Prevalence and Risk Factor Analysis of Equine Infestation with Gastrointestinal Parasites in Israel

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ABSTRACT

The horse is a host for a large number of intestinal helminthic parasites. This study was designed as a survey for the prevalence, species distribution and potential risk factors of equine intestinal helminth parasites among horses in Israel. Fecal floatation and egg counts were performed on 485 fecal samples collected from 403 horses (mostly adults) at 30 farms across Israel. Strongyle eggs were found in 116/485 (24%) of the samples from 18/30 (60%) farms, of which 44 (38% of positive samples, 9% of the total population) were highly infested (over 500 eggs/gm feces). Ascarids were found in 26/485 (5%) samples from 10/30 (33%) farms, 7 (27% of positive samples, 1.4% of the total population) of which were highly infested. Singular flatworm eggs (family *Anoplocephala*) were detected in two samples. Risk factors significantly ($p<0.005$) associated with Strongyle infestation by the univariate statistical analysis were the farm, geographical location, age of the horse and breed, and the time of last deworming treatment. Season, horse gender, horse age, and housing were significantly associated with ascarid infestation.Infestation with gastrointestinal helminths in Israel appears to be low, and resistance against anthelminthics in adult horses is probably uncommon. These findings should lead to re-investigation and re-evaluation of deworming regimes in Israel recommended for adult horses in equine facilities in areas with low infestation rates.

Keywords: Equine; Helminth; Fecal Floatation; Small Strongyles; Ascarids; *Parascaris equorum*; Risk Factors; Israel

INTRODUCTION

The horse is a host for a large number of intestinal helminthic parasites, including roundworms, flatworms and pinworms. Infestation may range from asymptomaticto life threatening, depending on the host, helminth species and parasite burden (1). In the past, large Strongyles, and mainly *Strongylus vulgaris*, were the main concern of horse owners and veterinarians due to its high occurrence and resulting high mortality. This encouraged most equine practitioners to advise routine anthelminthic treatments for most horses.The introduction of these routine treatments has led over the past few decades to changes in species distribution and to the emergence of parasite resistance to some of the anthelminthic drugs (2). In recent years small Strongyles, and mainly Cyathostomins have been the most prevalent helminth species in adult horses, with increasing reports of their clinical significance and resistance to benzimidazole and tetrahydropyrimidine drugs (2). *Parascaris equorum* is also a clinically important species, especially in young horses, with reports of resistance to macrocyclic lactones (2).

Israel has a climate ranging from Mediterranean to extreme arid, with very few pasture areas for horses. Most horses are stabled or turned out in small paddocks, a factor which may affect the probability of being infected by helminth parasites. The only survey that examined the distribution of different gastro-intestinal helminth species in horses in Israel was conducted three decades ago (3). That study revealed that 48% of horses had positive egg flotations, and the most prevalent species were small Strongyles (*Trichonemma* spp., in 78% of farms; *Triodontophorus* spp., in 22% of farms), *Parascaris equorum* (in 44% of farms), *Strongylus vulgaris* and *Oxiuris equi* (in 22% of farms respectively) (3). Since then, most horse owners and veterinarians have been administering periodic anthelminthic treatments. In recent years equine practitioners in Israel have been under the impression that they encounter more clinical cases of Parascaris infections in foals that have been regularly dewormed which raised the suspicion that resistance to treatment may have developed.

This study was designed to update the survey for the prevalence and species distribution of equine intestinal helminth parasites among adult horses in Israel, investigate potential risk factors for infestation, and to draw conclusions as to the probability of drug resistance.

MATERIAL AND METHODS

Sample collection

Between March 2012 and March 2013, 485 fresh fecal samples were collected from 403 horses at 30 stables, representing the distribution of farms across Israel. From some horses, fecal samples were collected more than once, on different collection dates. Fecal samples were collected from the rectum or from freshly voided feces. Data was collected regarding the management of the farm, the signalment of each horse, the deworming regime used, and the details of the last deworming treatment of each horse. After collection, samples were kept refrigerated and were examined within 48 hours.

Fecal egg count

Egg counts were performed according to a Modified McMaster technique: Briefly, three grams of feces were suspended in 42 ml water, filtered through a 100 mesh sieve, 15 ml were centrifuged at 1500 g for 5 minutes and the sediment was resuspended in a saturated NaCl solution. Sampled were examined microscopically, eggs were identified morphologically and counted using the McMaster counting slide (3). Infestation with specific helminth species was defined as low (<500 eggs per gram feces) or high (>500 eggs per gram feces) based on its egg count.

