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Effects of a lone star tick (*Amblyomma americanum*) burden on performance and metabolic indicators in growing beef steers

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ABSTRACT

We examined the response of selected animal performance, endocrine, immune, and metabolic factors from 13 steers (254 ± 6.1 kg) with and without a lone star (*Amblyomma americanum*) tick burden during progressive days of the tick feeding cycle. Steers were randomly assigned to either non-treated controls or treated with 300 adult pair of *A. americanum* per animal. Animals were weighed and blood sampled on days −7, 0, 10, 14, 21, 28, and 35 relative to tick treatment. Tick treatment did not affect ($P < 0.1$) animal performance. Experimental day did ($P < 0.05$) affect body weight gain and dry matter intake. Tick treatment did not affect ($P < 0.1$) metabolic indicators. Experimental day affected ($P < 0.05$) IGF1 and lactate, tended to affect cortisol ($P < 0.07$), but did not affect ($P < 0.1$) glucose concentrations. Tick treatment did not significantly ($P < 0.1$) affect growth hormone receptor (GHR) mRNA in liver, but liver tissue from treated animals had numerically lower GHR mRNA than did tissue from control animals. Day had a significant ($P < 0.05$) effect on liver GHR mRNA. There was a significant treatment by day interaction ($P < 0.05$) for liver IGF1 gene expression, as IGF1 mRNA was reduced in tick-treated cattle versus control cattle on day 35. Overall, liver IGF1 gene expression was lower ($P < 0.05$) in tick than in control animals while there was no effect ($P > 0.1$) due to day. Within the tick-treated group, correlations were found between quantitative female tick feeding characteristics and host metabolic indicators. Feeding by adult female lone star ticks did cause acute stress in growing beef steers on a moderate plane of nutrition as indicated by some physiologic indicators. In particular there may be longer term effects on the somatotrophic axis in the liver which could affect subsequent (i.e. feedlot) performance. It is not known how these observed effects would be manifest under a lower plane of nutrition, as is common and may become more so within the current native range of *A. americanum*. Other acute effects due to tick feeding may have been masked by the effects of handling and invasive sampling. Non-invasive experimental procedures are called for in order to study the effects of a stressor such as arthropod infestation on grazing animals. Future research efforts will be aimed at non-invasively elucidating the effects of tick stress on grazing animals under various nutritional environments.

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1. Introduction

The effects of stress can be harmful to animals. Pioneering work on the concepts and biology of stress by Seyle (1936), synthesized by the studies of Sapolsky (2003) and many others have advanced our understanding of stress and its consequences. Parasites such as ticks are stressors that can cause a reduction in animal well-being and subsequently, economic hardship on the livestock industry (Barnard, 1986; Kivaria, 2006). Ticks have been reported to decrease intake (Seebeck et al., 1971) and weight gain (Barnard, 1985; Williams et al., 1978), as well as increase heart (Willis et al., 1995), or respiration rate (Riley et al., 1995) in cattle. Infestation by ticks incurs a "cost of fitness" and thus impacts the availability or distribution of energy for the host (Sheldon and Verhulst, 1996; Lochmiller and Deerenberg, 2000; Demas, 2004). However, few published studies have examined the effects of tick burden on metabolic indicators such as glucose, insulin-like growth factor 1 (IGF1), or blood urea nitrogen; and or if interactions may occur between metabolism and immune system indicators such as blood protein and leucocytes, or on endocrine factors such as cortisol.

In the livestock industry, acaricide treatments are often administered for tick control opportunistically in conjunction with other routine management procedures without regard to tick life-cycle timing or level of infestation. Although there may be sound logistic reasons for doing so; such treatments are wasteful, ineffective, and if they contribute to the development of drug resistance, are irresponsible. Physiologic and economic thresholds of tick effects on livestock should be developed concurrently with improved non-invasive detection methods in an effort to streamline and target the use of acarcides for economic and environmental reasons. The objective of this study was to determine the response of selected animal performance, endocrine, immune, and metabolic factors from cattle with and without a lone star (*Amblyomma americanum*) tick burden, during progressive days of the tick feeding cycle.

