Comparative studies of early season moxidectin treatment and conventional ivermectin/benzimidazole treatments in the control of cyathostomes in horses

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ABSTRACT: Moxidectin administered in January or February at a single dose was tested for efficacy in horses on two farms for 12 and 11 months, respectively. Horses were infected with cyathostomes naturally in the previous grazing period. Forty horses of farm 1 and 20 horses of farm 2 were used in controlled tests to evaluate the efficacy of moxidectin 2% gel formulation at the dosage 0.4 mg moxidectin per kg of live weight, ivermectin commercial paste formulation at the dosage 0.2 mg ivermectin per kg of live weight, mebendazole and fenbendazole commercial paste formulation at the dosage both 7.5 mg mebendazole and fenbendazole per kg of live weight, all applied orally. Three control groups of 10 horses each (farm 1) were treated twice a year with ivermectin and benzimidazoles, respectively. Individual faecal egg counts, faecal cultures and larval differentiation were performed. Moxidectin had more prolonged and greater suppressive effects on the post-treatment reappearance and magnitude of strongyle egg counts than did ivermectin or benzimidazoles. In the moxidectin treated group (M1) strongyle eggs were seen for the first time in April and a slight increase in the mean count of eggs per gram of faeces (EPG) was observed during the rest of the season. Litter larval counts significantly reflected levels of exposure during the tested season. Twenty animals of farm 2 were allocated into two groups of ten horses each based on pre-treatment eggs per gram (EPG) counts (moxidectin treated group and control group). In the moxidectin treated group mean egg counts remained very low throughout the study. A plateau was reached by autumn, with egg counts ranging from 74 to 145 EPG. The faecal egg counts of moxidectin treated group (M2) were significantly higher in March, April, May and June.

Keywords: horses; control of cyathostomes; anthelmintic treatments; moxidectin; epidemiology

Internal parasite control is one of the most important and most frequent measures of health care taken in horses. Horse owners consider it essential for prevention of colic, maintenance of body weight and condition, and achievement of optimal growth and performance.

Cyathostomes (small strongyles) are the major nematode pathogens of horses. Cyathostomes were the subject of reviews by Ogbourne (1978), Reinemeyer *et al*. (1986), recently by Craig (1999), Lyons *et al*. (1999), Reinemeyer (1999) and the clinical state of larval cyathostomiasis was described by Giles *et al*. (1985), Uhlinger (1991) and Murphy *et al*. (1997).

The widespread use of highly efficient anthelmintics has reduced parasite problems of horses (Uhlinger, 1991). However, an expanding drug resistance problem has required a change of basic philosophy regarding the equine parasite control. Increasing resistance of parasites has demonstrated the dangers of over-reliance on chemical control and led to development of new strategies based on pasture hygiene or on seasonal treatments that reduce selection for drug-resistant parasites.

Alternative treatment strategies for the control of helminths in horses that are based on parasite epidemiology simplify the equine parasite control and conserve the efficacy of the few equine anthelmintics still unaffected by resistance. This approach is important because the number of drugs that can be developed with new mechanism of killing resistant worms is limited.

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The main purpose of this investigation was to determine the duration of faecal egg suppression treatment with moxidectin administered in January or February. An experiment was carried out to study the efficacy of the system including late-winter anthelmintic treatment compared to the conventional system.

MATERIAL AND METHODS

The investigation was carried out on 60 adult horses from two farms in the Czech Republic and it began in January 2000. Animals on each farm were randomly allocated to either conventional or moxidectin chemotherapy group.

