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Prevalence and Anthelmintic Resistance of Strongyle Infection of Donkeys in El-Wadi El-Gadid, Egypt

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ABSTRACT

Strongyle species infestation considered the main parasitic problem in equines specially donkeys. Veterinarians and owners used to depend on the affordable drugs, which led to development of resistance. A total number of 215 donkeys of different sexes, ages and in different locations at El Kharga city (El Wadi El Gadid Governorate, Egypt) were examined for detection of strongyle species infection. Fecal samples were collected and examined using floatation test and egg count was done using McMaster technique. The overall prevalence of strongyle species was 73.02% of examined donkeys. 35.03% of infested donkeys showed mild infection, 20.38% showed moderate infection and 44.59% showed severe infection. Prevalence of strongyle species was 75.56% in female donkeys and 71.2% in males. The highest prevalence rate was recorded at Al-Sherka55 (100%) followed by Al-Thawra areas (84.62%). Animals under 3 years old had a slightly higher prevalence than animals 3 – 8 years old, and donkeys > 8 years old showed no infection rate. The therapeutic efficacy of ivermectin, doramectin and pyrantel at the manufacturers recommended dose were evaluated in a controlled experiment, which involved 28 donkeys naturally infected with strongyle species worms. Doramectin was highly efficient against strongyle species worm infection than ivermectin and pyrantel. In ivermectin treated group, the mean FECR% reduced on day 28 to be 91.6%. Also, it has been found that small strongyle EPG counts are returned much quicker than when the drug was first marketed. Mean FECR % in pyrantel treated animals was less than 90% for the whole 28 days of treatment. In conclusion, this was the first study to report prevalence of strongyle species infection in donkeys in El-Kharga city, El-Wadi El-Gadid governorate, Egypt. Additionally, it was the first to report ivermectin resistance in infested donkeys in that area. Donkey's owners are recommended to use doramectin for treatment of parasitic infection.

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Introduction

Donkeys represent the most valuable and low-cost mean of transportation for man, they are adapted to poor quality grass or forages. Donkeys are easy to manage and spread widely in Africa and rural areas (Ahmed *et al*., 2011). In Egypt, horses and mules are less in population than donkeys (Mohsen, 1998); the latter is irreplaceable animals as they help the farmers in the field work, packing, riding, carting, and ploughing (Yoseph *et al*., 2005; Woodford, 2009).

Parasitic infection is the main problem that affecting equines specially donkeys. It affects animal breeding as it lowers fertility and reduces the animal's ability to work (Ahmed *et al*., 2011). Donkeys are considered hosts to a large number of parasites include red worms (Strongyles), round worms (*Parascaris equorum*), tape worms (*Anoplocephala* species), pin worms (*Oxyuris equi*), thread worms (*Strongyloides westeri*), lung worms (*Dictyocaulus arnfieldi*) liver flukes (*Fasciola hepatica*) and larvae of bot flies (*Gasterophilus* species) (Eckert *et al*., 2008). Family Strongylidae is the most common parasite infection of donkeys in the veterinary field (Ali *et al*., 2001; Eysker *et al*., 1992). It is usually found in the large intestine of the animal and adults commonly called strongyle nematodes or strongyles. Strongyles that infect equines are classified into subfamilies Strongylinae and Cyathostominae or large strongyles and small strongyles respectively, and both strongyles are highly pathogenic parasites (Duncan, 1973; Drudge and Lyons, 1977; Soulsby, 1986; Austin, 1994).

Infection with strongyle worms causes health problems in equines and its clinical signs are: colic, emaciation, decrease in physical performance, indigestion, abdominal distention, intestinal rupture, and death (Brady and Nichols, 2009). These worms usually suck blood resulting in anemia, destruct the intestinal mucosa resulting in inability to absorb nutrients, obstruct the intestinal lumen and damage other tissues during larvae migration (Brander *et al*., 1982). The pathogenic effect of strongyles is dependent on the immunity of the host, number of the ingested larvae species, and nutrition status of the animal (Soulsby, 1986).

