Characterization of the Acute-Phase Protein Response Following Vaccination and Weaning in Beef Steers

R. F. Cooke[1]
D. B. Araujo
J. D. Arthington

Vaccination with One Shot® stimulates a greater inflammatory response in Brahman x British steers compared to UltraBac® 7 and saline control, particularly during the 5 d following vaccination.

Summary

The objectives of this study were to assess the acute-phase protein response of beef steers following vaccination with two different vaccines, and to determine if this response is additive to weaning. Forty-eight Brahman x Angus steers (average age = 7 mo) were randomly assigned to one of six treatments in a 2 x 3 factorial arrangement, including: weaning vs. non-weaning, and vaccination with One Shot® (2 mL), UltraBac® 7 (5 mL), or saline control (5 mL). Blood samples were collected on d 0, 1, 3, 5, 7, 10, 14, and 21, relative to weaning and vaccination, for determination of plasma concentrations of inflammatory acute-phase proteins. During the course of the study, free-choice hay and a grain-based supplement (up to 10 lbs/steer daily) were offered to weaned steers, while non-weaned steers remained with their dams. Weaned steers had greater ($P<0.05$) ceruloplasmin concentrations on d 3, and greater haptoglobin concentrations on d 3 ($P<0.01$) and 5 ($P<0.05$) compared to non-weaned steers. Across weaning treatment, steers administered One Shot® had greater ($P<0.01$) fibrinogen concentrations on d 1, 3, and 5, greater ($P<0.01$) acid soluble protein concentrations on d 3, and greater ($P<0.01$) haptoglobin concentrations on d 1 and 3 compared to steers receiving UltraBac® 7 or saline control. Within weaned steers, those receiving One Shot® had greater ($P<0.05$) mean ceruloplasmin concentrations compared to steers receiving UltraBac® 7 or saline control. Data from this study imply that steers vaccinated with One Shot® experience a greater inflammatory response compared to steers vaccinated with UltraBac® 7 and saline control, and this response mainly occurs during the 5 d following vaccination. Further, additive effects of vaccination on weaning were only detected for plasma ceruloplasmin concentrations.

Introduction

The acute-phase response is a component of the innate body defense, and results in the production of a large and varied group of hepatic proteins (Carroll and Forsberg, 2007). These proteins, denominated acute-phase proteins (APP), are synthesized by the liver parenchymal cells and released into the bloodstream in response to several stressors, including local inflammation, bacterial infections, endotoxin injections, and physical injuries (Carroll and Forsberg, 2007). Recent research from our group indicated that elevated blood APP concentrations are detrimental to growth rates of cattle (Qiu et al., 2007); therefore, recognition of management procedures that stimulate the acute-phase response, and search for alternatives to alleviate APP synthesis will benefit beef cattle productivity.

In Florida's cow-calf operations, stressful practices such as weaning, vaccination, and transportation of calves may occur together or in a short period of time. Weaning and shipping have been shown to stimulate the acute-phase response in cattle (Arthington et al., 2003;

Arthington et al., 2005), whereas administration of vaccines containing adjuvants also increase blood concentrations of APP (Stokka et al., 1994). Therefore, calves vaccinated at weaning could exhibit additive effects on circulating APP concentrations. In addition, this increase may vary depending on the individual vaccine composition.

The objectives of this study was to assess the APP response of beef calves following vaccination with two different types of vaccines, and to determine if this response is additive to the weaning process.

Materials and Methods

Forty-eight Brahman x British crossbred steers were randomly allocated to one of the two weaning treatments: 1) Weaned calves or 2) Non-weaned calves, where weaned calves were separated from dams at the beginning of the study (d 0), whereas non-weaned calves remained with respective dams throughout the entire experimental period, with free access to bahiagrass (*Paspalum notatum)* pasture. Steers were further randomly allocated within weaning treatments, in a 2 x 3 factorial arrangement, to one of the three vaccination treatments: A) One Shot® (2 mL subcutaneous; Pfizer Animal Health, New York, NY), B) UltraBac® 7 (5 mL subcutaneous; Pfizer Animal Health), or C) Saline control (5 ml subcutaneous). Vaccination treatments were also applied on d 0 of the study. For weaned steers, stargrass (*Cynodon nlemfuensis*) hay was offered in amounts to ensure ad libitum intake together with grain-based supplement (72% TDN, 14% CP; DM basis), which was offered up to 10 lbs/steer daily.

