Cow-calf Producers' Willingness to Pay for Bulls Resistant to Horn Flies, *Haematobia irritans* (L.) (Diptera: Muscidae)

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Introduction

Horn flies (*Haematobia irritans* [L.]) can feed more than 30 times per day on cattle, which results in blood loss and exposure to pathogens that may cause disease (Arther 1991). These flies can result in decreases in weight gain, sickness, and reduced profitability. Due to the negative impact of flies on cattle, fly control methods garner significant attention each year.

The most often used tools to manage fly populations include insecticides (e.g., fly tags, sprays, drenches and back rubbers); larvicides and insect growth regulators (IGR) (i.e., feed through products); and mechanical methods (e.g., manure management and fly traps). Research has shown using these tools can result in positive returns to fly control (Campbell 1976; Harvey and Brethour 1979; Haufe 1982, 1986; Kunz et al. 1984; DeRouen et al. 1995, 2003; Sanson et al. 2003). However, limitations to fly control exist in the form of increased labor and, in some cases, resistance to insecticides (Quisenberry et al. 1984; Sheppard 1984; Sparks et al. 1985; Cilek et al. 1991; Byford et al. 1999; Barros et al. 2001). It is possible using these tools will increase production, but at the cost of more labor, resulting in decreased profits due to resistance or high labor costs.

Though there are several common methods to manage and reduce horn fly populations in cattle herds, an alternative proposal has been selecting cattle with horn fly resistance (Brown et al. 1992; Steelman et al. 2003). Several characteristics have been associated with lower fly counts including breed (Steelman et al. 1994; Guglielmone et al. 2000); host color (Schreiber and Campbell 1986); frame size (Steelman et al. 1996); and hair density

(Steelman et al. 1997). Additionally, there is variation of fly counts on individual animals within a breed (Steelman et al. 1991; Steelman et al. 1993; Pruett et al, 2003; Jensen et al. 2004).

With an understanding of the costs associated with managing horn flies in cattle and that some animals carry low populations of horn flies, we examined the question of whether cattle producers would be willing to adopt a horn fly-resistant bull into their herds. More specifically, we examined if cow-calf producers were willing to pay a premium for "horn fly resistant" (HFR) bulls where HFR is the term used for an animal that has lower fly counts compared to other animals in the herd (Pruett et al. 2003; Untalan et al. 2006).

In this publication, we report the survey results of cow-calf producers in Tennessee and Texas regarding their willingness to adopt a hypothetical HFR bull into their herds. This publication is adapted from McKay et al. (2019). In reporting these results, the objective is to inform cow-calf producers and seed stock producers of the factors that influence a producer's decision to adopt a HFR bull. Thus, seedstock producers can use this information to determine if it is worth breeding for the HFR characteristic, while commercial cow-calf producers can use the information to make informed purchasing decisions, if the trait becomes available.

Survey Design

An email for an online Qualtrics survey was sent to cattle producers participating in the Tennessee Agricultural Enhancement Program (TAEP) and to members of the Texas and Southwestern Cattle Raisers Association (TSCRA) in 2017. The response rate was 11 percent (464 of the 4,028) and 8 percent (317 of the 3,882) for Tennessee and Texas producers, respectively. Of the 464 Tennessee and 317 Texas survey respondents, 254 Tennessee producers and 119 Texas producers answered all questions.

Producers were informed that HFR was considered to be "an animal with few to minimal horn flies present, noticeable, or feeding on the animal. It also means that other traits producers select for would be unaffected by the addition of the horn fly resistance trait, so that the horn fly-resistant cattle and their current cattle are the same weight and have IDENTICAL muscling, gains, health and other traits." In other words, producers were asked to think of this as a hypothetical situation where they could institute HFR without influencing other traits.

Tennessee producers were presented with a base bull price of $3,000 and asked to select between the base and a HFR bull at one of four prices: $3,000, $3,500, $4,000 or $4,500. Texas producers were presented with a base bull price of $5,000 and asked to select between the base and a HFR bull at one of four prices: $5,000, $5,500, $6,000 or $6,500. Bull prices were based on average market prices and range of prices in Tennessee and western states at the time of the survey (University of Tennessee Bull Test 2017; Gardiner Angus Ranch 2017; Tri-State Livestock News 2017).

