The prevalence of the helminth parasites of stray dogs in Ismailia City

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Abstract:
In a study on the parasites of stray dogs in Ismailia City, 50 stray dogs of different sexes and ages were humanely euthanized, necropsied, and examined for helminth parasites. Twenty helminths (14 trematodes, two cestodes, and four nematodes) were detected. The total prevalence of helminths was 100%, with trematodes (36%), cestodes (100%), and nematodes (34%). Of the recorded 14 trematodes, Pygidiosis summa and Ascocotyle rara were recorded for the first time in Ismailia Province and might be for the first time among Egyptian dogs. The most prevalent trematode was Pygidiosis genata (20%). The detected cestodes were Dipylidium caninum (100%) and Taenia hydatigena (10%). The recovered nematodes were Toxocara canis (20%), Toxascaris leonina (10%), Spirocerca lupi (10%), and Rictularia affinis (8%). There was a highly significant difference (p<0.01) in the prevalence of trematodes between different ages (60% in adults and 0% in young dogs). The prevalence of Toxocara canis was significantly higher (p<0.05) in young dogs (40%) than in adult ones (6.7%). There was no significant difference (p > 0.05) in the prevalence of the detected helminths with the sex of dogs. Histopathological examination of the lungs and oesophagus of dogs infected with Spirocerca lupi revealed chronic pneumonia, pulmonary alveolar emphysema, granulation tissue formation, and an early stage of fibroma in the oesophagus. All necropsied dogs were infected with at least one zoonotic helminth parasite. In conclusion, stray dogs in Ismailia City carry several helminth parasites, thus posing a risk for both human and companion dog populations.

Key words: helminth, stray dogs, Ismailia, and prevalence

INTRODUCTION
The dog population in urban and suburban regions comprises dogs that roam only with their owners and stray and ownerless dogs that roam sporadically (Beck, 2000). Of the estimated 500 million dogs worldwide, about 400 million are stray ones (WSPA, 2009). Egypt has a large population of stray dogs that move freely within cities and contact other urban, suburban, and rural animals (Nabih, 1998). Dogs are associated with more than 60 zoonotic diseases, among which parasites, in particular helminthiasis, can pose serious health concerns (Rhindali et al., 2006) as well as significant economic impacts from a veterinary standpoint. Dogs play a pivotal role as parasite bridges between wildlife and humans (Sal et al., 2008).

Among zoonotic helminths that can infect dogs, Toxocara canis is particularly pathogenic to humans (McManus, 2006). This nematode can cause visceral larva migrans (VLM), ocular larva migrans (OLM), or both in humans, especially children (Gavignet et al., 2008). The human population in Ismailia City relies heavily on freshwater fish grown in aquaculture systems as a source of dietary protein. Numerous free-roaming dogs scavenge offal from fish farms and become infected by trematodes that utilize fish as an intermediate host. This trematode infection may also be transmissible to humans (Chai et al., 1986a; Chai and Lee, 1990). Canine trematodes in Egypt include Mesostephanus spp., Echinocausmus spp., Heterophyes spp., and Pygidiosis genata (El-Gayar, 2007). The distribution and intensity of parasitic diseases are influenced by climatic, geographical, cultural, and economic factors. Therefore, studying the helminth parasites in every given region is necessary.

The present work aims to study the prevalence and intensity of the helminth parasites in stray dogs in Ismailia City and discuss the zoonotic risk associated with these dogs.