Full bodyweight (BW) was obtained on d 0 and at the end of the study (d 21) for average daily gain (ADG) calculation. Blood samples were collected via jugular venipuncture into sodium-heparinized Vacutainer tubes (Beckton Dickinson, Franklin Lakes, NJ) on d 0, 1, 3, 5, 7, 10, 14, and 21 for plasma collection and determination of fibrinogen (Sigma diagnostic procedure n° 880; Sigma Diagnostics, St. Louis, MO), ceruloplasmin (Demetriou et al., 1974), haptoglobin (Makimura and Suzuki, 1982), and acid soluble protein concentrations (ASP; Sigma Diagnostics BCA kit following plasma acid-soluble protein extraction as described by Nakajima et al., 1982).

Data were analyzed using the PROC MIXED procedure of SAS (SAS Inst., Inc., Cary, NC). The model statement contained the effects of weaning treatment, vaccination treatment, d (for plasma APP analysis only), and the consequent interactions. Steer within weaning treatment by vaccination treatment was classified as the random variable. Steer was considered the experimental unit. Results are reported as LS means, and were separated using PDIFF. Pearson correlation coefficients among all APP and ADG were generated using the CORR procedure of SAS. Significance was set at $P \leq 0.05$, and tendencies were determined if $P > 0.05$ and ≤ 0.10. Only significant interactions are reported.

Results

Weaned steers had greater ($P < 0.01$) ADG compared to non-weaned steers (0.94 vs. 0.51 lbs/d, respectively; SEM=0.09). This effect can be attributed to the fact that weaned steers had access to free-choice hay and grain-based supplements, whereas the major source of nutrients for non-weaned steers was low-quality pasture and milk. No effects on ADG were observed among vaccination treatments (Table 1). The present study, however, was mainly designed to evaluate the APP response of both vaccination and weaning treatments, and not growth rates. Steer ADG was calculated using full BW instead of shrunk BW to avoid the addition of another stress source. This, combined to the short duration of the experimental period (21 d), is not adequate to have an acceptable assessment of animal growth. A weaning treatment x day interaction was detected ($P < 0.01$) for ceruloplasmin (Figure 1) and haptoglobin (Figure 2). Weaned steers had greater ($P < 0.05$) ceruloplasmin concentrations on d 3, and greater haptoglobin concentrations d 3 ($P < 0.01$) and d 5 ($P < 0.05$) compared to non-weaned steers. These results support previous data from our research group indicating that the weaning process stimulates the acute-phase response in beef calves (Arthington et al., 2003; Arthington et al., 2005).

Vaccination treatment x day interactions were detected (*P*<0.01), independently of weaning treatment, for fibrinogen, ASP, and haptoglobin analysis. Fibrinogen concentrations were greater (*P*<0.01; Figure 3) for One Shot® vaccinated-steers compared to saline control and Ultra Bac® 7 vaccinated-steers on d 1, 3, and 5, and tended to be greater for One Shot® vaccinated-steers compared to saline control and Ultra Bac® 7 vaccinated-steers on d 7 (*P*=0.06 and 0.10, respectively). Concentrations of ASP were greater (*P*<0.01; Figure 4) for One Shot® vaccinated-steers compared to saline control and Ultra Bac® 7 vaccinated-steers on d 3, and tended to be greater for One Shot® vaccinated-steers compared to saline control and Ultra Bac® 7 vaccinated-steers on d 5 (*P*=0.07 and 0.10, respectively). Haptoglobin concentrations were greater (*P*<0.01; Figure 5) for One Shot® vaccinated-steers compared to saline control and Ultra Bac® 7 vaccinated-steers on d 1 and 3, but greater for Ultra Bac® 7 vaccinated-steers compared to saline control (*P*<0.01) and One Shot® vaccinated-steers (*P*<0.05) on d 5. Within weaned steers only, mean ceruloplasmin concentrations during the study were greater (*P*<0.05) for One Shot® vaccinated-steers compared to saline control or Ultra Bac® 7 vaccinated-steers (Table 1).

