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SHORT COMMUNICATION

Haematobia irritans parasitism of F1 yak × beef cattle (*Bos grunniens* × *Bos taurus*) hybrids

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Abstract. The horn fly *Haematobia irritans* (Diptera: Muscidae) is a blood obligate ectoparasite of bovids that causes annual losses to the U.S. beef cattle industry of over US$1.75 billion. Climate warming, the anthropogenic dispersion of bovids and the cross-breeding of beef cattle with other bovid species may facilitate novel horn fly–host interactions. In particular, hybridizing yaks [*Bos grunniens* (Artiodactyla: Bovidae)] with beef cows (*Bos taurus*) for heterosis and carcass improvements may increase the exposure of yak × beef hybrids to horn flies. The present paper reports on the collection of digital images of commingled beef heifers ($n = 12$) and F1 yak × beef hybrid bovids (heifers, $n = 7$; steers, $n = 5$) near Laramie, Wyoming (∼ 2200 m a.s.l.) in 2018. The total numbers of horn flies on beef heifers and F1 yak × beef heifers [mean ± standard error (SE): 88 ± 13 and 70 ± 17, respectively] did not differ significantly; however, F1 yak × beef steers had greater total horn fly abundance (mean ± SE: 159 ± 39) than female bovids. The present report of this experiment is the first such report in the literature and suggests that F1 yak × beef bovids are as susceptible as cattle to horn fly parasitism. Therefore, similar monitoring and treatment practices should be adopted by veterinarians, entomologists and producers.

Key words. animal health, host–parasite ecology, integrated pest management, livestock, parasitism, rangeland, steppe.

Introduction

The horn fly, *Haematobia irritans* (L.), also called the buffalo fly, is an ectoparasite of primarily Bovidae species that causes great economic losses globally (Oyarzún *et al*., 2008). Currently, horn flies can be found on cattle and buffalo throughout the Americas, Europe, Asia and regions of Africa. In the U.S.A. alone, horn flies are estimated to cause annual losses to the domestic beef cattle industry of over US$1.75 billion (Swiger & Payne, 2016). Adult horn flies are obligate haematophages, taking 20–30 bloodmeals from bovid hosts daily. The feeding of adult flies on bovid hosts reduces animal performance as a result of blood loss and the physical biting irritation that elicits annoyance behaviour on the part of the host that includes switching of the tail, panniculus reflex, head throwing and foot stomping, all of which cumulatively reduce foraging time and weight gain (Oyarzún *et al*., 2008). Adult females leave the host only long enough to lay their eggs in fresh manure, the material necessary for larval development, and the complete lifecycle ranges from 10 to 20 days (Oyarzún *et al*., 2008). Thus, areas with longer winters and shorter summers will have fewer generations of horn flies than warmer areas.

In temperate climates, most horn flies persist as active adults but may overwinter in a dormant state. In colder climates, horn flies overwinter as pharate adults or die (Kaufman *et al*., 1999; Scasta, 2015). The ability of horn flies to reproduce and

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parasitize bovid hosts is thus generally buffered by elevation (Kaufman *et al*., 1999). Successful prevention methods include a variety of insecticidal applications involving both internal and external deployments, but also require baseline parasitism monitoring, especially for novel hosts and environments (Oyarzún *et al*., 2008; Scasta, 2015).

However, as novel bovid hosts are introduced to new areas such as those of lower elevation, and as the climate warms, new horn fly–host interactions may emerge because elevation (Scasta, 2015) and climate (Scasta *et al*., 2017) are directly related to parasites and parasitism of livestock. Generally, as elevation increases and temperature decreases, the parasite burden on animals declines; in addition, some parasite species may be endemic to particular ranges of elevation. Given recent climate change trends, emergence dates and historical parasite elevation ranges are changing as parasites push into higher elevations (Scasta, 2015; Scasta *et al*., 2017). Livestock producers, wildlife managers and veterinarians must be aware of parasite-related issues and diseases that were previously non-existent in their respective areas, but that may emerge as a result of climate change or the introduction of novel hosts.

One such novel horn fly–host interaction that may be emerging is that between the yak (*Bos grunniens*) and its associated hybrids with cattle. Yaks are bovids that originated in the extensive and high-elevation Qinghai–Tibetan Plateau region of China (Wiener *et al*., 2003). The harsh environmental conditions in places where yaks occur are characterized as being of high altitude (2000–5000 m a.s.l.), above the tree line and without frost-free periods; today, > 13 million yaks live in pastoral cultures in which very few other herbivores can even survive (Barsila *et al*., 2014). Hybridizing yaks with beef cows (*Bos taurus* and *Bos indicus*) yields heterosis that increases milk and meat production in the F1 generation for reliant human populations (Wiener *et al*., 2003; Dong *et al*., 2009).