2. Materials and methods

2.1. Tick procedures

Ticks used in this study originated from research and teaching colonies at the Texas A&M University Tick Research Laboratory. Experimental populations of *A. americanum* were established (and subsequently maintained) via progeny of gravid female ticks collected from cattle and horses at the Texas A&M University Sonora Experiment Station in Sutton county Texas, and at the Hill Ranch in Edwards county Texas. This particular colony has been maintained in our facility for >10 years with no clinical signs of pathogens in either ticks or host (authors personal observation). Prior to the study, tick colonies were maintained within separate glass humidity chambers. In these chambers, environmental conditions approximated 20 °C, 90% relative humidity, and a 14:10 L:D photoperiod (Strey et al., 2001). The *A. americanum* female feeding cycle begins with 1–3 days of location and attachment after the original infestation. This is followed by an early feeding period from days 4 to 7 and an intense feeding period from days 7 to 10. By day 10, female engorgement is near completion and drop-off occurs until approximately day 14. Males attach and feed early (days 1–4) then detach and seek females for breeding. An additional period of predominately male feeding extends beyond day 14. The entire feeding cycle for a uniform cohort of ticks is complete by day 21.

Tick exposure was accomplished via the method described in Tolleson et al. (2007). Briefly, ticks were confined within a series of six surgical cotton stockinette cells glued along each animal's top midline from withers to hips using a commercially available adhesive (Nasco Livestock ID Tag Cement, Ft. Atkinson, WI, USA) and secured by twisting the open end of the fabric tightly into a pigtail, held in place with rubber bands. Tick attachment and blood feeding was monitored by daily inspection of each stockinette cell. Count data for the number of engorging (i.e. "non-flat") female ticks were divided into two categories. Those achieving full engorgement prior to drop-off were designated as "replete", and those not fully engorged prior to drop-off were designated as "non-replete". Weights were obtained on the first 30 replete females harvested from each steer. Subjective measurements of host skin sensitivity (range = "0" no visible skin reaction to tick infestation, to "10" = extreme host skin reaction, ticks unable to feed to repletion) and animal reaction/behavior (range = "0" no rubbing/scratching of tick cells observed, to "10" = ticks/cells groomed off due to calf rubbing/scratching activity) were recorded each day.

2.2. Animal procedures

All animal procedures were conducted at the O.D. Butler Jr. Animal Science Complex (College Station, TX), under approval of the Texas A&M University Institutional Animal Care and Use Committee. Thirteen Angus cross-bred steers (9 ± 1 months, 254 ± 6.1 kg) were obtained post weaning from the Texas Department of Criminal Justice. The proportion of *Bos indicus* parentage ranged from 12.5% to 37.5%. All steers were housed outside in groups of 3–6 in concrete-floored pens (6.0 m × 10.0 m) with and fed using Calan Gate® feeders during a 35-day adaptation period. The steers were subsequently housed inside within individual concrete-floored stanchions (1.0 m × 2.5 m) during the 28-day test period. Tick infestation occurred on experimental day 0. Following the test period, steers were returned to the outside pens for an additional 7 days. Steers were individually fed the same cottonseed hull-based diet (14.7 ± 1.0% crude protein, 58 ± 1.2% total digestible nutrients) at approximately 10% over voluntary intake for 35 days prior to tick infestation, then individually fed for 7 days prior to and 21 days after tick infestation. *Ad libitum* water was provided throughout the study. Diet offered and orts were collected and weighed daily to determine intake. Animals were weighed (non-shrunk) on days −35, −7, 0, 10, 14, 21, 28, and 35. All thirteen animals were stratified by weight and pre-test dry matter intake (DMI), then assigned to either a non-tick-treated control, ($N = 6$), or treated with 300 pair of adult *A. americanum*, ($N = 7$), a level of adult *A. americanum* tick burden demonstrated to negatively impact physiological performance in growing