The survey was structured such that half of the producers taking the survey received information (information treatment) on the impacts of horn flies, while the other half of survey respondents did not receive this information. This was done to determine how the information about the effects of horn flies on cattle influenced producer preferences for the HRF trait. The information provided included the following:

ABOUT HORN FLIES AND CATTLE

Horn flies are a pest of cattle that inflict painful bites to draw 20 – 30 blood meals per day and have the following effects:

- Animals' defensive behaviors interrupt adequate rest and food consumption.
- Calves protected from horn flies have weaning weights 10 – 50 pounds more than unprotected calves with 200 or more flies.
- Stockers and replacement heifers protected from horn flies have weight 16 to 18 percent above unprotected animals.
- Horn flies can transmit bacteria that cause mastitis.

Results

Survey Descriptive Statistics

Variables and variable definitions analyzed when estimating producer adoption decisions of HFR bulls are available in **Table 1**. Descriptive statistics based on survey results are in **Table 2**. Eighty-one percent of Tennessee respondents and 89 percent of Texas respondents chose the HFR bull over a non-HFR bull (**Table 2**). The average producer education level for Tennessee and Texas was "some college or technical school education." The average *age* of producers completing the survey was 57 (Tennessee) and 62 (Texas) years, while the average age of farmers in the United States (U.S.) is 58 years (United States Department of Agriculture [USDA] National Agricultural Statistics Service [NASS] 2012a). Tennessee respondents reported average earnings of $50,000 to $99,999/year, while Texas producers

Table 1. Names and definitions of variables analyzed when determining willingness to pay for horn fly-resistant bulls

Variable	Description
Dependent Variable	
Horn fly-resistant (HFR) bull	% of respondents choosing the HFR bull
Price and Information Treatment	
HFR Bull Price	HFR bull prices: $3,000, $3,500, $4,000 or $4,500 for Tennessee; $5,000, $5,500, $6,000 and $6,500 for Texas
Information Treatment	1 if the Information Treatment was seen, 0 otherwise
Producer & Farm Demographics	
Education	Highest level of the producer's education [a]
Age	Age of the producer
Income	Level of total household income [b]
Sole Proprietorship	1 if business structure is sole proprietorship, 0 otherwise
Herd Size	Number of animals in the herd (bulls, cows and calves)
Charolais	1 if the producer has Charolais-influenced cattle, 0 otherwise
Angus	1 if the producer has Angus-influenced cattle, 0 otherwise
Texas	1 if the producer was in Texas, 0 otherwise [c]
Current Horn Fly Perceptions & Management Practices	
Horn Fly Intensity	Level of intensity of fly problem on back and withers [d]
Use of Insecticides	1 if the producer applies insecticides (e.g., pour-on) to animals to manage horn flies, 0 otherwise
Use of Ear Tag	1 if the producer uses ear tags to manage horn flies, 0 otherwise
Insecticide Effectiveness	Level of effectiveness of horn fly insecticides today compared to five years ago [e]
Labor is Burdensome	Level of agreement that additional labor needed to address horn flies is burdensome [f]
Extension	1 if the producer gained information about horn flies from Extension services, 0 otherwise
Perceptions of Incorporating Horn Fly Resistance into their Herds	
Expected Weight Gain	Estimated percentage weight gain change given the entire herd were resistant to horn flies
HFR Trait Importance	Assuming HFR was a possible trait, how would you evaluate its importance? [g]

Notes: [a] 1=Less than high school, 2=High school graduate, 3=Some college or technical school/associate's degree, 4=College degree or higher; [b] 1=Less than $10,000, 2=$10,000-$29,999, 3=$30,000-$49,999, 4=$50,000-$99,999, 5=$100,000-$149,999, 6=$150,000-$199,999, 7=$200,000-$249,999, 8=$250,000-$499,999, 9=$500,000 or greater; [c] Only included in the Texas model; [d] 1=No problem, 2=Minor problem, 3=Moderate problem, 4=Serious problem, 5=Very intense problem; [e] 1=Much less, 2=Somewhat less, 3=Slightly less, 4=As effective, 5= Slightly more, 6=Somewhat more, 7=Much more; [f] 1=Strongly disagree, 2=Somewhat disagree, 3=Somewhat agree, 4=Strongly agree; [g] 1=Not important, 2=Slightly important, 3=Moderately important, 4=Very important

Table 2. Dependent and independent variable means (standard deviations) and differences of means for Tennessee and Texas respondents

