https://doi.org/10.52973/rcfcv-e35491 Revista Científica, FCV-LUZ / Vol. XXXV

First report of ivermectin resistance in natural infected Foals by *Parascaris* spp. in Tiaret, Algeria

Primer informe de resistencia a ivermectina en potros infectados de forma natural por *Parascaris* spp. en Tiaret, Argelia

Selles Sidi Mohammed Ammar[1,2], Ait Amrane Amar[1,2], Kouidri Mokhtaria[1,3]*, Belhamiti Belkacem Tahar[1,2], Belmedjahad Mustapha[4], Bouchentouf Keltoum[5], Kadi Marwa[5], Mihoubi Amel[5]

[1]*University of Tiaret, Laboratory of research on local animal products. Tiaret, Algeria.*
[2]*University of Tiaret, Veterinary Sciences Institute. Tiaret, Algeria.*
[3]*University of Tiaret, Farm animal reproduction laboratory. Tiaret, Algeria.*
[4]*Chaou Chaoua National Stud. Tiaret, Algeria.*
[5]*University of Tiaret, Nature and Life Sciences Faculty. Tiaret, Algeria.*
**Corresponding author: mokhtariakouidri@yahoo.fr*

ABSTRACT

Equine parascarosis is a Worldwide endoparasitosis, caused by *Parascaris* spp., affecting mainly younger horses. This disease is considered as the most pathogenic parasitosis of young horses. In Algeria, no knowledge of the resistance of *Parascaris* spp. to Ivermectin is published. For this reason, the present study aims to evaluate the frequency of *Parascaris* spp. and the anthelmintic efficacy of Ivermectin and Fenbendazole against this parasite in a foal population in Tiaret, Algeria. Ninety–one foals were examined for the presence of *Parascaris* spp. from two stud farms. Among the positive, thirty–two faols were treated with Ivermectin formulations (Ivoral® and Eqvalan®) and Fenbendazole (Funcur®) at their recommended dosages. Fecal egg count reduction testing (FECRT) was used to determine the efficacy of each anthelmintic. *Parascaris* spp. was detected in 61 foals (67.03%). Decreased efficacy (reduction of *Parascaris* spp. fecal egg counts by less than 90%) was found for the two Ivermectin formulations (46.45% for Ivoral® and 70.29% for Eqvalan®). Nevertheless, fenbendazole showed 100% efficacy in all foals sampled in this study. These first data indicate that Ivermectin–resistant *Parascaris* spp. populations are present on horse farms in Algeria. Findings from this study can be used to create a more sustainable approach for parasite control programs.

Key words: *Parascaris* spp.; foals; frequency; ivermectin; resistance; Tiaret

RESUMEN

La parascarosis equina es una endoparsitosis mundial, causada por *Parascaris* spp., que afecta principalmente a caballos jóvenes, siendo esta enfermedad parasitaria más patógena de los potros. En Argelia no se tiene conocimiento de la resistencia de *Parascaris* spp. la ivermectina. Por esta razón, el presente estudio tiene como objetivo evaluar la frecuencia de *Parascaris* spp. y la eficacia antihelmíntica de Ivermectina y Fenbendazol contra este parásito en una población de potros en Tiaret, Argelia. Se examinaron noventa y un potros para detectar la presencia de *Parascaris* spp. procedentes de dos ganaderías. Entre los positivos, treinta y dos potros fueron tratados con formulaciones de Ivermectina (Ivoral® y Eqvalan®) y Fenbendazol (Funcur®) en sus dosis recomendadas. Se utilizó la prueba de reducción del recuento de huevos en heces (FECRT) para determinar la eficacia de cada antihelmíntico. *Parascaris* spp. se detectó en 61 potros (67,03 %). Se encontró una eficacia disminuida (reducción del recuento de huevos fecales de *Parascaris* spp. en menos del 90 %) para las dos formulaciones de ivermectina (46,45 % para Ivoral® y 70,29 % para Eqvalan®). Sin embargo, el fenbendazol mostró una eficacia del 100 % en todos los animales de un año incluidos en la muestra de este estudio. Estos primeros datos indican que existen poblaciones de *Parascaris* spp. resistentes a la ivermectina en granjas de caballos en Argelia. Los hallazgos de este estudio se pueden utilizar para crear un enfoque más sostenible para los programas de control de parásitos.

