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Short communication

Distribution of horn flies on individual cows as a percentage of the total horn fly population

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Abstract

Twenty-three mixed-breed herd cows were phenotyped for their ability to serve as a suitable host for *Haematobia irritans*, the horn fly. Based upon consistent observations within the lower quartile or upper quartile of individual fly counts, four cows were phenotyped as low carriers and five cows were phenotyped as high carriers of horn flies. The cows designated as low carriers consistently carried levels of flies below the economic threshold. However, during a period of fly population explosion, low carriers harbored flies well above the economic threshold. Although the number of flies counted on these low carrying cattle increased as the population increased, the relative percentage of the population that they carried changed very little. A hypothesis is proposed to explain this observation, and future studies are suggested.

Keywords: H. irritans; Resistance; Fly distribution

1. Introduction

Haematobia irritans irritans, the horn fly, is an economically important obligate blood-feeding ectoparasite of cattle (Palmer and Bay, 1981). Parasitism of cattle by an economic level of horn flies can result in reduced weaning weight, reduced weight gain as a result of decreased feed efficiency, and decreased milk production (Drummond, 1987; Steelman et al., 1991; Byford et al., 1992). In addition, diminished leather quality can result from intense horn fly feeding (Guglielmone et al., 1999). Therefore, control of the horn fly is a

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major economic problem for producers. Insecticide technology has been exclusively relied upon for economically effective control of this major pest of cattle. However, environmental and food safety concerns regarding insecticides have resulted in an increased interest in the development of novel methods of ectoparasite control.

Variation in the number of flies carried by an individual host has been noted, and the low carrying phenotype can be identified by frequent observation (Steelman et al., 1991, 1993). Because this trait appears to be heritable (Brown et al., 1992), it is suggested that selection of cattle with the low fly carrying trait may offer an alternative to insecticidal control. Donald (1996) suggests that the most sustainable method of parasite control would be selection for resistant animals. Although there is very little experimental information regarding the host immunological response to the horn fly, it is generally considered that cattle do not develop acquired immunological resistance to *H. irritans exigua* (Australian buffalo fly) as a result of repeated exposure (Kerlin and Allingham, 1992). Therefore, the heritable variation in horn fly carrying capacity appears to be the result of innate resistance. In an effort to elucidate the mechanism(s) of innate resistance, we began the process of phenotyping a herd of active cows and their progeny for their capacity to serve as susceptible hosts for the horn fly. We report the initial phenotyping of 23 active herd cows and the observed pattern of horn fly distribution on individual cattle. In consideration of the observed distribution, we offer a plausible explanation and suggest additional research to investigate the validity of the hypothesis.

2. Materials and methods

The data presented represent the phenotyping of 23 active herd cows for horn fly susceptibility during the spring and summer of 2001. Flies were counted once weekly on the same day and same time of day (early morning) for 18 observations by photographing both sides of the cows with digital cameras. Horn fly counts were made from the digital images using Corel Photo-Paint 9 software. Although of mixed-breed, cows were classified as red or black color based upon the predominant coat color.

The weather data presented were collected at the Knipling-Bushland, US Livestock Insects Research Laboratory, in Kerrville, TX. The cows were pastured 10.8 km NNW of the laboratory until DOY (day of year) 181 when they were moved to a pasture 20.6 km NNW of the laboratory, where they remained until completion of the study.

