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Field Evaluations of Insecticide Modes of Action Classes for Control of Horn Flies in Nebraska

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Figure 1. Cow with over 1,000 horn flies.

Summary with Implications

Insecticides of different Mode of Action (MoA) classes were tested for their ability to reduce horn fly populations on cattle in Nebraska pastures between 2009 and 2016. Macrocyclic lactone products were the most efficacious, reducing horn fly numbers by an average of 93% over ten location years of testing. Organophosphate and pyrethroid MoA products, tested in 7 and 12 location years, reduced fly numbers by 75% and 73%. Classes tested only once were METI (88% reduction) and a combination of organophosphate + pyrethroid (64%).

Introduction

The horn fly, *Haematobia irritans* (L.) (Diptera:Muscidae) is one of the most economically important external parasites of pastured cattle with annual losses estimated at over $1 billion. An estimated $60 million is spent annually to control horn flies. Horn fly feeding cause's dermal irritation, anemia, decreased feed intake leading to reduced weight gains, diminished milk production, and the spread of summer mastitis. Past Nebraska studies have established calf weaning weights were 10 to 20 pounds higher when horn flies were controlled on mother cows. The horn fly can also reduce yearling weights by much as 18 percent. The economic injury level (EIL) for horn flies is 200 flies per animal and is when the economic impact of the pest equals treatment costs. During the summer, horn fly numbers on untreated Nebraska cattle can exceed several thousand (Figure 1).

Horn flies are approximately 3/16" in length and usually found on backs, sides, and poll area of cattle. When daytime temperatures rise above 80° F they can be found on the belly region of cattle. Horn flies, both male and female, acquire more than 30 blood meals per day. After mating, the female will leave the animal to deposit eggs in fresh cattle manure. Eggs hatch within 1 week, and larvae feed and mature in the manure, pupating in the soil beneath the manure pat. Newly emerged horn flies can travel several miles searching for a host. The entire life cycle lasts 10 to 20 days depending upon the weather.

Livestock producers have an array of insecticide application options for managing horn flies on cattle, including dusts, sprays, pour-ons, feed-additives, insecticide impregnated ear tags, and a new delivery system called the Vet Gun.

Insecticide impregnated ear tags were introduced in the late 1970s. During the past 40 years, the active ingredients within the tags have been organophosphate and synthetic pyrethroid classes. In the early 2000s, the macrocyclic lactone class was developed and provided an alternative to organophosphate and synthetic pyrethroid insecticides for horn fly resistance management purposes.

The research reported herein was conducted to evaluate the efficacy of different insecticide mode of action classes against Nebraska horn fly populations.

Procedure

Ear tag and other studies were conducted in west central Nebraska from 2009 through 2016 at five locations (Table 1). Studies normally started during May and June each year and typically concluded in September. Cattle were tagged by University of Nebraska employees or livestock producers and grazed on pastures. Comparisons were made against near-by untreated cattle groups of 15–50 animals. All adult cattle associated with each treatment were provided 2 tags or 1 tag + strip with the exception of PYthon Magnum, (label rate is 1 tag per animal). Cattle were over 6 months of age and all cattle within a pasture received the same treatment. Treatment groups were maintained separately at all times. Herd sizes ranged from 15 to 450 head of cattle.

Table 1. Efficacy of various products and insecticide mode of actions on horn fly populations.