Currently, there are three broad spectrum drug classes which are the benzimidazoles, the tetrahydropyrimidines

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(pyrantel) and the macrocyclic lactones available for treatment of parasitic infections in equines (Gasser *et al*., 2004; Fischer, 2013). Management practices and drug availability are important factors in determining the timing and number of treatments the animal should receive (Ali *et al*., 2015).

A serious problem facing the control of gastrointestinal nematodes infection in donkeys specially cyathostomins is the anthelmintic resistance. Lyons *et al*. (1999) reported benzimidazoles resistance as well as piperazines and tetrahydropyrimidines. Resistance of small strongyles (Cyathostomins) to anthelmintics are now known world-wide (Kaplan, 2002; 2004). Resistance to benzimidazoles was reported before with five species of cyathostomins (Drudge *et al*., 1979). Therefore, macrocyclic lactones were used extensively during the past 20 years for treatment of strongyles infection in equines (Fischer, 2013). Ivermectin resistance was first reported in horses in Brazil by Molento *et al*. (2006). The only reported case of resistance against macrocyclic lactones in donkey was in the United Kingdom (Trawford *et al*., 2005).

According to the available literature, there is no data about strongyle infection in donkeys at El-Kharga city, El Wadi El Gadid governorate, Egypt. Also, only few reports are available about the efficacy of the anthelmintic drugs used for treatment of infested donkeys in that area. Therefore, the aim of this study was to determine the prevalence of strongyle infection in donkeys and to investigate the efficacy of the anthelmintic drugs used for treatment of infested donkeys in that area.

Materials and methods

Prevalence of strongyle *species infection in donkeys*

Animals

A total number of 215 donkeys belonged to El Kharga city, El-Wadi El-Gadid Governorate were included in this study for the detection of strongyle species worm infection during 2017-2018. Examined donkeys were 125 males and 90 females, while their ages were ranged from one year to 15 years old. Animals were categorized as young (< 3years old), adult (3-8 years) and old (> 8 years). These donkeys were from different locations in El Kharga city (Al-Sherka55, Al-Thawra, Al-Mounira, Al-Osierat, Al-Qattara, Al-Mallaha and Al-Bostan). Examined donkeys had no history of treatment with anthelmintic drugs.

Samples

Fecal samples were collected directly from the rectum of the examined donkeys in a clean plastic cups and the identification number of each animal was registered. Each sample was divided in to two parts; the first part was examined at the same day of collection by floatation sedimentation test for detection of helminths eggs (Kaplan and Nielsen, 2010). The second part was subjected to fecal egg count using McMaster technique (Presland *et al*., 2005). Degree of infection was determined according to number of eggs per gram of feces: < 500 eggs per gram of feces (EPG) considered to be mild infection, 500–1000 EPG is a moderate infection and > 1000 EPG is a severe infection (Soulsby, 1986).

Evaluation of drug efficacy

Drugs used in the study

The following drugs trademarks were used: Ivermectin (Noromectin® 1% injectable non- aqueous solution Norbrook Co.), dose 0.2 mg/kg body weight injected subcutaneously (s/c). Doramectin (Dectomax® 10mg/ml injectable solution Zoetis Co.) at a dose of 0.2 mg/kg body weight by s/c injection. Pyrantel (Banminth® Pfizer Co. 12.5% pyrantel tartrate) given by oral administration at a dose of 19 mg/kg body weight. Pyrantel dose was calculated, weighted and dissolved in distilled water in order to be administrated orally.

Animals used in evaluation of drugs efficacy

A total of 28 donkeys were selected (based on the inclusion criteria) for the drug efficacy experiment. Animals were kept under observation for 3 weeks before starting of the experiment, during which their fecal samples were examined twice per week to confirm single infection with strongyle species worms.

Inclusion criteria

Donkeys that agreed with the following criteria were included in the study; had no history of anthelminthic treatment, infected with strongyle species parasite only and showed a minimum fecal egg count of 250 EPG feces or more.