3. Results and discussion

3.1. Dynamics of the horn fly population

The weekly horn fly counts began on 22 May 2001, DOY 142 with 24 cows and 1 bull comprising the herd. A cow, with calf, had to be removed from the herd after the 3 July count (DOY 184), and the bull was removed after 90 days of a breeding cycle on the 2 August count (DOY 213). The horn fly population, the sum of all flies counted on all cows, remained stable at $\leq$4000 flies during the first seven weekly observations. Prior to the seventh observation on 3 July (DOY 184), the cattle were moved to an open pasture with very little brush. The first count after the move indicated a drop in the number of flies (DOY 177, 3443 flies; DOY 184, 2009 flies). However, within a week the horn fly population had increased to >7000 flies. The population peaked at >10,000 flies on 1 August (DOY 213) and began a weekly decline to 3535 flies on 21 August (DOY 233). The first 100 °F day was on 10 July (DOY 191) and the last 100 °F day was on 18 August (DOY 230). During these 40 days the high temperature was ≥100 °F on 25 days (maximum 104 °F, minimum 95 °F), and was ≥100 °F for 11 consecutive days from 20 July through 30 July. No rainfall was recorded from 10 July through 15 August. On 16 August 0.55 in. of rain was reported, and on 19 August another 0.55 in. of rain fell. The horn fly population increased to >30,000 flies on 28 August (DOY 240) following the rains, for a 10-fold increase in population over the preceding week. Rainfall continued until 5 September 2001 totaling an additional 7.37 in. The horn fly population responded with a steady increase to a total number of 53,354 flies on 11 September. The cattle were moved to a fall pasture following the 11 September count, the movement resulted in a decline in the fly count the following observation.

3.2. Median horn fly counts for individual herd cows

Eleven of 13 red cows had median horn fly counts below the lowest black cow (#159 with 206 flies, Table 1). All black cattle ($n = 10$) had median counts >200 flies, while only three of the red cows ($n = 13$) had median counts >200 flies. The red cattle ranged from median

Table 1
Individual cow median, mean (±S.D.), maximum, and minimum horn fly counts for the total observations (Obs.)[a]

Cow no.	Color	Obs.	Median	Mean	S.D.	Max	Min
152	Red	18	134	222.9	269.1	925	17
153	Red	18	205.5	566.1	884.3	2887	29
154	Black	18	221	370.7	482.2	1978	17
155	Red	17	150	428.6	593.5	1960	25
156	Black	17	343	827.9	1067.5	3385	50
157	Red	18	193	510.7	669.8	2548	20
158	Black	16	255	488	561.8	1639	57
159	Black	18	206	568.7	816.6	2755	49
160	Red	18	217.5	491.6	744.8	2601	16
161	Black	16	342	745.9	916.7	3164	95
162	Black	18	464.5	884.7	1032.6	3200	85
163	Black	18	244.5	743.8	1126.1	3936	82
164	Black	18	370.5	771.7	1019.7	3431	68
167	Red	18	146	377.3	522.2	1615	14
168	Red	18	476.5	957.9	1753.9	7547	53
169	Red	18	257	628.1	1253.7	5512	44
171	Red	18	176	506.1	777.3	3038	34
174	Red	18	93.5	315.6	615	2489	11
177	Red	18	75	202.7	276.3	832	4
179	Red	18	125.5	302.7	421.8	1388	19
180	Red	17	93	209.8	272.7	961	13
181	Black	18	475.5	783.8	954.4	4032	96
182	Red	18	112.5	161.3	154.4	562	27

[a] Coat color either red or black determined by predominant color.

counts of 75–476.5 flies, with eight head ≤150. The black cattle had median counts ranging from 206 to 475.5. Red cow #177 had the lowest median count at 75, weekly counts for cow #177 ranged from a low of 1 fly to a high count of 832. Black cow #181 had the greatest median count at 475.5, with weekly counts ranging from 96 to 4032. The highest individual weekly count recorded during the observations was 7547 on red cow #168 (median, 476.5, DOY 254).

3.3. Horn flies on an individual cow as a percentage of the total horn fly population

The mean distribution for horn flies on the 23 cows observed as a percentage of the total population was 4.01% with a rather large standard deviation of 2.73% (Fig. 1). Four red cows carried an average of between 1 and 2% of the population throughout the observation period, with a small standard deviation. Four black cows and 1 red cow carried an average above 6%. The mean% of the population carried ranged from 1.50 (red #177) to 7.86% (black #162). The highest percentage observed at a single observation was 14.15% for red cow #168 (DOY 254).