Variable	Tennessee (n = 254)	Texas (n = 119)	P-Value
Dependent Variable			
HFR Bull	0.81	0.89	0.028
Price and Information Treatment			
HFR Bull Price	3,767.72	5,789.92	0.000
Information Treatment	0.47	0.55	0.067
Producer & Farm Demographics			
Education[a]	3.38	3.61	0.002
Age	57.32	62.31	0.000
Income[b]	4.81	5.87	0.000
Sole Proprietorship	0.81	0.76	2.778
Herd Size	110.99	202.34	0.002
Charolais	0.21	0.14	0.111
Angus	0.87	0.65	0.000
Texas[c]	NA	0.91	NA
Current Horn Fly Perceptions & Management Practices			
Horn Fly Intensity[d]	3.20	3.68	0.000
Use of Insecticides	0.92	0.92	0.814
Use of Ear Tag	0.57	0.39	0.002
Insecticide Effectiveness[e]	4.09	4.20	0.522
Labor is Burdensome[f]	3.22	3.26	0.640
Extension	0.75	0.70	0.316
Perceptions of Incorporating Horn Fly Resistance into their Herds			
Expected Weight Gain	21.26	23.13%	0.217
HFR Trait Importance[g]	3.06	3.24	0.014

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01

Notes: [a] 1=Less than high school, 2=High school graduate, 3=Some college or technical school/associate's degree, 4=College degree or higher; [b]1=Less than $10,000, 2=$10,000-$29,999, 3=$30,000-$49,999, 4=$50,000-$99,999, 5=$100,000-$149,999, 6=$150,000-$199,999, 7=$200,000-$249,999, 8=$250,000-$499,999, 9=$500,000 or greater; [c] Only included in the Texas model; [d] 1=No problem, 2=Minor problem, 3=Moderate problem, 4=Serious problem, 5=Very intense problem; [e] 1=Much less, 2=Somewhat less, 3=Slightly less, 4=As effective, 5= Slightly more, 6=Somewhat more, 7=Much more; [f] 1=Strongly disagree, 2=Somewhat disagree, 3=Somewhat agree, 4=Strongly agree; [g] 1=Not important, 2=Slightly important, 3=Moderately important, 4=Very important

reported average earnings of $100,000 to $149,999/year, and the average U.S. household income for farms is $119,880 (Schnepf 2017). The average herd size for Tennessee and Texas respondents was 111 and 202 head, respectively. These herd sizes are more than double the state averages for beef cattle herds of 47 head in Tennessee and 74 head in Texas (USDA NASS 2012b, 2012c); thus, survey respondents operated larger-than-average cattle farms for their respective states. Fourteen percent of Texas producers and 21 percent of Tennessee producers owned Charolais-influenced cattle. Eighty-seven percent of Tennessee producers and 65 percent of Texas producers owned Angus-influenced cattle. Previous research has noted the lower fly counts on Brahman and Chianina cattle compared to English breeds and other European (Continental) breeds, but the same research has shown Charolais (European) have lower fly pressure than English breeds (Angus and Hereford) (Steelman et al. 1991; Steelman et al. 1994). This same research notes that tremendous variation in fly pressure can exist within a breed.

Producers from both states considered the level of *horn fly intensity* on their cattle a moderate to serious problem. Ninety-two percent of all producers used insecticides (e.g., pour-on, back-rubbers) to manage horn flies, while 57 percent of Tennessee producers and 39 percent of Texas producers used fly tags. Producers from Tennessee and Texas perceived horn fly insecticides "as effective" today as they were five years ago, and they "somewhat agreed" the additional labor needed to address horn flies was burdensome. Seventy-five percent of Tennessee producers and 70 percent of Texas producers received information about horn flies from Extension services.

Tennessee and Texas producers expected a 21 percent and 23 percent increase in cattle weight gains (*expected weight gain*), respectively, if their entire herds were resistant to horn flies. This resulted in producers from both states considering a HFR trait as "moderately important."

HFR Bull Adoption Results

All Tennessee producers who received information about horn flies chose the HFR bull over the non-HFR bull when they were the same price, while 97 percent of producers who did not receive information about horn flies chose the HFR bull over the non-HFR bull (**Figure 1a**). When the non-HFR bull price was $3,000 and information about the impact of horn flies was provided, HFR bulls were chosen 94 percent of the time at $3,500, 64 percent of the time at $4,000, and 53 percent of the time at $4,500. When no information was provided on the impact of horn flies, producers chose the HFR bull 86 percent ($3,500); 87 percent ($4,000); and 64 percent ($4,500) of the time compared to a non-HFR bull priced at $3,000. Results appear counterintuitive with the finding that producers receiving horn fly information adopt the HFR trait at a lower rate than those not receiving information on the impacts of HFR cattle. This may mean producers overestimate the negative impact of horn flies when not receiving the information.