Fecal cultures

Fecal cultures were performed by placing a moist sample in an uncovered 35 mm diameter Petri dish which was placed in a 90 mm diameter dish filled with water. After incubating the sample at 27ºC for 7 days the fluid from the larger Petri dish, which contained many of the larvae, was pipetted into a conical centrifuge tube and centrifuged at 1500 g for 3 min. The supernatant was discarded and the larvae were examined microscopically for identification (3).

Statistical analysis

Univariate and multivariate forward stepwise logistic regressions were calculated using statistical software program (SPSS® 19.0 for Windows®). Association between variables was considered significant when p-values were less than 0.05. All significant parameters in the univariate analysis were included in the multivariate analysis.

RESULTS

Population

Geographic Distribution

Fecal samples were collected at 30 stables across Israel. Between 1 and 47 samples were collected at each stable (Figure 1). Two of the stables were located in the Golan Heights (32 horses, 6.6%), 11 in the north (Galilee, Carmel, Ramot Menashe, 223 horses, 46%), 9 in central Israel (111 horses, 22.9%), 4 around Jerusalem (63 horses, 13%), and 4 in the Negev desert in the south (56 horses, 11.5%) (Figure 1).

Horse characteristics

A total of 485 fresh fecal samples were collected from 403 horses (some horses were sampled at more than one occasion). About half of the horses were mares (192, 48.4%), and the rest were geldings (173, 43.6%) and stallions (32, 8%). Most of the horses (158, 56.2%) were local breed horses, and the rest were Quarter horses (71, 25.3%), Arabians (20, 7.2%), Appaloosas (14, 5%), Ponies (11, 3.9%), Tennessee Walking horses (6, 2.1%) and one Warmblood (0.3%). Most of the horses were adults, and only 21 (4%) samples were collected from young horses under three years of age.

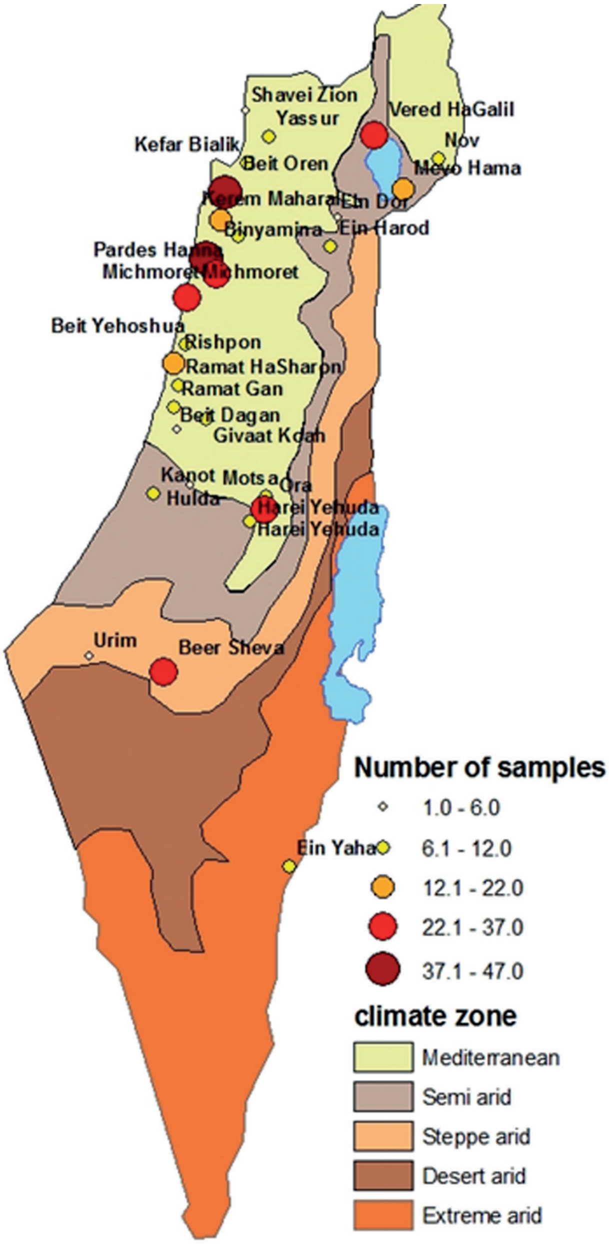

Figure 1: Geographic distribution of the farms sampled. The number of fecal samples collected in each ranch is represented by the size and color of each mark.

