<td>Ayer Keroh</td>
<td>2</td>
<td>10</td>
<td>2°16’2”N 102°17’54”E</td>
</tr>
</tbody>
</table>
(88–99.0°F) and minimum temperatures between 17.7°C (63.9°F) and 23.5°C (72.7–74°F), as detailed in Meteorology Malaysia (2010). The survey was conducted during both wet and dry seasons, with the mean temperature ranging between 25.5 and 28.6°C, and rainfall between >0.1 mm and 32.4 mm.

### Soil and faecal sampling

Between August 2009 and July 2010, a total of 300 soil samples was collected and examined from sandpits of 60 playgrounds, including public parks and residential playgrounds, from five localities in Peninsular Malaysia (table 1). All playgrounds surveyed were unfenced or semi-fenced, allowing access by animals and the public at all times. Using a small shovel, five soil samples, each weighing approximately 300 g, were taken at a depth of 0–5 cm from an area of 1.0 m² selected randomly per playground, from five localities in Peninsular Malaysia (2010). The survey was conducted during both wet and dry seasons, with the mean temperature ranging between 25.5 and 28.6°C, and rainfall between >0.1 mm and 32.4 mm.

### Detection of eggs/cysts in soil and faeces

Samples of 1g in weight were air-dried at room temperature and thoroughly ground in a pestle and mortar with a small amount of distilled water. The suspension was washed and sieved through a 2-mm mesh sieve to remove debris, and placed in a 15-ml centrifuge tube for centrifugation at 1500 g for 2 min. The supernatant was discarded, and the sediment re-suspended in 15 ml of saturated sodium chloride solution (SG1.25) using a Pasteur pipette and thoroughly mixed until all particles were evenly distributed. These procedures were replicated three times for each sample.

Helminth eggs and protozoan cysts were recovered using the modified McMaster flotation technique (Dunn & Keymer, 1986), which uses a counting chamber in a known volume of sample suspension (0.15 ml). For every sample, the number of eggs present within the grid chamber was counted and their genus determined microscopically. The mean number of eggs/cysts per gram (EPG) was calculated when both the weights of soil or faeces and the volume of flotation fluid used were known. Samples of the suspension were drawn off with a Pasteur pipette and added to the chambers of the McMaster slide (0.15 ml). Eggs/cysts present within the grid were counted and identified using the McMaster slide under low magnification (×10) and five replicates were counted.

### Data analysis

The overall infection rate and EPG for each parasite species were calculated and analysed using the software Quantitative Parasitology 3.0 (Reizigel & Rózsa, 2001) with 95% confidence intervals (Margolis et al., 1982). The infection rates were compared using Fisher’s Exact Test proposed by Rozsa et al. (2000) and the frequency distribution of eggs/cysts in soil samples was tested using a reformulated method of measuring the k parameter (Pal & Lewis, 2004). Helminth egg burdens were analysed using the SPSS version 16.0 (SPSS Inc., Chicago, Illinois, USA), together with GLIM (generalized linear models) and a Poisson regression model (Wilson & Grenfell, 1997) using two-way interactions between selected independent variables. These data were then transformed into two levels to confirm any significant differences, given as P < 0.01 unless otherwise stated, between variables such as wet and dry seasons, soil textures comprising sand and silt, and public and residential playgrounds.

### Results

#### Soil screening

All 60 playground samples from the five states in Peninsular Malaysia were mainly contaminated with helminth eggs, comprising four nematode genera. Soil contamination with *Toxocara* was the highest (95.7%), followed by *Ascaris* (93.3%), *Ancylostoma* (88.3%) and *Trichuris* (77%). *Toxocara* also showed the highest EPG with a mean of 251.51 ± 220.51, followed by *Ascaris* (116.64 ± 149.02), *Ancylostoma* (105.25 ± 101.82) and finally, *Trichuris* (56.45 ± 50.18) (table 2).

Relative to sites, playgrounds in Penang (northern coast) and Selangor (western coast) were the most contaminated, with all four nematode genera exhibiting 100% infection rates. Similar infection rates were shown for *Toxocara* and *Ancylostoma* in Malacca, with slightly lower values of 98% being recorded for *Ascaris* and *Trichuris* (table 2). Playground soils in Kuantan were slightly less contaminated with *Toxocara* (90%), *Ascaris* (76%), *Ancylostoma* (76%) and *Trichuris* (52%) and, similarly, in Kuala Lumpur, with *Toxocara* (89.3%), *Ascaris* (90.7%), *Ancylostoma* (70.7%) and *Trichuris* (40%). All ten playgrounds in Penang also exhibited high EPG for all nematodes, especially the playground in Popus Lane Park (57°25′10″N 100°19′46″E) with egg counts for *Toxocara* as high as 856.4 ± 1.054, and Kota Lama Esplanade Park with counts of 388.40 ± 1.21 for *Ancylostoma* and 189.20 ± 0.24 for *Trichuris*.
All four nematode genera comprising *Toxocara* sp., *Ascaris* sp., *Trichuris* sp. and *Ancylostoma* sp. showed infection rates above 70%. The Poisson regression model, using two-way interactions, showed significant effects for soil contamination in all nematode genera relative to season, soil texture and, especially, the type of park contaminated (table 3). With reference to seasonality, soil contamination was highest during the wet compared with the dry season for all four nematodes ($P < 0.001$). However, across the four genera, the two-way interaction was highly significant for soil texture with type of park only (table 3).