Year	Product	Mode of Action	Average No. Horn Flies per Animal			Study Length (Weeks)	No. herds	Location
			Control herd	Treated herd	Treatment % Reduction [1]			
2009	XP 820 tag	6	255	23	91%	15	1	North Platte area
2010	XP 820 tag	6	356	23	94%	16	1	WCREC[2]
2011	XP 820 tag	6	702	69	90%	16	1	North Platte area
2012	XP 820 tag	6	490	42	91%	12	1	Barta Bros.[3]
2013	XP 820 tag	6	547	52	90%	14	1	WCREC
2015	XP 820 tag + Strip	6	427	49	89%	16	1	WCREC
2016	XP 820 tag	6	1,117	77	93%	9	1	Sutherland
2016	XP 820 Strip + late tag	6	1,117	21	98%	9	1	Sutherland
2016	XP 820 tag + Strip	6	1,117	44	96%	9	1	Sutherland
2016	XP 820 tag + Strip	6	878	66	92%	14	1	GSL[4]
2010	Corathon tag	1B	346	101	71%	16	1	North Platte area
2011	Corathon tag	1B	227	90	60%	15	1	WCREC
2011	Warrior tag	1B	702	317	55%	16	1	North Platte area
2012	Corathon tag (A)	1B	325	167	49%	15	1	WCREC
2012	Corathon tag (B)	1B	490	118	76%	12	2	Barta Bros.
2016	Corathon tag	1B	995	89	91%	10	1	GSL
2016	Warrior tag	1B	849	119	86%	11	1	GSL
2011	Double Barrel VP tag	1B + 3A	702	252	64%	16	1	North Platte area
2015	Tolfenpro tag	21A	561	70	88%	11	1	GSL
2009	PYthon Magnum tag	3A	255	130	49%	15	1	North Platte area
2010	Cy Guard tag	3A	346	105	70%	16	1	North Platte area
2011	PYthon tag	3A	702	130	81%	16	1	North Platte area
2011	PYthon Magnum tag	3A	702	292	58%	16	1	North Platte area
2012	PYthon tag	3A	490	29	94%	11	1	Barta Bros.
2012	PYthon Magnum	3A	490	182	63%	12	1	Barta Bros.
2014	PYthon tag + Strip	3A	371	44	88%	15	1	WCREC
2015	AiM-L VetCaps	3A	578	114	80%	9	1	North Platte area
2015	Permethrin Pour-on	3A	439	119	73%	8	1	North Platte area
2016	AiM-L VetCaps	3A	616	198	68%	12	1	North Platte area
2016	CyLence Ultra tag	3A	995	138	86%	10	1	GSL
2016	PYthon tag + Strip	3A	525	306	42%	15	1	GSL

[1] Insecticide efficacy degrades over time and unless periodically re-applied, control efficacy will decline through the fly season. Thus in general, shorter period studies often appear to perform better than longer period studies.
[2] West Central Research and Extension Center, North Platte, NE.
[3] Barta Brothers Ranch, Rose, NE. [4] Gudmundsen Sandhills Laboratory, Whitman, NE.

Assessment of horn flies per animal in each treatment group was made every 7 days throughout the fly season. Assessments were made using digital photographs of one side of 15 randomly selected animals between the hours of 08:00 and 11:00 AM on each count day. These images were then viewed using a computer imaging program GIMP 2.6.11(GNV Image Manipulation Program). Each count of the 15 images was doubled to express the total number of flies per animal.

All fly count data were log transformed and analysis conducted on this variable. Repeated Measures and Least Square Means in GLIMMIX (*SAS Institute 9.2*) were used to determine effects of treatment and fly population numbers. A P-value ≤ 0.05 was considered significant. Percent reduction in fly numbers relative to the control was calculated for each week by subtracting the treatment mean fly count from the control for that week and dividing the result by the control count.

Table 1 describes products evaluated, Insecticide Resistance Action Committee (IRAC) Mode of Action Group (MoA),

Table 2. Summary of various modes of action classes of insecticides on horn fly populations from 2009 to 2016.

