Helminths in horses: use of selective treatment for the control of strongyles

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ABSTRACT

The current level of anthelmintic resistance in the horse-breeding industry is extremely high and therefore more emphasis is being placed on studies that focus on the judicious use of anthelmintic products. The aims of the study were to: 1) establish if there is variation in the egg excretion pattern of strongyles between the different age classes of Thoroughbred horses in the Western Cape Province (WCP), 2) test if a selective treatment approach successfully reduces the number of anthelmintic treatments and maintains acceptably low helminth burdens in adult Thoroughbred horses, and 3) evaluate the efficacy of subsampling large horse herds for faecal egg counts (FECs) to monitor the strongyle burden. In 2001 the FECs of 4 adult mare, 5 yearling and 3 weanling herds from 8 different farms were compared in the WCP. Within the mare herds there were generally fewer egg-excreting individuals with lower mean FECs compared with the younger age classes. Individual faecal samples were collected every 3–4 weeks from 52 adult Thoroughbred mares from 1 farm in the WCP during a 12-month period (2002/2003). Animals with strongyle FECs ≥100 eggs per gram (epg) were treated with an ivermectin-praziquantel combination drug (Equimax oral paste, Virbac). The mean monthly strongyle FEC for the entire group was <300 epg throughout the study and the number of treatments was reduced by 50 %. Resampling methods showed that an asymptote to mean FEC was reached at 55 animals for each of the pooled weanling, yearling and mare egg counts. Resampling within 4 different mare herds recorded asymptotes of between 24 and 28 animals. Subsampling entire herds for FECs therefore provided an effective approach to treatment management. This study demonstrates that selective treatment is both a practical and an effective approach to the management of anthelmintic resistance.

Key words: anthelmintics, anthelmintic resistance, cyathostomins, faecal egg counts, intestinal parasite management.

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INTRODUCTION

Anthelmintic products have traditionally been used worldwide as a prophylactic measure of helminth control in the horse-breeding industry, with treatments generally administered at 4–8-week intervals[1,11,20]. Anthelmintic resistance in the cyathostomins (or small strongyles) to the benzimidazoles (e.g. fenbendazole and oxibendazole) has been reported from numerous countries, including South Africa[2,4,6,15,17,20,26,27,30]. In addition, resistance to pyrantel has been recorded thus far in Denmark[4] and the USA[17]. Ivermectin has been used extensively for the last 2 decades and although there is no evidence of resistance against the macrocyclic lactones (e.g. abamectin, ivermectin and moxidectin) there is a growing threat of resistance developing[4,17,20]. High treatment frequencies are regarded as one of the main reasons for the extreme levels of current resistance[14,15]. Therefore, alternative control strategies that promote the judicious and sustainable use of anthelmintics are being encouraged[12,13,15,27,31]. Several studies have shown that selective or targeted treatments, i.e. treatment is only administered to animals with helminth infections above a certain threshold or to animals in poor body condition, may be a practical approach to anthelmintic resistance management in adult animals[5,16,17].

Selective treatment strategies are based on faecal egg counts (FECs; measured as eggs per gram of faeces (epg)) of the entire herd[5,16,17]. The rationale behind this practice is that within a herd there will be variation in the susceptibility to helminth infections and a small portion of the herd may carry a large portion of the total helminth population. This pattern, however, appears to be mainly associated with adult animals[5]. Younger animals are more susceptible to helminth infections and are associated with a higher mean FEC due to the absence of an age-acquired resistance[12,17]. As a result, younger animals require more frequent treatment than adult animals[5,17]. Nonetheless, the aim of selective treatment is to reduce the number of treatments per animal and number of animals treated (i.e. allow certain animals to remain untreated). This will ensure that some helminth generations or populations will remain untreated on the farm and delay the development of anthelmintic resistance[28].

In South Africa only 1 study has attempted to address the efficacy of a selective treatment approach in horses[16]. This study was done only on adult horses on 2 farms in the Gauteng Province (summer rainfall region). Although reductions in the number of treatments were recorded for farm 1, results from farm 2 were inconclusive, possibly due to benzimidazole resistance[16]. More recently, a questionnaire-based survey was conducted on the helminth control practices on Thoroughbred horse farms in South Africa, including a drug evaluation study on 10 of the larger farms in the Western Cape Province (WCP)[20]. The 57 farms included in the study were located mainly in the Western Cape and Kwa-Zulu-Natal provinces and the total herd sizes varied between 15 and 410 animals. The survey confirmed that anthelmintic products are generally used indiscriminately, every 8 weeks and on some farms every 4 weeks. Also, the use of FECs as a management aid in determining when to deworm is sporadic and FECs are mostly examined for only a few individuals at a time (e.g. animals that are in poor condition)[20]. The study also revealed that little attention is currently given to alternative management interventions (e.g. weekly faecal removal and selective treatment) that could potentially delay the development of anthelmintic resistance.