Experimental design and methodology

The 28 strongyles positive donkeys were selectively allocated into 3 treatment groups A, B, C, and one control non-treated group D. each group had mild, moderate and severe infected donkeys, which were treated with the respective drugs according to the manufacturers' recommendations. The experiment extended for 28 days and fecal samples were collected for egg count at day zero before treatment, and at the 7^{th}, 14^{th}, 21^{st} and 28^{th} days post treatment according to Seri *et al*. (2005). Each animal received a single dose of the selected anthelmintic drug after the first egg count at 0 day as follows:

Group A, included 9 donkeys with fecal egg count ranged from 300 to 5850 EPG, which received ivermectin at a dose 1ml/50 Kg body weight, injected subcutaneously (S/C). Group B, included 8 animals with fecal egg count ranged from 250 to 4100 EPG and received doramectin at a dose of 1ml/50Kg body weight by S/C injection. Group C, included 6 animals with fecal egg count ranged from 250–3750 EPG and received pyrantel by oral administration at a dose of 1g/10Kg body weight. Group D, included 5 donkeys with fecal egg count ranged from 450-1750 EPG and received no treatment as control group. Animal were kept in the stables of the Veterinary Teaching Hospital at Assiut University during the study period, and each group was kept in a separate room. Donkeys were observed for possible adverse reactions for 2 h after medication.

Measuring anthelmintic resistance

Fecal egg count reduction test (FECRT) is a technique for testing resistance and was calculated using the following equation (Coles *et al*., 2006):

$$FECR\% = \frac{\text{pre-treatment EPG - post treatment EPG}}{\text{pretreatment EPG}} \times 100$$

The post-treatment fecal egg count (FEC) values were compared with the pre-treatment values, and Arithmetic means (AM) were used. AM is directly proportional to the total egg count of the group of animals. FECR of > 95% for macrocyclic lactones and > 90% for pyrantel is expected for appropriate efficacy (Kaplan and Nielsen, 2010).

The FECR was used in conjunction with the Egg Reappearance Period (ERP) to determine resistance levels effectively. ERP may be a more sensitive early indicator of resistance. ERP

Is the time taken for worm eggs to reappear in the feces after de-worming.

All procedures involving animals were done in accordance with the ethical standards of Assiut University, Egypt. This article does not contain any studies with human participants.

Statistical analysis

Data of each individual animals and parasitological examination results were inserted into Microsoft excel spread sheet program to create a database. The data were analyzed statistically using SPSS 17 for windows (SPSS, Chicago, USA). Differences between parameters (sex, location and age) were tested for significance at probability levels of 0.05 or less. 95% confidence intervals (95% CI) for FECR% were calculated.

Results

Prevalence of strongyle *infection in donkeys*

157 out of the 215 examined donkeys (73.02%) were found to be infected. 93 donkeys out of the infected ones showed signs of emaciation, poor performance, loss of weight, lethargy with anorexia and rough coat, but only two cases had intermittent diarrhea. Infested donkeys were classified into three groups according to degree of infection: first group showed mild degree of infection and represented 35.03% (n.= 55) of donkeys, second group showed moderate degree of infection and represented 20.38% (n.= 32) of donkeys, while the third group showed severe degree of infection and represented 44.59% (n.= 70) of donkeys (Table 1).

Sex susceptibility

Prevalence of strongyle species in female donkeys (75.56%) was slightly higher than in male animals (71.2%), but statistically there were no significant difference (P= 0.478; Risk ratio 0.94 [95%Confidence Intervals 0.8 to 1.11]) between infection rate in both sexes (Table 2).

Location susceptibility

Prevalence of strongyle nematode worm showed a highly significant variation according to the location (P = 0.000; Chi square = 28.17). The highest prevalence was recorded at Al-Sherka55 (100%) followed by Al-Thawra (84.62%), then Al-Mounira and Al-Osierat (80%), and Al-Qattara (66.67%) and the lowest prevalence was at Al-Mallaha and Al-Bostan where it was 41.18% and 38.46% respectively (Table 2).