Insecticide Class	Mode of Action[1]	No. Trials [2]	Mean Study Length (Weeks) [3]	Season Average Horn Flies per Animal: Control Herds	Treated Herds	% Reduction in Horn Fly Numbers in Treatment Herds Relative to Control Herds
Macrocyclic lactone	6	10	13	701	47	93%
METI[4]	21A	1	11	561	70	88%
Organophosphate	1B	7	14	562	143	75%
Organophosphate + Pyrethroid	1B + 3A	1	16	702	252	64%
Pyrethroid	3A	14	13	542	149	73%

[1] Mode of action classification (Insecticide Resistance Action Committee, http://www.irac-online.org/modes-of-action/)
[2] May include multiple locations in a year.
[3] Ear tag efficacy naturally declines over time. As a result, shorter period studies may appear to perform better than longer period studies.
[4] Mitochondrial complex III electron transport inhibitor, acaricides and insecticides.

average no. horn flies per animal for treated vs untreated, study length, number of herds, and location tested.

Table 2 summarizes the results from 2009 to 2016 studies. Provided are mean results by insecticide class and mode of action, number of trials, and study length.

Results

2009

PYthon Magnum tags maintained horn fly numbers below the EIL of 200 through 9 weeks of a 15 week study, with a study average of 130 flies (P = .032) providing a 49 percent change in fly numbers compared with 255 flies observed on the untreated herd. The XP 820 ear tags kept fly numbers below the EIL of 200 for the entire 15 week study (P < 0.001) with an overall average of 23 flies per animal equating to a 91 percent change in fly numbers compared to 255 flies on the untreated herd.

2010

Corathon tags suppressed horn fly numbers below the EIL for 12 weeks, with an overall average of 101 flies per animal (P < 0.001) providing a 71 percent change in fly numbers for the 16 week study. Cy Guard ear tags sustained horn fly numbers below the EIL for 15 weeks, with an overall average of 105 flies per animal (P < 0.001) providing a 70 percent change in fly numbers. The XP 820 tags kept horn fly numbers below the EIL for the entire 15 week study. Overall, fly numbers averaged 23 (P < 0.001) per animal for the study, providing a 94 percent change in fly numbers compared to 356 flies an untreated herd.

2011

Horn fly numbers on cattle with Corathon ear tags remained below the EIL for 13 weeks of a 15 week study with horn fly numbers averaging 90 per animal (P < 0.001) compared to 227 flies on the untreated herd.

In a comparative fly tag study at North Platte, 5 different insecticide ear tags were evaluated for 16 weeks. PYthon Magnum tags kept horn fly numbers below the EIL for 7 weeks, with a study average of 29, providing a 58% change in fly numbers. Warrior tags maintained fly numbers below the EIL for 8 weeks with an overall average of 317 flies per animal providing a 54% change in fly numbers. Double Barrel VP maintained fly numbers below the EIL for 8 weeks with an overall average of 252 flies or a 64% change in fly numbers. Horn fly numbers on PYthon treated cattle were kept below the EIL for 13 weeks with an overall average of 130 flies per animal resulting in season-long, 81% reduction in fly numbers. The XP 820 tags held fly numbers below the EIL for 16 weeks with an overall average of 69 or a 90% change in horn fly numbers. There was no significant difference in horn fly numbers (P = 0.06) between PYthon Magnum, Double Barrel VP, and Warrior ear tags, but were significantly different from PYthon and XP 820 ear tags (P < 0.001). There was no significant difference (P > 0.05) in fly numbers between PYthon and XP 820 tags. Horn fly numbers for the untreated herd averaged 702 flies.

2012

Corathon ear tags were evaluated at two locations, North Platte and Barta Brothers. Horn fly numbers on cattle at North Platte exceeded the EIL during week 13 of the 15 week study with study average of 167 flies (P = 0.01) and a 49% change in fly numbers compared to an untreated herd with a study average of 325. Two herds of cattle were treated with Corathon tags at Barta Brothers, and counts recorded. Fly counts were averaged from the two herds and expressed as the overall average. Fly numbers held below the EIL for these herds until week 11 of the 12 week study with a study average of 118 (P = 0.02) and a 76 percent change in fly numbers compared to untreated herds with a study average of 490.