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**Materials and Methods**

This study was conducted on 50 stray dogs (23 male and 27 female) captured from Ismailia City. Their sex and age were recorded. Dogs less than one year were classified as young (n=20) and those over one year as adults (n=30). These dogs were humanely euthanized, necropsied, and examined for helminth parasites. At necropsy, exploration of the abdominal and thoracic cavities for the presence of extraintestinal parasites was carried out. The digestive tract and other organs (brain, lung, heart, liver, and urinary bladder) were separately examined. Each part of the alimentary canal was opened in a separate petri dish containing physiological saline. The intestinal contents were washed and inspected by the naked eye and then under a stereoscopic microscope for helminth parasites. The collected helminths were counted according to Bwalya (2012). Trematodes and cestodes were stained with Acetic Acid Alum Carmine, while nematodes were clarified with lactophenol. Then, we prepared permanent mounts from these helminths according to the method of Fleck & Moody (1993). The collected helminths matched the descriptive data and figures given by Yamaguti (1939,1958), Fahmy and Selim (1959), Soulsby (1982), Nabih (1998), and El-Gayar (2007). Specimens from the lungs and nodules in the oesophagus of Spiruocera lupi-infected dogs were fixed in 10% formal saline, embedded in paraffin, cut 5 µm thick, and stained with H&E stain (Drug et al., 1967). Chi-square test (Snedecor & Cochran, 1991) was used to analyze the categorical data and evaluate the statistically significant associations between the prevalence of helminths and the dog’s age and sex. Differences were considered significant at (p ≤ 0.05).

**Results**

Parasitological results:

The total prevalence of helminths was 100%, with trematodes (36%), cestodes (100%), and nematodes (34%) (Table 1). All detected parasites (Figs. 1-32) were found in the small intestine except for Spiruocera lupi, which was found in the oesophagus. Fourteen trematode species were recorded. The most prevalent trematode was Pygidiosus summa (4%), while Mesostephanus spp. had the highest mean intensity of 95.5 (18-170). Two cestodes (Dipylidium caninum and Taeonia hydatigena) were detected. Dipylidium caninum was the most prevalent cestode (100%) with a mean intensity of 62.3 (2-189) worms/dog. Four nematodes (Toxocara canis, Toxascaris leonina, Spiruocera lupi, and Rictularia affinis) were recovered. Toxocara canis was the most common nematode (20%) with a mean intensity of 7.3 (3-15) worms/dog (Table 2).

### Table 1: Prevalence of helminths in stray dogs in Ismailia City

<table>
<thead>
<tr>
<th>Helminthes</th>
<th>No. of infested/ no. of examined</th>
<th>Prevalence (%)</th>
<th>Intensity (range)</th>
<th>Mean intensity (worms/dog)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trematodes</td>
<td>18/50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cestodes</td>
<td>50/50</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nematodes</td>
<td>17/50</td>
<td>34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>50/50</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2: Prevalence and intensity of helminth parasites in stray dogs in Ismailia City

