MANAGEMENT OF HORN FLY RESISTANCE

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INTRODUCTION

Horn flies are the most important insect pest of cattle causing production losses of more than $700 million annually in the United States. The introduction of ear tags containing pyrethroid insecticides in the early 80s provided a highly effective and convenient method of horn fly control. Pyrethroid resistant horn flies, however, were able to establish throughout most of the cattle production areas of the U.S. within a relatively short period of time due to a number of factors including genetic predisposition, reproductive ability of the fly, and reliance of ear tags as the single means of control. Successful management of resistant flies now relies upon integration of biological considerations with correct timing of chemical applications to reduce fly numbers to acceptable levels.

LIFE CYCLE

A knowledge of the horn fly life cycle and understanding of the biology of the fly is needed in preparing strategy for control. The life cycle of the fly is depicted in Figure 1. The fly spends the majority of its adult life on the back of the animal out of reach of the head and tail. The fly feeds on blood 20-40 times daily by puncturing the skin. The female fly leaves the animal for short durations to deposit her eggs on fresh manure. She will usually deposit 20 eggs during each visit and she may lay up to 400 eggs in her lifetime. The eggs hatch in one day or less and the newly hatched larvae crawl into the manure to feed and develop. The larvae molt twice and then proceed to form pupae. Young flies emerge from the pupae and are capable of traveling 5-7 miles in search of cattle. During hot weather the complete cycle from egg to adult can be completed in 10 days. In all but the most southern areas of the United States horn flies overwinter as pupae (a condition known as diapause). These pupae remain in the soil and the flies emerge the following spring.

Throughout most of the United States horn flies are able to produce 5-10 generations per year. Fifteen generations may occur in much of the South and up to 18 generations per year can occur in South Florida. The short generation time and high reproductive potential of this fly contributed to acceleration of insecticide resistance.

Cattle can tolerate up to 200 flies/animal without economic loss. Greater numbers of flies, however, disturb feeding and will decrease weight gain and milk production. Cattle with sustained injurious levels of horn flies have increased heart rate, respiration rate, rectal temperature, and water intake. There are disturbances in the uptake and utilization of nitrogen and elevated blood hormone levels indicative of stress. Studies have shown an effective horn fly control program can provide a 15-30 Lb increased weight gain in stocker calves during a growing season.

HISTORY OF CONTROL

Horn flies were first introduced in Eastern U.S. from Europe along with imported cattle in the late 1800s and within a few years reached California. The practice of using insecticides for horn fly control was started in the 40s with the use of arsenic and DDT. From 1960-1965 there was an expansion in the number of compounds available for control including the use of toxaphene and the organophosphates. Treatment failures attributed to resistance to DDT and were first observed in the 60s. It is now known that the insecticide resistance mechanism the horn fly developed against DDT is similar to the resistance mechanism against pyrethroid insecticides.

The first pyrethroid ear tags containing permethrin and fenvalerate were introduced to the market in the early 80s. Initially, these tags were highly effective and resulted in a dramatic reduction of horn flies. The tags were convenient, required minimal labor and provided control for an entire season. This favorable situation only lasted a couple of years, however, when suspected pyrethroid resistance was first reported from Okeechobee County, FL. where these tags were no longer effective.

RESISTANCE

Horn fly resistance is usually indicated if pyrethroid ear tags fail to reduce horn flies to fewer than 150 flies/animal within 2 weeks of application or if laboratory testing of flies indicates a 50-100 times greater concentration of insecticide is required to kill captured wild flies compared to that needed to kill known susceptible fly strains. Horn fly control failure is not always due to resistance, however. Factors such as inadequate application of insecticide, poor timing, or sudden resurgence of flies may be perceived as resistance.

Pyrethroid resistance is widespread and has been reported from every major cattle producing area in the U.S. and parts of Canada. Pyrethroid resistance has been studied extensively over the past few years and five key points have been identified (Table 1). (1) The rapid development and spread of pyrethroid resistance was predisposed by cross resistance to DDT. (2) Resistance is widespread but not uniform. (3) Particular 'Hot Spots' of resistance may occur in isolated areas. (4) Cross resistance occurs among the pyrethroid insecticides. (5) The resistance mechanisms for pyrethroids are not the same as that of the organophosphate compounds.