The objective of this study was therefore, in the first place, to establish if there is variation in the egg-excretion pattern of strongyle eggs between the different age classes of Thoroughbred horses in the WCP. If this was found to be the case, recommendations could be made regarding those age classes most suited to a selective

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Table 1: **Age group, herd size** (listed in brackets for farms 1–3)**, number of animals with positive and zero faecal egg counts, individual mean faecal egg count** (FEC) **and group mean faecal egg count** (±SE) **on 8 Thoroughbred horse farms in the Western Cape Province during 2001. The percentage of animals are given in brackets. Different superscript letters denote significant differences between group means** ($P < 0.05$)**.**

Group	Class[1]	*n*	No. positive epg	No. zero epg	Individual mean FEC ±SE	Group mean FEC ±SE
1	M	53[+] (80)	36 (67.92)	17 (32.07)	674.00 ± 125.83	
2	M	66[+] (120)	37 (56.06)	29 (43.94)	422.73 ± 71.50	
3*	M	50[+] (150)	11 (22)	40 (78)	31.00 ± 15.18	
4	M	55	22 (40)	33 (60)	150.00 ± 50.32	327.67 ± 41.67[a]
5*	Y	79	72 (91.14)	7 (8.86)	2528.48 ± 197.24	
6[#]	Y	49	47 (95.92)	2 (4.08)	928.57 ± 141.81	
7[†]	Y	11	10 (90.91)	1 (9.01)	654.55 ± 160.74	
8	Y	20	19 (95)	1 (5)	657.50 ± 140.73	
9[‡]	Y	12	12 (100)	0	345.83 ± 81.76	1577.49 ± 122.28[b]
10[‡]	W	15	15 (100)	0	1726.66 ± 210.38	
11[†]	W	26	25 (96.15)	1 (3.85)	1069.23 ± 181.55	
12[#]	W	65	56 (86.15)	9 (13.85)	373.85 ± 56.15	735.85 ± 79.29[c]

[1]Adult mare/yearling/weanling. [+]Representative sample. [*, #, †, ‡]Animals from the same farm.

treatment approach. Second, to determined whether a selective treatment approach could successfully reduce the number of anthelmintic treatments and maintain acceptably low helminth burdens in adult Thoroughbred horses. Third, the efficacy of subsampling large horse herds for FECs to monitor the strongyle burden was evaluated. This study, therefore, provided a basis for evaluating the feasibility of selective treatment as a tool for anthelmintic resistance management in horses in the WCP.

MATERIALS AND METHODS

Study design

During 2001 faecal material was collected from 224 mares, 171 yearlings and 106 weanlings on 8 Thoroughbred horse farms in the WCP of South Africa (winter rainfall region). Faecal material was collected from either all (groups 4–12 in Table 1) or a representative sample (groups 1–3 in Table 1) of the animals in the relevant age groups. None of the animals received any anthelmintic treatment for approximately 8 weeks prior to the study. Horses were individually stabled at night and faecal material was collected from the stable floor, placed in premarked plastic bags and transported to the laboratory. Samples were refrigerated if they could not be transported on the day of collection. Nematode FECs were recorded for each of the samples using a modified McMaster technique based on 4 g faeces with a minimum detection of 50 epg of faeces[24].

A selective treatment survey was also conducted on 1 of the 8 above Thoroughbred horse farms over a period of 12 months during 2002/2003 (hereafter referred to as farm A). Faecal material was collected on 10 occasions from all the brood mares ($n = 52$) that were kept permanently on the farm. The mares were individually stabled every 4–5 weeks and faecal samples were collected from the stable floor. The McMaster technique was used for the processing of the nematode FECs[24]. In addition, the presence of tapeworm eggs (*Anoplocephala perfoliata*) was noted while the absence of tapeworm eggs was not taken to imply that the animal tested negative for tapeworms. The McMaster technique is not regarded as an acceptable diagnostic tool for the detection of tapeworm eggs due to the small amount of faeces examined and the sporadic discharge of tapeworm eggs in the faeces[22,32]. All the mares with strongyle egg counts ≥ 100 epg were treated with an ivermectin-praziquantel combination drug (Equimax oral paste, Virbac) within 5 days of faecal collection and counting. Previously, infection thresholds of 50, 200 and 300 epg were used to select animals for treatment[5,16,17]. However, in the present study a more conservative value (≥100 epg) was used due to the high economic value of the animals. Animals positive for tapeworms were treated with the same product. All dosages were based on the individual weight of each animal using the Equi-feeds weigh band (95 % accuracy: F E van Niekerk, University of Stellenbosch, pers. comm., 2001). Faeces with positive strongyle egg counts were pooled and cultured (10 days at 27 ± 2 °C) every 3rd month to determine the strongyle generic representation.

