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Efficacy of chlorfenapyr (AC 303630) experimental pour-on and CyLence formulations against naturally acquired louse infestations on cattle in New York

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Abstract

The four chlorfenapyr formulations examined provided 100% control of both the nymphal and adult stages of naturally acquired *Bovicola bovis* (L.) on cattle up to 35 days after application. Treatment with 6 mg chlorfenapyr per kg BW in a 0.12 ml per kg BW formulation was as effective as treatment with CyLence™ (cyfluthrin) in controlling naturally acquired *Solenopotes capillatus* (Enderlein) on cattle for 35 days. Percent reduction was never greater than 90% with any chlorfenapyr application against *Linognathus vituli* (L.). However, percent reduction was greater than 90% with CyLence™ from day 21 through 35. No adverse effects were noted on cattle from any of the chlorfenapyr dosages used.

Keywords: Mallophaga; Anoplura; Cattle biting louse; *Bovicola bovis*; Longnosed cattle louse; *Linognathus vituli*; Little blue cattle louse; *Solenopotes capillatus*

1. Introduction

Cattle in New York are often infested with more than one species of cattle louse. In a previous survey, all New York cattle herds examined were found to be infested with lice, with the predominant species being *Bovicola bovis* (L.) (Geden et al., 1990).

Reduced productivity, anemia, hair loss due to scratching and difficulty in handling are often observed with louse infested animals (Butler, 1985). Gibney et al. (1985) and Cummins and Graham (1982) reported reduced weight gains in cattle supporting heavy louse infestations.

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Chlorfenapyr (AC 303630) is a pro-insecticide that is converted to the toxic form by mixed function oxidizes within the insect (Black et al., 1994). This compound has been found efficacious against several crop pests (Pimprale et al., 1997; Mascarenhas and Boethel, 1997) as well as the horn fly, *Haematobia irritans* (L.) (Sheppard and Joyce, 1998).

The objective of this study was to evaluate the effectiveness of four chlorfenapyr pour-on formulations in controlling natural infestations of lice on cattle.

2. Materials and methods

Forty Hereford-cross cattle naturally infested with cattle lice were purchased from local New York auctions and farms in early November 1998. All animals were double ear-tagged for identification and housed communally with both indoor and outdoor access until day 0 (14th January 1999) at the Cornell University Reed farm. Animals were provided with 13 kg corn silage and 3.5 kg dry hay per head per day and were provided with free choice water and a salt and mineral block throughout the holding period and study.

On day 7, pre-treatment louse counts were performed on all 40 animals. The numbers of *Solenopotes capillatus* (Enderlein) were used to rank the animals from the highest count to the lowest. Four animals were removed from the study; three due to low louse numbers and one for disposition. Based on the *S. capillatus* counts, a randomized complete block design consisting of six blocks with six animals was used to allocate animals into treatment groups. Insecticides evaluated included chlorfenapyr, an experimental compound under investigation by Fort Dodge Animal Health and CyLence^{TM} (Bayer, Kansas City, MO) a newer generation pyrethroid currently available to producers. Details of the treatment groups are presented in Table 1.

Animals were weighed on day 1 (weight range 116.1–220.0 kg) and dosages calculated. Prior to treatment, each animal was individually held in a squeeze chute where abnormal skin observations were noted and recorded. The appropriate chlorfenapyr and CyLence^{TM} formulations were applied to the dorsal mid-line from the poll to the base of the tail. Following treatment, animals were observed for adverse reactions and checked weekly for skin abnormalities.

Table 1
Experimental materials and dosage rates applied to the dorsal mid-line of cattle for controlling cattle lice

Group	Formulation	a.i.[a]	a.i.[a] (%)	Application rate	
				(ml/kg BW[a])	(mg a.i./kg BW[a])
A	AN 0216-28-1	Chlorfenapyr	10.0	0.06	6
B	AN 0216-28-2	Chlorfenapyr	5.0	0.06	3
C	AN 0216-28-3	Chlorfenapyr	2.5	0.12	3
D	AN 0216-28-4	Chlorfenapyr	5.0	0.12	6
E	CyLence^{TM}[b]	Cyfluthrin	1.0	Label rate[c]	Label rate[c]
F	None	None	–	–	–

[a] Active ingredient: a.i. and cattle body weight: BW.
[b] Bayer corporation, lot # 455025.
[c] Cattle with BW $<$ 182 kg received 8 ml and BW between 182 and 363 kg received 16 ml.

The numbers of adult and nymphal lice of each species were recorded for each of the 8 predilection areas (specific locations on cattle that lice frequent) identified by Watson et al. (1997). The location and dimensions of these sites were as follows: topline (5×15 cm), withers (5×15 cm), around right eye (10×15 cm), right cheek (5×10 cm), muzzle (5×25 cm), around left eye (10×15 cm), left cheek (5×10 cm) and dewlap (5×15 cm). Identification to species was consistent with published keys (Matthysse, 1946). Louse counts were performed on the following days with respect to the study: day −7, −1, 7, 14, 21, 28, and 35 where day 0: January 14th, 1999.