Although historically yaks have been present in Asiatic regions, human-driven expansion has brought them into new environments in North America, Europe and New Zealand's South Island, and hence yaks have become exposed to lower elevations and more temperate environments (Wiener *et al*., 2003). In addition to the anthropogenic introduction of purebred yaks to new environments, the cross-breeding of beef cattle with yaks in North America is being explored by the University of Wyoming as a strategy to combat brisket disease in mountainous areas and has garnered increasing interest in the U.S.A. (Anand *et al*., 1986). Brisket disease is a medical issue in cattle that stems from cattle exposure to high-altitude conditions and subsequent prolonged hypoxia that causes hyperplasia of the pulmonary arterioles and ultimately hypertrophy of the right ventricle (Holt & Callan, 2007).

Given the animal health and economic consequences of unmanaged horn fly parasitism on bovid hosts, the anthropogenic movement of yaks to lower altitudes and temperate climates, the interest in yak × beef hybrids, and the lack of details about the parasitism of yaks and yak × beef hybrids by horn flies, the present study evaluated black Angus heifers and F1 yak × beef hybrids (heifers and steers) to determine if these bovids are as susceptible as their beef cattle counterparts to horn fly parasitism and if similar assessments and treatments are warranted.

Materials and methods

An initial search of the literature, using Google Scholar and the search terms 'yak horn fly' and 'yak *Haematobia irritans*' was conducted in English-language sources in June 2018. This did not yield any studies quantifying horn fly parasitism of yaks or yak × beef hybrids. Given this lack of information, the study group then evaluated commingled beef heifers ($n = 12$) and F1 yak × beef hybrids (heifers, $n = 7$; steers, $n = 5$) near Laramie, Wyoming (~ 2200 m a.s.l.) in 2018 during a period of peak horn fly parasitism. Beef cows were artificially inseminated to yak bulls to determine if the resulting heterosis would eliminate the pulmonary hypertension seen at high elevations without sacrificing the carcass characteristics of the beef animal. The crossbreeding resulted in phenotypic variation of the two bovid genotypes (beef and F1 yak × beef hybrid) that included solid black individual females of both genotypes, black baldy (white-faced) individual females of both genotypes, solid brindle (tiger-striped) F1 yak × beef hybrid steers and heifers, and brindle baldy (white-faced) F1 yak × beef hybrid steers and heifers (Fig. 1). In a separate project assessing black Angus heifers for horn fly parasitism, the F1 yak × beef hybrids were commingled with the approximately 50 beef heifers for a short period (3 weeks) and the data for this investigation were collected at the end of this period. The animals used in this study were managed according to the guidelines outlined in the Guide for the Care and Use of Agricultural Animals in Research and Teaching (Federation of Animal Science Societies, 1999). Horn fly populations on the 24 commingled bovids were sampled using a high-resolution camera equipped with a 250-mm zoom lens to produce digital images of each individual animal. Images were collected between 07.00 hours and 10.00 hours (Scasta *et al*., 2017). Each image depicted a single bovid that filled the frame, was illuminated by the morning sun (which was at the photographer's back), and included the animal's visual identification ear tag to ensure accurate individual animal identification [methods following Scasta *et al*. (2017)]. Because there were approximately 50 beef heifers, images of as many heifers as possible were collected and a random number generator was then used to select 12 beef heifer images for laboratory analyses in order to provide a sample size equal to that of the F1 yak × beef hybrids, which numbered 12 animals in total. In the laboratory, digital images of the 24 bovids were stratified into six specific body regions for the counting of horn flies, consisting of the head, side, tailhead, brisket, belly and legs. Horn flies were individually counted in each specific body region in the laboratory with the assistance of digital zoom; subsequently, for each animal, the counts for each body region were summed to give a total animal horn fly count. Data were analysed using a generalized linear model with negative binomial distribution and a Type 3 effect test to determine significant differences ($\alpha = 0.05$) attributable to animal genotype for each of the six specific body regions and then for the total animal horn fly count.

