Development of a novel self-medicating applicator for control of internal and external parasites of wild and domestic animals

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ABSTRACT

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Four trials, three in the United States and one in South Africa, were conducted to evaluate the potential value of a novel self-medicating applicator in the passive control of gastrointestinal nematodes in cattle and deer, and of flies and ticks on cattle using oil-based treatments. The results of the trials demonstrated that this applicator is an effective and practical device for the passive treatment of both deer and cattle for trichostrongyle infections using the endectocide, moxidectin (Cydectin®, Fort Dodge Animal Health, USA), of cattle for horn fly (*Haemotobia irritans*) infestations using the insecticide, cyfluthrin (CyLence®, Bayer AG, Germany) and of cattle for tick infestations (in particular *Amblyomma hebraeum* and *Rhipicephalus appendiculatus*) using the acaricides deltamethrin and amitraz (Delete All®, Intervet, South Africa).

Keywords: Amitraz, cattle, cyfluthrin, deer, deltamethrin, fly control, moxidectin, nematode control, self-medicating applicator, tick control

INTRODUCTION

Wildlife are important hosts for ticks in many regions of the world (Hoogstraal & Aeschlimann 1982). In an attempt to develop a practical and stress-free method for control of ticks on wild animals, a self-medicating applicator was designed and tested successfully on deer (Sonenshine, Allan, Norval & Burridge 1996). It did not, however, lend itself to use with large numbers of animals. Consequently, an improved self-medicating applicator was developed, which could be retrofitted to existing devices that attract wild animals, such as troughs containing feed or water (Burridge, Simmons & Simmons 2000, 2003; Simmons, Burridge & Simmons 2001). This improved applicator was designed to transfer oil-based acaricides passively to wild animals, but its versatile design was such that it had the potential to be used to treat animals of any size with any oil-based compound. Consequently preliminary trials with this applicator were formulated to test whether the concept of delivery of oil-based treatments to both domestic and wild animals through the device was practical using various animal species naturally infected or infested with endo- or ecto-parasites. Initial studies were conducted to determine the efficacy of the applicator as a method for delivery of treatments to control gastrointestinal nematodes in cattle and deer in the United States, flies on cattle in the United States, and ticks on cattle in South Africa. The results of these trials are described in this report.

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MATERIALS AND METHODS

Self-medicating applicator

The applicator, given the trademark of the Appli-Gator™ (University of Florida), is a semicircular device composed of a solid outer pipe made of rigid polyvinyl chloride containing a rigid porous internal pipe made of high-density polyethylene, with an upper portion of the outer pipe removed to allow animals to contact the internal porous material (Fig. 1). It was attached to a feed trough using plastic ties or nuts and bolts, and primed with a predetermined volume of oil-based compound sufficient to saturate the porous pipe, after which an additional measured treatment dose is added to the porous pipe. Both the priming and treatment doses were added by syringe through treatment fill ports in the exposed porous pipe. When cattle or deer feed from the trough the applicator deposits the compound on the neck region, thus treating them in a stress-free manner without the need for handling equipment.

Treatments

Anthelmintic

The anthelmintic used was Cydectin® (Fort Dodge Animal Health, Fort Dodge, Iowa, USA) containing 0.5 % of the second-generation endectocide moxidectin. Moxidectin was selected because it is highly efficacious against gastrointestinal parasites of cattle and deer (Craig 1999), it is of low toxicity in terms of tissue residues and ecological safety (Herd 1995), it has been used successfully for internal parasite control in farmed deer in New Zealand (Audigé, Wilson & Morris 1998; Waldrup, Mackintosh, Duffy, Labes, Johnstone, Taylor & Murphy 1998), it has a persistent effect against target nematodes (Eysker & Eilers 1995; Hubert, Kerboeuf, Cardinaud & Blond 1995; Rendell & Callinan 1996), and it is formulated as an oil-based pour-on that is absorbed through the skin.