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of infested/ no. of examined</th>
<th>Prevalence (%)</th>
<th>Intensity (range)</th>
<th>Mean intensity (worms/dog)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prohemistemum vivax</td>
<td>2/50</td>
<td>4</td>
<td>1-5</td>
<td>3.0 (6/2)</td>
</tr>
<tr>
<td>Mesostephanus appendiculatus</td>
<td>8/50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mesostephanus melvi</td>
<td>3/50</td>
<td>6</td>
<td>18-170</td>
<td>95.5 (764/8)</td>
</tr>
<tr>
<td>Mesostephanus sp.</td>
<td>1/50</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Echinococcusus liliiputans</td>
<td>8/50</td>
<td>16</td>
<td>10-36</td>
<td>19.0 (158/8)</td>
</tr>
<tr>
<td>Heterophyes dispar</td>
<td>7/50</td>
<td>14</td>
<td>5-20</td>
<td>13.0 (93/7)</td>
</tr>
<tr>
<td>Pygidiosus genata</td>
<td>10/50</td>
<td>20</td>
<td>10-40</td>
<td>26.7 (267/10)</td>
</tr>
<tr>
<td>Pygidiosus summa</td>
<td>3/50</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ascocotyle rara</td>
<td>2/50</td>
<td>4</td>
<td>2-4</td>
<td>3.0 (6/2)</td>
</tr>
<tr>
<td>Phagilota longus</td>
<td>3/50</td>
<td>6</td>
<td>2-10</td>
<td>5.7 (17/3)</td>
</tr>
<tr>
<td>Phagilota longicollis</td>
<td>2/50</td>
<td>4</td>
<td>1-3</td>
<td>2 (4/2)</td>
</tr>
<tr>
<td>Metagonimus yokogawai</td>
<td>2/50</td>
<td>4</td>
<td>2-3</td>
<td>2.5 (5/2)</td>
</tr>
<tr>
<td>Haplorchis pumilio</td>
<td>3/50</td>
<td>6</td>
<td>2-4</td>
<td>3.0 (6/2)</td>
</tr>
<tr>
<td>Apophallus donicus</td>
<td>2/50</td>
<td>4</td>
<td>1-3</td>
<td>2 (4/2)</td>
</tr>
<tr>
<td>Dipylidium caninum</td>
<td>50/50</td>
<td>100</td>
<td>2-189</td>
<td>62.3 (3116/50)</td>
</tr>
<tr>
<td>Taeonia hydatigena</td>
<td>5/50</td>
<td>10</td>
<td>1-4</td>
<td>2 (10/5)</td>
</tr>
<tr>
<td>Toxocara canis</td>
<td>10/50</td>
<td>20</td>
<td>3-15</td>
<td>7.3 (73/10)</td>
</tr>
<tr>
<td>Toxascaris leonina</td>
<td>5/50</td>
<td>10</td>
<td>2-8</td>
<td>4.4 (22/5)</td>
</tr>
<tr>
<td>Spiruocera lupi</td>
<td>5/50</td>
<td>10</td>
<td>3-8</td>
<td>5.6 (28/5)</td>
</tr>
<tr>
<td>Rictularia affinis</td>
<td>4/50</td>
<td>8</td>
<td>1-2</td>
<td>1.8 (7/4)</td>
</tr>
</tbody>
</table>
Figure 1-8: Trematodes of stray dogs in Ismailia City
1: Prohemistomum vivax adult,
2: Mesostephanus appendiculatus adult,
3: Mesostephanus melvi adult,
4: Mesostephanus sp. adult,
5a: Echinocausmus liliputans adult, 5b: E. liliputans anterior end,
6: Heterophyes dispar adult,
7: Pygidiopsis genata adult,
8: Pygidiopsis summa adult arrow showing spines on the genital sucker.
(O.S.: oral sucker, V.S.: ventral sucker, Ph.: Pharynx, P. Ph.: pre-pharynx, Oes.: oesophagus, T.: testis, Ov.: ovary, Vit.: vitellaria,
Helminth parasites of stray dogs in Ismailia city

Figure 9-14: Trematodes of stray dogs in Ismailia City
9: Ascocotyle rara adult, 10: Phagicola longus adult,
11: Phagicola longicollis adult,
12: Metagonimus yokogawai adult,
13: Haplorchis pumilio adult,
14: Apophallus donicus adult
(C.S.: cirrus sac, Ut.: uterus, v. sem.: vesicula seminalis, r.s.: receptaculum seminis and Eg.: Egg).

Figure 15-20: Cestodes of stray dogs in Ismailia City
15: Dipylidium caninum scolex,
16: Dipylidium caninum mature segment
17: Dipylidium caninum gravid segment
18: Taenia hydatigena scolex
19: Taenia hydatigena mature segment
20: Taenia hydatigena gravid segment
Figure 21-32: Nematodes of stray dogs in Ismailia City
21: *Toxocara canis* anterior end
22: *Toxocara canis* female posterior end
23: *Toxocara canis* eggs
24: *Toxascaris leonina* anterior end
25: *Toxascaris leonina* male posterior end
26: *Toxascaris leonina* egg
27: *Spirocerca lupi* anterior end
28: *Spirocerca lupi* female posterior end
29: *Spirocerca lupi* male posterior end
30: *Spirocerca lupi* egg
31: *Rictularia affinis* anterior end
32: *Rictularia affinis* male posterior end
As shown in Table (3), the frequency of mixed infection with helminths (70%) was higher than that of the single infection (30%). All necropsied dogs were infected with at least one zoonotic helminth parasite. The zoonotic helminths were one nematode (Toxocara canis), one cestode species (Dipylidium caninum) and seven trematodes (Prohemistomum vivax, Heterophyes dispar, Phagocila longus, Pygidiosis summa, Metagonimus yokogawai, Apophallus donicus, and Haplorchis pumilio).