Palabras clave: *Parascaris* spp.; potros; frecuencia; ivermectina; resistencia; Tiaret

Received: 15/07/2024 Accepted: 05/10/2024 Published: 06/01/2025

INTRODUCTION

Internal parasitic infections are Worldwide pathologies in foals and young horses [1, 2]. Although *Strongylus* spp. in particular *Strongylus vulgaris* is rare nowadays in horses (*Equus caballus)* given the routine deworming programs on farms [3]. Ascarids (*Parascaris* spp.), are common and ubiquitous equine parasite [4], and are considered the most pathogenic parasite in young horses, especially in foals [3, 5, 6]. It is a nematode belonging to the family *Ascarididae* [6]. Two species of *Parascaris* have been described, *P. equorum* and *P. univalens* [7], these are morphologically indistinguishable and are seldom distinguished [8]. In adult horses, infection is generally rare and less intense because protective immunity against *P. equorum* starts to develop at 6 months of age–old [6]. *Parascaris* infection manifests as nasal discharge and coughing [9], slow growth, weight loss, cough, and colic [8, 10, 11]. When worm burdens are numerous, adult ascarids cause intestinal obstruction, intussusception, or even rupture [6].

Several studies have shown that few compounds are approved for the treatment of roundworms in various countries [3, 6, 12]. These drugs are the primary means of controlling internal parasites in horses, and their use can have beneficial effects on the growth and performance of horses [13]. Three classes of drugs are used for the control of ascarids: benzimidazole (e.g., fenbendazole, oxibendazole), tetrahydro pyrimidine (e.g., pyrantel), and macrocyclic lactones (e.g., ivermectin, moxidectin) [3, 4, 6, 12, 14, 15]. The nematocidal and larvicidal activity as well as the effect on target migrating larval stages of macrocyclic lactones make these drugs frequently used in foals and young horses [6].

Nevertheless, the extensive use of anthelmintic drugs has led to the development of anthelmintic resistance in several parasites of veterinary importance [11]. This resistance in intestinal nematodes of horses is considered a global problem [16].

In the last decades, the anthelmintic resistance has made the control of ascarids more difficult mainly due to the decrease in the activity of ivermectin (IVM), which was initially very active on these parasites [3]. Likewise, has allowed the emergence of *Parascaris* populations resistant to all major classes of anthelmintics in many countries [17].

The resistance of *Parascaris* spp. to ivermectin was reported for the first time in the Netherlands by Boersema *et al.* [18]. Since, several studies have mentioned this resistance to ivermectin in various parts of the world [2, 10, 14, 17, 19, 20, 21, 22, 23, 24].

In Algeria, the only anthelmintic resistance data refer to the study by Kouidri and Selles [25] on the resistance of intestinal strongyles to benzimidazoles in foals, but since then and to our knowledge, no additional data has been published on the resistance of *Parascaris* spp. to ivermectin. This study aimed to evaluate the frequency of *Parascaris* spp. and the Ivermectin and Fenbendazole efficacy against this parasite in yearling's population in Tiaret, Algeria.

MATERIAL AND METHODS

Study area

The present study was conducted in the Tiaret area (western Algeria), from November 2019 to February 2020. Tiaret is located 340 km from the capital Algiers in the north–west of Algeria at the latitude of 35°15' N and longitude of 1°26' E. Climatologically, this region is a semi–arid area characterized by cold and humid winter and hot and dry summer. The foals studied belong to the Chaouchaoua National stud farm and a private farm

Horses

Ninety–one foals (46 colts and 45 fillies) aged between six months to 2 years belonging to two main breeds (Arabian and Barb) and having not been dewormed at least 8 weeks before the test was included in this study.