Insecticide

The insecticide used is CyLence® (Bayer AG, Leverkusen, Germany) containing 1% cyfluthrin. Cyfluthrin was selected because it was commercially marketed for use in fly control on cattle in the USA, it is available as an oil-based pour-on formulation, and it is an effective insecticide (Sulaiman, Pawanchee, Othman, Jamal, Wahab, Sohadi, Rahman & Pandak 1998; Vale, Mutika & Lovemore 1999).

Acaricide

The acaricide used was Delete All® (Intervet, Isando, South Africa) containing 0.5 % deltamethrin, 2 % amitraz and 0.5 % piperonyl butoxide. This acaricidal combination was selected because it is formulated as an oil-based pour-on and because deltamethrin and amitraz are effective for the control of ticks on cattle in Africa (Haigh & Gichang 1980; Luguru 1991; Kagaruki 1996; Mekonnen 2001).

Experimental designs

Anthelmintic trial

Nineteen male fallow deer (*Dama dama*), resident on a private wildlife ranch in Putnam County, Florida, USA, were selected for the cervid anthelmintic trial. They were 2–5 years of age and were naturally infected with trichostrongyles. The deer were randomly assigned to one of two fenced pastures on the ranch. Ten of them were kept in a pasture containing an applicator attached to a feed trough (the applicator group) and the remaining nine on the other pasture with no attachments to the feed trough (the control group).

Eight Brahman, Angus and Hereford cattle from a privately owned farm in Hendry County, Florida, were selected for the bovine anthelmintic trial. They were 1–4 years of age and consisted of four heifers, two steers and two bulls, all naturally infected with trichostrongyles. The cattle were assigned randomly by sex to one of two fenced pastures so that each group contained two heifers, one steer and one bull. They were divided into an applicator group and a control group as for the deer.

The 19 deer and eight cattle were individually restrained in squeeze chutes, and faecal material was removed manually from the rectum of each animal for examination for trichostrongyle eggs. The animals were then returned to their respective pastures on either the wildlife ranch or the cattle farm. The applicators were primed with enough moxidectin to saturate the porous columns, then additional moxidectin (80 mℓ for the ten deer and 84 mℓ for the four cattle) was added to the devices to form reservoirs for treatment, based on a dosage of 0.5 mg moxidectin per kg body mass. Commercial deer or cattle feed was placed in the feed trough in each of the pastures, and the animals were allowed to feed. While feeding, the ten deer and the four cattle in the applicator groups received a total of 80 mℓ and 84 mℓ of moxidectin respectively, until all