3.4. Definition of low and high carriers of horn flies

The four red cows that were defined as low carriers of horn flies had mean percentages below 2% (#177, #180, #182, and #174) were frequently observed in the lower quartile of

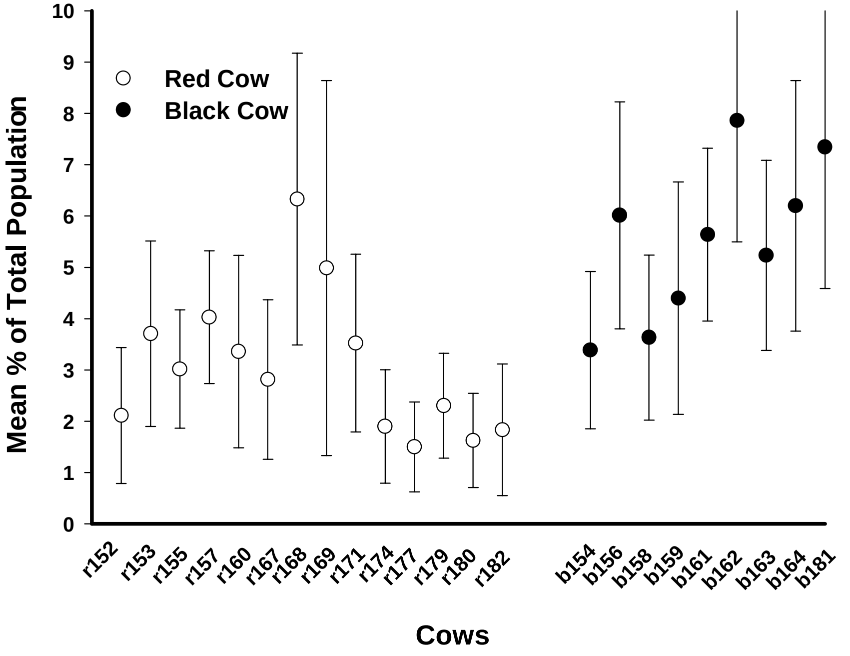

Fig. 1. Horn fly distribution on individual cows presented as a mean percentage of the total population (±S.D.) over 18 weekly observations.

counts, and never had counts in the upper quartile. Cow #177 was in the lower quartile of counts on 14 of 18 observations, cow #180, 13 of 17, cow #182, 14 of 18, and cow #174, 11 of 18. In contrast the five cows (#156, #164, #168, #181, and #162) that were high carriers of horn flies, all black except for red cow #168, had mean percentages above 6% and were frequently observed in the upper quartile of counts and were never observed in the lower quartile. Cow #162 was in the upper quartile of counts on 16 of 18 observations, cow #156, 10 of 17, cow #164, 13 of 18, cow #168, 10 of 18, and cow #181, 11 of 18. The remaining herd cows were most frequently found between the 25th and the 75th percentiles of fly counts.

3.5. Horn fly population size and the number of flies carried by the low carrying phenotype as a percentage of the population

Red cow #177 carried the lowest mean percentage of the total population ($1.50 \pm 0.88\%$). The percentage of the population found on this cow also varied the least. Cow #177 was a host that consistently carried low horn fly numbers, however, when the total population was large in late August following the seasonal rains the number of flies on #177 approached 1000 (825 on DOY 240, and 832 on DOY 254). On DOY 233, cow #177 was host to 81 horn flies (2.29% of the total population), on DOY 240 was host to 825 horn flies (2.66%), and on DOY 247 was host to 832 (1.97%). Although the total population of horn flies increased 10-fold from DOY 233 to DOY 240, and the horn flies on cow #177 also increased 10 times, the % of the population that cow #177 was host to did not change appreciably.

3.6. Hypothesis to explain horn fly distribution on individual cattle

To describe a host as resistant to horn flies, either by innate or acquired immunological mechanisms, implies that the host is capable of defending itself against parasitism by the horn fly. Because horn fly resistant cattle would serve as poor hosts, the horn fly population should also be adversely affected. Previous reports have defined horn fly resistant cattle (Steelman et al., 1993) as those hosts consistently carrying low numbers of horn flies, and have suggested that this heritable trait may be used as a chemical free method of horn fly control (Brown et al., 1992). Although cattle mount an immune response to salivary secretions of the horn fly as a result of natural exposure, those immune effectors appear to be ineffective either at protecting the individual from parasitism or at reducing the horn fly population (Kerlin and Allingham, 1992). Thus, it appears more likely that the trait of carrying low numbers of horn flies is the result of an innate non-immunological mechanism(s). Unequal distribution of horn flies on individual hosts has been attributed to complex sensory physiological keys such as breed differences (Tugwell et al., 1969; Steelman et al., 1993), skin color (Hadwen, 1928; Franks et al., 1964), skin temperature (Morgan, 1964), hair density and sebaceous secretions (Savio et al., 1972; Christensen, 1975; Steelman et al., 1997). If low carrying cattle are simply repellent or less attractive to the fly, then these cattle should carry a low number of flies regardless of the size of the fly population. However, as reported in this study, when environmental and ecological conditions result in an explosion of the horn fly population an economic number of horn flies were found on cattle that were phenotyped as low carriers. Although these low carriers were infested with an economic level of horn flies during the population explosion, they remarkably carried the same relative percentage of the population as when it was low. Simple repellence or lack of attraction of the host are insufficient reasons to explain the observed fly distribution.