Stud history of farm A

The total number of horses on the farm ranged from 100–120 of which 60–70 were brood mares and the remainder were yearlings and weanlings. The animals were kept on approximately 100 ha of pasture with an average stocking rate of 5 animals per ha. Helminth control practices in the past depended largely on the use of anthelmintics. Mares were given 5 treatments per annum, yearlings 6 and weanlings 8. The anthelmintic dosage administered was based on the estimated average group weight. Doramectin, ivermectin, praziquantel and pyrantel had been used on the farm for the previous 5 years. A faecal egg count reduction study conducted on the adult mares on the farm in 2001 recorded resistance against oxibendazole, while ivermectin was still effective[20]. Since 2002, faecal removal has taken place on a daily basis in each of the paddocks. This was mainly due to the awareness created by the questionnaire survey and the anthelmintic resistance status study conducted in the WCP in 2000[20].

Data analysis

The proportion of individuals with positive strongyle FECs as opposed to individuals with zero FECs, and mean FECs and standard errors were calculated for each of the herds from the 8 horse farms in 2001. A Kruskal-Wallis analysis of variance, followed by a non-parametric multiple comparison test of mean ranks for all groups, was performed on the pooled strongyle FEC data for each of the 3 age groups[33].

The change in the mean FEC and standard deviation with an increase in the number of animals sampled was calculated using Resampling Stats software for Microsoft Excel[3]. The mean FEC was calculated by resampling (without replacement and 100 repeats) from the 3 original data sets (age groups pooled across farms, $n = 105$ weanlings, 171 yearlings and 224 mares). The procedure was

repeated by resampling different numbers of individuals, or group sizes, i.e. 1, 2, 3, 4 . 50, 55, 65, 75 to *n* animals, within each of the 3 age groups. The point (i.e. number of animals) where an asymptote was reached in the mean FEC was recorded for each age group. This asymptote value represents the minimum number of animals that should be sampled to obtain an accurate FEC estimate for a region or herd. The Resampling Stats procedure was repeated for each of the 4 adult mare herds individually (Table 1). Between 50 and 66 faecal samples were obtained from each of the farms to determine the asymptote value within herds. The mean FEC, standard error, and 95 % and 99 % confidence intervals were calculated for the egg count asymptote values of the pooled data sets and for the individual mare herds. Also, the relationships between the minimum number of animals required to reach an egg count asymptote and a) the percentage of animals with a zero FEC in a herd, and b) the mean FEC of the herd was examined for the individual mare herds (i.e. individual farms). This was done to further examine the feasibility of subsampling herds to estimate the mean herd FEC.

RESULTS

Egg-excretion pattern

A smaller percentage of the individuals were positive (range 22–67.92 %) in the individual mare herds compared with either the yearlings (range 90.91–100 %) or weanlings (range 86.15–100 %) (Table 1). The mean group FECs for adult mares were also lower (327.67 ± 41.67) compared with the yearlings (1577.49 ± 122.28) and weanlings (735.85 ± 79.29) (Table 1). The mean FEC data for the individual age groups were significantly different ($H_{2,501} = 146.56$, $P < 0.001$). Mean FEC was significantly lower in the mares than in the weanlings ($P < 0.01$), while both the mare and weanling groups were significantly lower than the yearling group ($P < 0.001$). There were, therefore, generally fewer egg-excreting mares and the mares had lower mean FECs in this study compared with younger horses.

Selective treatment approach

Thirty-two mares (61.53 %) required 3 treatments or fewer during the 12-month study. Of the remainder, 18 (34.62 %) were treated 4–5 times and 1 animal received 7 treatments. A total of 116 treatments were administered for strongyle counts ≥100 epg. Eggs of the tapeworm *Anoplocephala perfoliata* and the ascarid *Parascaris equorum* were sporadically recorded with the McMaster technique and the respective horses were treated (Table 2) (An additional 10 treatments were administered due to the presence of tapeworm eggs). In total, 126 treatments were administered over the 12-month period.

Thirty-six mares (69.23 %) recorded mean individual faecal egg counts below 100 epg (range 0 to 95) of which 8 (15.38 %) had a zero egg count throughout the 12-month study. Of the remaining 16 (30.76 %) horses, 14 had mean counts between 100 and 400 epg and 2 animals recorded mean counts of 510 and 969 epg (Table 2). Within each month >40 % of the mares recorded zero egg counts. The mean monthly strongyle egg count for the group was less than 100 epg for 6 of the 10 collection times (range 45–71 epg). Counts conducted in July 2002 and January, February/March and April/May 2003 exceeded 100 epg on average (range 102–267 epg) (Table 2). The collection intervals for the first 8 sampling times were a mean of 27.43 days (±4.47 days), while the collection intervals for the 2nd-last and last sampling times were 40 and 60 days, respectively. Irrespective of the interval times the mean monthly FEC for the herd remained below 300 epg throughout the study. Examination of the cultured larvae confirmed the predominance of cyathostomins in the horses.