The group of farm 1 included 40 adult horses, predominantly Thoroughbred, consisting of cycling or early pregnancy mares. Group M1 consisted of 10 horses and they were treated with Equest 2 gel (Fort Dodge Animal Health, 0.4 mg/kg b.w., Fort Dodge) once a year, on January 8, 2000. The animals in control groups CI, CM and CF were treated with antiparasitic remedies twice a year. The CI, CM and CF groups were treated on the basis of a deworming programme that was used during previous 10 years, whereas the horses were treated with benzimidazole/ivermectin product twice a year. A macrocyclic lactone product (ivermectin 0.2 mg/kg b.w., Equalan Paste, Agvet) was used for all treatments of control groups on June 12, 2000 and for treatment of group CI on October 10, 1999, while benzimidazole (fenbendazole 7.5 mg/kg b.w., Panacur Paste, Hoechst Agvet – CF, mebendazole 7.5 mg/kg b.w., Panacur Paste, Hoechst Roussel Vet-CF, mebendazole 7.5 mg/kg b.w., Telmin ®vet., Janssen Pharm.-CM) products were used for the remaining treatments on October 10, 1999. The horses were housed in box stalls.

In January 2000 twenty Guzul mares from farm 2 were obtained and randomly allocated to two groups of ten animals each. The horses were loose housed in a building with floors covered with wood shavings that were replaced twice a year. The horses were grazed from May 15, 2000 onwards on a pasture of 20 ha. The horses of group M2 were treated with moxidectin on February 22, 2000. Five horses in the second group were dosed with fenbendazole on September 5 (subgroup CT) and the other horses remained undosed throughout the period of the experiment (subgroup CC).

Monthly faecal analyses for 1 year included a quantitative nematode egg count per gram of faeces (EPG for each horse, according to McMaster's method). Larval cultures were carried out monthly for each horse to differentiate the cyathostome third-stage larvae (L3) from those of Strongylinae and the identification of these larvae was based on morphological description.

The litter samples consisted of approximately 500 g of litter collected by hand from 5 places in each box stall. The larvae were isolated by means of modified Baerman's technique. Larval counts were expressed in terms of L_3 per kilogram of dry matter for each box stall and examined for the first, second and third stage strongyle larvae. Herbage larval counts were examined regularly at monthly intervals between May and October 2000 (at the time of horse grazing) from all pastures. Herbage samples were collected between 6 and 7 a.m., by the methods of Hasslinger (Hasslinger, 1981; Hasslinger and Bittner, 1984). The results are expressed as the number of L3 per kg of dry matter (L3/kg D.M.).

Statistical analyses were carried out using SAS (SAS Institute, 1989). The mean EPG as well as strongyle larval yield recovered from the litter of the stables were computed for groups within each farm for 12 (11) months. The level of significance was set at $P < 0.05$.

RESULTS

Farm 1

On farm 1 the infections determined coproscopically were caused by Cyathostominae, Strongylinae (*Strongylus edentatus), Parascaris equorum, Strongyloides westeri* and *Habronema* spp. The mean faecal egg counts of the horses together with the stable larval counts on farm 1 during 2 000 are presented in Table 1.

The mean EPG of moxidectin treated animals (M1) was significantly lower than that of conventionally treated animals in groups CI, CM and CF. The faecal egg output of the strongyles of moxidectin treated horses (group M1) was markedly reduced until November, it was completely suppressed during the first 3 months. Control counts were slightly increased in May and June, the mean EPG ranged from 21.0 ± 20.9 to 81.0 ± 96.1.

Treatment on January 8 resulted in low levels of litter contamination by preinfective larvae of Cyathostominae. Significant differences ($P < 0.05$) were observed between litter preinfective larval

Table 1. Egg per gram counts (EPG) of cyathostome parasites of Thoroughbred horses treated with moxidectin (M1) in January 2000 and control groups of horses treated traditionally (CI, CF, CM)

