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SHORT COMMUNICATION

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)

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Abstract The activity of three anthelmintics (fenbendazole–FBZ; oxibendazole–OBZ; and pyrantel pamoate–PRT) was ascertained against the ascarid *Parascaris equorum* in horse foals on eight farms in Central Kentucky (2009–2010) in field tests. A total of 316 foals were treated, and 168 (53.2%) were passing ascarid eggs on the day of treatment. Evaluation of drug efficacy was determined qualitatively by comparing the number of foals passing ascarid eggs in their feces before and after treatment. The main purpose was to obtain data on current activity of these compounds against ascarids. Additionally, the objective was to compare these findings with those from earlier data on the efficacy of these three compounds on nematodes in foals in this geographical area. Efficacies (average) for the foals ranged for FBZ (10 mg/kg) from 50% to 100% (80%), for OBZ (10 mg/kg) from 75% to 100% (97%), and for PRT at 1× (6.6 mg base/kg) from 0% to 71% (2%) and at 2× (13.2 mg base/kg) 0% to 0% (0%). Although the efficacy varied among the drugs, combined data for all farms indicated a significant reduction of ascarid infections for FBZ ($p<0.0001$) and OBZ ($p<0.0001$) but not for PRT ($p=0.0953$).

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Introduction

Ascarids (*Parascaris equorum*) typically are found only in young equids. However, they can also be found in older horses (Clayton 1986). The present authors found 53 mature ascarid specimens in a 4-year-old horse at necropsy (Lyons et al. 2006b). These are the most important parasites in young equids. The effect in infected individuals varies from no obvious clinical problem to poor body condition, colic, and even death in some situations (Clayton and Duncan 1977; Srihakim and Swerczek 1978). These nematodes are virtually impossible to eradicate altogether. This is because the eggs are passed in the feces into the environment and have a thick shell protecting the embryo that develops inside into the infective second stage larva (Clayton 1986; Reinemeyer 2009). The egg does not hatch until it is ingested by the host. The eggs can remain viable for long periods of time in the environment (Drudge and Lyons 1983; Reinemeyer 2009).

Commercial classes of parasiticides currently on the market in the USA and elsewhere include benzimidazoles (fenbendazole–FBZ, and oxibendazole–OBZ), macrocyclic lactones (ivermectin and moxidectin, and pyrimidines (pyrantel pamoate—PRT) for the control of ascarids in equids. Initially, they provided excellent efficacy on these nematodes (Lyons and Tolliver 2009). However, in some geographical areas, decreased efficacy on ascarids has been found for some of these compounds such as the macrocyclic lactones and pyrantel pamoate (Boersema et al. 2002; Craig et al. 2007; Hearn and Peregrine 2003; Kaplan et al. 2006; Peaty 2008; Lyons et al. 2006a, b, 2008; Lyons and Tolliver 2009; Reinemeyer and Marchiondo 2007; Reinemeyer 2009; Reinemeyer et al. 2008, 2010; Schougaard and Nielsen 2007; Slocombe et al. 2007; van Doorn et al. 2007; Veronesi

et al. 2009, 2010; von Samson-Himmelstjerna et al. 2007). The purpose of the present study was to obtain up-to-date data in field tests on the efficacy of FBZ, OBZ, and PRT on ascarids in horse foals in Central Kentucky. An attempt was also made to compare these results with earlier similar research in this geographical area (Lyons et al. 2006a, 2008).

Materials and methods

Horse foals on eight commercial farms (BP, CC, FL, FT, MC, MT, TM, and VK) in Central Kentucky were used in the parasite study evaluating the efficacy of FBZ, OBZ, and PRT on ascarids in field tests in 2009 and 2010 (Table 1). A

Table 1 Data on horse foals treated (n=316; 168 positive for ascarid eggs pretreatment) with three anthelmintics on eight farms in Central Kentucky (2009–2010)