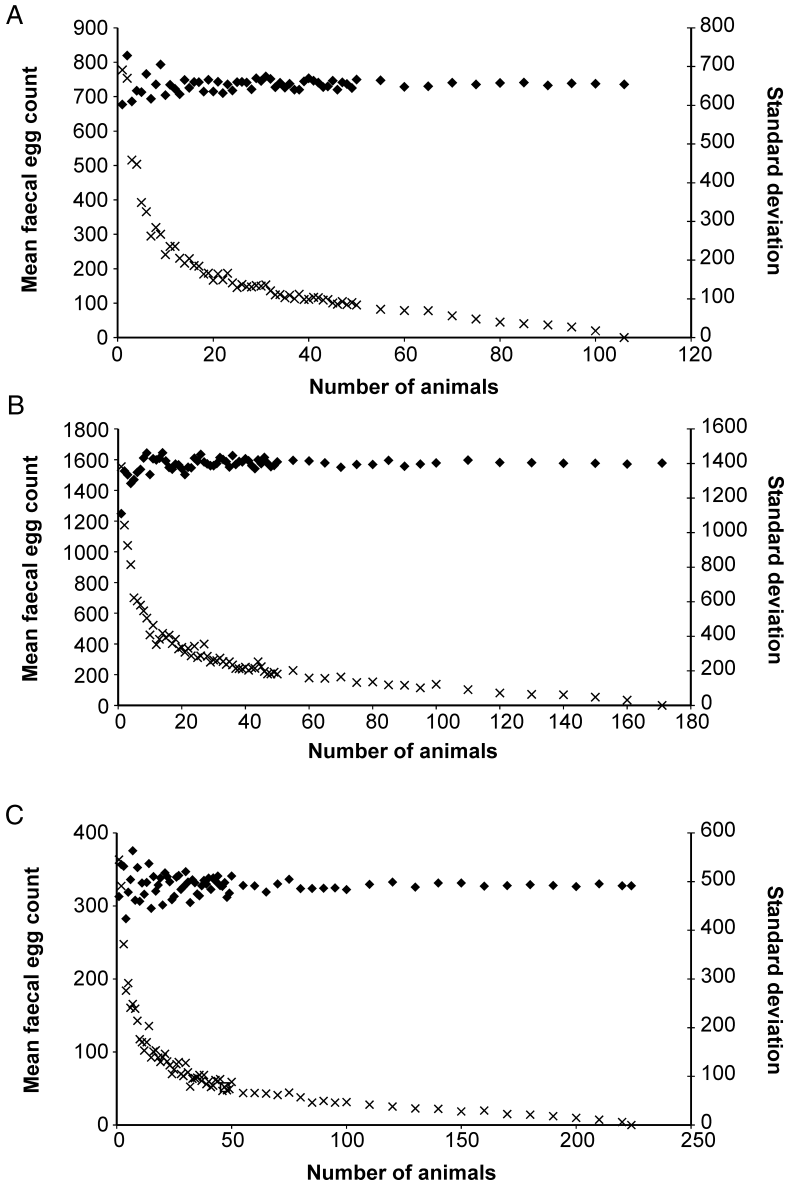

Fig. 1: **Change in mean faecal egg count (◆) and standard deviation** (X) **with an increase in the number of animals sampled for** (A) **weanlings** (*n* = 106), (B) **yearlings** (*n* = 171)**, and** (C) **mares** (*n* = 224).

Subsampling technique

Asymptotes in the mean FEC were reached at approximately 55 animals for each of the pooled weanling, yearling and mare groups (Fig. 1A–C). The mean FEC (±95 % CI) at the asymptote value of 55 individuals was 747.37 epg (±14.33) for weanlings, 1595.58 epg (±39.58) for yearlings and 328.20 epg (±12.85) for the adult mares (Table 3). The subsamples represent 52 % of the weanling herd (*n* = 106),

Table 2: **Individual animal and mean monthly strongyle faecal egg count** (epg) **and standard deviation** (SD) **of 52 Thoroughbred mares sampled over a period of 12 months.**