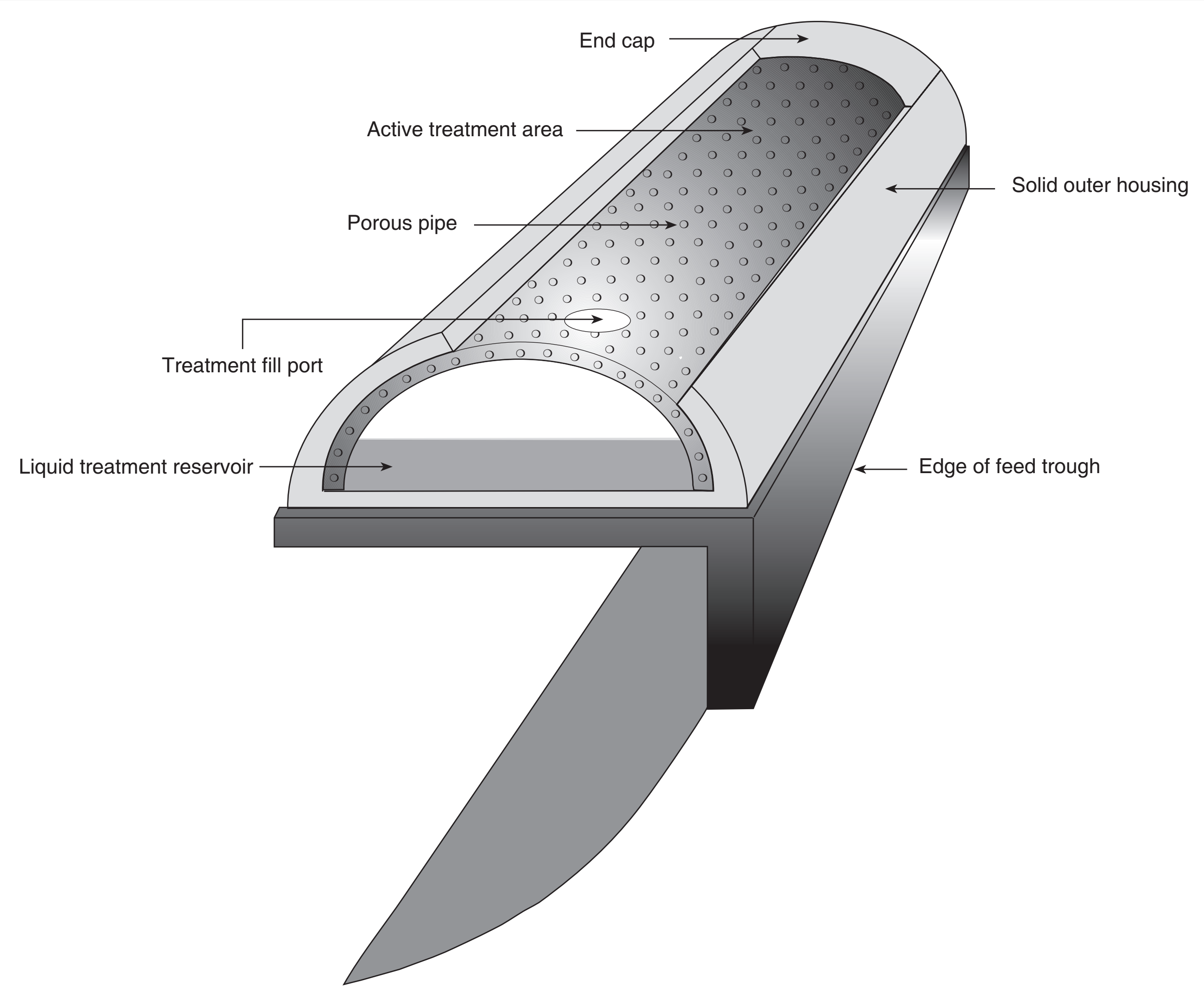

FIG. 1 Schematic drawing of cross-section of an AppliGator™ self-medicating applicator mounted on the edge of a feed trough

available moxidectin in the reservoirs had been transferred to the necks of the animals. The deer and cattle were restrained individually again on days 6 and 12 and on days 7, 14, and 21 respectively, after initiation of the trials to obtain a series of post-treatment faecal samples.

Each faecal sample was placed in a plastic bag immediately after collection, and the bag was sealed and stored on ice for transport to the laboratory. The sample was quantitatively examined for trichostrongyle eggs using a modification of the McMaster egg-counting method (Whitlock 1948). A 4 g amount of faeces was mixed with 26 mℓ of Fecal Float (Phoenix Pharmaceuticals Inc., St. Joseph, Missouri, USA), poured through a layer of cheese cloth, and distributed to a two-chambered McMaster slide. After a 5-min interval the McMaster slide egg-counting grid was examined microscopically at 100x magnification for the presence of trichostrongyle eggs.

Insecticidal trial

Sixteen 2 to 5-year-old Brahman-cross cows from a privately owned ranch in Starr County, Texas, USA, were selected for the insecticidal trial. They were randomly assigned in equal numbers to one of two fenced pastures at the ranch, and were divided into an applicator group and a control group as in the anthelmintic trial. The trial commenced in March when horn flies (*Haematobia irritans*) were naturally abundant on the cattle on the ranch.