		No. of foals		
Anthelmintic dose rate/farm	Treatment no.	Examined	Pre	Post (% red.)
FBZ at 10 mg/kg				
Farm BP	1	10	4	2 (50%)
Farm CC	1	6	3	0 (100%)
Farm CC	2	6	2	1 (50%)
Farm FL	1	12	1	0 (100%)
Farm FL	2	5	4	2 (50%)
Farm MC	1	6	5	0 (100%)
Farm MT	1	5	5	1 (80%)
Farm TM	1	12	9	1 (89%)
Farm TM	2	16	8	1 (88%)
Farm VK	1	5	3	1 (66%)
All 7 farms		83	44	9 (80%)
OBZ at 10 mg/kg				
Farm BP	1	10	4	0 (100%)
Farm CC	1	5	1	0 (100%)
Farm CC	2	5	4	0 (100%)
Farm FL	1	10	3	0 (100%)
Farm FL	2	9	6	0 (100%)
Farm FT	1	11	4	1 (75%)
Farm FT	2	23	9	0 (100%)
Farm MC	1	6	5	0 (10%)
Farm TM	1	21	12	1 (92%)
Farm TM	2	17	12	0 (100%)
Farm VK	1	9	4	0 (100%)
All 7 farms		126	64	2 (97%)
PRT at 6.6 mg base/kg				
Farm BP	1	10	4	4 (0%)
Farm CC	1	5	3	1 (66%)
Farm CC	2	5	3	2 (33%)
Farm FL	2	8	7	2 (71%)
Farm FT	1	14	5	4 (20%)
Farm FT	2	15	5	5 (0%)
Farm MC	1	5	5	2 (60%)
Farm MT	1	5	3	3 (0%)
Farm TM	1	20	16	16 (0%)
Farm VK	1	6	1	1 (0%)
All 8 farms		93	52	40 (2%)
PRT at 13.2 mg base/kg				
Farm TM	2	14	8	8 (0%)
Total all foals		316	168	59

FBZ fenbendazole, *OBZ* oxibendazole, *PRT* pyrantel pamaote, *Pre* pretreatment, *Post* (*% red.*) posttreatment (% reduction)

total of 316 foals were treated, but only 168 (53.2%) were passing eggs in their feces on the day of treatment. All three compounds were used on all of the farms except for FBZ on farm FT and OBZ on farm MT. Paste formulations of each drug were administered intraorally once. The dose rate of FBZ (Panacur/Safe-guard, Intervet, Millsboro, DE) was 10 mg/kg for 44 infected foals, that of OBZ (Anthelcide EQ, Pfizer, NY, NY) was 10 mg/kg for 64 infected foals, and those of PRT (Strongid Paste, Pfizer, NY, NY—38 foals; Pyrantel Paste, Durvet, Blue Springs, MO—4 foals; and Pyrantel Paste, Phoenix, St. Joseph, MO—10 foals) were 6.6 mg base/kg for 52 infected foals and 13.2 mg base/kg for 8 infected foals. The individual farms supplied the drugs for each treatment, so the authors had to utilize the brand the farm manager chose. One farm (TM), at our request, used the therapeutic dose rate (1×) of PRT for one trial, but they wanted to give, and did give, a double dose rate (2×) for the second trial. Girth tape measurement of the foals was used to estimate their weight. The foals (4 to 68 per farm) were Thoroughbreds on seven farms but were mixed-lighthorse type on the eighth farm (MC).

Fecal samples were collected on the day of treatment and at 7 to 22 days after treatment. Collection of feces mostly was done rectally. Occasionally, feces was collected from stall bedding when it was known to be from suckling foals as opposed to dams, based on the size, shape, and consistency of the pile, or from weanlings in individual stalls. Qualitative examination of the feces was by a method previously published (Lyons et al. 2006a). Evaluation of drug activity was by determining the number of foals passing ascarid eggs in feces before and after treatment, thus determining efficacy (% reduction in positive foals). There were two main reasons that a qualitative vs. quantitative (eggs per gram, EPG count) method was used: (1) the qualitative procedure allows more concentration of eggs for flotation than does doing EPG counts, and (2) usually, only a small amount of feces was collected from the rectum, especially from young foals. In addition, rectal sampling was done quickly to avoid potentially injuring foals by restraining them.

The Paleontological Statistics Software (Hammer et al. 2001) was used for statistical analysis of the results obtained. The data obtained in the current study were compared with previous findings on efficacy of the three compounds on parascarids in foals in this area (Lyons et al. 2008).

Results and discussion

Drug efficacies (average) against ascarids in the infected foals ranged from 50% to 100% (80%) for FBZ (10 mg/kg), from 50% to 100% (97%) for OBZ (10 mg/kg), and for PRT at 1× (6.6 mg base/kg) from 0% to 7% (2%) and at 2× (13.2 mg base/kg) 0% to 0% (0%) (Table 1). Efficacy with PRT using the Pfizer compound was 0% to 71% (average, 3%) vs. that of non-Pfizer compounds which was 0% to 20% (average, 7%).