Correlation coefficients among concentrations of ceruloplasmin, fibrinogen, ASP, haptoglobin (all pooled across d) and ADG were determined among all steers (n=46) with Pearson correlation coefficient (Table 2). Significant positive correlations were observed among all APP. However, only haptoglobin was significantly correlated with ADG (*P*<0.05; Table 2), and this correlation was positive. Haptoglobin has been negatively associated with ruminal pH (Gozho et al., 2005; Gozho et al., 2006). Since ADG is associated positively with supplement intake (Vizcarra et al., 1998; Lapierre et al., 2000), and supplement intake is negatively correlated with rumen pH (Gozho et al., 2005; Gozho et al., 2006), it can be speculated that steers with greater haptoglobin concentrations were those that consumed more grain-based supplement, and consequently had lower ruminal pH but greater ADG.

In conclusion, data from this study imply that steers vaccinated with One Shot® have greater inflammatory response compared to cohorts vaccinated with UltraBac® 7 or saline control, and this response is mainly observed during the following 5 d after vaccination. Additive effects between vaccination and weaning were only observed for plasma ceruloplasmin concentrations. Furthermore, significant positive correlations were observed among all APP; however none was negatively correlated herein with steer ADG.

Literature Cited

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[1]R. F. Cooke, Former Graduate Student; D. B. Araujo, Graduate Student; J. D. Arrthington, UF-IFAS Range Cattle Research and Education Center, Ona, FL

Table 1. Average daily gain (ADG) and plasma ceruloplasmin concentrations of weaned or non-weaned steers, vaccinated with One Shot®, UltraBac® 7 or saline control [a,b].

	ADG (lbs/d) [c]	Ceruloplasmin (mg/100mL)
Weaned steers		
One Shot®	1.03 ± 0.15 [a]	28.37 ± 1.34 [a]
UltraBac® 7	0.94 ± 0.15 [a]	24.18 ± 1.35 [b]
Saline control	0.85 ± 0.17 [a]	24.49 ± 1.45 [b]
Non-weaned steers		
One Shot®	0.65 ± 0.17 [a]	25.80 ± 1.43 [a]
UltraBac® 7	0.43 ± 0.16 [a]	26.01 ± 1.44 [a]
Saline control	0.43 ± 0.15 [a]	24.13 ± 1.35 [a]

[a] Values reported as mean ± standard error
[b] Within weaning treatment and variable, values with different letters differ ($P < 0.05$)
[c] Calculated using initial (d 0) and final (d 21) full BW

Table 2. Correlations between plasma measurements and ADG of steers [a].

Item	Ceruloplasmin	Acid soluble protein	Haptoglobin	Fibrinogen
Acid soluble protein	0.27			
	0.07			
Haptoglobin	0.45	0.41		
	< 0.01	< 0.01		
Fibrinogen	0.33	0.35	0.52	
	< 0.05	< 0.05	< 0.01	
ADG [b]	- 0.05	0.11	0.31	-0.03
	0.72	0.46	< 0.05	0.81

[a] Upper row = correlation coefficients. Lower row = *P*–values.
[b] Calculated using initial (d 0) and final (d 21) full BW

Figure 1. Plasma ceruloplasmin concentrations of weaned and non-weaned steers. A weaning treatment x day interaction was detected ($P < 0.01$). Daily comparison between weaning treatments; * $P < 0.05$.