Study design

Collecting samples

Fecal samples were collected from fresh deposits in the bedding but were always positively associated with a particular horse (care was taken to remove the surface parts of the dung, which had not been in contact with the soil). Each fecal sample was placed in a labeled plastic bag (containing the name, breed, date of birth of the horse, and date of collection). These samples were transported to the Parasitology Laboratory of the Veterinary Institute of Tiaret, Algeria. In general, samples were processed on the same day, or stored at 4°C in in the refrigerator (Condor, Algeria) until been processed (not to exceed 4 days) following sampling.

Microscopic examination (Optika, Italy) of the presence of *Parascaris* spp. eggs were performed after fecal flotation in the saturated salt solution. Parasite egg counts were carried out using the modified McMaster technique [26] 3 g of feces to 42 mL NaCl solution (specific gravity of 1.2). The final number of eggs counted in two chambers was multiplied by 50 to give the EPG egg per gram (EPG).

Group treatments

Thirty–tow foals infected by *Parascaris* spp. (with a number of eggs per gram of fecal matter greater than or equal to 100) were divided into three groups and received anthelmintic treatments respectively: Gr01: twelve foals : Ivoral (Ivermectin 0.8 mg·ml^{-1}, 0.32 mg·kg^{-1} in oral suspension, Algeria), Gr 02 seven foals: Eqvalan (Ivermectin 18,7 mg·g^{-1} oral paste, 1.07 g of dough per 100 kg of live weight, France) and Gr 03: thirteen foals Funcur (Fenbendazole 2.5%, 10 mg·kg^{-1} in oral suspension, Algeria). The weight was estimated by the Zoometric tape (Virbac, France), which allows us to indicate the weight in kg using the chest measurement. The oral solutions were administered using an applicator gun.

Fecal egg count reduction test (%)

The efficacy of treatment was evaluated based on the reduction between pre–and post–treatment FEC (Fecal egg count) for each horse separately and on the arithmetic mean reduction between pre–and post–treatment FEC per treatment. To perform a FEC Reduction Test (FECRT) a fecal egg count should be performed on day (d) 0 and again on d 14. FECRT (%) was calculated according

to the American Association of Equine (AAEP) Parasite Control Guidelines [27]. Using the equation below, the FECR (%) for each horse in the group was calculated individually. The formula used to calculate FECRT (%):

$$FECRT(\%) = Egg\ Reduction\ (\%) = \frac{EPG\ (Pre\text{-}Treatment) - EPG\ (14\ days\ Post\text{-}Treatment)}{EPG(Pre\text{-}Treatment)} \times 100$$

While equine–specific criteria are yet to be established to define the presence of resistance, the AAEP Parasite Control Guidelines [27] recommend using a reduction of mean fecal egg count < 95%. When fecal egg counts increased for an individual horse after treatment, the percentage FECRT was considered to be zero to avoid negative percentages.

RESULTS AND DISCUSSION

Parascaris spp. was detected in 61 yearlings with a prevalence of 67.03% (61/91). In the present study, the frequency was higher than 53% reported in Saudi Arabia by Alanazi *et al.* [17] and 58.3% in Australia noticed by Armstrong *et al.* [14]. Likewise, this rate is high than those cited by Aromaa *et al.* [1] and Näreaho *et al.* [28] in Finland with rates of 11.5% and 21%, respectively. The same is high compared to that suggested by Laugier *et al.* [6] in France at 30.5% and Studzińska *et al.* [10] in Poland at 40%. A lower rate (6.3%) was observed by Scala *et al.* [12] in Italy. Othman and Alzuheir [29] mentioned a lower prevalence rate (15.6%) in West Bank Palestine. However, these same authors noted a high prevalence in Jericho city with a rate of 70%. This higher rate of infection in the present study might be due to the number of analyzed samples that were lower than the other studies. Often, the foals of the current study grazed in open fields, this can contaminate the grazing environment and consequently ensures the infection or reinfection of sensitive animals.

In this study, only 32 foals were used to determine FECRT. The foals considered in this study had EPG levels with a minimum of 100 and a maximum of 10100 and their mean fecal egg count varied between groups from 566.67 to 2800.