In tables 4 & 5, the Chi-square analysis of the prevalence of different helminths in relation to the age and sex of dogs revealed that there was a highly significant difference (p ≤ 0.01) in the prevalence of trematodes and T. canis in relation to the age of dogs. However, there was no significant difference (p > 0.05) in the prevalence of Taenia hydatigena, Toxascaris leonina, Spirocerca lupi, and Rictularia affinis in relation to the age of dogs. No significant difference (p > 0.05) was found in the prevalence of helminths between dogs of different sexes.

Table 3: The frequency of single, multiple, and zoonotic infection

<table>
<thead>
<tr>
<th>Helminthes</th>
<th>No. of infested/no. of examined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single infection</td>
<td>15/50</td>
<td>30</td>
</tr>
<tr>
<td>Mixed infection</td>
<td>35/50</td>
<td>70</td>
</tr>
<tr>
<td>Two helminth species</td>
<td>10/50</td>
<td>20</td>
</tr>
<tr>
<td>Three helminth species</td>
<td>5/50</td>
<td>10</td>
</tr>
<tr>
<td>Four helminth species</td>
<td>5/50</td>
<td>10</td>
</tr>
<tr>
<td>More than four species</td>
<td>15/50</td>
<td>30</td>
</tr>
<tr>
<td>Zoonotic infection</td>
<td>50/50</td>
<td>100</td>
</tr>
</tbody>
</table>

Histopathological alterations:
The lungs of dogs infected with Spirocerca lupi showed pulmonary alveolar emphysema, with focal mononuclear cell infiltration and granuloma formation (Fig. 33-34). The oesophagus of Spirocerca lupi-infected dogs revealed focal aggregations of mononuclear cells, with marked fibrosis, granulation tissue formation, and early fibroma (Fig. 35-38).

Table 4: Chi-square analysis of the prevalence of different helminths in relation to the age of dogs

<table>
<thead>
<tr>
<th>Helminthes</th>
<th>Age</th>
<th>No. of infested/ no. of examined</th>
<th>Prevalence (%)</th>
<th>X²</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trematodes</td>
<td>Young</td>
<td>0/20</td>
<td>0.0</td>
<td>16.24</td>
<td>0.00**</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>18/30</td>
<td>60.0</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Dipyldium caninum</td>
<td>Young</td>
<td>20/20</td>
<td>100.0</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>30/30</td>
<td>100.0</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Taenia hydatigena</td>
<td>Young</td>
<td>0/20</td>
<td>0.0</td>
<td>2.08</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>5/30</td>
<td>16.7</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Toxocara canis</td>
<td>Young</td>
<td>8/20</td>
<td>40.0</td>
<td>6.38</td>
<td>0.01**</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>2/30</td>
<td>6.7</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Toxascaris leonina</td>
<td>Young</td>
<td>4/20</td>
<td>40.0</td>
<td>2.08</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>1/30</td>
<td>3.3</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Spirocerca lupi</td>
<td>Young</td>
<td>0/20</td>
<td>0.0</td>
<td>2.08</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>5/30</td>
<td>16.7</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Rictularia affinis</td>
<td>Young</td>
<td>0/20</td>
<td>0.0</td>
<td>1.37</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>4/30</td>
<td>13.3</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

* significant difference p ≤ 0.05, ** highly significant difference p ≤ 0.01, NA: not applicable