Animal No.	Age (years)	2002 May	Jun	Jul	Aug	Sep	Nov	Dec	2003 Jan	Mar	May	Mean	SD	No. of treatments
1	7	0	0	0	0	0	0	0	0	0+	0	0	0	1
2	17	0	0	0	0	0	0	0	0	0	0	0	0	0
3	12	0	0	0	0	0	0	0	0	0	0	0	0	0
4	15	0	0	0	0	0	0	0	0	0	0+	0	0	1
5	9	0	0	0	0	0	0	0	0	0	0	0	0	0
6	13	0	0	0	0	0	0	0	0	0	0	0	0	0
7	7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	10	0	0	0	0	0	0	0	0	0	0	0	0	0
9	9	0	0	0	0	0	0	0	50	0	0	5	15.81	0
10	11	0	0	0	0	0	0	0	50	0	0	5	15.81	0
11	8	0	0	0	0	50	0	0	0	0 (200)	0	5	15.81	1
12	9	0	0	0	0	0	0	0	0	50	50+	10	21.08	1
13	15	0	0	0	100	0	0	0	0	0	0	10	31.62	1
14	16	0	0	0	0	0	0	0	50	50	50	15	24.15	0
15	7	50	0	0	0	0	0	0	0	0	100	15	33.75	1
16	9	0	0	0	0	0	0	0	100	0	50	15	33.75	1
17	7	0	0	0	150	0	0	0	0	0	50	20	48.30	1
18	8	0	0	0	0	0	50	200	0	0	0	25	63.46	1
19	6	0	50	0	50	100	0	50	0	0	0	25	35.36	1
20	8	50	200	0	0	0	0	0	0	0	0	25	63.46	1
21	8	0	0	50	0	0	0	0	50	50	200	35	62.58	1
22	9	0	0	0	50	200	0	0	50	50 (1500)	0	35	62.58	2
23	10	0	0+	0	0	0	0	350	50	0 (600)	0	40	110.05	3
24	13	0	0	100	0	0	0	100	0	0	200	40	69.92	3
25	14	0	0	0	250	0	0	0	200	0	50	50	94.28	2
26	8	0	50	150	0	0	0	0	0	300	0	50	100	2
27	5	0+	0	0	150	0	0	250	0	150	50	60	90.68	4
28	14	0	50	200	0	0	200	0	100	0	NS*	61.11	85.80	3
29	12	0	0	250	0	50	50	150	0	150	50	70	85.63	3
30	16	0	50	50	250	150	0	0	50	50	100	70	78.88	3
31	11	0	0	300	0	0	100	0	0	300 (50)	0	70	125.17	3
32	7	0	100	0	100	0	0	150	0	400	50	80	125.17	4
33	6	0	50	0	0	0	50	300	0	50	400	85	143.47	2
34	7	0	300	0	0	100	0	100	0	200	200	90	110.05	5
35	6	50	50	50	150	0	50	50 (1000)	100	50	400	95	114.14	4
36	5	0	200	0	0	200	0	0	0	250	300	95	125.72	4
37	6	0	150	0	50	0	0	150	0	150	500	100	156.35	4
38	5	0	150	0	50	350	0	100	50	50	300	105	125.72	4
39	10	0	0	550	0	0	250	0	150	50	100	110	176.07	4
40	19	0	0	150	0	0	50	50	0	900	0	115	279.93	2
41	8	0	0	120	0	0	350	0	250	0	550	142.73	191.79	4
42	11	0	100	0	0	0	0	0	500	0	1600	220	509.47	3
43	7	50	100	0	0	0	450	0	150	0	1650	240	514.67	4
44	8	200	0	0	50	0	1400	50	150 (1900)	50	750	265	458.29	4
45	16	NS	NS	50	1200	0	250	0	200	0	450	268.75	408.78	4
46	9	0	50	1200	0	0	250	0	0	1200	50	275	493.43	3
47	8	150	0	0	550	0	0	200	50	NS	1600	283.33	525	4
48	6	0	600	0	0	1600	0	100	50	50	850	325	537.61	4
49	7	NS	NS	1550	0	100	0	200	50	600	250	343.75	525.38	5
50	8	800	0	750	0	150	50	800	250	300 (50)	600	370	335.16	7
51	9	1300	0	450	0	0	300	0	2600	50	400	510	836.93	5
52	8	800	0	3200	0	150	NS	NS	0	1950	1650	968.75	1190.42	5
Mean epg		69	45	176.35	60.58	61.54	75.49	65.69	101.92	146.08	266.67			126
SE		33.18	14.30	72.15	25.88	31.72	29.98	18.94	50.64	47.85	62.74			

Animals ranked on the basis of mean monthly strongyle epg of each animal.
NS = no sample.
Parascaris equorum count is given in brackets.
+Denotes the presence of *Anoplocephala perfoliata* eggs.

32 % of the yearling (n =171) and 25 % of the adult mare herd (n = 224). Resampling within the 4 different mare herds resulted in asymptotes of between 24 to 28 animals, which represent 46.23 % (±2.96) of a herd size of between 50 and 66 animals (Table 4). The asymptote value for the individual mare herds remained between 24 and 28 animals even though the percentage of adult horses with zero egg counts varied between 32.07 % and 78 % and the mean faecal egg count of the herds ranged between 31 and 674 epg (Table 1).

DISCUSSION

Egg-excretion pattern

The results of this study confirm variation in the susceptibility to helminth infection between adult and younger animals. In general, a smaller percentage

Table 3: **Mean faecal egg count** (FEC)**, minimum and maximum mean egg count, standard deviation** (SD)**, standard error** (SE) **and 95 % and 99 % confidence intervals** (CI) **recorded for a subsample** (S) **size of 55 individuals and for all the individuals sampled for each of the pooled age group.**

Age group		No. of individuals	Mean FEC	Min	Max	SD	SE	95% CI	99% CI
Weanlings	S	55#	747.37	523.61	928.20	73.11	7.31	14.33	18.83
	All	106	735.85	–	–	–	79.29	–	–
Yearlings	S	55#	1595.58	1026.43	2035.52	201.97	20.19	39.59	52.02
	All	171	1577.49	–	–	–	122.28	–	–
Mares	S	55#	328.20	153.61	509.14	65.57	6.56	12.85	16.89
	All	224	327.67	–	–	–	41.67	–	–

#Data based on 100 repeats.