Pyrethroid resistance in the horn fly is a complex process that involves three behavioral adaptions. The major mechanism is known as KDR (knock-down resistance). This mechanism involves a modification of the binding site so the nerve of the insect is insensitive to the insecticide. The second mechanism is metabolic resistance, in which the fly is able to produce enzymes that detoxify the insecticide. The third mechanism is behavioral. These flies are able to detect the presence of insecticide and locate along the ventral aspect of the animal to avoid the chemical. These flies are difficult to control since they avoid areas of the cattle where most insecticide is deposited.

The genetic basis for resistance due to KDR is controlled by an incompletely recessive (R) gene (Figure 2). Horn flies consist of homozygous susceptible flies (SS), heterozygous hydrids (RS) and homozygous resistant flies (RR). Initially, most horn flies were homozygous susceptible and the frequency of the R gene in the population was quite low. Use of DDT and pyrethroids increased the frequency of the R gene in the population. As long as the frequency of the R gene is low, flies can be controlled satisfactorily.

The pyrethroids insecticides have a spectrum of activity against the heterozygous population. Higher dosage levels of pyrethroids and/or prolonged exposure of the flies to the insecticide increases the selection pressure for the R gene and the genetic make-up of the fly population will shift toward homozygous resistance (RR) fly population.

Management of resistance involves three considerations (Table 2). Immigration of genetically susceptible flies into a resistant population is needed to breed the susceptible genes back into the population. One of the major criticisms of ear tags is that even when tags are no longer effective in killing heterozygous flies they continue to kill new susceptible flies entering the population. Refugia (i.e. providing the insect a refuge to escape from the insecticide) is a common practice followed during application of insecticides to crops. By not treating some animals in a location the selection pressure is reduced and increases the opportunity to breed susceptible genes back into the fly population. Rotation of chemical classes of insecticide and application methods are of prime importance. Ideally, a different class of insecticides should be used for treatment after several fly generations to shift the resistance mechanisms. Table 3 lists insecticide classes and common chemical names. It is important to rotate between the classes and not just between brand or common names of the insecticides.

MANAGEMENT RECOMMENDATIONS

Two committees composed of Federal, State and Industry horn fly experts have been formed to explore insecticide resistance and to make specific recommendations for fly control. One of these is Insecticide Resistance Action Committee (IRAC) and the other is the Regional Research Committee for Livestock Pest Management (NCR-99).

Seven recommendations have been issued by NCR-99 as suggestions for management of pyrethroid resistant horn flies (Table 4):

1. Do not treat unless fly levels exceed injury levels (200 flies/animal).
2. Separate mature cows from growing calves and lactating cows. Only treat animals that will benefit economically from fly control.
3. Delay control procedures until flies exceed the injury level.
4. Use periodic treatment with sprays, dusts and back rubbers (using organophosphate insecticides).
5. Treat with insect growth regulants (IGRs) or oral larvacides.
6. Late season treatment to reduce overwinter phase.
7. Remove ear tags in the Fall.

SUMMARY

Management of resistant horn flies focuses upon control procedures to reduce the fly population of growing or lactating animals below injurious levels rather than attempts for total pest elimination. Reliance of a single chemical or application method will increase resistance development. Management procedures should include measures to allow genetically susceptible flies to enter the population and refuge areas for flies to escape insecticide to reduce selection pressure for resistance. Strategy should include periodic rotation of different chemical classes of insecticides and application methods.