TABLE I shows the summary of the results of FECRT. The FECRT values on day 14 (D14) in each treatment group were 46.74%, 70.29%, and 100% (groups treated with Ivoral, Eqvalan, and Funcur, respectively).

This is the first report of *Parascaris* spp. resistance to Ivermectin in Algeria. The FECRT showed that at two weeks post–treatment, the efficiency percentages were much lower than 95% (46.45% and 70.29% for Ivoral and Eqvalan, respectively). Our detected FECR values suggest resistance to Ivermectin. Previous studies have described a decrease in the efficacy of Ivermectin in different parts of the world including Europe [2, 5, 6, 10, 18, 19, 20, 21, 28, 30, 31, 32, 33, 34], North America [24, 30, 35, 36], Australia and New Zealand [14, 37, 38] and in Arab Gulf States [17]. Several factors can cause the development of resistance to Ivermectin among them we can mention the use of Ivermectin in mares, which yields a high content of this molecule in their milk secretions and consequently a sub–optimal exposure of parasite populations. This underdosing is a significant factor in the emergence of drug–resistant isolates [39, 40]. Additionally, the administration of anthelmintics to foals during their first month of life and then in a repeated manner at intervals of less than three months to reduce environmental contamination from eggs contributes to the development of resistant ascarid populations [5, 41, 42, 43]. In the present study, intensive use of the Ivoral in the two farms was found for its low price. Fritzen *et al.* [44] also reported that intensive use of Ivermectin appears to be associated with the development of resistance in *Parascaris* spp. populations. Whereas, Pérez *et al.* [45] noted that plasma levels of Ivermectin can persist

TABLE I
Results of fecal egg count reduction per foal and arithmetic mean following treatments with Ivoral, Eqvalan and Funcur

Yearlings	Ivoral			Eqvalan			Funcur		
	EPG1 (0 D)	EPG2 (14 D)	reduction (%)	EPG1 (0 D)	EPG2 (14 D)	reduction (%)	EPG1 (0 D)	EPG2 (14 D)	reduction (%)
1	100	50	50	2950	2500	15.25	850	0	100
2	350	950	0	10100	5250	48.02	1800	0	100
3	1150	50	95.65	5650	1200	78.76	1200	0	100
4	2500	50	98	100	50	50	1600	0	100
5	150	100	33.33	100	0	100	400	0	100
6	150	250	0	150	0	100	100	0	100
7	200	100	50	550	0	100	150	0	100
8	200	50	75	–	–	–	1200	0	100
9	350	100	71.43	–	–	–	350	0	100
10	1200	150	87.5	–	–	–	300	0	100
11	200	300	0	–	–	–	700	0	100
12	250	400	0	–	–	–	450	0	100
13	–	–	–	–	–	–	350	0	100
Mean of EPG	566.67	212.5	62.5	2800	1285.71	54.08	726.92	0	100
Mean of %	–	–	46.45	–	–	70.29	–	–	100

for several days or weeks after a single treatment. However, drug concentrations inevitably decrease over time and newly acquired parasites during this phase may be exposed to sub–therapeutic concentrations [41] leading to the development of Ivermectin resistance by the larvae of *Parascaris* spp. within 10 weeks of the prepatent period [18] then the transmission of resistance alleles to subsequent generations [17].

Schougaard and Nielsen [20] incriminated the transport of horses between farms or between countries as a factor in the spread of resistance once detected.

In the present investigation, the FECRT was 100% for Fenbendazole. This result shows that this product was effective in agreement with Kaplan *et al.* [46] and Martin *et al.* [47] reported that the drug of choice commonly used to treat *Parascaris* spp. is fenbendazole. Conflicting reports regarding the effectiveness of Fenbendazole have been raised across the world. Some authors still note the effectiveness of Fenbendazole [21, 22, 36, 47], while other authors have reported *Parascaris* spp resistance to this molecule [14, 17, 48, 49].