Table 5: Chi-square analysis of the prevalence of different helminths in relation to dog sex

<table>
<thead>
<tr>
<th>Helminthes</th>
<th>Sex</th>
<th>No. of infested/ no. of examined</th>
<th>Prevalence (%)</th>
<th>X²</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trematodes</td>
<td>Male</td>
<td>10/23</td>
<td>43.5</td>
<td>0.52</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>8/27</td>
<td>29.6</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Dipyldium caninum</td>
<td>Male</td>
<td>23/23</td>
<td>100.0</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>27/27</td>
<td>100.0</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Taenia hydatigena</td>
<td>Male</td>
<td>3/23</td>
<td>13.0</td>
<td>0.04</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>2/27</td>
<td>7.4</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Toxocara canis</td>
<td>Male</td>
<td>4/23</td>
<td>17.4</td>
<td>0.01</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>6/27</td>
<td>22.2</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Toxascaris leonina</td>
<td>Male</td>
<td>3/23</td>
<td>17.4</td>
<td>0.04</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>2/27</td>
<td>22.2</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Spirocerca lupi</td>
<td>Male</td>
<td>1/23</td>
<td>4.3</td>
<td>0.57</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>4/27</td>
<td>14.8</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Rictularia affinis</td>
<td>Male</td>
<td>1/23</td>
<td>4.3</td>
<td>0.12</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3/27</td>
<td>11.1</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

* significant difference p ≤ 0.05, ** highly significant difference p ≤ 0.01, NA: not applicable
Figure 33-38: Histopathological alterations of lungs and oesophagus of dogs infected with *Spirocerca lupi* H&E stain  
33: Lung showing pulmonary alveolar emphysema with focal mononuclear cells infiltration  
34: Lung showing a chronic inflammatory reaction with granuloma formation (arrows)  
35: Oesophagus showing focal aggregations of mononuclear cells (arrow)  
36: Oesophagus showing chronic inflammatory reactions with marked fibrosis (arrow)  
37: Oesophagus showing granulation tissue with newly formed capillaries (arrows)  
38: Oesophagus showing proliferation of fibroblasts in a characteristic form of early fibroma
DISCUSSION
This study was carried out on 50 stray dogs, and 20 helminth parasites were detected. The total prevalence of helminths was 100%, similar to El-Gayar (2005) (100%) in Ismailia City, Jones et al. (2011) (100%) in Ethiopia, and Traub et al. (2002) (99%) in northeastern India. However, a lower prevalence was recorded by Abd-Alla (2002) (86.2%), Adamu et al. (2012) (13.8%), and Adinezadeh et al. (2013) (84%). The total prevalence of trematodes was 36%, higher than that recorded by Abd-Alla (2002) (13.79%) and El-Gayar (2005) (13.3%). The total prevalence of cestodes was 100%, higher than that recorded by Abd-Alla (2002) (86.2%) and El-Gayar (2005) (73%). The total prevalence of nematodes was 34%, higher than that reported by Mehrabani et al. (2002) (24.8%) in Iran but lower than that reported by Abd-Alla (2002) (55.17%), El-Gayar (2005) (46.6%), and Yacob et al. (2007) (95%) in Ethiopia.