	January	February	March	April	May	June	July	August	September	October	November	December
M1 mean	0.00#&	0.00*#&	0.00#&	3.15#	7.35*#&	2.80*#&	2.63	3.15	1.94	6.61#	12.06	31.11
SD[1]	0.00	0.00	0.00	9.45	11.34	6.22	3.39	5.74	3.73	10.49	23.11	49.65
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	0.00	0.00	0.00	31.50	28.00	21.00	10.50	17.50	10.50	35.00	73.50	161.00
CI mean	1.17	9.69	0.58	17.18	38.18	63.00	3.18	18.77	2.86	15.56	10.11	20.34
SD	2.18	16.48	1.93	40.77	43.32	90.35	5.67	47.53	3.28	25.78	13.75	27.74
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	7.00	63.00	7.00	143.50	143.50	318.50	17.50	168.00	10.50	80.50	42.00	84.00
CF mean	10.45	57.66	16.72	17.11	45.11	21.00	3.00	2.50	0.50	26.50	3.50	24.50
SD	24.52	147.83	22.91	18.83	54.96	20.85	3.94	4.85	1.22	22.98	4.04	29.97
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	87	545.00	77.00	77.00	185.50	13.50	10.50	14.00	3.50	59.50	10.50	84.00
CM mean	4.28	8.56	10.50	3.00	81.00	47.50	3.50	0.58	4.43	2.25	8.40	27.00
SD	7.87	12.25	11.07	4.74	96.10	88.64	6.39	1.3	9.68	3.85	12.245	84.44
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	24.50	42.00	31.50	10.50	2 730.00	262.50	17.50	3.50	28.00	10.50	31.50	213.50

[1]Standard deviation

*Group CI is significantly different ($P < 0.05$) from horses treated with ivermectin in October 1999 and in June 2000

#Group CF is significantly different ($P < 0.05$) from horses treated with fenbendazole in October 1999 and with ivermectin in June 2000

&Group CM is significantly different ($P < 0.05$) from horses treated with mebendazole in October 1999 and with ivermectin in June 2000

Table 2. Counts of preinfective larvae per 1 kg of litter in Thoroughbred horses treated with moxidectin (M1) in January 2000 and control groups treated traditionally (CI, CF, CM)

	February	March	April	May	June	July	August	September	October	November	December
M1 mean	31.10[&]	16.10[&]	0.00[*#]	0.00[*#&]	7.10	0.00[*&]	0.00[*#]	236.00	21.40[*&]	114.44	41.50[*]
SD	44.57	48.30	0.00	0.00	21.30	0.00	0.00	375.91	42.80	215.78	79.52
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	138.00	161.00	0.00	0.00	71.00	0.00	0.00	741.00	107.00	572.00	98.00
CI mean	7.00	187.69	110.17	131.82	497.42	159.09	670.30	51.57	2 515.00	69.66	1 913.17
SD	16.61	459.97	189.49	364.13	911.52	179.96	1 926.04	83.48	6 357.00	170.21	4 277.97
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	52.00	1 714.00	684.00	1 272.00	3 222.00	492.00	6 445.00	214.00	19 329.0	548.00	11 479.00
CF mean	157.42	202.75	584.20	200.60	84.56	0.33	201.17	82.25	69.00	132.00	472.80
SD	431.65	495.45	1 050.65	540.73	134.18	0.75	385.08	82.65	127.19	225.78	576.35
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	1 579.00	1 706.00	3 666.00	1 819.00	435.00	2.00	1 053.00	176.00	198.00	579.00	1 567.00
CM mean	197.33	75.33	20.71	1 286.86	779.14	626.33	19.14	162.43	77.33	0.00	236.80
SD	314.97	78.95	50.74	2 688.08	1 552.84	987.74	46.89	210.13	54.84	0.00	426.76
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	897.00	208.00	145.00	7 819.00	4 571.00	2 789.00	134.00	578.00	121.00	0.00	1 087.00

*Group C1 is significantly different ($P < 0.05$) from horses treated with ivermectin in October 1999 and in June 2000

[#]Group C2 is significantly different ($P < 0.05$) from horses treated with fenbendazole in October 1999 and with ivermectin in June 2000

[&]Group C3 is significantly different ($P < 0.05$) from horses treated with mebendazole in October 1999 and with ivermectin in June 2000

Table 3. Counts of infective larvae per 1 kg of litter in Thoroughbred horses treated with moxidectin (M1) in January 2000 and control groups treated traditionally (CI, CF, CM)