CONCLUSION

This study detected the presence of Ivermectin resistance in *Parascaris* spp. for the first time in yearlings reared in two farms in the Tiaret region while these parasitic isolations remain sensitive to the activity of Fenbendazole. Further research for good knowledge of the mechanisms involved in the development of resistance to Ivermectin and regular monitoring of the effectiveness of anthelmintic against *Parascaris* spp. and other parasites could help adopt measures to slow the development of this resistance and therefore optimize local parasitic control programs.

ACKNOWLEDGMENTS

The authors would like to thank the general direction of scientific research and technological development (DGRSDT) for their support.

Author Contributions

All authors contributed to the study's conception and design. Sampling [Bouchentouf Keltoum], [Kadi Marwa] and [Mihoubi Amel], Treatment of foals [Belmedjahad Mustapha], Material preparation [Kouidri Mokhtaria], [Selles Sidi Mohammed Ammar] and [Belhamiti Belkacem Tahar], data collection and analysis were performed by [Kouidri Mokhtaria], [Ait Amrane Amar], [Bia Taha] and [Selles Sidi Mohammed Ammar]. The first draft of the manuscript was written by [Selles Sidi Mohammed Ammar] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding information

The study was not sponsored by any authority

Conflict of interest

The authors declare that there is no conflict of interest in this study.

Ethical approval

This paper does not contain any studies with human participants or animals performed by any of the authors.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

BIBLIOGRAPHIC REFERENCES

[1] Aromaa M, Hautala K, Oksanen A, Sukura A, Näreaho A. Parasite infections and their risk factors in foals and young horses in Finland. Vet. Parasitol. Reg. Stud. Reports [Internet]. 2018; 12:35–38. doi: https://doi.org/g8xnbv

[2] Martin F, Svansson V, Eydal M, Oddsdóttir C, Ernback M, Persson I, Tydén E. First report of resistance to ivermectin in *Parascaris univalens* in Iceland. J. Parasitol. [Internet]. 2021; 107(1):16–22. doi: https://doi.org/gmphk6

[3] Lyons ET, Dorton AR, Tolliver SC. Evaluation of activity of fenbendazole, oxibendazole, piperazine, and pyrantel pamoate alone and combinations against ascarids, strongyles, and strongyloides in horse foals in field tests on two farms in Central Kentucky in 2014 and 2015. Vet. Parasitol. Reg. Stud. Reports [Internet]. 2016; 3–4:23–26. doi: https://doi.org/g8xnbw

[4] Leathwick DM, Sauermann CW, Donecker JM, Nielsen MK. A model for the development and growth of the parasitic stages of *Parascaris* spp. in the horse. Vet. Parasitol. [Internet]. 2016; 228:108–115. doi: https://doi.org/f88rrw

[5] Bodecek S, Svetlikova J, Hargitaiova K, Kecerova Z, Mrackova M. Monitoring the avermectin and pyrantel resistance status of nematode parasites of horses in the Czech Republic. Vet. Med. [Internet]. 2018; 63(7):299–305. doi: https://doi.org/gdx7px

[6] Laugier C, Sevin C, Ménard S, Maillard K. Prevalence of *Parascaris equorum* infection in foals on French stud farms and first report of ivermectin–resistant *P. equorum* populations in France. Vet. Parasitol. [Internet]. 2012; 188(1–2):185–189. doi: https://doi.org/gdkzqx

[7] Biocca E, Nascetti G, Iori A, Costantini R, Bullini L. Descrizione di Parascaris univalens parassita degli equine, e suo differenziamento da Parascaris equorum. Rend. Lincei Sci. Fis. Nat. [Internet] 1978 [cited 25 May. 2024]; 65(3–4)133–141. Available in: https://goo.su/XVRRV

[8] Nielsen MK, Wang J, Davis R, Bellaw JL, Lyons ET, Lear TL, Goday C. Parascaris univalens—a victim of large–scale misidentification? Parasitol. Res. [Internet]. 2014; 113(12):4485–4490. doi: https://doi.org/f6qf2h

[9] Cribb NC, Coté NM, Bouré LP, Peregrine AS. Acute small intestinal obstruction associated with *Parascaris equorum* infection in young horses: 25 cases (1985–2004). N. Z. Vet. J. [Internet]. 2006; 54(6):338–343. doi: https://doi.org/b792s9