Age susceptibility

Donkeys under the age of 3 years old had a slightly higher prevalence (77.42%) than animals from 3–8 years old (76.88%). Donkeys more than 8 years old showed no infection rate as showed in Table 2. Age of the animal had significant effect on prevalence of strongyle worm infection (P = 0.000; Chi square = 31.39).

Table 1. Prevalence of strongyle infection in donkeys and classification of them according to degree of infection.

Number of EPG	Degree of infection	Number	Percentage
< 500	Mild	55	35.03
500 - 1000	Moderate	32	20.38
> 1000	Severe	70	44.59
Total		157	73.02

EPG: Egg per gram;

Table 2. Prevalence of strongyle infection in donkeys based on sex, location and age.

	Examined animals	Positive (%)	Negative (%)	P value
Sex				
Male	125	89 (71.2)	36 (28.8)	0.478
Female	90	68 (75.56)	22 (24.44)	
Total	215	157 (73.02)	58 (26.98)	
Location				
Al -Thawra	39	33 (84.62)	6 (15.38)	
Al-Mounira	25	20 (80)	5 (20)	
Al-Mallaha	17	7 (41.18)	10 (58.82)	
Al-Sherka55	16	16 (100)	0	0
Al-Bostan	13	5 (38.46)	8 (61.54)	
Al-Osierat	45	36 (80)	9 (20)	
Al-Qattara	60	40 (66.67)	20 (33.33)	
Total	215	157 (73.02)	58 (26.98)	
Age				
< 3 years	31	24 (77.42)	7 (22.58)	
3-8 years	173	133 (76.88)	40 (23.12)	0
> 8 years	11	0	11 (100)	
Total	215	157 (73.02)	58 (26.98)	

Risk ratio (Sex)= 0.94, (95% Confidence Intervals 0.8 to 1.11), Chi square (Location)= 28.17, Chi square (Age) = 31.39.

Efficacy of anthelmintics on strongyle *infection in donkeys*

Efficacy of ivermectin on strongyle infection in donkeys

Mean FECR percentage was 97.05% on day 7 with fecal egg counts 0-650 EPG, and it reached the peak at day 14 (99.6%) with 0–50 egg counts range. On day 21, the mean FECR percentage reached 98.3% with a range of 0–150 EPG, while on day 28, it reduced to 91.6% and egg count range of 0-1200 EPG (Table 3). Small strongyles eggs began reappearing at the 4th weeks after treatment.

Efficacy of doramectin on strongyle infection in donkeys

At day 7 after treatment the fecal egg counts ranged from 0–200 EPG and mean FECRT% was 98.6%, while the number of infested animals declined to zero on day 14 after treatment and the mean FECR% reached 100%. Later the egg counts return to increase gradually on days 21 and 28 as it ranged from 0–50 and 0-150 EPG respectively and its efficacy slightly decreased to 98.6% on day 21 and 98.2% on day 28 after treatment (Table 4).

Efficacy of pyrantel on strongyle infection in donkeys

At the 7th day after treatment the fecal egg counts ranged from 50–950 EPG with reduction of the mean egg counts by 83.84%. On day 14, fecal egg counts were ranged from 0 - 1400 EPG with mean egg reduction percentage 82.14%, while the mean fecal count reduction percentage decreased markedly on days 21, and 28 to 78.60% and 67.69% respectively. With increased egg counts range from 0- 1300 EPG at day 21 and from 50–2250 EPG on day 28 (Table 5).

Table 3. Mean fecal egg counts and mean FECR% for ivermectin treated donkeys.