Counts of horn flies were made visually on each of the 16 cattle in the trial on the day prior to onset of the trial. The applicator was primed with enough cyfluthrin to saturate the porous column, then 96 mℓ of additional cyfluthrin were added to the device to form a reservoir for treatment of the cattle, based on a dosage of 12 mℓ for animals exceeding 363 kg body mass. Commercial cattle feed was placed in the trough in each pasture, and the animals were allowed to feed. Counts of horn flies were made on day 1 and then weekly from days 7–42 to obtain a series of post-treatment fly counts.

Acaricidal trial

Fifteen Beefmaster-cross cattle on a farm belonging to the Intervet Research Unit in Malelane, Mpumalanga Province, South Africa were selected for the acaricidal trial. The cattle were 1-year-old animals of mixed sexes and were randomly assigned in equal numbers to one of three fenced tick-infested pastures at the farm. Five cattle were kept on a pasture containing an applicator attached to a feed trough (the applicator group) and five each in two other pastures with no attachments to the feed troughs (the positive control and negative control groups). The trial commenced in January when ticks (including *Amblyomma hebraeum*, *Rhipicephalus appendiculatus*, *Rhipicephalus simus* and *Boophilus* spp.) were naturally abundant on the pastures of the farm.

Counts of adult ticks were made by species on each of the 15 cattle on the day prior to onset of the trial. The ticks were counted macroscopically *in situ* while the animals were restrained on a cement floor in a crush pen with both a head and a body clamp. Two people performed the tick count on each animal, and a third person recorded the data. Disposable latex gloves were worn during tick counting, with new sets of gloves worn for each experimental group. The applicator was primed with enough deltamethrin/amitraz to saturate the porous column, then 95.5 mℓ of additional deltamethrin/amitraz was added to the device to provide a reservoir for treatment of the cattle, based on a dosage of 0.1 mℓ per kg body mass. Cattle on the pasture containing the positive control group were treated by application of deltamethrin/amitraz pour-on along the back line using a dosage of 0.1 mℓ of pour-on per kg body mass. Cattle in the pasture containing the negative control group were treated only for ethical reasons when their tick burdens became too heavy, and in those instances the acaricide used was Triatix Cattle Spray® (Intervet, Isando, South Africa) containing 12.5 % amitraz at a rate of 5 ℓ per animal. Commercial cattle feed was added to the trough in each pasture, and the animals were allowed to feed.

Cattle in the applicator and positive control groups were treated with deltamethrin/amitraz weekly from days 0 to 77 using an applicator and pour-on, respectively. After tick counts had been made, cattle in the negative control group were treated with amitraz for ethical reasons on days 0, 14, 28, 35, 49, 63 and 84 due to the heavy tick challenge. Counts of adult ticks were made on day 7 after treatment and then weekly to day 84 to obtain a series of post-treatment tick counts by species.

Statistical analyses

The data were analyzed for statistical differences in trichostrongyle egg counts, fly counts and tick counts between the test groups using the two-tailed t test. For egg and fly counts, differences between treated and untreated animals were analyzed for each day on which counts were made. For tick counts, differences between treated animals (the applicator and positive control groups) and untreated animals (the negative control group) were analyzed only for those days when the negative control cattle were treated for ethical reasons, with the tick counts on negative control cattle preceding treatment. These analyses were selected to minimize

TABLE 1 Effect of moxidectin on trichostrongyle infections in fallow deer when applied passively using a self-medicating applicator

Animal no. by group	No. of trichostrongyle eggs per gram of faeces by day of trial			
		Day 0	Day 6	Day 12
Applicator group	362	75	0	a
	367	25	0	0
	374	300	0	0
	400	100	a	0
	441	75	0	0
	444	25	0	0
	489	75	0	0
	523	100	0	0
	544	125	a	0
	561	75	0	0
Control group	307	50	50	50
	364	50	75	75
	372	125	125	125
	410	75	50	50
	467	125	125	150
	490	25	25	a
	533	100	125	100
	568	150	100	175
	586	75	100	75

a = No sample collected due to empty rectum the effect of treatment of the negative control cattle. Ideally from the scientific point-of-view, the negative controls should not have been treated, increasing the number of ticks on each animal, but ethically these cattle had to be treated periodically to minimize the impact of the heavy burdens on their health and well-being.