[10] Studzińska MB, Sallé G, Roczeń–Karczmarz M, Szczepaniak K, Demkowska–Kutrzepa M, Tomczuk K. A survey of ivermectin resistance in *Parascaris* species infected foals in south–eastern Poland. Acta. Vet. Scand. [Internet]. 2020; 62(1):28. doi: https://doi.org/g8xnbx

[11] Reinemeyer CR. Diagnosis and control of anthelmintic–resistant *Parascaris equorum*. Parasit. Vectors [Internet]. 2008; 2(Suppl. 2):S8. doi: https://doi.org/bwnbsc

[12] Scala A, Tamponi C, Sanna G, Predieri G, Meloni L, Knoll S, Sedda G, Dessì G, Cappai MG, Varcasia A. *Parascaris* spp. eggs in horses of Italy: a large–scale epidemiological analysis of the egg excretion and conditioning factors. Parasit. Vectors [Internet]. 2021; 14(1):246. doi: https://doi.org/g8xnbz

[13] Porr CAS, Hedinger VF, Hamm LR, Ernst MM, Papajeski BM, Santiago ML, Davis AJ. Effects of ivermectin and moxidectin on fecal egg count and egg reappearance rate in horses. J. Equine. Vet. Sci. [Internet]. 2017; 57:51–55. doi: https://doi.org/gb4xzd

[14] Armstrong SK, Woodgatem RG, Gough S, Heller J, Sangster NC, Hughes KJ. The efficacy of ivermectin, pyrantel and fenbendazole against *Parascaris equorum* infection in foals on farms in Australia. Vet. Parasitol. [Internet]. 2014; 205(3–4):575–580. doi: https://doi.org/f6nvwg

[15] Kaplan RM, Nielsen MK. An evidence–based approach to equine parasite control: It ain't the 60s anymore. Equine. Vet. Educ. [Internet]. 2010; 22(6):306–316. doi: https://doi.org/d8cv93

[16] Kaplan RM. Anthelmintic resistance in nematodes of horses. Vet. Res. [Internet]. 2002; 33(5):491–507. doi: https://doi.org/fpj576

[17] Alanazi IO, Al–Mohammed HI. A field study on the anthelmintic resistance of *Parascaris* spp. in Arab foals in the Riyadh region, Saudi Arabia. Vet. Q. [Internet]. 2017; 37(1):200–205. doi: https://doi.org/g8xnb2

[18] Boersema JH, Eysker M, Nas JWM. Apparent resistance of *Parascaris equorum* to macrocylic lactones. Vet. Rec. [Internet].2002; 150(9):279–281. doi: https://doi.org/cwhxzr

[19] Stoneham S, Coles G. Ivermectin resistance in *Parascaris equorum*. Vet. Rec. [Internet]. 2006; 158(16):572–572. doi: https://doi.org/cjqqhf

[20] Schougaard H, Nielsen MK. Apparent ivermectin resistance of *Parascaris equorum* in foals in Denmark. Vet. Rec. [Internet]. 2007; 160(13):439–440. doi: https://doi.org/dnb6j5

[21] Samson–Himmelstjerna GV, fritzen B, Demeler J, Schürmann S, Rohn K, Schnieder T, Epe C. Cases of reduced cyathostomin egg–reappearance period and failure of *Parascaris equorum* egg count reduction following ivermectin treatment as well as survey on pyrantel efficacy on German horse farms. Vet. Parasitol. [Internet]. 2007; 144(1–2):74–80. doi: https://doi.org/d8p395

[22] Lindgren K, Ljungvall Ö, Nilsson O, Ljungström BL, Höglund J. *Parascaris equorum* in foals and in their environment on a Swedish farm, with notes on treatment failure of ivermectin. Vet. Parasitol. [Internet]. 2008; 151(2–4):337–343. doi: https://doi.org/b5c43f