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Table 1. Pyrethroid Resistance - Key Points
Predisposed By Earlier Insecticide Use (DDT)
Widespread Pattern of Distribution
"Hot Spots" of Resistance In Isolated Areas
Cross Resistance Among Pyrethroids
No Cross Resistance To Organophosphate Insecticides

Table 2. Principal Considerations for Resistance Management
Immigration of Susceptible Flies into the Population
Refuge Areas for the Flies to Escape
Rotation of Chemical Classes and Application Methods

Table 3. Insecticides For Horn Fly Control	
Chemical Class	**Common Names**
Organophosphates	Chlorpyrifos Coumaphos Crotoxyphos Diazinon Dichlorvos (DDVP) Fenthion Malathion Stirophos Tetrachlorvinphos
Pyrethroids	Cypermethrin Fenvalerate Flucythrinate Permethrin
New Generation Pyrethroids	Cyfluthrin Lamda Cyhalothrin
Macrocyclic Lactone Disaccharide	Ivermectin
Insect Growth Regulant (IGR)	Methoprene
Oral Larvacides	Diflubenzuron Phenothiazine Tetrachlorvinphos

Table 4. NCR-99 Recommendations For Resistance Management
Only Treat When Levels Exceed 200 Flies/Animal Separate Adults From Growing Calves Delay Early Spring Treatment Use Periodic Application With Sprays, Dusts and Backrubbers Use IGRs and Oral Larvacides Late Season Treatment Before Diapaus Remove Ear Tags In the Fall

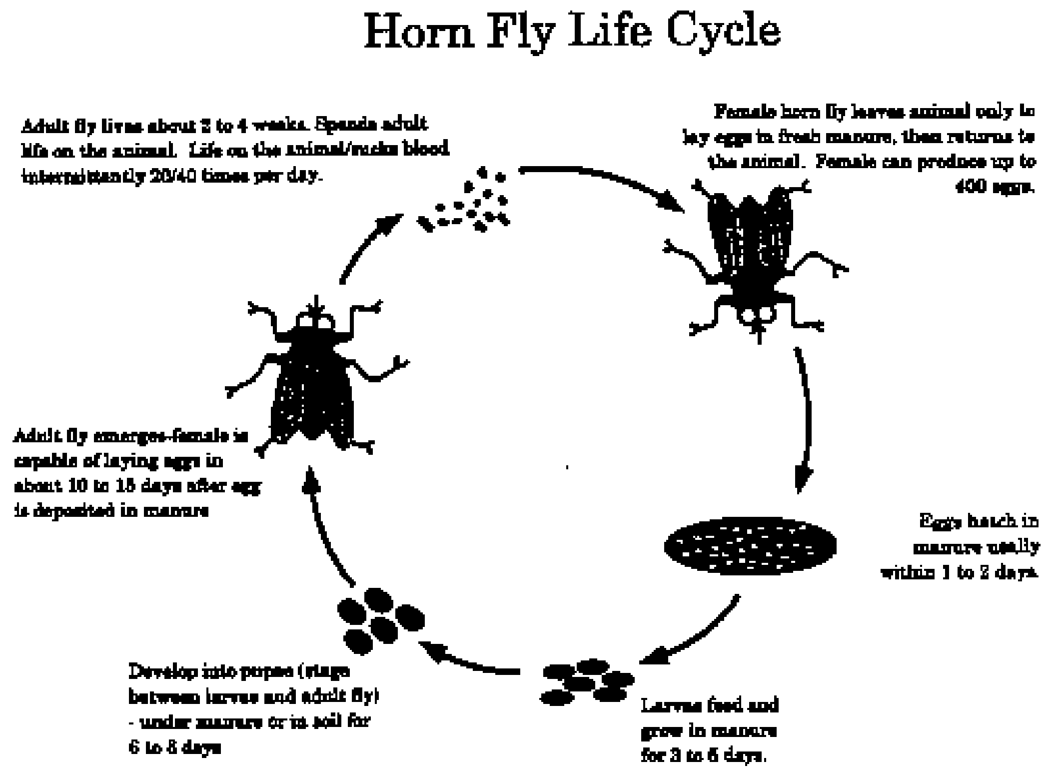

Figure 1. Horn Fly Life Cycle.

. Single Chemical Without Rotation
. Prolong Exposure to the Insecticide
. Increasing Dosage Levels
. All of the Population TREATED

SS	RS	RR
(Homozygous Susceptible)	(Heterozygous Resistant)	(Homozygous Resistant)

. Intermittent Treatments
. Rotation of Chemicals
. Refuge From Exposure
. Immigration of Susceptible Flies

Figure 2. Genetic Basis of Pyrethroid Resistance.