RESULTS

Anthelmintic trials

The ten deer in the applicator group had a mean burden of 97.5 trichostrongyle eggs per gram (epg) of faeces before treatment with moxidectin from an applicator. The egg counts in all deer in the group dropped to zero by day 6 post-treatment and remained at zero by day 12 post-treatment (Table 1). The trichostrongyle egg counts were significantly less ($P < 0.001$) in the deer treated using the applicator than were those in the untreated deer on both days 6 and 12 of the trial.

The four cattle in the applicator group had a mean trichostrongyle egg count of 300 epg of faeces before treatment with moxidectin. After treatment, the egg counts dropped to zero in three of the four cattle, the exception being steer no. 109 in which the count dropped to 50 epg (Table 2). This steer did not feed from the trough during the first day of the trial and thus had no contact with the applicator

TABLE 2 Effect of moxidectin on trichostrongyle infections in cattle when applied passively using a self-medicating applicator

Animal no. by group		No. of trichostrongyle eggs per gram of faeces by day of trial			
		Day 0	Day 7	Day 14	Day 21
Applicator group	102	250	0	0	0
	105	475	0	0	0
	109[a]	200	50	50	50
	111	275	0	0	0
Control group	101	225	175	175	200
	107	175	200	225	300
	110	400	475	500	550
	113	200	175	175	175

[a] Steer no. 109 did not make contact with the applicator during the first day of trial

TABLE 3 Effect of cyfluthrin on horn fly infestations on cattle when applied passively using a self-medicating applicator

Animal no. by group		No. of horn flies on animal by day of trial							
		Day -1	Day 1	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
Applicator group	34	150	0	0	4	18	70	220	470
	39	300	0	0	4	20	50	200	500
	41	200	0	0	2	26	110	240	500
	42	200	0	0	10	24	100	240	480
	43	250	0	0	4	14	68	180	500
	44	400	0	0	12	18	76	300	450
	45	300	0	0	6	16	60	200	600
	47	550	0	0	14	22	80	250	450
Control group	38	180	200	470	400	400	400	450	600
	48	250	250	500	380	420	380	470	460
	49	300	400	550	400	370	300	440	500
	50	500	450	600	470	410	500	450	450
	55	280	300	400	360	350	360	400	500
	61	200	250	450	350	380	400	380	450
	73	550	600	560	500	450	500	500	480
	93	300	400	600	480	400	450	500	550

TABLE 4 Effect of deltamethrin/amitraz on tick infestations on cattle when applied passively using a self-medicating applicator

Animal number by group		No. of adult ticks[a] on animal by day of trial												
		Day -1	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56	Day 63	Day 70	Day 77	Day 84
Applicator group[b]	01/01	485	78	17	17	11	27	14	9	18	5	16	20	7
	01/02	542	45	11	22	23	34	13	20	17	15	4	3	18
	01/11	448	40	13	9	12	19	12	11	13	4	1	6	3
	01/22	423	294	40	71	26	64	56	36	39	19	15	23	19
	02/04	385	62	46	39	18	71	42	26	73	20	52	22	11
Positive control group[b]	01/13	382	192	102	77	182	27	65	7	7	27	19	5	6
	01/14	451	320	203	135	224	48	99	7	7	116	36	25	11
	01/24	492	436	140	100	160	32	53	19	9	32	22	12	14
	01/32	457	87	87	86	169	24	58	22	8	17	10	9	5
	02/08	299	69	77	31	106	8	36	12	3	17	14	4	6
Negative control group[c]	01/03	355	294	546	116	652	151	154	322	47	202	18	94	117
	01/06	356	312	651	158	836	174	152	317	83	316	30	100	133
	01/12	383	373	546	185	636	216	183	410	124	418	34	109	128
	01/26	394	373	671	163	726	172	131	501	40	431	28	107	127
	02/07	500	241	635	47	912	154	173	713	41	483	26	66	146