The detected trematodes during this study were Prohemistomum vivax (4%), Mesostephanus appendiculatus (16%), Mesostephanus melvi (6%), Mesostephanus sp. (2%), Echinococclus liliiputans (16%), Heterophyes dispar (14%), Pygidiopsis genata (20%), Pygidiopsis summa (4%), Ascocotyle rara (4%), Phagicola longus (6%), Phagicola longicollis (4%), Metagonimus yokogawai (4%), Haplorchis pumilio (6%), and Aporhalius donicus (4%). These trematodes were previously recorded singly or collectively by several authors; Fahmy and Selim (1959), Selim (1967) in Cairo and Giza Governorates, Vanparijs & Thienpont (1973) in Belgium, Massoud et al. (1981) in Iran, Fahmy et al. (1984) in Assiut province, Nieddu & Lochi (1988) in Italy, Ibrahim et al. (1989) in Assiut province, EI-Seify & Nabih (1998) in Giza Governorate, Abd-Alla (2002) in Zagazig City, El-Gayar (2005) in Ismailia City and Wang et al. (2006) in China. Pygidiopsis summa and Ascocotyle rara were recorded for the first time in Ismailia province, and this may be the first time to be recorded among Egyptian dogs. Pygidiopsis summa was firstly detected in dogs fed on brackish water fish infected with the metacercariae in Japan (Onji & Nishio, 1916). Pygidiopsis summa is also prevalent in the Republic of Korea (Chai & Lee, 2002). The descriptions and measurements of the detected trematodes were matched to those of Fahmy & Selim (1959), Kurtz & Chandler (1956), Fahmy & Selim (1959), Yamaguti (1939), Fahmy et al. (1984), and Niemi& Macy (1974).

Prohemistomum vivax was differentiated from Mesostephanus spp. by the absence of a caudal dorsal appendage, and the body was oval and not bipartite rather than elongated (Yamaguti, 1939). Mesostephanus appendiculatus was differentiated from M. melvi, which possesses a visible oesophagus and an elongated, club-shaped cirrus pouch and lacks a vaginal sphincter. Moreover, the gonads were in the middle of the body in Mesostephanus appendiculatus but posteriorly in M. melvi (El-Gayar, 2007). Pygidiopsis genata was differentiated from P. summa by the presence of a small posterior appendage on the oral sucker of P. summa (Skrjabin, 1964) and the presence of spines on gonotyl in P. summa. The ceca of P. genata reached the level of the ovary, turning slightly dorsomedial at the terminal portion, while in P. summa extended down to the level of anterior of testes and had distended ends instead of turning medially (Chai et al., 1986b). The ventral sucker was nearly round and globular in Pygidiopsis genata but constantly elliptical, transversely oblique, and sub-median in P. summa. Phagicola longicollis was differentiated from P. longa by the following: the body was much more elongate; the pharynx was situated at a considerably greater distance from the anterior end in P. longicollis than in P. longa; the ventral sucker in P. longicollis was round and smaller (49 µm), whereas that in P. longa was elongate (70 µm); and the oral sucker was armed with 14 or 15 spines compared with 16 spines in P. longa (Kuntz & Chandler, 1956). The present specimens of Ascocotyle rara were compared to Ascocotyle mcintoshi, recorded by El-Seify & Nabih (1998). Ascocotyle rara could be differentiated by its larger size and the absence of excretory bladder compared to the laterally branched voluminous excretory bladder of A. mcintoshi (Yamaguti, 1958). Kurtz & Chandler (1956) attributed the variation in the prevalence of trematodes infesting dogs to the variation in localities from which dogs were collected and to the season during which dogs were exposed to infestation. In our opinion, the available food, such as fish, frogs, and snakes, could also play an essential role in the occurrence and prevalence of digenetic trematodes in dogs in this study. The present study revealed a highly significant difference (p < 0.01) in the prevalence of trematodes between different ages (60% in adults and 0% in young dogs). This difference might be related to the availability of intermediate hosts to adults due to the free-roaming character of adult stray dogs, exposing these animals to fish offal infected with encysted metacercariae.