Similar results were found in Texas. Using a base price of $5,000 for a non-HFR bull and comparing it to HFR bulls priced at $5,000, $5,500, $6,000 and $6,500, the producers receiving information about the impacts of horn flies chose the HFR bull 100 percent, 100 percent, 79 percent and 76 percent of the time, respectively. Producers not receiving information about the impacts of horn flies chose the HFR bull 100 percent ($5,000); 92 percent ($5,500); 90 percent ($6,000); and 83 percent ($6,500) of the time compared to purchasing a non-HFR bull for $5,000 (**Figure 1b**).

Factors Influencing HFR Adoption

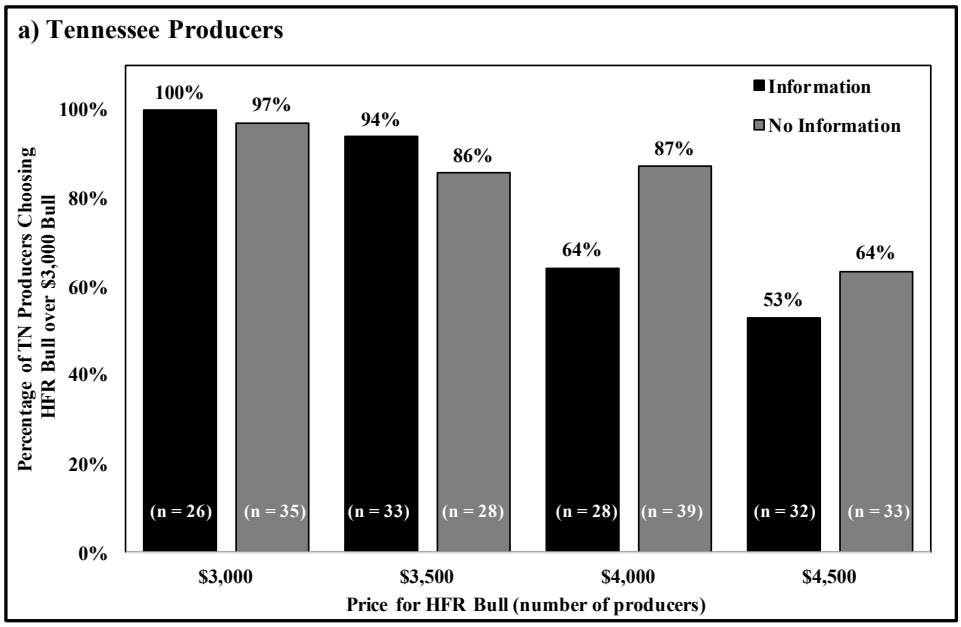
As the *HFR bull price* increased relative to the non-HFR bull price, producers were less likely to purchase the HFR bull (**Table 3**). For each $100 increase in the *HFR bull price*, Tennessee producers were 3 percent and Texas producers were 1 percent less likely to choose the HFR bull.

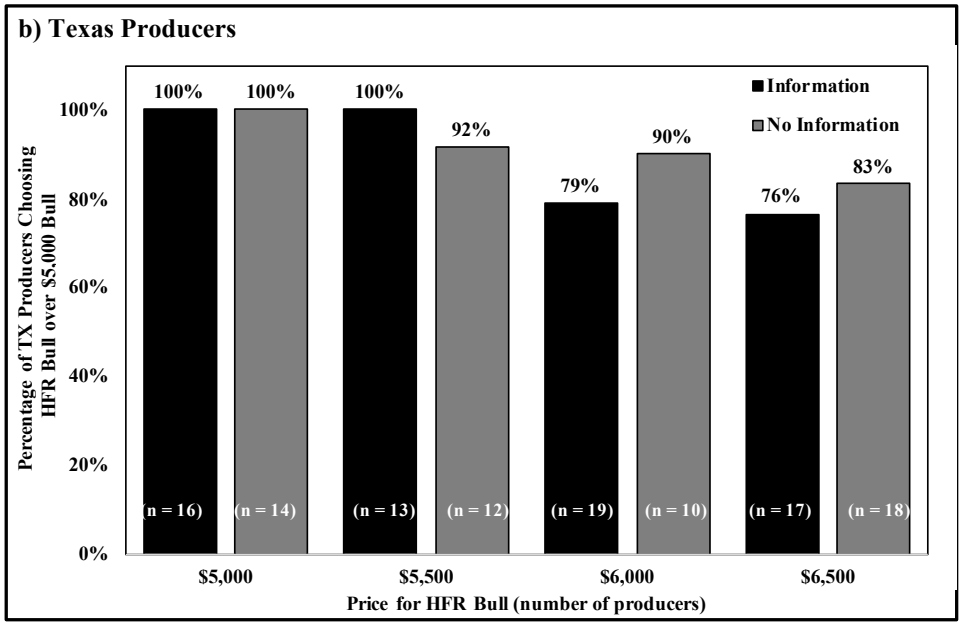
For every one year increase in age for Texas producers, they were 1 percent more likely to choose the HFR bull. The probability of Texas producers choosing a HFR bull increased 3 percent for each increase in household income level. Operations in Texas managed under a sole proprietorship were 9 percent less likely to choose the HFR bull, while respondents with Angus-influenced cattle were 10 percent more likely to choose the HFR bull. As herd size increased by 100 head in Texas, producers were 3 percent more likely to choose the HFR bull. These demographics were not found to be significant for Tennessee producers.