[23] Lyons ET, Tolliver SC, Ionita M, Collinns SS. Evaluation of parasiticidal activity of febendazole, ivermectin, oxibendazole, and pyrantel pamoate in horse foals with emphasis on ascarids (*Parascaris equorum*) in field studies on five farms in Central Kentucky in 2007. Parasitol. Res. [Internet]. 2008; 103(2):287–291. doi: https://doi.org/d5tz8j

[24] Cooper LG, Caffe G, Cerutti J, Nielsen MK, Anziani OS. Reduced efficacy of ivermectin and moxidectin against *Parascaris* spp. in foals from Argentina. Vet. Parasitol. Reg. Stud. Reports [Internet]. 2020; 20:100388. doi: https://doi.org/g8xnb3

[25] Kouidri M, Selles–Sidi MA. Anthelmintics efficacy against intestinal strongyles in foals. Veterinaria [Internet]. 2020 [cited 20 May 2024]; 69(3):213–220. Available in: https://goo.su/JZdeeK

[26] Chartier C, Itard J, Morel PC, Troncy PM. Précis de parasitologie vétérinaire tropicale. Paris (France): Tec et Doc – Lavoisier, Editions médicales internationales – Lavoisier (EM Inter); 2000. 774 p. French.

[27] Nielsen MK, Mittel L, Grice A, Erskine M, Graves E, Vaala W, Tully RC, French DD, Bowman R, Kaplan RM. AAEP Parasite Control Guidelines. Lexington (Kentucky, USA): AAEP Parasite Control Subcommittee of the AAEP Infectious Disease Committee; 2016. 89 p.

[28] Näreaho A, Vainio K, Oksanen A. Impaired efficacy of ivermectin against *Parascaris equorum*, and both ivermectin and pyrantel against strongyle infections in trotter foals in Finland. Vet. Parasitol. [Internet]. 2011; 182(2–4):372–377. doi: https://doi.org/c734gk

[29] Othman R, Alzuheir I. Prevalence of *Parascaris equorum* in native horses in West Bank Palestine. Iraqi. J. Vet. Sci. [Internet]. 2019; 33(2):433–436. doi: https://doi.org/g8xnb4

[30] Hearn FPD, Peregrine AS. Identification of foals infected with *Parascaris equorum* apparently resistant to ivermectin. J. Am. Vet. Med. Assoc. [Internet]. 2003; 223(4):482–485. doi: https://doi.org/bfx55x

[31] Lind EO, Christensson D. Anthelmintic efficacy on *Parascaris equorum* in foals on Swedish studs. Acta. Vet. Scand. [Internet]. 2009; 51(1):45. doi: https://doi.org/drhjgw

[32] Veronesi F, Moretta I, Moretti A, Fioretti DP. Genchi C. Field effectiveness of pyrantel and failure of *Parascaris equorum* egg count reduction following ivermectin treatment in Italian horse farms. Vet. Parasitol. [Internet]. 2009; 161(1–2):138–141. doi: https://doi.org/c2shpb

[33] Geurden T, Betsch JM, Maillard K, Vanimisetti B, D'Espois M, Besognet B. Determination of anthelmintic efficacy against equine cyathostomins and *Parascaris equorum* in France. Equine. Vet. Educ. [Internet]. 2013; 25(6):304–307. doi: https://doi.org/nzqg

[34] Relf VE, Lester HE, Morgan ER, Hodgkinson JE, Matthews JB. Anthelmintic efficacy on UK Thoroughbred stud farms. Int. J. Parasitol. [Internet]. 2014; 44(8):507–514. doi: https://doi.org/f592fk

[35] Lyons ET, Tolliver SC, Collins SS. Field studies on endoparasites of Thoroughbred foals on seven farms in central Kentucky in 2004. Parasitol. Res. [Internet]. 2006; 98(5):496–500. doi: https://doi.org/b4k3kr

[36] Slocombe JOD, de Gannes RVG, Lake MC. Macrocyclic lactone resistant *Parascaris equorum* on stud farms in Canada and effectiveness of fenbendazole and pyrantel pamoate. Vet. Parasitol. [Internet]. 2007; 145(3–4):371–376. doi: https://doi.org/brb58z