Day	Arithmetic mean (EPG) ± SD	Range	Mean Reduction %	95% CI
0	2633.33±2360.22	300 –5850	-	-
7th	77.78±215.22	0–650	97.05	91.9–97.8
14th	11.11±22.048	0–50	99.6	99.1–99.9
21st	44.44±52.70	0–150	98.3	97.1–99.6
28th	222.22±405.52	0–1200	91.6	81.9–98.8

EPG: Egg per gram; FECR%: Fecal egg count reduction percentage; CI: Confidence interval

Table 4. Mean fecal egg counts and mean FECR % for doramectin treated donkeys.

Day	Arithmetic mean (EPG) ± SD	Range	Mean Reduction %	95% CI
0	1971.43±1709.74	250–4100	-	-
7th	28.57±75.59	0–200	98.6	95.9–98.9
14th	0	0	100	99.9-100
21st	28.57±26.73	0–50	98.6	97.6–99.5
28th	35.71±55.63	0-150	98.2	96.3–99.9

Table 5. Mean fecal egg counts and mean FECR % for pyrantel treated donkeys.

Day	Arithmetic mean (EPG) ± SD	Range	Mean Reduction %	95% CI
0	1908.33±1438.89	250–3750	-	-
7th	308.33±392.96	50–950	83.84	69.1–98.6
14th	341.67±548.10	0–1400	82.14	61.5–97.3
21st	408.33±551.74	0–1300	78.6	57.8–99.4
28th	616.67±909.2121	50–2250	67.69	33.5–98.1

Table 6. Mean fecal egg counts and FECR % for control non-treated donkeys.

Day	Arithmetic mean (EPG) ± SD	Range	Mean Reduction %
0	850±525.59	450-1750	-
7th	1110±705.69	200–1850	-30.59
14th	1170±797.34	250–2200	-37.65
21st	1190±830.21	450–2300	-40
28th	1200±639.92	500-2250	-41.18

Discussion

Donkeys represent an important source of traction and income for poor people (Ramaswamy, 1994; Gebreab, 1998). Reviewing the available literature indicated that strongyle infection appears to be the most prominent parasite that infects donkeys. Strongyles appear to cause many health problems such as colic, profuse diarrhea and un-thriftiness (Soulsby, 1986). According to the authors knowledge, this is the first study to report the prevalence and intensity of strongyle worm infection in donkeys in El Kharga city, El Wadi El Gadid Governorate, and the efficacy of the commonly used drugs for treatment.

The overall prevalence of strongyle species infection of donkeys in El Kharga city was 73.02% (157/215). This finding was in agreement with that of Feseha *et al.* (1991) and Tesfu *et al.* (2014), who reported prevalence of 70% and 72.2% in Scotland and Ethiopia respectively. The recorded prevalence was lower than previous reports of Ahmed (1984); Mohsen (1998); Ayele *et al.* (2006); Getachew *et al.* (2010); Ahmed *et al.* (2011) and Bogale *et al.* (2012), who recorded 93.80%, , 96.38%, 100%, 99%, 81.54% and 82.75% respectively in equines. Meanwhile, it was higher than that recorded by Seri *et al.* (2004); Imam *et al.* (2010); Waqas *et al.* (2015); Enigidaw *et al.* (2015); Musa *et al.* (2016) and Osman (2017), who reported 35.8%, 26.5%, 50.8%, 47.4%, 37.8% and 30.5% respectively. The diversity between our result and those of others may be due to differences in sample size, hygienic status, geographical conditions between study areas and the availability of anthelmintic drugs.

Strongyle worm infection was tested positive in 157 donkeys, 93 of these donkeys were suffering from emaciation, poor performance, weight loss, rough coat, lethargy and anorexia, but only two donkeys suffered from intermittent diarrhea. These clinical signs were observed previously by Umur and Acici (2009) and Waqas *et al.* (2015).

The observed clinical signs in the 95 infested donkeys may result from the feeding habits of adult worms, as they feed on mucosal plugs of the intestine of infested host resulting in hemorrhage leading to debility and weight loss or may be due to migration of larvae (Eckert *et al.*, 2008; Osman, 2017). The remaining 62 donkeys appeared clinically healthy which agreed with the findings of Urquhart *et al.* (1996), who found that naturally infested animals may tolerate infection if exposed to larvae in small doses over a prolonged period.