[a] *Amblyomma hebraeum, Rhipicephalus appendiculatus, Rhipicephalus simus* and *Boophilus* spp. ticks

[b] Each animal treated with deltamethrin/amitraz at weekly intervals from day 0 through day 77

[c] Each animal treated with amitraz on days 0, 14, 28, 35, 49, 63 and 84 for ethical reasons due to heavy tick challenge

TABLE 5 Effect of deltamethrin/amitraz on *Amblyomma hebraeum* infestations on cattle when applied passively using a self-medicating applicator

Trial group[a]	Mean no. of adult ticks on animal by day of trial												
	Day -1	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56	Day 63	Day 70	Day 77	Day 84
Applicator	73.4	24	16.2	9	5.4	6.8	7.6	3.2	3.8	2	4.2	1.6	2.2
Positive control	74.6	12.6	6.2	4	3.6	1.4	1.4	0.8	0.2	6.8	6.6	4.6	3.4
Negative control	86.8	14.4	53.2	4.8	59.4	8.4	1.6	37.8	2.2	43.2	2	8	14.6

[a] Applicator group and positive control group treated with deltamethrin/amitraz at weekly intervals from day 0 through day 77; negative control group treated with amitraz on days 0, 14, 28, 35, 49, 63 and 84 for ethical reasons due to heavy tick challenge

TABLE 6 Effect of deltamethrin/amitraz on *Rhipicephalus appendiculatus* infestations on cattle when applied passively using a self-medicating applicator

Trial group[a]	Mean no. of adult ticks on animal by day of trial												
	Day -1	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42	Day 49	Day 56	Day 63	Day 70	Day 77	Day 84
Applicator	363.8	4.8	4.4	13	4.2	27.6	14.4	7.2	9.8	0.4	0.2	0.2	0.6
Positive control	320.6	111.8	84.2	65.2	140.6	22.8	54.6	7.2	3.8	36	11.2	4.4	3.8
Negative control	285.6	248.4	522	109	532.4	148.6	146.6	375.2	60	301.2	21.2	79.4	106.8

[a] Applicator group and positive control group treated with deltamethrin/amitraz at weekly intervals from day 0 through day 77; negative control group treated with amitraz on days 0, 14, 28, 35, 49, 63 and 84 for ethical reasons due to heavy tick challenge

until day 1 post-treatment. The trichostrongyle egg counts were significantly less ($P < 0.02$) in the cattle treated using the applicator than were those in the untreated cattle on days 7, 14 and 21 of the trial.

Insecticidal trial

The eight cattle in the applicator group had a mean infestation of 293.8 horn flies before treatment with cyfluthrin from an applicator. After treatment, the fly counts on these cattle dropped to zero by day 1 post-treatment, remained at zero through day 7, and gradually increased from a mean of 7.0–493.8 during days 14–42 post-treatment (Table 3). The fly counts were significantly less ($P < 0.001$) on the cattle treated using the applicator than on the untreated cattle on days 1 through 35 of the trial.

Acaricidal trial

Control of all tick species

The five cattle in the applicator group had a mean infestation of 456.6 adult ticks before treatment with deltamethrin/amitraz from an applicator, after which their mean adult tick count fell with weekly treatments to 11.6 adult ticks by day 84 of the trial (Table 4). Similarly, the five cattle in the positive control group had a mean infestation of 416.2 adult ticks before treatment with deltamethrin/amitraz pour-on, after which their mean adult tick count fell with weekly treatments to 8.4 adult ticks by day 84 of the trial (Table 4). In contrast, the tick challenge in the negative control group was so heavy that the cattle in this group had to be treated on days 14, 28, 35, 49, 63 and 84 of the trial for ethical reasons. The adult tick counts were significantly less ($P < 0.001$) on both the cattle treated using the applicator and those treated by pour-on than were those for the cattle in the negative control group on days 14, 28, 35, 49, 63 and 84 of the trial. Furthermore, adult tick counts were significantly less ($P < 0.05$) on the cattle treated using the applicator than on those treated by pour-on on days 14, 21 and 42 of the trial.