Regarding cestodes, Dipylidium caninum was recorded in 100% of examined dogs. This data agreed with the results of Selim (1967), who reported that D. caninum is
the most prevalent tapeworm in Egyptian dogs. This result was higher than that recorded by El-Gayar (2005) (73%), El Menyawe & Abdel Rahman (2007) (5%), Umar (2009) (75.0%), Pestechian et al. (2012) (22.9), Nabavi et al. (2014) (7.2%) and Gugsa et al. (2015) (72.7%). The intensity of Dipylidium caninum was 62.3 (2-189) worms/dog, lower than that of Xhaxhiu et al. (2011) (2-309), but higher than that of Wang et al. (2006) (1-96), Umar (2009) (5-6) and Eslami et al. (2010) (1) worm/dog. This high prevalence and intensity of D. caninum could be attributed to the high prevalence of fleas and lice, the intermediate hosts of those worms among stray dogs in Ismaília City. The prevalence of Taenia hydatigena was 10%, nearly like that of Pestechian et al. (2012) (13.5%), higher than that reported by Eguía-Aguilar et al. (2002) (21%), but lower than that reported by Adinezadeh et al. (2013) (61%), Nabavi et al. (2014) (28.6%) and Gugsa et al. (2015) (63.63%). The intensity of T. hydatigena was 2 (1-4) worms/dog, which agreed with that of Umar (2009) (5-6), Eslami et al. (2010) (2-4), and Gugsa et al. (2015) (4), while lower than that reported by Wang et al. (2006) (1-14), Dai et al. (2009) (1-17) and Xhaxhiu et al. (2011) 5.1 (1-38) worms/dog. However, no significant difference in the prevalence of T. hydatigena in relation to age was found in this study. Taenia hydatigena prevalence in adult dogs (16.7%) was higher than in young (0%). This finding was most probably because of the longer exposure of older dogs to the source of infection and the longevity of the worms (Adinezadeh et al., 2013).

The prevalence of Toxocara canis was 20%, nearly similar to that of Minnaar et al. (2002) (21%), Yacob et al. (2007) (21%), and Eslami et al. (2010) (22%), higher than that reported by El-Gayar (2005) (10%), Umar (2009) (6.3%), Pestechian et al. (2012) (6.3%), and Adinezadeh et al. (2013) (7%), but lower than that recorded by El Menyawe & Abdel Rahman (2007) (39.2%), Xhaxhiu et al. (2011) (75.7%), and Abere et al. (2013) (39.8%). The intensity of Toxocara canis was 7.3 (3-15) worms/dog, nearly similar to that of Xhaxhiu et al. (2011) 8.3 (1-54), while higher than that reported by Umar (2009) (2-4) and Eslami et al. (2010) (1-2) but lower than that reported by Wang et al. (2006) (1-72) and Dai et al. (2009) (1-100). There was a highly significant difference (p<0.01) in the prevalence of Toxocara canis in the current study with the age of dogs (40% in young dogs and 6.7% in adult ones). This result was consistent with previous studies (Gholami et al., 2011; Das et al., 2012; Abere et al., 2013). The age-related difference in the prevalence could be explained by the transmission pattern of this nematode (mainly by transplacental and transmammary routes) and the acquired age-dependent immunity caused by repeated exposure (Gillespie & Pearson, 2001). The prevalence of Toxascaris leonina was 10%, nearly like that of El-Gayar (2005) (6.7%) and Razmi et al. (2006) (6%), higher than that recorded by Gholami et al. (2011) (2%) and Xhaxhiu et al. (2011) (0.9%), but lower than that reported by Dai et al. (2009) (32.3%), Pestechian et al. (2012) (21.9%) and Adinezadeh et al. (2013) (53%). The intensity of Toxascaris leonina was 4.4 (2-8) worms/dog, similar to that of Xhaxhiu et al. (2011) (4), but lower than that reported by Dai et al. (2009) (1-56). This variation in the prevalence and intensity of Toxascaris leonina can be attributed to the age effect (Urquhart et al., 1996).