The current study reported that 35.03% of the examined donkeys showed mild strongyle species infection, 20% of donkeys showed moderate degree of infection and 44.59% of donkeys had a severe degree of infection. These findings were lower than that of Wells *et al.* (1998), who recorded that all tested positive donkeys were severely infested and were also lower than that of Getachew *et al.* (2010), who indicated that over 55% of the examined donkeys were severely infested by strongyle species as they have fecal egg count more than 1000 EPG. Moreover, this finding agreed with Upjohn *et al.* (2010), who reported that 48.8% of examined horses were severely infested with FEC over 1000 EPG.

Concerning sex of the examined donkeys, prevalence of strongyle species infection was slightly higher in female animals (75.56%) than in males (71.2%). The difference in prevalence between male and female animals was statistically insignificant (P = 0.478), which indicate that sex of the animals has no significant effect on infection with strongyle worms. Previous studies reported that males and females' donkeys were equally infested with strongyle worms, but the slightly increased infection rate in females may be due to their hormonal activities (Dietz *et al.*, 1984). Similar findings were recorded by Ahmed *et al.* (2011); Sori *et al.* (2017) and Addis *et al.* (2017). In contrast, Upjohn *et al.* (2010) mentioned that female equines are more susceptible to strongyle infection than male animals. Furthermore, Bogale *et al.* (2012) observed that female animals were more susceptible (84.39%) than male animals (83.41%). Also, Osman (2017) reported that there was a significant difference between sex of the animals and rate of strongyle infection as female equines are more susceptible to infection (57.9%) than male animals (25.7%). Meanwhile, Enigidaw *et al.* (2015) recorded that male animals are 1.65 more susceptible to strongyle species infection than females.

Regarding location of the examined donkeys in El-Kharga city, prevalence of strongyles was 100% at EL-Sherka55; 84.62% at Al-Thawra; 80% at Al-Mounira and Al-Osierat, and 66.67% at Al-Qattara. The lowest prevalence of strongyle infection was recorded at Al-Mallaha and Al-Bostan as it was 41.18% and 38.46% respectively. This result may be due to the different management methods, poor conditions of housing donkeys, poor nutrition, different workloads and lack of deworming practices between different areas (Feseha, 1997).

Regarding age of infested donkeys, our study revealed that infection rate with strongyle species was slightly higher in young animals than in adult and no infection found in old ones. it was 77.42%, 76.88% and 0% in the three age groups respectively. Statistical analysis indicated that the most susceptible age for strongyle infection was young donkeys (< 3 years of age, P = 0.00). It may be due to the development of age immunity to strongyles in adult donkeys (Chitra *et al.*, 2011). Lack of immunity against cyathostomins infections could be one reason for greater accumulation of encysted larvae in the intestinal mucosa in young equines (Herd and Gabel, 1990). Similar finding was observed previously by Wells *et al.* (1998) and Addis *et al.* (2017), they recoded that the highest infection rate was at < 3 years old donkeys, followed by donkeys at 3-8 years old and > 8 years (98.7% and 97.4% respectively). Upjohn *et al.* (2010) recoded that the young animals were more susceptible to infection with strongyle worms than adults. In contrast, Ahmed *et al.* (2011) recorded that old donkeys were more susceptible to infection with large and small strongyles than young ones.