Table 4: **Mean faecal egg count** (FEC)**, minimum and maximum mean egg count, standard deviation** (SD)**, standard erro**r (SE) **and 95 % and 99 % confidence intervals** (CI) **recorded for the subsample** (S) **value and for all the individuals sampled in each of the 4 adult mare herds.**

Mare herd		No. of individuals	Mean FEC	Min	Max	SD	SE	95% CI	99% CI
1	S	24#	31.81	4.20	60.43	16.39	1.64	3.21	4.22
	All	50*	31.00	–	–	–	15.18	–	–
2	S	25#	151.92	40.11	266.67	52.94	5.29	10.38	13.64
	All	55*	150.00	–	–	–	50.32	–	–
3	S	28#	419.16	196.44	655.45	86.80	8.68	17.00	22.36
	All	66*	422.72	–	–	–	71.55	–	–
4	S	26#	669.02	384.62	1001.98	133.92	13.39	26.25	34.49
	All	53*	673.67	–	–	–	125.83	–	–

*Total number of faecal samples obtained from the relevant farm.
#Data based on 100 repeats.

of the mares recorded positive FECs compared with the yearling or weanling groups. A similar pattern was found for the mean FEC with lower counts recorded for the mares compared to the younger age groups. These findings agree with a previous study in the UK that noted poorer anthelmintic performance (oxibendazole, pyrantel pamoate and ivermectin) and higher mean FECs in yearlings (655–852 epg) compared with adult mares (<200 epg) during a 6-year period[12]. Also, a more recent selective treatment study in the USA reported higher mean monthly FECs for foals (range 0 to >4000 epg) compared with adult mares (0 to 600 epg) over a 30-month period[17]. In the same study, a shorter egg reappearance time after ivermectin treatment was also recorded for the foals (6 weeks) compared with the mares (<8 weeks). Several studies have now shown that young animals are more often clinically affected by helminth parasite infections, especially cyathostomin infections[18,19,23,27]. Animals in these age groups can also suffer from a syndrome called larval cyathostominosis that is characterised by low or zero FECs and is associated with the rapid emergence of large numbers of encysted larvae from the host's gut wall. The symptoms related to this syndrome include non-responsive diarrhoea, weight loss and in severe cases, death[19,23,25,27]. Based on these studies and the results presented, it is evident that younger animals excrete larger numbers of eggs, are re-infected much faster following treatment and are more susceptible to clinical disease associated with helminth parasites. It is therefore recommended that helminth control practices should be adapted for each age group on each farm[12,27]. We also show that a selective treatment approach is likely to be more effective for managing helminth burdens in adult herds, mainly due to lower individual FECs and a smaller percentage of positive animals. Therefore, selective treatment is generally not recommended for yearlings or weanlings.

Selective treatment approach

The selective treatment approach adopted here reduced the number of anthelmintic treatments and maintained acceptably lower levels of helminth infections in a herd of adult Thoroughbred horses. There was an approximately 50 % reduction in the number of treatments administered when only horses with FECs of 100 epg or more were treated compared with the conventional programme of 5 times per year, irrespective of the FEC. During the study period the horses were closely monitored and there was no report of disease associated with helminth parasites. Two earlier studies on adult horses in South Africa and the USA also recorded noticeable reductions in treatment frequencies; one recorded a 50 % reduction when treatment was administered at an infection level of ≥300 epg (the conventional treatment regimen on the farm was 4 times per year)[16] and the other obtained a 77.6 % reduction with an infection level of >200 epg (the conventional treatment regimen on the farm was 6 times per year)[17]. This study thus confirms that selective treatment results in fewer anthelmintic treatments compared with conventional practices. This will retard anthelmintic resistance development as fewer treatments will facilitate the survival of susceptible worms and increase their numbers on pastures[29,31].

The success of a selective treatment approach will, however, be influenced by the effectivity of the drugs that are used and it is therefore recommended that the resistance status of the products used on the farm should be evaluated at least once a year. Furthermore, it is important to note that the number of treatments administered with a selective treatment approach will be influenced by: 1) the infection threshold that is used (e.g. 50 or 300 epg) to select individuals for treatment, 2) the type of substrate that the animals are kept on (e.g. sand or irrigated grass pasture), and 3) the use of pasture hygiene practices (i.e. removal of faeces) (Fig. 2). These factors will vary between farms, due to variation in farm manage-