Other Barta Brothers studies evaluated PYthon, PYthon Magnum, and XP 820 treatments. Horn fly numbers were held below the EIL by the PYthon treatment, with an average of 29.4 flies (P < 0.001) and a 94% change in fly numbers for the 11 week study. Horn fly numbers on cattle with the PYthon Magnum treatment exceeded the EIL during week 9, with a study average of 181.5 flies (P = 0.07) and a 63% change in fly numbers. Cattle with the XP 820 treatment had horn fly numbers maintained below the EIL until week 12 of the study. Fly numbers were changed by 91% with a study average of 42.15 flies per animal (P = 0.03) compared to 490.17 flies for the untreated herd. No significant difference in fly numbers was detected between Python and XP 820 ear tags (P = 0.07).

2013

The XP 820 treatment suppressed horn fly numbers below the EIL for the entire 14 week study with an average of 52 flies (P < 0.001) compared to 547 flies for an untreated herd, a 90% change in fly numbers.

2014

Horn fly numbers on cattle treated with PYthon tags and Insecticide Cattle Strips were held below the EIL for the entire 15 week study with an average of 44 flies (P < 0.001) contrasted to an untreated herd with 371 flies, equating to an 88% change in fly numbers.

2015

The XP 820 ear tags and Insecticide Cattle Strips maintained horn fly numbers below the EIL through week 15 of the 16 week study with fly numbers averaging 49 per animal (P < 0.001) compared to 427 flies on an untreated herd resulting in an 89% change in fly numbers.

Horn fly numbers on cattle treated with Tolfenpro tags a new MoA (Table 1) were held below the EIL through the 11 week study. Horn fly numbers averaged 70 flies per animal (P < 0.001) with 88% reduction in fly numbers. Horn fly numbers on a control herd averaged 561 per animal.

Two non-ear tag studies were completed in 2015. Permethrin 1% pour-on applied twice during an 8 week study maintained horn fly numbers below the EIL for an average of 22 days per appliction. Fly numbers averaged 119 flies (P < 0.001) with a 73% change in fly numbers compared to an average of 439 on the untreated herd.

VetGun Aim-L VetCaps applied twice during a 9 week period maintained horn fly numbers below the EIL an average of 24 days, and provided an 80% change in fly numbers with an average of 114 flies (P < 0.001) compared to 578 flies for an untreated herd.

2016

Four different insecticide ear tags were evaluated at GSL: Corathon, CyLence Ultra, Warrior, and XP 820 tags and Insecticide Cattle Strips.

Horn fly numbers on Corathon treated cattle kept fly numbers below the EIL for 10 weeks, with a treatment average of 88 (P < 0.001) a 91% change in fly numbers compared to 955 flies for the untreated herd.

CyLence Ultra ear tags held horn fly numbers below the EIL for 8 weeks, with a treatment average of 138 (P < 0.001) with an 86% change in fly numbers compared with an untreated herd with a mean of 955 for the 10 week study.

Horn fly numbers on Warrior treated cattle kept fly numbers below the EIL for 11 weeks. The treatment average for the 12 week study was 119 (P < 0.001) with an 86% change in fly numbers compared to an average of 849 for an untreated herd.

The XP 820 ear tags and Insecticide Cattle Strips maintained horn fly numbers below the EIL for 13 weeks with an average of 66 flies (P < 0.001) or a 92% reduction in fly numbers for the 14 week study. In contrast, fly numbers on an untreated herd averaged 878.

Cattle at WCREC were treated with PYthon tags and Insecticide Cattle Strips. Horn fly numbers were held below the EIL for just 6 weeks, with a study average of 306 (P < 0.001) and a 41% change in fly numbers compared to an untreated herd with an average of 525 for the 15 week study.

VetGun Aim-L VetCaps applied three times over a 12 week period maintained horn fly numbers below the EIL an average of 15 days, providing a 68% change in fly numbers with an average of 198 flies (P < 0.001) compared to 616 flies for an untreated herd.