Control of Amblyomma hebraeum

The five cattle in the applicator group had a mean infestation of 73.4 adult *A. hebraeum* (range 35–114) before treatment with deltamethrin/amitraz from an applicator, after which the mean adult *A. hebraeum* count fell with weekly treatments to 2.2 adult ticks (range 0–5) by day 84 of the trial (Table 5). Similarly, the five cattle in the positive control group had a mean infestation of 74.6 adult *A. hebraeum* (range 47–100) before treatment with deltamethrin/amitraz pour-on after which the mean adult *A. hebraeum* count fell with weekly treatments to 3.4 adult ticks (range 2–5) by day 84 of the trial (Table 5). In contrast, the mean adult *A. hebraeum* count in the negative control group remained high, necessitating treatment with amitraz on days 14, 28, 35, 49, 63 and 84 of the trial for ethical reasons. The adult *A. hebraeum* counts were significantly less ($P < 0.01$) on both the cattle treated using the applicator and those treated by pour-on than were those for the cattle in the negative control group on days 14, 28, 49, 63 and 84 of the trial.

Control of Rhipicephalus appendiculatus

The five cattle in the applicator group had a mean infestation of 363.8 adult *R. appendiculatus* (range 295–430) before treatment with deltamethrin/amitraz from an applicator, after which the mean adult *R. appendiculatus* count fell dramatically with weekly treatments to 0.6 adult ticks (range 0–2) by day 84 of the trial (Table 6). Similarly, the five cattle in the positive control group had a mean infestation of 320.6 adult *R. appendiculatus* (range 229–362) before treatment with deltamethrin/amitraz pour-on, after which the mean adult *R. appendiculatus* count fell with weekly treatments to 3.8 adult ticks (range 0–8) by day 84 of the trial (Table 6). In contrast, tick challenge with *R. appendiculatus* in the negative control group was so heavy that the cattle in the group had to be treated on days 14, 28, 35, 49, 63 and 84 of the trial for ethical reasons. The adult *R. appendiculatus* counts were significantly less ($P < 0.001$) on both the cattle treated using the applicator and those treated by pour-on than on the cattle in the negative control group on days 14, 28, 35, 49, 63 and 84 of the trial. Furthermore, adult *R. appendiculatus* counts were significantly less ($P < 0.05$) on the cattle treated using the applicator than were those for those treated by pour-on on days 7, 14, 21, 28, 42 and 70 of the trial.

DISCUSSION

Since the advent of deer farming in the early part of the last century, it has become apparent that nematode parasites can cause severe disease and death in deer and, when infections are subclinical, they can lead to reduced productivity (Fletcher 1982; Mackintosh, Mason, Manley, Baker & Littlejohn 1985). Control of nematodes has relied on treatment of deer with ivermectin administered by injection, as an oral drench or by topical application (Mackintosh *et al.* 1985; Rehbein & Visser 1997). More recently moxidectin (Waldrup *et al.* 1998) has been the anthelmintic of choice. The administration of anthelmintics to deer requires the use of handling facilities, and it induces stress in the animals and incurs labour costs. These constraints increase the costs of parasite control, result in losses of deer due to stress and/or handling accidents, and limit the frequency of treatments. Use of self-medicating applicators is an alternative delivery method for anthelmintics to deer, and has the advantages of eliminating stress in the deer and of minimizing costs in labour and facilities.