**Faecal screening**

More than half of the stray cat and dog populations were infected with parasites. Of the feline faecal samples screened, 54% were positive for two nematodes, one cestode and one protozoan species. The highest contamination in feline samples comprised eggs of *Toxocara* (37%; EPG, 42.47 ± 156.08) followed by the protozoan *Isospora* (35%; EPG, 65.83 ± 191.75), *Ancylostoma* (29%; EPG, 38.64 ± 122.63) and the cestode *Spirometra* (22%; EPG, 21.09 ± 81.63) (table 4). Up to 57% of canine samples were infected with four nematodes and one protozoan species. This included a high infection rate for *Ancylostoma* (54%; EPG, 197.16 ± 383.28) followed by *Toxocara* (25%; EPG, 42.51 ± 198.29), *Isospora* (25%; EPG, 43.52 ± 196.07), *Trichuris* (16%; EPG, 20.80 ± 108.96) and *Toxascaris leonina* (7%; EPG, 29.06 ± 281.94). In both canine and feline hosts, the frequency distribution of eggs within the faeces was found to be overdispersed and fitted a negative binomial distribution with $k$ values ranging from 0.041–0.078 in feline and 0.009–0.121 in canine samples. With regard to stool texture and consistency there was little association between parasitic infections in both types of faeces, although in feline samples the protozoan *Isospora* tended to occur in runny stools ($P < 0.05$) whereas *Ancylostoma* was more frequent in runny stools of canines ($P < 0.01$).

**Discussion**

Soil samples from playgrounds in five states from Peninsular Malaysia were found to be highly contaminated with helminth eggs and occasionally protozoan cysts. Four genera of nematodes dominated the infections, with *Toxocara* being the most frequent (95.7%), which was similar to the results of previous studies undertaken by Himonas *et al.* (1992), Correa *et al.* (1995), Uga *et al.* (2000) and Alonso *et al.* (2001), but higher than prevalences of 54.5% and 12.1%, respectively, recorded by Loh & Israf (1998) and Noor Azian *et al.* (2008).

It was also noted that high levels of contamination were observed, with egg counts as high as 800 EPG in one study site in Penang. Higher infection rate of zoonotic nematodes, especially with *Toxocara* eggs, were likely to be linked with playgrounds being exposed to stray animals scavenging and defecating in residential areas. Such high incidences, especially of *Toxocara, Ancylostoma* and *Trichuris* eggs in the soil, were due to the open access of playgrounds, with no fencing to protect these locations from stray animals. These animals were free to roam and
In Penang. Present with high numbers of helminth EPG, especially than other sites, with all nematode genera being Selangor were found to be more highly contaminated in Poland. Playgrounds in the two states of Penang and Pereira et al. (2010) in Brazil and Blaszkowska et al. (2011) and therefore molecular characterization was possible due to human defecation. Similar findings were also found by Horiuchi et al. (2013) in the Philippines, where helminth egg counts in soil were as high as 410 (A. lumbricoides), 134 (Toxocara spp.) and 134 (Trichuris spp.). These authors concluded that contamination of soil was mainly due to stray animal and human defecation.

These circumstances, combined with optimum temperatures and high levels of humidity and moisture in the soil, particularly during the wet season in Malaysia, would undoubtedly enhance the survival and viability of ascarid and trichurid eggs and larval stages of hookworms such as Ancylostoma.

Higher infection rates of other nematode species were also observed in the playgrounds under investigation, including Ascaris (93.3%), Ancylostoma (88.3%) and Trichuris (77%), and these findings were significantly higher than those reported by Noor Azian et al. (2008) in Malaysia, Ajala & Asaolu (1995) in Nigeria, Mandarino-Pereira et al. (2010) in Brazil and Blaszkowska et al. (2011) in Poland. Playgrounds in the two states of Penang and Selangor were found to be more highly contaminated than other sites, with all nematode genera being present with high numbers of helminth EPG, especially in Penang.