A study was designed to evaluate XP 820 tags and Insecticide Cattle Strips on horn fly numbers when applied early to yearling beef heifers. Three different treatments were applied; (1) one tag + one strip, (2) one strip + one tag applied mid-season, and (3) two tags. The initial treatments were applied in early May and the late applied ear tags, in late June. The observations were initiated 6/10/17 and continued weekly until the study was ended. Horn fly numbers for weeks 1 through 4 were not significantly different between the three treatments (P > 0.06) but were significantly different compared with the untreated herd (P < 0.001). During weeks 5 through 9, fly numbers for Treatment 1 (72/animal) were significantly different from Treatment 2 (28 per animal) P = 0.002, but not significantly different from Treatment 3 (114 per animal) P = 0.12. Fly numbers for Treatment 2 were significantly different from Treatment 3 (P < 0.001).

Treatment 1 kept horn fly numbers below the EIL for 9 weeks with an average of 43, a 96% change in fly numbers. Treatment 2 held horn fly numbers below the EIL for 9 weeks with a study average of 21 and a 98% change in fly numbers. Treatment 3 maintained fly horn fly numbers below the EIL for 9 weeks with an average of 77 flies, and a 93% change in fly numbers. Overall, a significant difference in fly numbers existed between Treatments 1 and 2 (P = 0.03) and between Treatments 1 and 3 (P < 0.001). A significant difference in fly numbers existed between Treatment 2 and 3 (P < 0.001). The untreated herd had a study average of 1117 flies. Actual time treatments on the animals were as follows: Treatment 1 and 2, 14 weeks, and Treatment 3, 14 weeks for the Insecticide Cattle Strip and 6 weeks for the ear tag.

An overview of Mode of Action class performance against horn fly populations for years 2009 through 2016 is described in (Table 2). Macrocyclic lactone control products delivered a 93% change in horn fly numbers with an average of 47 flies per animal. A METI control product reduced horn fly numbers by 88% with an average of 70 flies per animal. Organophosphate control products reduced horn fly numbers by 75% with an average of 143 flies per animal. Organophosphate + pyrethroid control products reduced horn fly numbers by 64% with an average of 252 flies per animal. Pyrethroid treatments reduced horn fly numbers by 73% with an average of 149 flies per animal.

Conclusion

Field resistance to organophosphate (MoA 1B) and pyrethroid (MoA 3A) insecticides is widespread in horn fly populations nationally. In Nebraska, concern about potential insecticide resistance and early season loss of control prompted ongoing efficacy trials starting in 2009. Our field efficacy trials show horn fly control from organophosphate and pyrethroid products are not as effective as newer macrocylic lactone and METI ear tags.

In 2015 and even more so in 2016 we received reports of poor horn fly control from Nebraska producers using pyrethroid ear tags. In 2016 two field populations of horn flies were collected and bioassayed for synthetic pyrethroid resistance. Horn flies collected from GSL had a 288x level of resistance to permethrin, and flies collected from WCREC were found to have a 112x level of resistance to permethrin when compared to a susceptible lab strain.

These lines of evidence indicate that effective insecticide resistance management is vital to retain horn fly control in Nebraska. Producers should adopt an annual rotation plan among the three mode of action classes (6, 1B, and 3A) labeled for horn fly control in Nebraska (Table 2).

A frequent complaint about insecticide ear tags and strips is they lose efficacy against fly populations late in the summer. To improve and extend horn fly control through the fly season insecticide ear tags and strips should be applied as late as possible before cattle are turned out to pasture, preferably late May or early June. Field studies conducted during the past 10 years indicate maximum length of acceptable control from insecticide ear tags or strips on horn fly numbers would be 15 to 16 weeks depending on the control product used. Livestock producers who turn their cattle out in early May or earlier with insecticide ear tags will most likely have to re-tag by mid-summer or switch to an alternative horn fly control method for late season control.

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