Tennessee producers indicating *horn fly intensity* was more of a problem were 8 percent more likely to choose the HFR bull than those who did not make this distinction. Alternatively, Texas producers indicating that *horn fly intensity* was more of a problem were 5 percent less likely to choose the HFR bull. There is no clear explanation as to why Texas producers who view horn fly intensity as a problem were less likely to choose the HFR bull. Tennessee and Texas producers indicating they *use insecticide* for horn fly management were 12 percent

and 14 percent more likely to choose the HFR bull, respectively. Producers in Texas who *use ear tags* for horn fly management were 12 percent less likely to choose the HFR bull, which may point to the thought that current horn fly management technologies are

Figure 1. Percent of Tennessee (a) and Texas (b) producers who chose a HFR bull over a $3,000 bull in Tennessee and a $5,000 bull in Texas.





Notes: "Information" refers to respondents who saw the Information Treatment, and "No Information" refers to respondents who did not see the Information Treatment.

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Table 3. Factors Impacting the Probability That Tennessee and Texas Cattle Producers Choose a Horn Fly-Resistant Bull. Reported Model Marginal Effects

Variable	Tennessee	Texas
Price and Information Treatment		
HFR Bull Price[a]	-3% ***	-1% ***
Information Treatment	-8% **	2%
Producer & Farm Demographics		
Education	0.1%	-4%
Age[b]	-0.2%	1% ***
Income	2%	3% **
Sole Proprietorship	-2%	-9% *
Herd Size[c]	2%	3% *
Charolais	-7%	1%
Angus	2%	10% **
Texas	NA	-2%
Current Horn Fly Perceptions & Management Practices		
Horn Fly Intensity	8% ***	-5% **
Use of Insecticide	12% **	14% **
Use of Ear Tags	4%	-12% ***
Insecticide Effectiveness	-1% *	0.2%
Labor is Burdensome	-6% **	12% ***
Extension	6%	5%
Perceptions of Incorporating Horn Fly Resistance into Their Herds		
Expected Weight Gain (1 pound)	1% ***	1% ***
HFR Trait Importance	7% **	5% **

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01
[a] Percent change for $100 change in price.
[b] Percent change for one-year change in age.
[c] Percent change for 100-head change in herd size.

adequate in controlling fly pressure. As agreement that *labor is burdensome* in treating horn flies increased, Tennessee producers were 6 percent less likely to choose the HFR bull. Alternatively, as agreement that horn fly management *labor is burdensome* increased, Texas producers became 12 percent more likely to choose the HFR bull. Again, there does not appear to be a good explanation for Tennessee producers to be less likely to choose the HFR bull when labor is considered burdensome.

As *expected weight gain* increased by 1 percent, producers were 1 percent more likely to choose the HFR bull. Tennessee and Texas producers were 7 percent and 5 percent more likely to choose the HFR bull, respectively, as they placed a greater value on *HFR trait importance*.

WTP Estimates

Tennessee producers' average WTP for a HFR bull was $4,652 ($4,621 median), resulting in a $1,652 (59 percent) premium compared to the $3,000 base price for a bull. Similarly, Texas producers' average WTP for a HFR bull was $7,949 ($7,708 median), resulting in a premium of $2,949 (55 percent) compared to the base bull price of $5,000.