However, a plausible hypothesis explaining the observed distribution can be based upon feeding success. Horn flies, males and females, are totally dependent upon mammalian blood as a food source (Harris et al., 1974), and their preferred choice is bovine blood (Kuramochi, 2000). Unlike other transient dipteran blood-feeders they feed intermittently, taking small blood meals throughout the 24 h day (Cupp et al., 1998). Adult horn flies begin to seek a host approximately 1 h after eclosion (Bruce, 1964). They primarily emerge in the afternoon and seek their host between the hours of 3:00 and 6:00 p.m. (Bruce, 1964; Steelman, 1966). Adults would seek a host, based upon sensory physiological keys as mentioned above, and attempt to obtain a blood meal. If they were unsuccessful at obtaining a satisfactory blood meal from their initial host selection it is presumed they would seek another more suitable host. As this experiential host selection process proceeds, the flies would eventually aggregate upon suitable hosts within the herd. In this study, we observed the cows in the early morning, thus it is possible that the host selection process had neared stabilization for the adults that emerged on the previous day. The result of this process would be a stable percentage of flies on low carriers, consisting mainly of newly emerged flies, and an increasing number and percentage of older flies, to a limiting carrying capacity, on the more suitable host.

To sustain life and reproduce, blood-feeding arthropod ectoparasites must overcome host hemostasis to obtain a blood meal. The saliva of lower dipterans like *Simulium* spp. contains a diversity of antihemostatic agents that effect vasodilation, platelet aggregation, and coagulation (Cupp et al., 1998). Ribeiro (1995) suggested that pool-feeding arthropods should rely principally upon anticoagulants, whereas arthropods feeding directly from vessels would need to overcome vasoconstriction and platelet aggregation. The horn fly is a pool feeder, and the saliva contains only a single factor that inhibits coagulation (Cupp et al., 2000). The factor targets the serine protease thrombin in the common coagulation pathway (Cupp et al., 2000), and has been purified and identified as thrombostasin (Zhang et al., 2002). Zhang et al. (2001) determined that considerable polymorphism exists within the thrombostasin gene, and at least five mature active peptides with different molecular masses are encoded. They suggest that the polymorphic forms of thrombostasin indicate that the gene is in a state of adaptation for either biochemical activity, an ideal inhibitor of coagulation, and/or reduced antigenicity, a foreign molecule more host compatible.

4. Conclusions

The hypothesis proposed to explain the horn fly distribution observed in this study is dependent upon the feeding success of the individual horn fly on a particular host. Studies are needed to experimentally test if flies have differential feeding success on the low versus high horn fly carrying hosts. If horn flies have difficulty feeding on low carriers, then are those flies that we observed on them in the experiential process of host selection, or are they flies that possess a variant thrombostasin that is inhibitory for the low carrier thrombin? If they are in the process of host selection, the age-grade of the flies should favor those that are newly emerged. However, if they possess a variant thrombostasin that is an effective inhibitor of low carrier thrombin, then they would find the low carrier a suitable host. This variant thrombostasin gene could possibly increase in frequency within the fly population yielding an adaptation to the low carrier. If a variant thrombostasin is not an effective inhibitor of low carrier thrombin, this result would suggest that there may be differences between individuals and breeds in the thrombin molecule or some other aspect of the coagulation system. To validate the proposed hypothesis, and for the observed natural host resistance defined by the trait of low carrying capacity to be genetically selected for as a viable alternative control method, these questions need to be answered.

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