Stable interface

Approximately half of the samples (243, 50.1%) were collected from horses that were housed in stalls, and the remainder from horses in either paddocks (86, 18%) or pastures (126, 26%). Information regarding the date of the last deworming treatment was available for only 75% of the horses. Almost half of the latter (174, 48%) were not treated against helminthes over the previous 6 months. Drugs used for deworming treatment were Ivermectin (208, 88.9%), Pyrantel (22, 9.4%) or VermX (4, 1.7%).

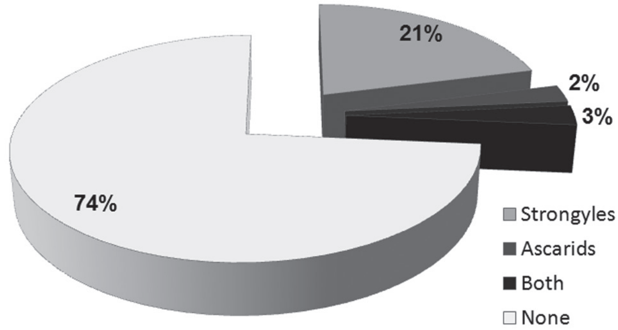

Figure 2: Prevalence of the presence of helminth eggs in equine fecal samples (n=486), from the families Strongylidae, Ascaridea or both.

Prevalence of different helminth species

Two major helminth families (*Strongylidea* and *Ascaridea*) were detected by fecal flotation examination (Figure 2). Strongyle eggs were found in 116/485 (24%) of the samples, 44 of which were highly infested with over 500 eggs/gr feces (38% of positive samples, 9% of the total population). *Parascaris equorum* eggs were found in 26/485 (5%) samples, 7 of which were highly infested (27% of positive samples, 1.4% of the total population). In two samples a low number of Anoplocephala eggs were detected.

Both Strongyle and Ascarid eggs were detected in 7/30 farms (23.3%). Eleven farms (36.6%) were infested only with Strongyles, while 3 farms (10%) were infested only with Ascarids. In 9 farms (30%), no parasites were detected.

A sample of 10 specimens positive for Strongyles were cultured to identify their species, and were all classified as small Strongyles.

Risk factors associated with infestation with different helminth species

Strongyles

The data from all horses was analysed to detect potential risk factors for Strongyle infestation. Univariate analysis showed that the stable, geographical location, horse age and breed and the time of last deworming treatment were significantly ($p<0.005$) associated with low or high infestation with Strongyles (Table 1). Similar analysis were conducted for Strongyle infestation as a binary parameter (i.e. whether

Table 1: Univariate analysis of risk factors considered to be associated with low (under 500 eggs/gr feces) or high (over 500 eggs/gr feces) infestetion of Strongyles. *P values under 0.05 were considered significant, and appears in bold*