	February	March	April	May	June	July	August	September	October	November	December
M1 mean	6.10[#]	2.80	14.60	29.70	0.00	0.00[*#&]	0.00[#&]	144.30	0.00[*#&]	0.00[#]	56.38
SD	12.22	8.40	43.80	63.62	0.00	0.00	0.00	353.78	0.00	0.00	149.15
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	32.00	28.00	146.00	214.00	0.00	0.00	0.00	1 011.00	0.00	0.00	451.00
CI mean	179.54	0.00	26.75	1 815.64	7.55	2 156.91	1 220.00	126.71	273.43	43.66	78.00
SD	608.22	0.00	53.79	5 051.35	23.86	3 116.40	3 278.13	272.48	433.89	106.21	121.00
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	2 286.00	0.00	178.00	17 750.0	83.00	10 290.00	11 045.0	222.00	1 257.00	341.00	321.00
CF mean	275.00	4.92	97.90	97.70	12.11	409.17	2 454.29	24.80	20.00	1 994.00	69.00
SD	594.21	16.31	177.59	112.52	34.26	224.08	4 298.16	49.60	34.21	3 559.32	120.81
Min.	0.00	0.00	0.00	0.00	0.00	128.00	0.00	0.00	0.00	0.00	0.00
Max.	2 182.00	59.00	500.00	297.00	109.00	789.00	4 452.00	124.00	79.00	9 871.00	279.00
CM mean	33.78	0.00	27.00	67.86	0.00	1 139.00	74.33	19.14	80.66	0.00	28.00
SD	55.32	0.00	66.14	126.82	0.00	1 671.11	130.52	46.89	61.45	0.00	48.49
Min.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max.	163.00	0.00	189.00	364.00	0.00	4 789.00	357.00	134.00	149.00	0.00	279.00

*Group C1 is significantly different ($P < 0.05$) from horses treated with ivermectin in October 1999 and in June 2000

[#]Group C2 is significantly different ($P < 0.05$) from horses treated with fenbendazole in October 1999 and with ivermectin in June 2000

[&]Group C3 is significantly different ($P < 0.05$) from horses treated with mebendazole in October 1999and with ivermectin in June 2000

Table 4. Egg per gram counts (EPG) of Cyathostominae-type parasites in Guzul horses treated with moxidectin (M1) in February 2000 and control groups of horses (CO, CC)

	February	March	April	May	June	July	August	September	October	November	December
M2 mean	52.82	0.00*#	0.00*#	0.95*#	21.95*#	60.77#	129.05#	145.25	127.75	74.28	102.20#
SD	65.93	0.00	0.00	3.02	42.19	125.83	194.44	179.38	166.69	73.45	80.60
Min.	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	14.00
Max.	248.50	0.00	0.00	10.50	136.50	444.50	472.50	483.00	504.00	227.00	248.00
CO mean	3.50	63.00	157.50	132.30	396.38	224.70	179.20	23.10	93.10	161.70	322.50
SD	2.21	64.73	25.40	89.87	178.42	359.20	240.37	24.51	52.46	151.30	419.25
Min.	0.00	0.00	133.00	56.00	147.00	14.00	0.00	0.00	35.00	21.00	56.00
Max.	7.00	178.50	192.50	140.00	651.00	941.50	630.00	59.50	161.00	367.50	1 155.00
CC mean	8.75	21.00	123.20	205.10	53.38	310.10	1 452.50	95.20	77.70	35.00	135.10
SD	1.75	12.86	133.34	183.32	31.04	214.44	1 179.62	157.17	82.18	25.11	149.31
Min.	7.00	0.00	38.50	35.00	14.00	3.50	56.00	0.00	3.50	0.00	0.00
Max.	10.50	31.50	388.50	542.50	98.00	619.44	3 636.50	406.00	238.00	66.50	374.50

*Group CO is significantly different ($P < 0.05$) from horses treated with fenbendazole in September