The prevalence of Spirocerca lupi was 10%, approaching that of Minnaar et al. (2002) (13%) in South Africa and Gholami et al. (2011) (6%) in Iran and lower than that recorded by Das et al. (2011) (40%) in Bangladesh, Perera et al. (2013) (22.2%) in Sri Lanka, and Gugsa et al. (2015) (72.7%) in Ethiopia. Our results revealed that Spirocerca lupi intensity was 5.6 (3-8) worms/dog, slightly lower than that recorded by Gugsa et al. (2015) (9.13). The high prevalence of spiricercoosis could be attributed to the large number of wandering stray dogs and the ease of contact with poultry offal and insects/beetles (Das et al., 2011). In the present study, the oesophagus of dogs infested with S. lupi exhibited focal aggregations of mononuclear cells, with marked fibrosis, granulation tissue formation, and early fibroma. This result agreed with that reported by Mazaki-Tovi et al. (2002) and Ranen et al. (2004). The prevalence of Rictularia affinis was 8%, higher than that recorded by Gholami et al. (2011) (2%) in the north of Iran and Pestechian et al. (2012) (3.13%) in Isfahan but lower than that recorded by Dalimi et al. (2006) (12.5%) in the west of Iran. Rictularia affinis was previously recorded by AbdelAal (1990) in foxes in the Sinai Area, but this was the first time to be recorded in dogs in Ismailia province. The prevalence of R. affinis depends on the availability of cockroaches and entomphagous vertebrates, such as lizards (intermediate and paratenic hosts), as food sources (Zare-Bidaki et al., 2010).

Here, mixed helminth infection with two or more different species was more common (70%) than infection with one species. These results agree with that of Eslami et al. (2010) (mixed infection, 80%) in Iran, Jones et al. (2011) (mixed infection, 84.6%) in Ethiopia, Paulos et al. (2012)
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(mixed infection, 81%) in Ethiopia, and Perera et al. (2013) (mixed infection 73.3 %) in Sri Lanka. The most likely explanation for the high prevalence of mixed parasitic infections in this study is that stray dogs act as scavengers and do not receive regular veterinary care (Paulos et al., 2012). There was no significant difference (p > 0.05) in the prevalence of detected helminths between sexes, consistent with previous works (Awoke et al., 2011; Abere et al., 2013; Onyeabor, 2014).

In the present study, all the necropsied stray dogs harbored at least one zoonotic helminth (100%), in agreement with Traub et al. (2002) (99%) and Dalimi et al. (2006) (100%), but higher than that reported by Costin et al. (2011) (61.9%). Dipylidium caninum accidentally infects human beings, especially children or those in close contact with dogs. The zoonotic nematode recorded in this study was Toxocara canis, which produces a condition known as visceral larva migrans (VLM) in children and ocular migrans in adult human beings (Gavignet et al., 2008). We detected seven trematodes (Prohemistemum vivax, Heterophyes dispar, Pygidiopsis summa, Phagicola longus, Metagonimus yokogawai, Apophallus donicus, and Haplorchis pumilio) previously recorded in humans. Nasr (1941) reported the first case of human infestation with P. vivax in Egypt. Human infections with H. dispar were reported in two Korean men who returned from Saudi Arabia (Chai et al., 1986a) and Thailand (Yu & Mott, 1994). Human infections with P. summa were first reported in Japan by detecting eggs in feces (Takahashi, 1929) and adult flukes in the human intestine (Yokogawa et al., 1965). Additionally, Chai & Lee (1990) detected P. summa in humans in Korea. Human infections with P. longus were reported in Brazil (Chieffi et al., 1992). Metagonimus yokogawai is probably the most common intestinal fluke infecting humans in the Far East (Chai & Lee, 2002). Human infections with M. yokogawai were reported in Korea (Chai & Lee, 1990), the northern provinces of Siberia, Israel, the Balkan states, and Spain (Yu & Mott, 1994). Experimental human infection with Apophallus donicus was successful in the United States of America (Niemi & Macy, 1974). There were other reports of infection with this species in humans where fish are eaten raw (Schell, 1985). Human infections with Haplorchis pumilio were reported in the Philippines, Thailand, Laos, South China, Taiwan, and Egypt (Yu & Mott, 1994).

In conclusion, stray dogs in Ismailia City carry a multitude of helminth parasites, thus posing a threat to the human population and companion dogs.

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