Variable	Category (n)	Number of carriers/ n in category (%)			P-value (χ^2)
		0	<500	>500	
Ranch	Beer Sheva	15/29 (52%)	10/29 (34%)	4/29 (14%)	**<0.0001**
	Beit Dagan	3/3 (100%)	0	0	
	Beit Oren	21/39 (54%)	11/39 (28%)	7/39 (18%)	
	Beit Yehoshua	10/11 (91%)	1/11 (9%)	0	
	Binyamina	23/47 (49%)	8/47 (17%)	16/47 (34%)	
	Ein Dor	4/5 (80%)	1/5 (20%)	0	
	Ein Harod	10/10 (100%)	0	0	
	Ein Yahav	9/9 (100%)	0	0	
	Givaat Koah	12/12 (100%)	0	0	
	Harei Yehuda	8/8 (100%)	0	0	
	Hulda	3/6 (50%)	3/6 (50%)	0	
	Kanot	12/12 (100%)	0	0	
	Kefar Bialik	9/11 (82%)	2/11 (18%)	0	
	Kerem Maharal	16/22 (73%)	4/22 (18%)	2/22 (9%)	
	Mevo Hama	6/21 (29%)	6/21 (29%)	9/21 (43%)	
	Michmoret	25/32 (78%)	6/32 (19%)	1/32 (3%)	
	Motsa	8/8 (100%)	0	0	
	Nahal Alexander	7/8 (87%)	1/8 (12%)	0	
	Nov	2/11 (18%)	5/11 (45%)	4/11 (36%)	
	Ora	36/37 (97%)	1/37 (3%)	0	
	Pardes Hanna	30/34 (88%)	4/34 (12%)	0	
	Ramat Gan	11/11 (100%)	0	0	
	Ramat HaSharon	5/10 (50%)	4/10 (40%)	1/10 (10%)	
	Ramot Menashe	8/9 (89%)	1/9 (11%)	0	
	Rishpon	19/19 (100%)	0	0	
	Shavei Zion	1/1 (100%)	0	0	
	Urim	6/6 (100%)	0	0	
	Vered HaGalil	32/32 (100%)	0	0	
	Yassur	9/12 (75%)	3/12 (25%)	0	
	Zur Hadassa	9/10 (90%)	1/10 (10%)	0	
Geographical area	Golan Heights	8/32 (25%)	11/32 (34%)	13/32 (41%)	**<0.0001**
	North	164/223 (73%)	34/223 (15%)	25/223 (11%)	
	Center	94/111 (85%)	15/111 (13%)	2/111 (2%)	
	Jerusalem	61/63 (97%)	2/63 (3%)	0	
	South	42/56 (75%)	10/56 (18%)	4/56 (7%)	
Season	Spring (Apr-Jun)	26/39 (67%)	9/39 (23%)	4/39 (10%)	0.31
	Summer (Jul-Sep)	37/57 (65%)	11/57 (19%)	9/57 (16%)	
	Autumn (Oct-Dec)	103/138 (75%)	23/138 (17%)	12/138 (9%)	
	Winter (Jan-Mar)	168/215 (78%)	28/215 (13%)	19/215 (9%)	

Variable	Category (n)	Number of carriers/ n in category (%)			P-value (χ^2)
		0	<500	>500	
Horse gender	Gelding	136/173 (79%)	25/173 (14%)	12/173 (7%)	0.063
	Stallion	20/32 (62%)	5/32 (16%)	7/32 (22%)	
	Mare	133/192 (69%)	35/192 (18%)	24/192 (12%)	
Horse age	<3 years	12/21 (57%)	2/21 (9%)	7/21 (33%)	**0.012**
	3-15 years	181/258 (70%)	50/258 (19%)	27/258 (10%)	
	>15 years	49/59 (83%)	6/59 (10%)	4/59 (7%)	
Horse breed	Appaloosa	8/14 (57%)	3/14 (21%)	3/14 (21%)	**0.027**
	Arabian	13/20 (65%)	5/20 (25%)	2/20 (10%)	
	Grade	113/158 (71%)	29/158 (18%)	16/158 (10%)	
	Pony	7/11 (64%)	3/11 (27%)	1/11 (9%)	
	Quarter Horse	62/71 (87%)	7/71 (10%)	2/71 (3%)	
	Tennessee Walking Horse	2/6 (33%)	2/6 (33%)	2/6 (33%)	
	Warmblood	1/1 (100%)	0	0	
Farm interface	Stall	193/243 (79%)	33/243 (14%)	17/234 (7%)	**0.001**
	Paddock	69/86 (80%)	12/86 (14%)	5/86 (6%)	
	Pasture	78/126 (62%)	26/126 (21%)	22/126 (17%)	
Last deworming	under 2 months	46/54 (85%)	4/54 (7%)	4/54 (7%)	**<0.0001**
	2-4 months	52/61 (85%)	7/61 (11%)	2/61 (3%)	
	4-6 months	58/70 (83%)	11/70 (16%)	1/70 (1%)	
	over 6 months	105/174 (60%)	36/174 (21%)	33/174 (19%)	
Drug used for last deworming	Ivermectin	158/208 (76%)	32/208 (15%)	18/208 (9%)	0.347
	Pyrantel	17/22 (77%)	2/22 (9%)	3/22 (14%)	
	VermX	2/4 (50%)	1/4 (25%)	1/4 (25%)	

or not eggs were detected), and led to similar (slightly more significant) results (data not shown).