Data analyzed included louse counts from pre-treatment day 1 and post-treatment days 7, 14, 21, 28 and 35. Statistical analyses on louse counts were performed separately for each species using total counts (combining adults and nymphs). Louse counts were transformed by a $Y = \log_{10}(\text{count}+1)$ transformation to stabilize the variance prior to statistical analysis.

A combined post-treatment analysis on transformed *B. bovis* and *S. capillatus* count data was conducted using an analysis of variance (ANOVA) procedure with treatment, block, day, treatment by block, and treatment by day terms in the model. The treatment effect was tested against the treatment by block interaction at the 5% level of significance while the treatment by day interaction was tested with the residual error at the 25% level of significance.

If the treatment by day interaction was found to be significant for *B. bovis* or *S. capillatus* counts, a two way ANOVA with treatment and block terms in the model was conducted for each day. The treatment effect was tested with the residual error at the 5% level of significance.

The least square means (LSMeans) of the transformed *B. bovis* and *S. capillatus* counts for each treatment group were obtained for the combined post-treatment days as well as for both pre-treatment days and each post-treatment day separately. The LSMeans were compared among the groups using the two sided unprotected least significant difference (LSD) procedure at the 5% level of significance.

Percent efficacy based on the geometric means was calculated for analyzed post-treatment louse counts, as follows:

$$\%\,\text{Efficacy} = \frac{\text{mean count control group} - \text{mean count treated group}}{\text{mean count control group}} \times 100$$

where the geometric mean was calculated as $\text{Gmean} = 10^{\text{LSMean}} - 1$.

Because animals were allocated to treatment groups based on their *S. capillatus* count, an unequal distribution of *Linognathus vituli* (L.) was observed among the groups. This necessitated a different analysis. Percent reduction based on arithmetic means for *L. vituli* counts was analyzed using a two way ANOVA with treatment and block terms in the model. The treatment effect was tested with the residual error at the 5% level of significance.

The LSMean of *L. vituli* percent reduction for each treatment group was obtained and compared among all post-treatment days using the two sided unprotected LSD procedure at the 5% level of significance. Percent reduction of *L. vituli* counts were computed for each animal as follows:

$$\%\,\text{Reduction} = \frac{\text{pre-treatment (day-1) count} - \text{post-treatment count}}{\text{pre-treatment (day-1) count}} \times 100$$

Table 2
Geometric means and percent efficacy of total (nymphs and adults) *B. bovis* counts following treatment with one of five insecticide formulations applied to the dorsal mid-line of cattle

Day	Untreated	Geometric means[a] (percent efficacy)[b]				
		Chlorfenapyr				CyLence™
		A	B	C	D	E
−1	85.7 (–)	116.0 (–)	51.0 (–)	47.4 (–)	49.0 (–)	134.0 (–)
7	109.4a (–)	1.7b (98.45)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)
14	172.6a (–)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)
21	183.6a (–)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)
28	207.2a (–)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)
35	186.3a (–)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)	0.0b (100.00)

[a] Within a row, geometric means followed by the same letter are not significantly different, $\alpha = 0.05$.
[b] Percent efficacy based on control for that study day.

3. Results and discussion

On day 1, group averages of *S. capillatus* ranged from 429 to 938 lice per animal, *B. bovis* ranged from 55 to 351 lice per animal and *L. vituli* ranged from 34 to 293 lice per animal. Populations of *B. bovis* and *S. capillatus* remained heavy on the untreated animals throughout the study. *L. vituli* populations, although present on all untreated animals throughout the study, declined slightly.

Chlorfenapyr was highly efficacious against the cattle biting louse. Significantly more lice were present on animals in the untreated group than on animals in any of the treated groups at all post-treatment count days (Table 2). *B. bovis* were not observed on chlorfenapyr-treated animals in groups B, C or D or on CyLence™-treated animals at any count day after application, nor on group A cattle following the day 7 count.

On days 14 and 35, animals in the untreated group had significantly higher *S. capillatus* counts compared to animals in all treated groups (Table 3). The lack of significant differences between the untreated group and group C (low a.i. and high volume) on days 7, 21 and 28 may have been the result of both hatching nymphs that were not killed prior to louse counts and lower efficacy of chlorfenapyr. Chlorfenapyr treatments applied to group D, which received the highest rate of active ingredient (a.i.) (6 mg a.i. per kg body weight, BW), was the most efficacious against *S. capillatus*. Group D, which received both the high volume (0.12 ml per kg BW) and high a.i. rate, was not significantly different from the CyLence™ application on any post-treatment day and was significantly better than the other chlorfenapyr groups. These results suggest that to be most effective, chlorfenapyr must be dispensed at both a high volume and high a.i. rate. A high volume application would allow for greater movement of the a.i. across the surface of the animal.