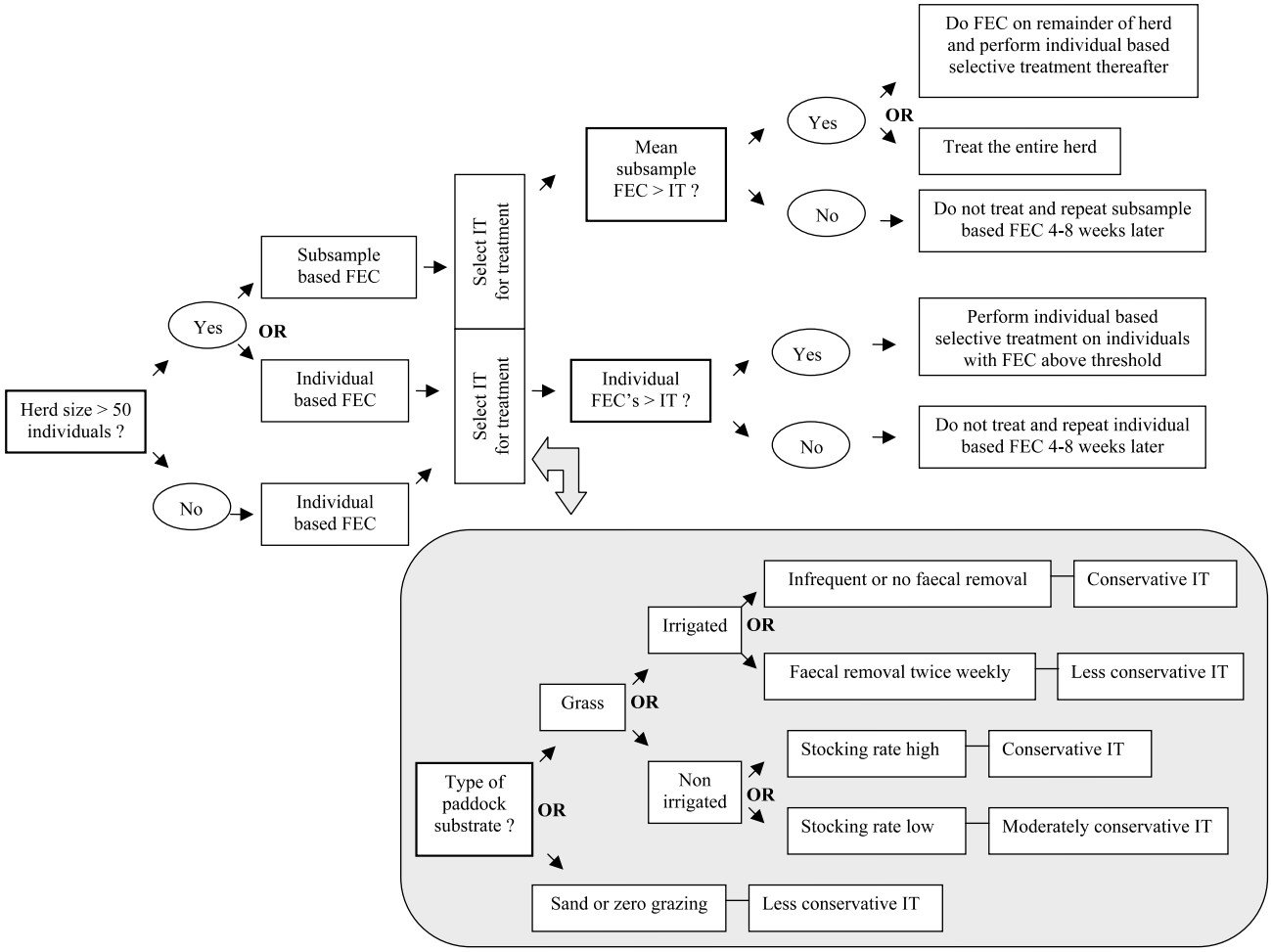

Fig. 2: **Decision diagram for helminth parasite management, with the focus on the judicious use of anthelmintic products, on horse farms. Area in grey is a guideline to the selection of an infection threshold** (IT)**, based on faecal egg counts, for the selective treatment of strongyle parasites in horses.**

ment practices, and will influence the size of the worm population on the pasture and the helminth re-infection rate in the animals. In Fig. 2 (shaded area) a guideline is provided for the selection of a threshold value for the selective treatment of strongyle parasites that considers these factors in combination.

The infection threshold used to select animals for treatment may vary between age groups, farms and between regions. Ideally the infection threshold must be low enough to prevent clinical disease associated with helminth parasites, but high enough to ensure that a portion of the worm population within the herd will be left untreated and contribute to the free-living worm population on pasture. At present there is no empirical information available to say confidently what is a low or a high FEC in horses. The FEC is only a reflection of the adult egg-producing worms and provides no information on the potential larval population within an animal. Unfortunately there is currently no method available to assess quantitatively the extent of the larval or immature worm population within a live animal. However, it is generally accepted that a strongyle FEC <200 epg is low, 500 to 800 epg is moderate and >1000 epg is high. This is comparable with the guideline used for interpreting nematode FECs in cattle[9]. In the present study a conservative infection threshold of 100 epg or more was used to select animals for treatment. This together with weekly faecal removal from the pastures maintained the helminth burdens of the herd at an acceptably low level throughout the 12-month study (mean monthly FEC ranged between 45 and 266.67 epg). Similarly, 2 other studies on adult mares successfully maintained the mean monthly FECs <600 epg over a 12-month and 30-month period, respectively[16,17]. Although the mean monthly FECs of the herds in the 2 studies were comparable, they did vary in the infection threshold that was used as well as the management of the animals during the trials[16,17]. Krecek and co-workers[16] adopted a less conservative selective treatment approach and used an infection threshold of ≥ 300 epg in combination with sand camps from which the faecal material was removed weekly. The feed of the animals was also placed in feed containers that were elevated above the ground. Little and co-workers[17] used a more conservative infection threshold (FEC > 200 epg), but left the faeces on the pastures. Pasture hygiene practices will reduce the free-living helminth population on the pastures and the re-infection rate in the animals. The latter will in fact contribute to a reduction in treatments required to maintain low FECs and it would therefore be acceptable to use a less conservative approach (see Fig. 2, shaded area). Twice weekly faecal removal is recommended as the majority of worms are physically removed from the pasture before they can develop and re-infect animals[10]. This practice maintains a sufficiently high helminth level on pastures so that the resistance of animals is maintained[10]. The use of sand paddocks can also be seen as a form of pasture hygiene as the survival of the free-living stages will be negatively affected due to unsuitable micro-environmental conditions compared with irrigated pastures[21] (Fig. 2 in grey).