The prevalence of Strongyles in different stables ranged from zero (in several stables) to 82% (in Nov), and when grouped to geographic provinces it ranged from 15% around Jerusalem to 75% in the Golan Heights. Both stable and geographic location were found to be factors significantly associated with infestation, with the stables in Nov and Mevo Hama, both located in the Golan heights, with higher risk of infestation. Horse breed was found to be significantly associated with infestation, with Tennessee Walking horses more prone to infestation. Horses that did not receive anthelminthic treatment at least 6 month prior to sampling were found to have a significantly higher risk for infestation with Strongyles.

The stable was the only factor found significant in multivariate statistical analysis, and the stables of Mevo Hama (32°44'15.6"N 35°39'19.3"E, p=0.01) and Nov (32°49'56.3"N 35°47'01.3"E, p=0.037) had highest risk of infestation. The relative risk of infestation in Nov was 87 times higher (p<0.001, 95% CI: 4.26-1793) than in Ramat Gan (a stable located in central Israel, with similar number of horses).

Ascarids

Univariate statistical analysis was performed to detect risk factors associated with low or high Ascarid egg counts. Season (spring), horse gender (stallion), horse age and farm interface (paddock) were significantly associated with Ascarid infestation. When evaluating infestation as a binary parameter farm geographical location and the drug used in the last deworming were also found to be significant (Table 2). Multivariate analysis did not reveal any significant risk factors.

Table 2: Univariate analysis of risk factors considered to be associated with low (under 500 eggs/gr feces) or high (over 500 eggs/gr feces) infestetion of Ascarides. P values under 0.05 were considered significant, and appears in bold. Parameters that were significant when examined as binary (ascarid eggs present or not) are starred

Variable	Category (n)	Number of carriers/ n in category (%)			P-value (χ^2)
		0	<500	>500	
Ranch	Beer Sheva	22/29 (76%)	5/29 (17%)	2/29 (7%)	-
	Beit Dagan	3/3 (100%)	0	0	
	Beit Oren	37/39 (95%)	2/39 (5%)	0	
	Beit Yehoshua	10/11 (91%)	0	1/11 (9%)	
	Binyamina	38/47 (81%)	7/47 (15%)	2/47 (4%)	
	Ein Dor	5/5 (100%)	0	0	
	Ein Harod	9/10 (90%)	0	1/10 (10%)	
	Ein Yahav	9/9 (100%)	0	0	
	Givaat Koah	11/12 (92%)	1/12 (8%)	0	
	Harei Yehuda	8/8 (100%)	0	0	
	Hulda	6/6 (100%)	0	0	
	Kanot	12/12 (100%)	0	0	
	Kefar Bialik	10/11 (91%)	0	1/11 (9%)	
	Kerem Maharal	22/22 (100%)	0	0	
	Mevo Hama	21/21 (100%)	0	0	
	Michmoret	30/32 (94%)	2/32 (6%)	0	
	Motsa	8/8 (100%)	0	0	
	Nahal Alexander	8/8 (100%)	0	0	
	Nov	11/11 (100%)	0	0	
	Ora	37/37 (100%)	0	0	
	Pardes Hanna	34/34 (100%)	0	0	
	Ramat Gan	11/11 (100%)	0	0	
	Ramat HaSharon	10/10 (100%)	0	0	
	Ramot Menashe	9/9 (100%)	0	0	
	Rishpon	19/19 (100%)	0	0	
	Shavei Zion	1/1 (100%)	0	0	
	Urim	6/6 (100%)	0	0	
	Vered HaGalil	31/32 (97%)	1/32 (3%)	0	
	Yassur	11/12 (92%)	1/12 (8%)	0	
	Zur Hadassa	10/10 (100%)	0	0	
Geographical area	Golan Heights	32/32 (100%)	0	0	0.148
	North	208/223 (93%)	11/223 (5%)	4/223 (2%)	*0.013
	Center	107/111 (96%)	3/111 (3%)	1/111 (1%)	
	Jerusalem	63/63 (100%)	0	0	
	South	49/56 (87%)	5/56 (9%)	2/56 (4%)	
Season	Spring (Apr-Jun)	32/39 (82%)	5/39 (13%)	2/39 (5%)	**0.001**
	Summer (Jul-Sep)	54/57 (95%)	2/57 (3%)	1/57 (2%)	
	Autumn (Oct-Dec)	127/138 (92%)	9/138 (6%)	2/138 (1%)	
	Winter (Jan-Mar)	211/215 (98%)	2/215 (1%)	2/215 (1%)	
Horse gender	Gelding	170/173 (98%)	3/173 (2%)	0	0.002
	Stallion	27/32 (84%)	2/32 (6%)	3/32 (9%)	
	Mare	177/192 (92%)	11/192 (6%)	4/192 (2%)	