[37] Bishop RM, Scott I, Gee EK, Rogers CW, Pomroy WE, Mayhew IG. Sub–optimal efficacy of ivermectin against *Parascaris equorum* in foals on three Thoroughbred stud farms in the Manawatu region of New Zealand. N. Z. Vet. J. [Internet]. 2014; 62(2):91–95. doi: https://doi.org/g8xnb5

[38] Beasley A, Coleman G, Kotze AC. Suspected ivermectin resistance in a south–east Queensland *Parascaris equorum* population. Aust. Vet. [Internet]. J. 2015; 93(9):305–307. doi: https://doi.org/g8xnb6

[39] Le Jambre LF, Dobson RJ, Lenane IJ, Barnes EH. Selection for anthelmintic resistance by macrocyclic lactones in *Haemonchus contortus*. Int. J. Parasitol. [Internet]. 1999; 29(7):1101–1111. doi: https://doi.org/dqvg33

[40] Mayinda G, Serreau D, Gesbert A, Reigner F, Sutra JF, Lespine A, Sallé G. Ivermectin treatment in lactating mares results in suboptimal ivermectin exposure in their suckling foals. Vet. Parasitol. [Internet]. 2021; 296:109511. doi: https://doi.org/g8xnb7

[41] Sangster NC. Pharmacology of anthelmintic resistance in cyathostomes: will it occur with the avermectins/milbemycins? Vet. Parasitol. [Internet]. 1999; 85(2–3):189–204. doi: https://doi.org/d9829j

[42] Kaplan RM. Drug resistance in nematodes of veterinary importance: a status report. Trends. Parasitol. [Internet]. 2004; 20(10):477–481. doi: https://doi.org/cfgvdb

[43] Craig TM, Diamond PL, Ferwerda NS, Thompson JA. Evidence of ivermectin resistance by *Parascaris equorum* on a Texas horse farm. J. Equine. Vet. Sci. [Internet]. 2007; 27(2):67–71. doi: https://doi.org/cs7z5s

[44] Fritzen B, Rohn K, Schnieder T, Samson–Himmelstjerna GV. Endoparasite control management on horse farms – lessons from worm prevalence and questionnaire data. Equine. Vet. J. [Internet]. 2010; 42(1):79–83. doi: https://doi.org/ft42hh

[45] Pérez R, Godoy C, Palma C, Cabezas I, Muñoz L, Rubilar L, Arboix M, Alvinerie M. Plasma profiles of ivermectin in horses following oral or intramuscular administration. J. Vet. Med. A. [Internet]. 2003; 50(6):297–302. doi: https://doi.org/d3j8tt

[46] Kaplan RM, Klei TR, Lyons ET, Lester G, Courtney CH, French DD, Tolliver SC, Vidyashankar AN, Zhao Y. Prevalence of anthelmintic resistant cyathostomes on horse farms. J. Am. Vet. Med. Assoc. [Internet]. 2004; 225(6):903–910. doi: https://doi.org/dwmrpc

[47] Martin F, Hoglund J, Bergstrom TF, Lindsjö OK, Tydén E. Resistance to pyrantel embonate and efficacy of fenbendazole in *Parascaris univalens* on Swedish stud farms. Vet. Parasitol. [Internet]. 2018; 264:69–73. doi: https://doi.org/gjcq68

[48] Lyons ET, Tolliver SC, Kuzmina TA, Collins SS. Further evaluation in field tests of the activity of three anthelmintics (fenbendazole, oxibendazole and pyrantel pamoate) against the ascarid *Parascaris equorum* in horse foals on eight farms in Central Kentucky (2009–2010). Parasitol. Res. [Internet]. 2011; 109(4):1193–1197. doi: https://doi.org/cnmmzw

[49] Peregrine AS, Molento MB, Kaplan RM, Nielsen MK. Anthelmintic resistance in important parasites of horses: Does it really matter? Vet. Parasitol. [Internet]. 2014; 201(1–2):1–8. doi: https://doi.org/f5w29s