Although mean egg counts were low, the variation in the strongyle egg excretion pattern in the adult herd was relatively high. A large percentage of the mares

(>40 %) on farm A consistently recorded zero or low FECs (≤200 epg), while the remainder recorded more positive counts (50–3200 epg). This is not unusual, and within-herd variation in egg excretion was previously recorded in a herd of 25 horses (mixed breed and predominantly adult animals) in the UK[5]. Krecek and co-workers[16] also mentioned that some adult horses repeatedly excreted ≥ 300 epg and as a result required more frequent treatments. In spite of this level of variation, the results of our study demonstrate that performing individual FECs at monthly intervals for at least a 6-month period will provide a reliable strongyle egg-excretion profile for the relevant herd. This will allow the identification and treatment of only the most heavily infected animals[5]. Also, with this baseline information, the management of the relevant herd can be adjusted so that individual FECs are performed less frequently on the portion of animals that makes no or a small contribution to pasture contamination.

In addition to resistance management advantages, several studies have shown that a selective treatment approach using effective anthelmintic products is economically advantageous[5,17,20]. In the present study the selective treatment of 52 adult mares for a 12-month period resulted in a R10 000.00 saving (R18 184.00 [include 126 treatments at R108.00 per 500-kg animal for Equimax and 572 faecal egg counts at R8.00* per count]) compared with the conventional treatment practice on the farm (R28 080.00). Although cost saving must necessarily be secondary to a reduction in selection for resistance in helminth populations, it does provide an incentive to the horse breeder, especially those with larger herds.

Subsampling technique

Pooled FEC data from several farms in the WCP was used to determine the optimal subsample size that will give an accurate estimate of the mean herd FEC for the individual age groups. This analysis demonstrated that a subsample of at least 55 animals should be examined for each age group. However, this recommendation incorporates regional variability in FECs, and is likely to be the same or higher than an estimate based on farm-level variability. It therefore provides a conservative (higher than possibly necessary) estimate of the number of animals to be sampled. Indeed, within-farm estimates revealed that fewer animals are needed, i.e. at least 24 animals should be examined for adult herds consisting of between 50 and 66 individuals. This estimate was unaffected by either the number of animals with zero counts in the herd, or the average herd FEC. However, the guidelines developed here are based on only a proportion of herds in the WCP, and may be refined with sampling more broadly, or by sampling more animals per farm on farms with very large herds. Nonetheless, the subsample size for individual herds recommended here is comparable to those made for diagnosing helminth problems in ruminants using FECs[9]. Here it is suggested that at least 20 animals should be sampled in a herd or flock of 26–100 animals and at least 30 animals for herds of 101–200 individuals[9]. It is recommended that subsample-based FECs should only be considered for herd sizes larger than 50 individuals (Fig. 2). The extent of the helminth infection (e.g. if the mean subsample FEC is above or below the infection threshold) can be used to select the appropriate management action (Fig. 2). Subsampling should, however, always be combined with close monitoring of the condition of the herd. The availability of a reliable estimate for subsampling herds may, however, encourage horse breeders with large herds to monitor FECs of the herd more regularly. This will contribute significantly to the sustainable management of helminth parasites in horse herds.

It is possible to delay the development of anthelmintic resistance with the use of sound management practices[7,8,13,29]. These include the use of integrated strategies, reduced treatment frequencies and treating at a higher infection threshold, rotation between chemical classes and leaving some generations or populations of helminths untreated (as outlined in Fig. 2). Selective treatment of adult horses and subsampling of herds for faecal counts are 2 strategies that may contribute significantly to achieving this objective. Importantly, the responsibility for resistance management, i.e. the adoption and promotion of sustainable helminth control practices that are based on the judicious use of anthelmintic products, must necessarily lie with horse breeders, veterinarians, scientists and pharmaceutical companies.

*Price of nematode faecal egg count conducted at the Western Cape Provincial Veterinary Laboratory, Stellenbosch, 2004.

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