Results

The total number of horn flies per individual animal image ranged from 21 to 189 for beef heifers, 86 to 294 for F1

Fig. 1. Phenotypic variation of two bovid genotypes (beef cattle and F1 yak × beef hybrids) sampled for horn fly abundance: (A) solid black beef heifer; (B) black baldy beef heifer; (C) brindle F1 yak × beef hybrid steer; (D) baldy brindle F1 yak × beef hybrid steer; (E) solid black F1 yak × beef hybrid heifer; (F) black baldy F1 yak × beef hybrid heifer. F1 yak × beef hybrid heifers included solid brindle and baldy brindle individuals similar to those in (C) and (A), respectively. [Colour figure can be viewed at wileyonlinelibrary.com].

yak × beef hybrid steers, and 31 to 141 for F1 yak × beef hybrid heifers (Fig. 2A). Mean ± standard error (SE) total numbers of horn flies on beef heifers (88 ± 13) and on F1 yak × beef hybrid heifers (70 ± 17) were significantly lower ($P = 0.03$) than mean ± SE total horn flies on F1 yak × beef hybrid steers (159 ± 39) (Fig. 2B). When numbers of horn flies were analysed by specific body region, F1 yak × beef hybrid steers had more horn flies on the legs ($P = 0.01$) than did the female bovids in the group (Table 1). Numbers of horn flies did not differ significantly ($\alpha = 0.05$) among the remaining body locations (Table 1).

Discussion

The results reported here indicate that F1 yak × beef hybrid bovids are just as susceptible to horn fly infestations as their beef counterparts on the same range. This susceptibility is