Populations of *L. vituli* in both the untreated and treated groups declined during the study, but infestations on treated groups were not eliminated. Percent reduction in all chlorfenapyr groups was never >90% (Table 4). Percent reduction in the CyLence™-treated group did not reach 90% until day 21. On study days 21 and 35, animals in the untreated group had a

Table 3
Geometric means and percent efficacy of total (nymphs and adults) *S. capillatus* counts following treatment with one of five insecticide formulations applied to the dorsal mid-line of cattle

Day	Untreated	Geometric means[a] (percent efficacy)[b]				
		Chlorfenapyr				CyLence™
		A	B	C	D	E
−1	250.2 (–)	222.0 (–)	224.6 (–)	218.6 (–)	168.3 (–)	303.4 (–)
7	214.0a (–)	44.5bc (79.22)	41.8bc (80.47)	68.6ab (67.94)	37.8bc (82.32)	14.9c (93.05)
14	230.2a (–)	30.6bc (86.69)	23.7bc (89.70)	40.9b (82.23)	5.6d (97.56)	9.5cd (95.87)
21	210.9a (–)	49.4b (76.58)	37.5b (82.22)	82.3ab (60.98)	8.2c (96.13)	4.2c (98.01)
28	193.0a (–)	56.5b (70.74)	46.4b (75.97)	88.2ab (54.31)	8.5c (95.60)	3.3c (98.29)
35	225.5a (–)	47.6b (78.90)	39.8b (82.36)	69.7b (69.08)	7.7c (96.57)	3.0c (98.65)

[a] Within a row, geometric means followed by the same letter are not significantly different, $\alpha = 0.05$.
[b] Percent efficacy based on control for that study day.

significantly smaller percent reduction of *L. vituli* compared to animals in all other treatment groups. On day 28, significantly greater percent reduction was observed in groups B–E than the untreated group.

L. vituli, as reported by Watson et al. (1997), exhibited the least contagious distribution of the four cattle louse species with individuals distributed across the host. However, on day 14 of the current study, a predominant number of *L. vituli* observed on chlorfenapyr treated animals were found on the dewlap region, which is the count area furthest from the treatment site. This post-treatment distribution suggested that the chlorfenapyr formulations applied to these cattle were active against *L. vituli* near the treated areas, but not efficacious at more distal regions. Watson et al. (1997) also reported that *L. vituli* ova were predominantly

Table 4
Arithmetic means and percent reduction of total (nymphs and adults) *L. vituli* counts following treatment with one of five insecticide formulations applied to the dorsal mid-line of cattle

Day	Untreated	Arithmetic means[a] (percent reduction)[b]				
		Chlorfenapyr				CyLence™
		A	B	C	D	E
−1	34.3 (–)	86.0 (–)	63.3 (–)	49.0 (–)	293.3 (–)	106.7 (–)
7	33.8 (–17.33)a	23.7 (–24.15)a	28.0 (59.15)a	23.7 (57.40)a	38.5 (56.14)a	77.3 (61.82)a
14	22.3 (19.74)b	21.7 (51.81)ab	35.7 (18.00)b	27.2 (43.48)ab	50.2 (75.72)a	30.3 (86.06)a
21	30.3 (31.81)b	11.5 (71.13)a	17.3 (73.06)a	22.0 (63.09)a	25.7 (82.63)a	17.5 (92.70)a
28	21.8 (46.53)b	6.2 (72.47)ab	12.8 (84.04)a	15.0 (76.25)a	14.3 (89.62)a	15.3 (93.98)a
35	17.2 (52.57)b	5.5 (87.43)a	12.5 (83.77)a	9.2 (81.64)a	14.3 (87.16)a	10.7 (95.55)a

[a] Within a row, percent reduction values followed by the same letter are not significantly different, $\alpha = 0.05$.
[b] Percent reduction relative to pre-treatment day 1 count. Percent reduction was obtained for each animal at each treatment date and the average for each treatment group presented above. The method of calculation is as follows: percent reduction = (pre-treatment (day-1) count − post-treatment count)/(pre-treatment (day-1) count) × 100.

deposited on the sides, and lower body regions. Apparent egg hatch in combination with reduced concentrations of chlorfenapyr (in time and space) may explain *L. vituli* survival on treated cattle and the resultant low efficacy observed in this study. As discussed previously, a larger pour-on volume or additional a.i. in the formulation may provide acceptable *L. vituli* control.

The increase in *L. vituli* numbers observed on day 14 in the low a.i. rate groups (B and C) are indicative of hatching eggs and an insecticide with reduced efficacy (Table 4). Percent reduction continued even after day 14, indicating that chlorfenapyr continued to be somewhat effective, however, efficacy never exceeded 90%. With many pyrethroid formulations it is necessary to apply a second treatment to cattle to kill nymphs that hatch within 14 days of the initial treatment. Accordingly, a second application of chlorfenapyr 14 days following the first application may have provided >99% control of *L. vituli* and *S. capillatus*.

No abnormal health observations or skin irritations related to treatment were observed during the study.

This study demonstrated that treatment of cattle with any of the chlorfenapyr formulations or CyLence^{TM} provided nearly 100% control of both the nymphal and adult stages of naturally acquired *B. bovis* for 35 days after application. Treatment with the 6 mg chlorfenapyr per kg BW in a 0.12 ml per kg BW formulation was as effective as treatment with CyLence^{TM} in controlling naturally acquired *S. capillatus* on cattle for 35 days. Percent reduction of *L. vituli* following treatment was never greater than 90% with any chlorfenapyr application.

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