It may seem premature to conclude the role of strays in contaminating playgrounds based on only one sampling site in Kuala Lumpur. However, Mohd Zain et al. (2013) confirmed the presence of Toxocara cati, Toxocara malaysiensis, Ancylostoma ceylanicum and Ancylostoma brasiliensis in stray cat populations from four states in Malaysia, while Mahdy et al. (2012) recorded A. ceylanicum and Ancylostoma caninum in stray dogs. This further confirms the role of strays as a source of environmental contamination, particularly for Toxocara and Ancylostoma, but molecular approaches are required to identify eggs of other helminth species.

Although several authors have reported that dogs can mechanically transmit human parasites such as Ascaris (Traub et al., 2002, 2005; Shalaby et al., 2010), the present study found no evidence of Ascaris eggs despite screening up to 100 dog faecal samples. The relatively high incidence of Ascaris was more likely to originate from human defecation, because potential animal sources of infection, such as pigs, were strictly confined to farms on the outskirts of urban areas as a result of Islamic prohibitions. Therefore, pigs are unlikely to inhabit playgrounds in residential sites. Previous studies in Malaysia have shown that children are infected with Ancylostoma lumbricoides, Trichuris trichiura and A. ceylanicum (Bundy et al., 1988; Rajeswari et al., 1994; Rahman, 1998; Ngui et al., 2012) and therefore molecular characterization

<table>
<thead>
<tr>
<th>Parasite species/genus</th>
<th>(%), CI</th>
<th>EPG ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feline samples</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxocara cati</td>
<td>37.0</td>
<td>0.28–0.47</td>
<td>42.47 ± 156.08</td>
</tr>
<tr>
<td>Ancylostoma</td>
<td>29.0</td>
<td>0.21–0.30</td>
<td>38.64 ± 273.70</td>
</tr>
<tr>
<td>Isospora</td>
<td>35.0</td>
<td>0.26–0.45</td>
<td>65.83 ± 191.75</td>
</tr>
<tr>
<td>Spirometra</td>
<td>22.0</td>
<td>0.15–0.31</td>
<td>21.09 ± 81.63</td>
</tr>
<tr>
<td>Canine samples</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxocara canis</td>
<td>25.0</td>
<td>0.17–0.34</td>
<td>42.51 ± 198.29</td>
</tr>
<tr>
<td>Ancylostoma</td>
<td>54.0</td>
<td>0.44–0.63</td>
<td>197.16 ± 383.28</td>
</tr>
<tr>
<td>Trichuris vulpis</td>
<td>16.0</td>
<td>0.10–0.24</td>
<td>20.80 ± 108.96</td>
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<tr>
<td>Toxascaris leonina</td>
<td>7.0</td>
<td>0.03–0.14</td>
<td>29.06 ± 281.94</td>
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<tr>
<td>Isospora</td>
<td>25.0</td>
<td>0.17–0.34</td>
<td>43.52 ± 196.07</td>
</tr>
</tbody>
</table>

Table 3. Variation in the infection rate of parasitic eggs in soil samples relative to season (wet and dry), soil texture (sand and silt) and type of park (public and residential), using a Poisson regression model. EC, expected log count for one unit of increase in each parameter; ER, expected infection rate of nematode eggs and level of significant differences given as $P < 0.01$, except for *, $P < 0.05$; and **, $P < 0.10$.

<table>
<thead>
<tr>
<th>Nematode genus</th>
<th>Toxocara</th>
<th>Ascaris</th>
<th>Trichuris</th>
<th>Ancylostoma</th>
</tr>
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<tr>
<td>Principle interactions</td>
<td>EC</td>
<td>ER</td>
<td>EC</td>
<td>ER</td>
</tr>
<tr>
<td>Season</td>
<td>1.029</td>
<td>2.799</td>
<td>1.463</td>
<td>4.319</td>
</tr>
<tr>
<td>Soil texture</td>
<td>−0.212</td>
<td>0.809**</td>
<td>−0.350</td>
<td>0.705</td>
</tr>
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<td>Type of park</td>
<td>−1.202</td>
<td>0.301</td>
<td>−1.170</td>
<td>0.310</td>
</tr>
<tr>
<td>Soil texture × type of park</td>
<td>1.063</td>
<td>2.894</td>
<td>1.059</td>
<td>2.883</td>
</tr>
</tbody>
</table>

Table 4. The infection rate (%) and mean number of eggs /cysts (EPG ± SD) in each of 100 stray feline and canine faecal samples from animal shelters in Kuala Lumpur, January 2011 to February 2012; CI, 95% confidence intervals.
is also necessary to confirm whether or not playgrounds contaminated with *Ascaris* are of human or animal origin.

In the case of zoonotic helminths, the arrival of the wet season in playgrounds significantly increased the number of eggs of all four nematode genera compared with the dry season. Stojcevic *et al.* (2010) also reported an increase in the number of helminth eggs during the rainy season, as embryonation of eggs increases in tropical temperatures with high soil humidity. This result is similar to the results of studies by Uga & Kataoka (1995), Rai *et al.* (2000) and Nurdian (2004), where high levels of rainfall contributed to higher diversities and prevalence of parasite species. In addition, helminth eggs such as those of *Toxocara* and *Ascaris* possess thick external layers, which provide protection from environmental factors (Mizgajska, 1997).