#Group CC is significantly different ($P < 0.05$) from untreated horses

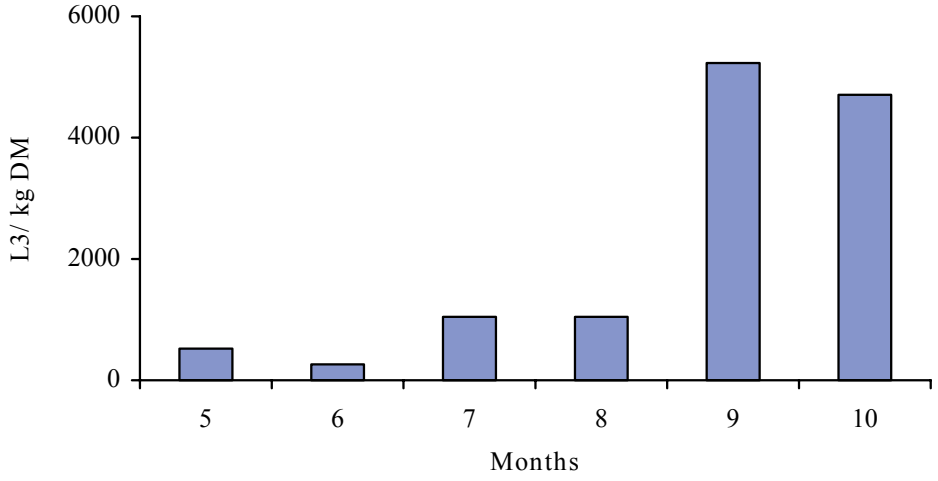

Figure 1. Monthly variations of herbage larval counts on the pasture of farm 1

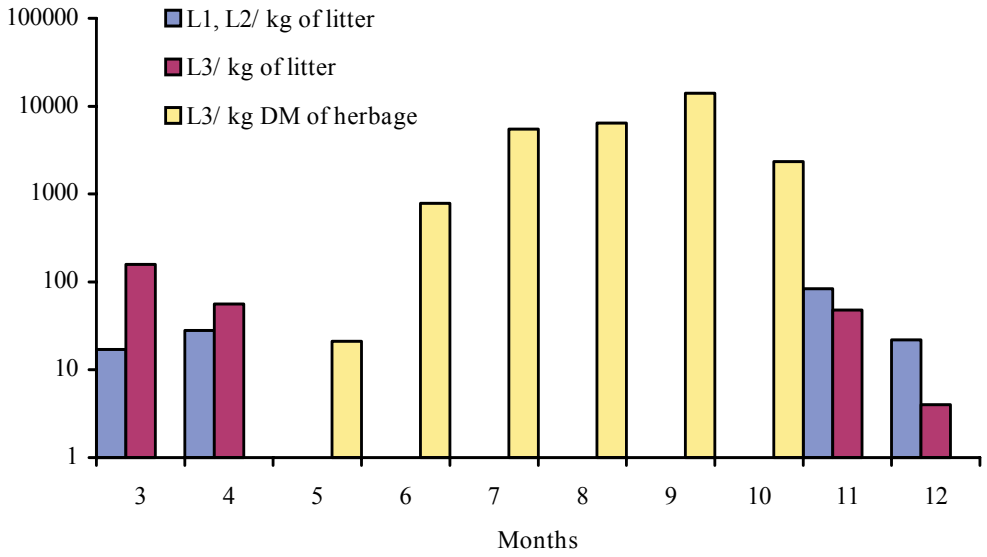

Figure 2. Monthly variations of litter and herbage larval counts on the pasture or in stables of farm 2

counts of all four groups in May (Table 2). The litter infective larval counts of moxidectin treated horses (group M1) remained low due to treatment with moxidectin and therefore the horses were exposed only to a minimum level of infection. Evidence of stable contamination occurred in control groups (CI, CM, CF), a gradual increase in the mean infective larval counts until a peak of 2 454.29 L3/kg was recorded in April in group CF (Table 3).

The number of L3/kg D.M. was very low until September, an increase in herbage contamination was observed from September, coinciding with the accumulation of larvae on pasture (Figure 1).

Farm 2

The results of the studies are presented in Table 4, showing the mean faecal egg count of the horses on farm 2. In fresh faeces or coprocultures were present *Moniezia*, *Strongyloides westeri*, Cyathostomini, *Triodontophorus* spp., *Strongylus vulgaris*, *S. edentatus*, *S. equinus*, *Parascaris equorum*, *Habronema* spp.