Statistical analysis of data on the efficacy of the three anthelmintics for each farm indicated that FBZ and OBZ showed a significant ($p<0.005$) reduction of the proportion of positive foals after treatment (Table 2). Oxibendazole had the highest efficacy of all farms examined despite decreased efficacy at first treatment of foals at FT and TM farms. Efficacy of FBZ was lower at five of the seven farms examined; however, total efficacy of this drug was significantly high. Data for PRT showed no significant reduction ($p=0.09686$) of parascarid infections in foals on all farms examined. There was 0% reduction of positive foals on five of the seven farms examined. Doubling the dosage rate (13.2 mg base/kg) did not increase PRT efficacy at farm TM.

Statistical analysis of positive/negative data for every foal on each farm separately indicated that treatment with FBZ caused a significant reduction in the positive foals on four of the seven farms (57%): TM ($p=0.0003$), CC ($p=0.0388$), MT ($p=0.0161$), and MC ($p=0.0253$).

Treatment of foals with OBZ significantly reduced the proportion of positive foals on six of the seven farms (86%): BP ($p=0.0367$), CC ($p=0.0149$), FL ($p=0.0007$), FT ($p=0.0003$), MC ($p=0.0004$), and VK ($p=0.0352$).

Treatment with PRT at the 1× dose rate (6.6 mg base/kg) significantly reduced infection in foals with parascarids only on one of seven farms (14%): farm FL ($p=0.0112$). No significant reduction of foal infection was observed on other farms as well after treatment of the 2× dose rate on farm TM.

In pooling data on the total number of observations for every foal on all farms, we observed a significant reduction of ascarid infections for FBZ ($p<0.0001$) and OBZ ($p<0.0001$), but no significant reduction for PRT ($p=0.0953$). None of the foals showed signs of colic related to parascarids during the study period.

Table 2 Statistical analysis of FBZ, OBZ, and PRT efficacy against *P. equorum* by the Wilcoxon test

Anthelmintic/dose rate	*N*	*W*	*Z*	*P* value
FBZ @ 10 mg/kg	10	55	2.812	0.0049203
OBZ @ 10 mg/kg	11	66	2.941	0.003268
PRT @ 6.6 mg base/kg	10	21	2.214	0.096857
PRT @ 13.2 mg base/kg	1			

FBZ fenbendazole, *OBZ* oxibendazole, *PRT* pyrantel pamoate, *N* number of studies at farms examined, *W* Wilcoxon signed rank test, *Z* Z-test

Comparison of the current results with our previous data on efficacy of these three compounds against *P. equorum* in foals in Central Kentucky (Lyons et al. 2008) showed that fenbendazole is still effective against this nematode species. Even though there was a percent reduction with fenbendazole on farm FL (from 70% in 2007 to 50% at the second treatment in 2010) and on farm VK (from 96% in 2007 to 66% in 2010), these data are insignificant because of a big difference in numbers of foals included in our studies in 2007 and 2009–2010. The efficacy of OBZ was very high in both studies (from 91% to 100% in 2007 and 97% in the present study). The authors are not aware of publications indicating overall reduced activity of FBZ and OBZ against ascarids. Pyrantel had low efficacy against parascarids in the previous study (from 0% at the 6.6 mg base/kg dose rate to 23% at the 13.2 mg base/kg dose rate). The current study did not reveal any positive changes in PRT efficacy (average 2% at 6.6 mg base/kg dose rate and 0% at 13.2 mg base/kg dose rate). Although only a small number of foals ($n=8$) were treated at the 2× dose rate of PRT in the present study and efficacy was low, the results seem more valid when the number of foals ($n=10$) from the previous study with similar results are included. Craig et al. (2007) have reported reduced activity of PRT against ascarids. There are several reports of PRT being active on ascarids at 1× and 2× that showed resistance to ivermectin or moxidectin (Reinemeyer 2009; Reinemeyer and Marchiondo 2007; Reinemeyer et al. 2008, 2010; Slocombe et al. 2007; Veronesi et al. 2009; von Samson-Himmelstjerna et al. 2007).

The present study revealed the benefit of periodic monitoring of the activity of antiparasitic compounds against parascarids in horses in this geographical area and other parts of the world. This will provide up-to-date knowledge in recommending chemotherapeutic control of these parasites.