There are numerous reports summarizing the adverse impact of nematodes on the productivity of cattle (Williams 1983; Gibbs & Herd 1986; Craig 1988; Hawkins 1993; Reinemeyer 1994; Clymer 2001; Vercruysse & Claerebout 2001). However, nematode control programmes are often difficult or impossible to implement economically on cattle farms which lack animal handling facilities (Herd 1988). Herd (1988) reviewed new anthelmintic delivery systems, such as medicated feed blocks and water dispensers, designed to simplify worm control in bovines by eliminating the necessity to handle animals or to put them in a crush to deliver the anthelmintic. He pointed out that, if these new delivery systems were to be used, profitable worm control strategies could be introduced to farms where lack of handling facilities had previously prevented any type of control programme. He argued that farmers want fast, simple and easy deworming programmes that involve minimal handling of cattle. Self-medicating applicators could provide such an anthelmintic delivery system for cattle producers.

It is apparent from the cattle trial in Florida, that animals must feed readily from the trough to which the applicator is attached in order to receive an appropriate dose of anthelmintic. Steer no. 109 was unaccustomed to supplemental feeding and did not feed from the trough during the first day of the trial and, consequently, was only partially treated for trichostrongyles. It is recommended, therefore, that animals to be treated using a self-medicating applicator be allowed to acclimatize to feeding from a trough (or whatever receptacle to which the applicator is attached) before treatment commences.

The results of the trial on the cattle ranch in Texas demonstrated that self-medicating applicators can be effective devices for the passive treatment of cattle for fly infestations. Other self-medicating devices have been developed for fly control on cattle. They include dust bags, cable back-rubbers and oilers. Dust bags typically consist of two burlap sacks one inside the other which contain insecticidal dust (Adkins & Seawright 1967). Dust bags are suspended in a place which cattle frequent such as over gate openings, which force the animals to brush against the bags, dispensing the insecticidal dust from the burlap sacks onto their heads and backs. Dust bags require shelter and may be unsatisfactory in humid climates (Foil & Hogsette 1994). Cable back-rubbers consist of a chain or barbed wire suspended between two posts, with the chain or wire wrapped with burlap sacks which are soaked with an insecticidal solution (Rogoff & Moxon 1952) which is typically an insecticide diluted with diesel or mineral oil (Dobson & Peterson 1963). Cattle passing under and contacting the back-rubbers are treated. The oiler consists of a tank containing insecticide which is attached to a post and from which is suspended a rubbing element such as a rope or a mop-like device (Barlow & Surgeoner 1979). When cattle rub the element, small quantities of insecticide are delivered to it, some of which is passed on to the cattle.

The results of the trial on the research farm in South Africa demonstrated that self-medicating applicators can be effective devices for the passive treatment of cattle for tick infestations. Other self-medicating devices have been developed for tick control on animals. They include the Duncan applicator and the '4-poster' device. The Duncan applicator consists of a drum-like base incorporating a feed bin, with an acaricide container on top of a treatment column rising from the centre of the bin (Duncan & Monks 1992). The Duncan applicator has been used to control ticks on eland (*Taurotragus oryx*), African buffaloes (*Syncerus caffer*) and cattle using the acaricide flumethrin (Duncan & Monks 1992; Duncan 1992). The '4-poster' device consists of a central feed bin with a feeding/application station on each side of the bin, each station consisting of one bait port and two vertical pesticide-impregnated application rollers (Pound, Miller, George & Lemeilleur 2000). The '4-poster' device has been tested experimentally in the United States as a passive method for control of ticks on white-tailed deer (*Odocoileus virginianus*) using the acaricide amitraz (Pound, Miller & George 2000).

The results of this and other studies have demonstrated that the concept of passive delivery of treatments to animals using self-medicating applicators has practical potential in the control of gastrointestinal nematodes, flies and ticks. These devices should be of value for parasite control particularly in situations where animals are difficult to handle, such as on game ranches, and where handling facilities are not available due to lack of economic resources. Furthermore, self-medicating applicators provide a method for the control of vectors of diseases of public health importance where the primary hosts of the vectors are wildlife, such as with control of Lyme disease through control of its tick vectors on wild deer.

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