The main aim of this study was to measure the efficacy of ivermectin and other medications (doramectin and pyrantel) commonly used for treatment of strongyle worms in El-Kharga city. In ivermectin treated group, FEC was reduced by 97.05% on the 7th day, 99.6% on the 14th day, 98.3% on the 21st day, and 91.6% on the 28th day. This finding was nearly similar to that observed previously by Sipra *et al.* (1999); Davies and Schwalbach (2000); Imam *et al.* (2010); Fangama *et al.* (2013) and Zak *et al.* (2017), they mentioned that the reduction in strongyles FEC was 99.9% at day 14 after treatment with ivermectin. In the present study, although ivermectin showed high reduction percentage in FEC of strongyles eggs during the first 21 days after treatment, the reduction percentage highly reduced to lower than the 95% resistance limit at the 28th day of treatment. High activity of ivermectin on small strongyles was reported before, however recently it has been found that small strongyles eggs began reappearing at 4 weeks, which is less than the initial approximate 8 weeks estimated when the drug first was marketed (Little *et al.*, 2003; Trawford *et al.*, 2005; von Samson-Himmelstjerna *et al.*, 2007). Taylor and Kenny (1995); Jacobs *et al.* (1995) and Monahan and Klei (2002) also reported that egg reappearance period for ivermectin was 8-14 weeks.

Doramectin treated group showed 98.6% FECR on the 7th day, 100% on the 14th day, 98.6% on the 21st day and 98.2% on the 28th day after treatment. This finding was previously observed by Davies and Schwalbach (2000) and Seri *et al.* (2005), they indicated that equines treated by doramectin showed 100% reduction in fecal egg count for 28 days after

treatment.

In pyrantel treated group, the mean reduction percentage in strongyles egg count was 83.84%, 82.14%, 78.60% and 67.69% on the 7th, 14th ,21st and 28th days respectively, after treatment. The mean FECR percentage was less than 90% for the whole 28 days treatment period, and according to WAAVP recommendations, resistance is found when FECRT% is less than 90%, which may indicate resistance of treated animals to the used drug. This result agreed with Ihler and Bjern (1996); Craven *et al.* (1998); Traversa *et al.* (2007); Molento *et al.* (2006); Näreahoa *et al.* (2011) and Traversa *et al.* (2012). Underdosing has been suggested as an important factor in hastening the development of resistance to pyrantel and this is often a risk associated with oral dosing, as spillage frequently occurs (Luz Pereira *et al.*, 1995).

Data from this study showed that highest to the lowest ranking of drug efficacy against strongyles was doramectin, ivermectin and pyrantel. It was shown that donkeys treated with pyrantel drugs had lower EPG values than those treated with doramectin and ivermectin, probably due to the effect of macrocyclic lactones on late luminal larval stages, which give a longer suppression of fecal egg output compared with other anthelmintics (Eysker *et al.*, 1992; Uhlinger, 1992). These findings may be also attributed to the availability of pyrantel as anthelmintic drug, resistance of the animals to oral doses form of this drug, and higher treatment frequency of pyrantel as it considered cheap anthelmintic drugs in Egypt, unlike ivermectin and doramectin.

The high activity of ivermectin against small strongyles, indicated by the data at the first two weeks after treatment, may be misleading because EPG counts of these parasites have been returning at about 4 weeks post-treatment. Lumsden *et al.* (1989) compared the reappearance of nematode eggs in feces after treatment with ivermectin and pyrantel and found that the median period until eggs reappeared in feces was 70 days for ivermectin and 39 days for pyrantel. Based on these results, they suggested a 10-week interval between ivermectin treatments.

Cyathostomes, unlike other nematodes, can remain in an encysted/arrested state in the intestinal mucosa of equines for extended periods of time following infection. This period of arrest can last for months or more, resulting in an infection dynamic where the majority of Cyathostomes infesting the animal are often the mucosal larval stages. Unlike in ruminant hosts, ivermectin does not penetrate these cysts and therefore does not kill these mucosal stages. Because the mucosal stages do not 'see' the drug and are not selected by treatment, they serve as refugia (Kaplan, 2002).

Conclusion

This study was the first to report prevalence of strongyle species infection in donkeys in El-Kharga city, El-Wadi El-Gadid governorate, Egypt. Also, it was the first to report ivermectin resistance in infested donkeys in that area. Donkey's owners are recommended to use doramectin for treatment of parasitic infection.

Conflict of interest

The authors declare that they have no conflict of interest

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