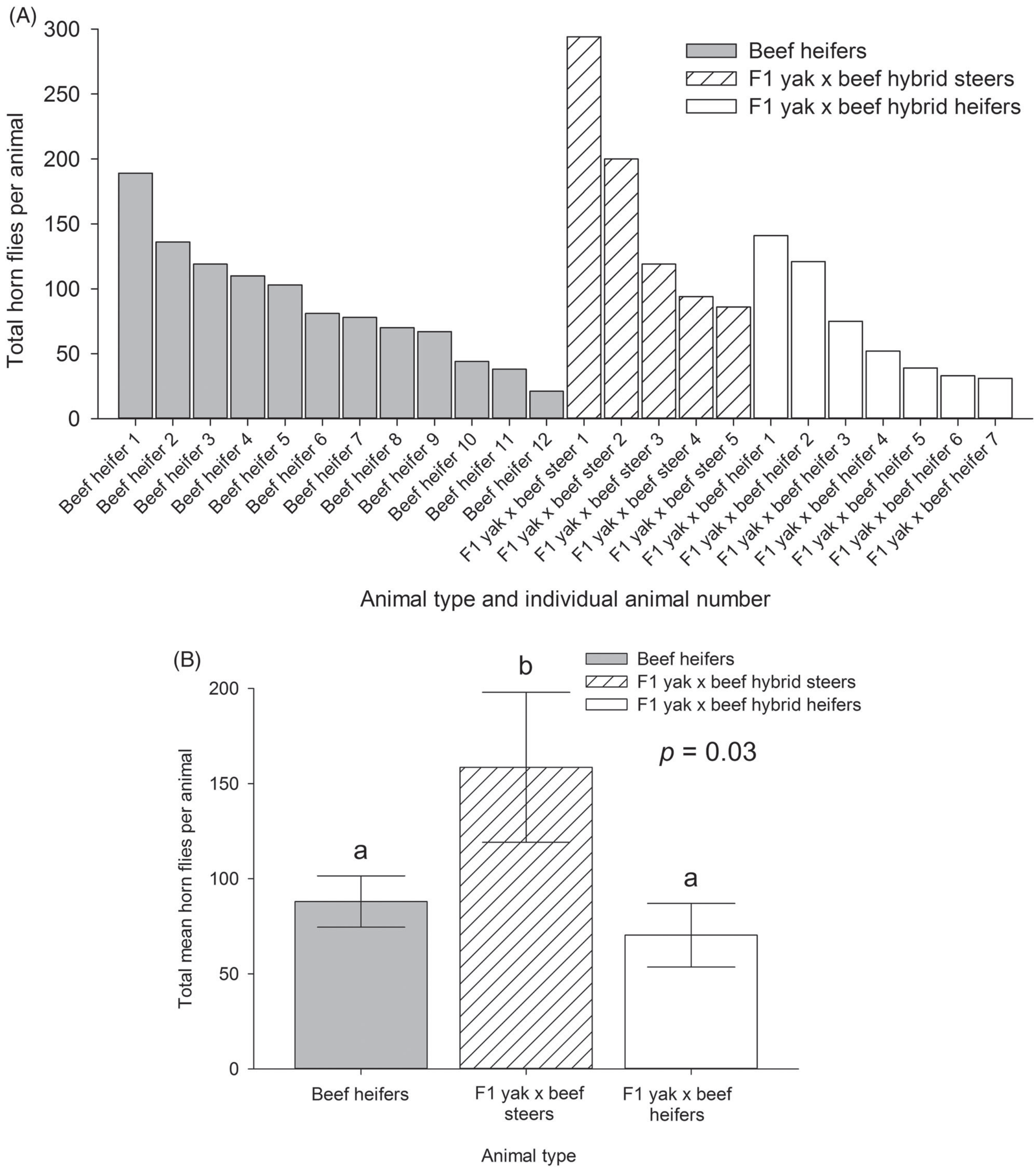

Fig. 2. (A) Individual bovids ranked by horn fly abundance from highest to lowest within respective species and sex classes (beef heifers, F1 yak × beef hybrid steers, and F1 yak × beef hybrid heifers). (B) Mean horn fly per bovid side for respective species and sex classes (beef heifers, F1 yak × beef hybrid steers, F1 yak × beef hybrid heifers). Letters (a, b) indicate significant differences between groups based on a generalized linear model using a negative binomial distribution and a Type 3 effect test to determine significant differences attributed to animal type at $\alpha = 0.05$.

Table 1. Estimates of numbers of horn flies at various locations of bovid bodies.

Body location	Horn flies by animal type, mean ± SE			χ^2-value	*P*-value
	Beef heifer	F1 yak × beef hybrid steer	F1 yak × beef hybrid heifer		
Head	0.8 ± 0.3	1 ± 0.6	1 ± 0.5	0.62	0.75
Side	72 ± 12	118 ± 29	53 ± 12	5.33	0.07
Tailhead	3 ± 2	0.6 ± 0.4	1 ± 0.6	1.70	0.43
Brisket	0.3 ± 0.2	0.2 ± 0.2	0.1 ± 0.1	0.68	0.71
Belly	13 ± 3	29 ± 7	14 ± 5	4.93	0.09
Legs	0.8 ± 0.4	10 ± 7	1 ± 0.6	8.50	0.01
Total body	88 ± 13	159 ± 39	70 ± 17	6.91	0.03

Horn fly data were analysed using a generalized linear model with a negative binomial distributional model and a Type 3 effect test to determine significant differences attributed to animal genotype at $\alpha = 0.05$.
SE, standard error.

important to note in the context of the double coat that is typical of yaks, which includes a coarse outer coat and a finer undercoat (Wiener *et al*., 2003), with the longest outer fur on the head, tail and brisket although such genotypic expression is variable (Fig. 1C–F). In addition, male F1 yak × beef hybrids may have greater numbers of horn flies than female animals as a result of their greater size and differences in their hormonal or carbon dioxide outputs, as is common for beef cattle and other bovids generally (Guglielmone *et al*., 2000; Oyarzún *et al*., 2008). In the context of the present group's review of the published literature, this is the first quantification of horn fly parasitism and risk for parasitism on F1 yak × beef hybrid bovids, and indicates that horn fly parasitism could have negative effects on the growth and production of these novel hosts (Oyarzún *et al*., 2008; Swiger & Payne, 2016). The present authors postulate that the lack of published studies on this topic can be attributed to the fact that yaks and their associated hybrids have historically occupied areas of high elevation and cold climates (Wiener *et al*., 2003). These environmental conditions are less favourable for biting flies than warmer lower elevations and consequently yaks and their associated hybrids are less likely to have been exposed to biting flies. This elevation constraint has been shown for horn flies in the U.S.A., where cattle at the highest elevation (2400 m a.s.l.) had lower horn fly densities than cattle at lower elevations (800 m and 1800 m a.s.l.) and the effects of parasitism never reached the economic threshold considered necessary to warrant treatment (Kaufman *et al*., 1999).

However, as humans disperse yaks to more temperate and low-altitude regions of the world, and as warming trends escalate and parasites expand their ranges in terms of both altitude and latitude, the potential exposure to biting flies can be anticipated to increase (Scasta, 2015; Scasta *et al*., 2017). An awareness of the risk for parasitism of F1 yak × beef hybrids by horn flies is important for practising veterinarians, entomologists and agricultural producers in Europe and North America in order that appropriate monitoring protocols and preventative treatment strategies can be developed, and decisions on interventions made during peak parasitism periods (Oyarzún *et al*., 2008; Swiger & Payne, 2016). Initial assessments such as that reported in this study, like the initial reports by Otranto *et al*. (2006) for *Hypoderma* species (Diptera: Oestridae) in yaks and cattle in China, have similar medical and veterinary applications that are also relevant to the traditional regions of production of yaks and their associated hybrids in Asia (Saravanan *et al*., 2008; Barsila *et al*., 2014; Angell *et al*., 2018).

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The authors declare no conflicts of interest.

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