The test was conducted between February and December 2000 using 20 horses. The number of horses of moxidectin treated group with zero counts remained high until June. Differences between faecal egg counts of the groups and subgroups (M2,

CO, CC), respectively, were significant ($P < 0.05$) in March, April, May and June.

DISCUSSION

The purpose of this article is to propose an optimal time of anthelmintic treatment based upon the current knowledge of aetiology and life cycles of parasites. This experiment was designed to provide the following information: first, to establish a precise timing of larvicidal treatments of horses in the Czech Republic, secondly, to determine the duration of faecal egg suppression treatment with moxidectin administered in January or in February.

The experiments have demonstrated the high level of continuous efficacy in the control of cyathostome parasites and advantage of moxidectin administration only in January or February in comparison with the results of horses treated twice with ivermectin/benzimidazole products and untreated controls. The evident efficacy in the control of worm populations in these trials was in accordance with previously reported high levels of efficacy of ivermectin against cyathostomes observed in yearlong controlled studies (Langrová *et al*., 2001).

Horses in northern latitudes show a seasonal rise of worm egg output, with peak counts in spring. This effect occurs in all horses, unrelated to gender, pregnancy or lactation. These seasonal rises have important epidemiologic implications because they occur by the beginning of grazing season. In cold climates, the transmission begins in spring and continues throughout the warm months of the year, with peak transmission in summer and autumn. By late autumn, a high percentage of newly ingested infective larvae become hypobiotic, arresting their development in the colonic mucosa as the third-stage larvae (Ogbourne, 1975; Eysker *et al*., 1984). Peaks of faecal egg counts occur in spring and in late summer or early autumn again (Herd, 1986), however, the spring seasonal rises are derived largely from worms developing from previously ingested larvae rather than from newly ingested larvae (Herd *et al*., 1985).

The best control strategy is to minimise infection rates by reducing environmental contamination by eggs and subsequent accumulation of infective larvae on the pasture or in stables. Information on the pre-parasitic development and seasonal fluctuations of strongyle faecal egg counts in the Czech Republic was provided by Langrová (1998), who found that the highest number of strongyle eggs was transmitted in early spring (February, March). Therefore anthelmintic treatments should be carried out in January or February before the secretion of eggs reaches the highest level and when the larvae are no longer in hypobiotic state. The principal goal was the prevention of environmental contamination by nematode eggs, and the precise timing of treatments is a measure for the long-term faecal egg suppression, low contamination of pastures and stables by eggs and subsequent accumulation of infective larvae there and consequently lower nematode burdens to animals.

The herbage larval counts increased during the summer months, followed closely by a marked rise in the levels of the third stage strongyle larvae on the pasture. Subsequently, the horses showed evidence of patent infection in September with fairly rapid increase in the mean faecal egg count to over 1 000 EPG by the end of November (farm 2).

The most crucial elements in the success of an equine parasite control program are selection of appropriate anthelmintics and proper timing of administration. A widely recommended worm control programme is to treat horses 3–4 times a year (Herd and Coles, 1995; Abbot, 1998; Klei and French, 1998). A spring and summer treatment strategy is recommended by Herd (1986) for northern latitudes, such as northern USA and Europe. A new approach is needed to solve the problems caused by drug resistance. In seasonal deworming, fewer treatments are given each year, and selective pressure for drug resistance is lower. The proposed treatments based upon the larvicidal treatment in late winter could lead to all animals being treated less frequently, in January (February) and as the case may be in autumn. The benefit of moxidectin higher activity against encysted cyathostome larvae shown in the study by Monohan *et al*. (1996) and favourable comparison with the control groups in this study demonstrated that moxidectin is a promising alternative to ivermectin in the control of cyathostome parasites of horses.

In a previous article (Langrová *et al*., 2001) the benefits of January–February timing of ivermectin administration for worm control were described. With this approach, moxidectin and other currently effective drugs can remain useful in the 21st century. The aim of the present study was to compare the faecal egg counts as well as stable (pasture) larval counts as the indicators of the levels of nematode parasites in moxidectin and conventionally treated

groups of horses managed by completely different schemes.

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