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References

Boersema JH, Eykser M, Nas JWM (2002) Apparent resistance of *Parascaris equorum* to macrocyclic lactones. Vet Rec 150:279–281

Clayton HM (1986) Ascarids. Recent advances. In: Herd RP (ed) Veterinary clinics of North America (Equine Practice), vol. 2. Sanders, Philadelphia, pp 313–328

Clayton HM, Duncan JL (1977) Experimental *Parascaris equorum* infection of foals. Res Vet Sci 23:109–114

Craig TM, Diamond PL, Ferwerda NS, Thompson JA (2007) Evidence of ivermectin resistance by *Parascaris equorum* on a Texas horse farm. J Equine Vet Sci 27:67–71

Drudge JH, Lyons ET (1983) Ascariasis. In: Robinson NE (ed) Current therapy in equine medicine. Saunders, Philadelphia, pp 262–289

Hammer Ø, Harper DAT, Ryan PD (2001) PAST: paleontological statistics software package for education and data analysis. Paleontologia Electronica 4 (1): 9. http://palaeo-electronica.org/2001_1/past/issue1_01.htm. Accessed 19 January 2011

Hearn FP, Peregrine AS (2003) Identification of foals infected with *Parascaris equorum* apparently resistant to ivermectin. J Am Vet Med Assoc 223:482–485

Kaplan RM, Reinemeyer CR, Slocombe O, Murray MJ (2006) Confirmation of ivermectin resistance in a purportedly resistant Canadian isolate of *Parascaris equorum* in foals. Proc Am Assoc Vet Parasitol 51:69

Lyons ET, Tolliver SC (2009) Some historic aspects of small strongyles and ascarids in equids featuring drug resistance with notes on ovids-emphasis on research at the University of Kentucky. SR-102 (Bulletin) Ag Exper Stat, University of Kentucky College of Agriculture, Lexington, KY

Lyons ET, Tolliver SC, Collins SS (2006a) Field studies on endoparasites of Thoroughbred foals on seven farms in central Kentucky in 2004. Parasitol Res 98:496–500

Lyons ET, Tolliver SC, Collins SS (2006b) Prevalence of large endoparasites at necropsy in horses infected with Population B small strongyles in a herd established in Kentucky in 1966. Parasitol Res 99:114–118

Lyons ET, Tolliver SC, Ionita M, Collins SS (2008) Evaluation of parasiticidal activity of fenbendazole, 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 103:287–291

Peaty M (2008) *Parascaris equorum* resistance to moxidectin? Vet Rec 162:387

Reinemeyer CR (2009) Diagnosis and control of anthelmintic-resistant *Parascaris equorum*. Parasit Vectors 2 (Suppl 2):S8

Reinemeyer CR, Marchiondo AA (2007) Efficacy of pyrantel pamoate in horses against a macrocyclic lactone-resistant isolate of *Parascaris equorum*. Proc Am Assoc Vet Parasitol 52:78

Reinemeyer CR, Prado JC, Marchiondo AA (2008) Efficacy of 2X pyrantel pamoate paste against a macrocyclic lactone-resistant isolate of *Parascaris equorum* in horses. Proc Am Assoc Vet Parasitol 53:32

Reinemeyer CR, Prado JC, Eric C, Nichols EC, Marchiondo AA (2010) Efficacy of pyrantel pamoate against a macrocyclic lactone-resistant isolate of *Parascaris equorum* in horses. Vet Parasitol 171:111–115

Schougaard H, Nielsen MK (2007) Apparent ivermectin resistance of *Parascaris equorum* in foals in Denmark. Vet Rec 160:439–440

Slocombe JO, de Gannes RV, Lake MC (2007) Macrocyclic lactone resistant *Parascaris equorum* on stud farms in Canada and effectiveness of fenbendazole and pyrantel pamoate. Vet Parasitol 145:371–376

Srihakim S, Swerczek TW (1978) Pathologic changes and pathogenesis of *Parascaris equorum* infection in parasite-free pony foals. Am J Vet Res 39:1155–1160

van Doorn DCK, Lems S, Weteling A, Ploeger HW, Eysker M (2007) Resistance of *Parascaris equorum* against ivermectin due to frequent anthelmintic treatment of foals in The Netherlands. Proc World Assoc for the Advan Vet Parasitol, 21st Inter Conf, 19–23 August, 2007, Gent, Belgium

Veronesi F, Moretta I, Moretti A (2009) Field effectiveness of pyrantel and failure of *Parascaris equorum* egg count reduction following ivermectin treatment in Italian horse farms. Vet Parasitol 161:138–141

Veronesi F, Fioretti DP, Genchi C (2010) Are macrocyclic lactones useful drugs for the treatment of *Parascaris equorum* infections in foals? Vet Parasitol 172:164–167

von Samson-Himmelstjerna G, von Fritzen B, Demeler J, Schürmann S, Rohn K, Schnieder T, Epe C (2007) 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 144:74–78