Variable	Category (n)	Number of carriers/ n in category (%)			P-value (χ^2)
		0	<500	>500	
Horse age	<3 years	11/21 (52%)	5/21 (24%)	5/21 (24%)	**<0.0001**
	3-15 years	247/258 (96%)	10/258 (4%)	1/258 (0.5%)	
	>15 years	59/59 (100%)	0	0	
Horse breed	Appaloosa	14/14 (100%)	0	0	0.146
	Arabian	19/20 (95%)	1/20 (5%)	0	
	Grade	151/158 (96%)	5/158 (3%)	2/158 (1%)	
	Pony	11/11 (100%)	0	0	
	Quarter Horse	69/71 (97%)	1/71 (1%)	1/71 (1%)	
	Tennessee Walking Horse	4/6 (67%)	0	2/6 (33%)	
	Warmblood	1/1 (100%)	0	0	
Farm interface	Stall	232/243 (95%)	7/243 (3%)	4/243 (2%)	**0.016**
	Paddock	75/86 (87%)	8/86 (9%)	3/86 (3%)	
	Pasture	123/126 (98%)	3/126 (2%)	0	
Last deworming	under 2 months	48/54 (89%)	5/54 (9%)	1/54 (2%)	0.2
	2-4 months	60/61 (98%)	0	1/61 (2%)	
	4-6 months	67/70 (96%)	2/70 (3%)	1/70 (1%)	
	over 6 months	166/174 (95%)	6/174 (3%)	2/174 (1%)	
Drug used for last deworming	Ivermectin	200/208 (96%)	7/208 (3%)	1/208 (0.5%)	0.068
	Pyrantel	18/22 (82%)	4/22 (18%)	0	*0.042
	VermX	4/4 (100%)	0	0	

Age was a significant risk factor for both helminth species, with young horses more prone to infestation, and with a higher chance of high infestation (over 500 eggs/gr feces). The distribution of the presence of both helminths in relation to age is depicted in Figure 3.

DISCUSSION

This study was designed to re-investigate the prevalence and species distribution of intestinal helminths in horses in Israel. The overall helminth prevalence appears to be low, with only 24% of horses positive for Strongyle eggs, 5% positive for Ascarid eggs and less than 1% positive for Anoplocephala eggs in their faeces.

At present, small Strongyles is the most common helminth family known to infest horses worldwide, with prevalence ranging from 61-100% of horses, and 98-100% of stables in most European countries (1, 4, 5, 6, 7, 8, 9). The low prevalence we found (24% of horses) is similar to the findings of the 2009 survey from Greece, that found Strongyle eggs in 25.6% of horses (8). The last survey of the Israeli horse population was conducted in 1986 (3). Here, small Strongyle eggs were found in 60% (18/30) of the farms, which is less than the 78% prevalence that was found in the 1986 survey (3). In this time period, routine deworming programs were introduced to most of the horse population. Although the decline in prevalence was not statistically significant, it may suggest a trend. This concurs with another study from Louisiana conducted over similar time scale, which demonstrated a decrease in the infestation of most helminth species, and a shift in species distribution of small strongyles (10). In the current survey, most of the horses sampled were adults that had not received anthelminthic treatment for at least two months prior to sampling.

Current recommendations for deworming strategies are for targeted deworming, since most studies show that about 10% of horses are responsible for over 80% of helminth egg contamination on a specific farm (1, 11). However, our study found that ten of eighteen farms infested with Strongyles had only horses with low infestation (fewer than 500 eggs per gram feces). In farms with higher infestation, the prevalence of high shedding horses (over 500 eggs per gram feces) were 9-43% (9% of the study population) of the horses, and 14-