Discussion

In general, cow-calf producers from Tennessee and Texas were willing to pay a premium for a HFR bull compared to a non-HFR bull with the same traits. Current producer practices and their perceived impact of horn fly resistance also influenced their decision to adopt a HFR bull.

Texas producers who were older and had greater herd sizes were more likely to choose the HFR bull. This finding may be due to recognizing the need for reduced labor as one gets older and a stated preference for less labor-intensive fly control methods. Texas producers with greater incomes were more likely to choose the HFR bull, which could reflect their greater propensity to pay for the trait or improved genetics in general. Additionally, Texas producers with Angus-influenced cattle were more likely to choose the HFR bull, which is supported by the fact that the Angus breed is not known for horn fly resistance (Steelman et al. 1991).

Tennessee producers indicating that horn fly intensity was more of a problem were more likely to choose the HFR bull. This finding was expected since producers having an observable horn fly problem and/or failing to control horn flies with other measures may be interested in alternative horn fly management. Alternatively, Texas producers were found to have the opposite result, which could be explained by Texas producers finding current control methods effective as compared to previous years.

Texas producers managing horn flies with ear tags were more likely to choose the non-HFR bull. It is possible that producers found the ear tags to be effective at treating horn flies, and thus they had no need for the additional expenses of a HFR bull. The assumption was that producers who considered labor burdensome for horn fly control would choose the HFR bull. However, Tennessee producers were less likely to choose the HFR bull, while Texas producers were more likely to choose the HFR bull. The authors were unable to identify the reason for the divergent views.

Tennessee and Texas producers were willing to pay a premium of $1,652 and $2,949 over the base price, respectively, for a HFR bull. The genetics in a HFR bull would then be passed on to his offspring, impacting the calf crop and replacement heifers, if retained. Fly control technologies including fly tags, sprays, drenches, back rubbers, larvicides and insect growth regulators may range in a direct cash cost of $5 to $8 per head, resulting in an annual cost exceeding $300 for a 40-cow herd. These costs do not include labor costs of fly control application or other associated costs. Additionally, research has determined that cows managed with larvicides weaned 12 to 16 more pounds of calf than cows under no horn fly management system (Campbell 1976; Kunz et al. 1984). Thus, a herd of 40 cows would wean 480 to 640 more pounds per year, resulting in $720 to $960 of additional annual revenue at a calf price of $150 per hundredweight. Thus, assuming $800 of additional revenue and $400 in costs ($300 + $100 for labor), the use of an insecticide to control flies would return $10 per head ([$800 - $400] ÷ 40 head) annually.

The use of a HFR bull may be expected to achieve similar production results as the use of the previously mentioned fly control methods. Thus, the additional annual revenue would be $800 for the 40-cow herd and $3,200 total if the bull is utilized for four years. For Tennessee producers, this would result in an annual return of $387 ([$3,200 - $1,652] ÷ 4 years) or $9.68 per head ($387÷ 40 head) annually. Texas producers' returns are considerably smaller with an annual per calf return of $1.57.

Findings show Tennessee and Texas producers recognize the impact of horn flies, as these producers were utilizing technologies (insecticides) to manage horn fly populations, and they also had a stated preference for a HFR bull. Several findings differed between Tennessee and Texas cow-calf

producers. These differences may be due to differing demographics. Tennessee survey respondents participated in TAEP, which is cost-share program requiring participants to have a minimum of 30 head of cattle and be Beef Quality Assurance certified for the 35 percent cost-share level and participate in the University of Tennessee Extension Advanced Master Beef Producer program to qualify for a 50 percent cost share up to the TAEP program maximum. Thus, TAEP producer and farm demographics may be more similar than those of Texas respondents since TAEP participants attend similar educational opportunities, which influence production, management and marketing decisions.

Conclusion

Economic losses to the cattle industry from horn flies include decreased weight gain, loss in milk productivity, and transmission of bacteria causing mastitis in cattle. In some cases, horn fly control management strategies are labor intensive and can become ineffective due to insecticide resistance. Research has indicated that some cattle herds with genetically similar animals have fewer flies. This may suggest those animals are resistant to horn flies and that the trait is heritable. Results of this study indicate producers are willing to pay a premium for the HFR bull and that producers value the HFR trait. Thus, there may be a market for seedstock producers to breed for the HFR trait and market this to other seedstock producers and commercial cow-calf operations. Additionally, producers looking to purchase this trait should expect to pay more for a sire with this trait. However, it is important to be able to compare the costs of current horn fly management technologies with the additional cost of purchasing the trait in a bull.

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