The effects of two factors, the type of soil and size of playgrounds, also played a significant role in determining the number of helminth eggs recovered from soil samples. Ayaji & Duhlinska (1999), Duwel (1984) and Omudu *et al.* (2003) observed that *Toxocara* eggs were found more readily in soil rich with sand compared with other soil types, and also that particle size was important.

High levels of contamination with eggs of *Toxocara, Ascaris* and *Trichuris* occurred in smaller residential playgrounds compared with public parks and these results are similar to those of Mizgajska (2001) and Dubna *et al.* (2007). The open access of smaller residential playgrounds allowed stray animals, pets and the public to defecate repeatedly and indiscriminately in confined spaces, thereby increasing the density of eggs in the soil. On the other hand, a significant reduction in contamination with eggs was found in the soil of public playgrounds as these tend to be protected with fencing. Nevertheless, the presence of eggs of *Toxocara, Ancylostoma* and *Trichuris* in playground soil and stool samples suggests that stray animal populations play an important role in contaminating sandpits in both public and residential areas. Dogs, in particular, exhibit behavioural patterns by selecting previously used defecation sites (Rubel & Wisnivesky, 2005).

Canine faeces in the present study revealed a high infection rate of *Ancylostoma* (54%) followed by *Toxocara canis* (25%), *Isospora* (25%), *Trichuris* (16%) and *T. leonina* (7%), and these results were significantly higher than those reported by Noor Azian *et al.* (2008) in Malaysia for *T. canis* (12.1%), *Ancylostoma* (4.9%) and *Trichuris* (1.6%). Subsequent reports by Mahdy *et al.* (2012) in Malaysia showed that both hookworm species *A. caninum* and *A. ceylanicum* were found in urban stray dogs, with *A. ceylanicum* being the more prevalent species (76.2%), which was comparable with *Ancylostoma* (88%) recorded by Tanwar & Kachawha (2007) in India. Kutdang *et al.* (2010) also recorded a high infection rate of hookworms, with up to 50% infected in a dog population in Nigeria, together with 38.2% and 31.8% infected with *T. canis* and *Trichuris vulpes*, respectively. In the present investigation on canine faeces, the other *Toxocara* species (*T. cati/T. malaysiensis*) was also most frequently recovered (37%), followed by *Isospora* (35%), *Ancylostoma* (29%) and *Spirometra* (22%). On the other hand, Jittapalapong *et al.* (2007) reported much lower infections of *Toxocara* spp. (3.5%) and *Ancylostoma* spp. (9.9%) in Thailand.

Apart from host parameters, extrinsic factors such as faecal texture may also be linked with infectivity, as in the present study the number of infective stages of *Ancylostoma* (*P* < 0.01) and *Isospora* (*P* < 0.05) was higher in runny compared with soft/hard stools, but whether the viability of eggs or cysts is related to texture of stools requires further investigation.

Dubinsky *et al.* (1995) reported that the main source of food for most stray cats and dogs included small mammals such as rodents, which can act as paratenic hosts for helminths, thus increasing levels of infection in these feline and canine definitive hosts. The large numbers of parasite eggs recovered in this study clearly highlight the potential health risk to children, who may acquire infection when playing in the sandpits of playgrounds located in various sites in Peninsular Malaysia.

The present study has revealed high numbers of helminth eggs contaminating soil in playgrounds surveyed in Peninsular Malaysia, and such high levels of environmental contamination, especially with *Toxocara*, were mainly due to defecation by stray animals (and also domestic pets), or the public in the case of *Ascaris*. The origins of some helminth genera (*Trichuris, Ancylostoma*) were not determined, but high prevalences of *Toxocara* and *Ascaris* clearly confirm that both animals and humans are important sources of contamination. However, molecular approaches are now required to identify helminth species from soil samples, notably the identification and host origin of *Ascaris* since dog faeces were free from infection.

Factors contributing to soil contamination with helminth eggs include the type of playground, soil texture and season. In addition, the presence of helminth eggs/larvae in the stools of dogs and cats can be influenced by faecal texture. Nevertheless, highly contaminated soil in playgrounds in urban areas does highlight the need for substantially improving the management of stray animals and enhancing hygiene practices in Malaysia. Municipalities nationwide must be responsible for the control of stray animals and should include awareness programmes; improve playground designs for children, to exclude strays and the public from defecating in public and residential parks; and promote better hygiene practices within the community.

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Conflict of interest

None.

Ethical standards

The study approach was approved by the University of Malaya Ethical Committee, reference number ISB/31/01/2013/SNMZ (R).

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