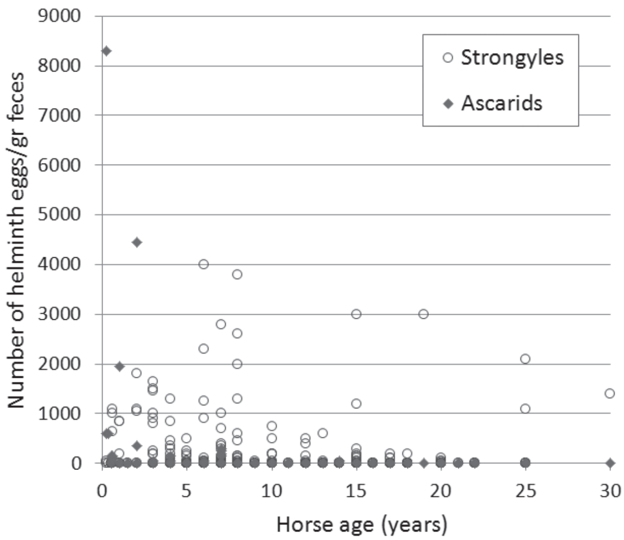

Figure 3: Age distribution of helminth carriage. Each mark represents the number of Strongyle (circle) or Ascarid (rhombus) eggs per gram feces of one horse of a certain age.

66% (38% of the study population) of shedding horses, much higher than reported elsewhere.

Factors that were significantly associated with Strongyle egg shedding in univariate analysis were the stable, geographical location, horse age and breed and the time of the last deworming treatment. The only factor that was significantly associated with infestation with Strongyles in multivariate analysis was the stable. The two stables with significantly higher infestation are located in the Golan Heights, where the horses are turned out in pastures, and are not routinely treated against helminthes. The fact that young horses are more susceptible to Strongyle infestation has been established in many different surveys (1, 6, 7). In this study the population consisted of mostly adult horses, which may partially explain the low prevalence. Other risk factors that have been previously demonstrated to influence Strongyle infection are breed, gender, farm interface, deworming regime, season and precipitation. Of these factors only pasture (without rotation) was consistent in most studies (1, 4, 6, 7, 9). Our findings concur with some of these risk factors, although it is hard to rule out confounders, since many of the examined factors were not distributed normally and might be linked (for example, management, breed and geographical area, as demonstrated before).

The time of the last deworming was linked to Strongyle egg shedding. This was not unexpected, although the only group of horses with significantly higher shedding was the group that had not been treated for at least 6 months. The life cycle of different Strongyle species varies from six to twelve weeks. This fact led to regular and intensive anthelmintic treatments (11). Our findings suggest that owners that still treat horses periodically should re-examine the necessary time interval between treatments in adult horses. The low shedding rates in all treated horses may imply that anthelminthic resistance of Strongyle species in Israel is probably low.

Parascaris equorum is a common parasite in young horses worldwide, and its prevalence ranges between 0.4 and 76% of horses in different surveys (1, 5, 6, 7, 8, 9, 12). In this study, only one third of the farms had horses infested with *Parascaris equorum*, which was even lower than the prevalence that was found in the previous survey which was 44.4% (3), although this difference was not statistically significant. The low prevalence found in this study may reflect the fact that our study population consisted mostly of adult horses. The significance of risk factor analysis for Parascaris egg shedding was limited, due to the low number of positive samples. The only factor that was consistently found to influence infestation with Parascaris in other surveys was young age (1, 7, 9). Many recent publications indicate high levels of drug resistance in *Parascaris equorum*, mostly to macrocyclic lactones (2). Many equine practitioners in Israel suspect that they encounter an increasing number of cases caused by Parascaris infestation in young horses that have been regularly treated against helminths, and relate this phenomenon to drug resistance. In this survey we did not find an indication of such resistance, but in order to explore this possibility a survey of younger horses is necessary.

Tapeworm eggs were only found in two cases. This may suggest a low prevalence, but may be an underestimation, since egg flotation is not the preferred detection method for flatworms (13).

CONCLUSIONS

This work examined the prevalence and risk factors for infestation with gastrointestinal helminths in Israel. The overall prevalence appeared to be low, and has declined over the last 20 years. Small Strongyles were the most common species (24% of horses, 60% of farms) and *Parascaris equorum* was found in small numbers (5% of horses, 33% of farms). The distribution of egg shedding in infested farms appears to be different than previously described. Anthelminthic resistance was probably low. These findings should lead to a further investigation of infestation patterns in younger horses and re-examination of parasite control strategies in adult horses.

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