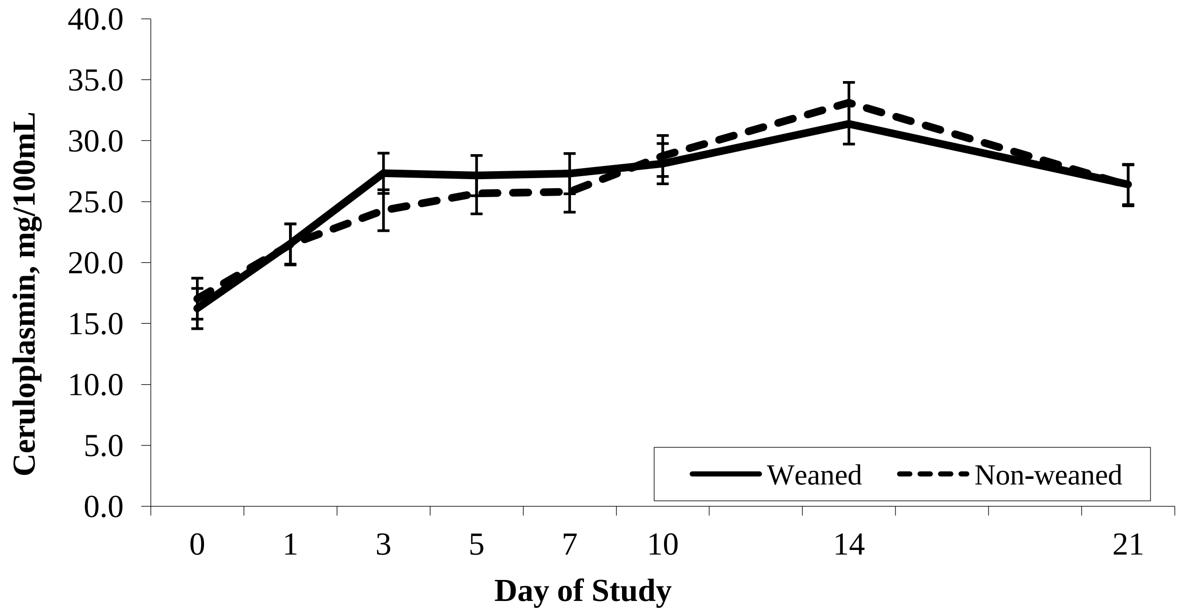

Figure 2. Plasma haptoglobin concentrations of weaned or non-weaned steers. A weaning treatment x day interaction was detected ($P < 0.01$). Daily comparison between weaning treatments; * $P < 0.05$, and ** $P < 0.01$.

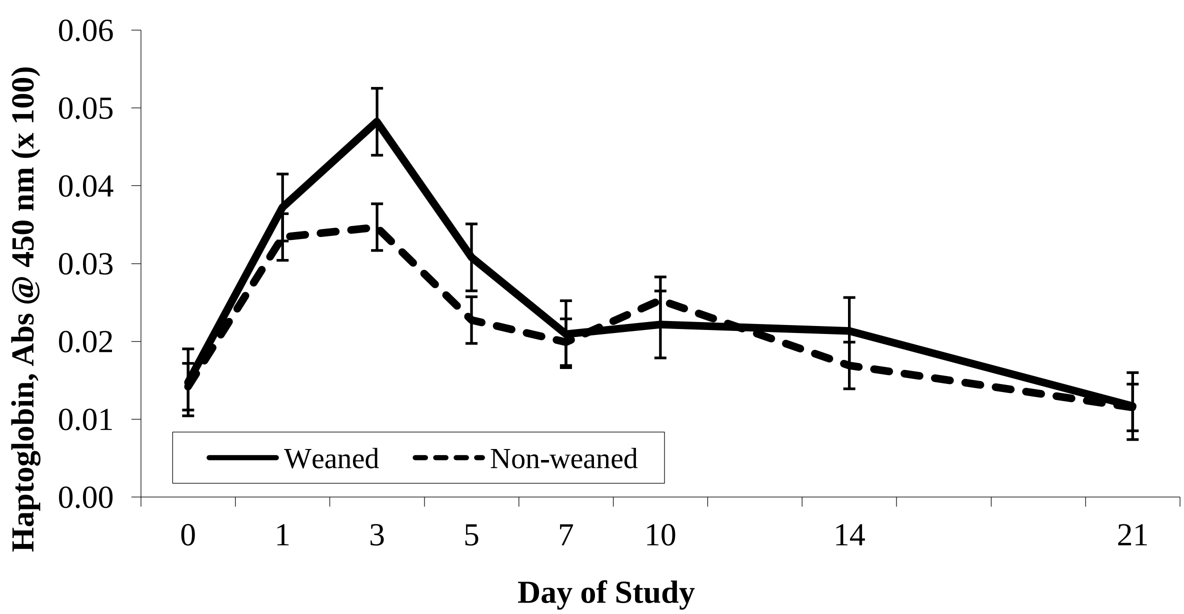

Figure 3. Plasma fibrinogen concentrations of steers vaccinated with One Shot®, UltraBac® 7, or saline control. A vaccination treatment x day interaction was detected ($P < 0.01$). Daily comparison among vaccination treatments: ** One Shot® vs. Ultra Bac® 7 and saline control ($P < 0.01$); † One Shot® vs. Ultra Bac® 7 and saline control ($P = 0.06$ and 0.10, respectively).

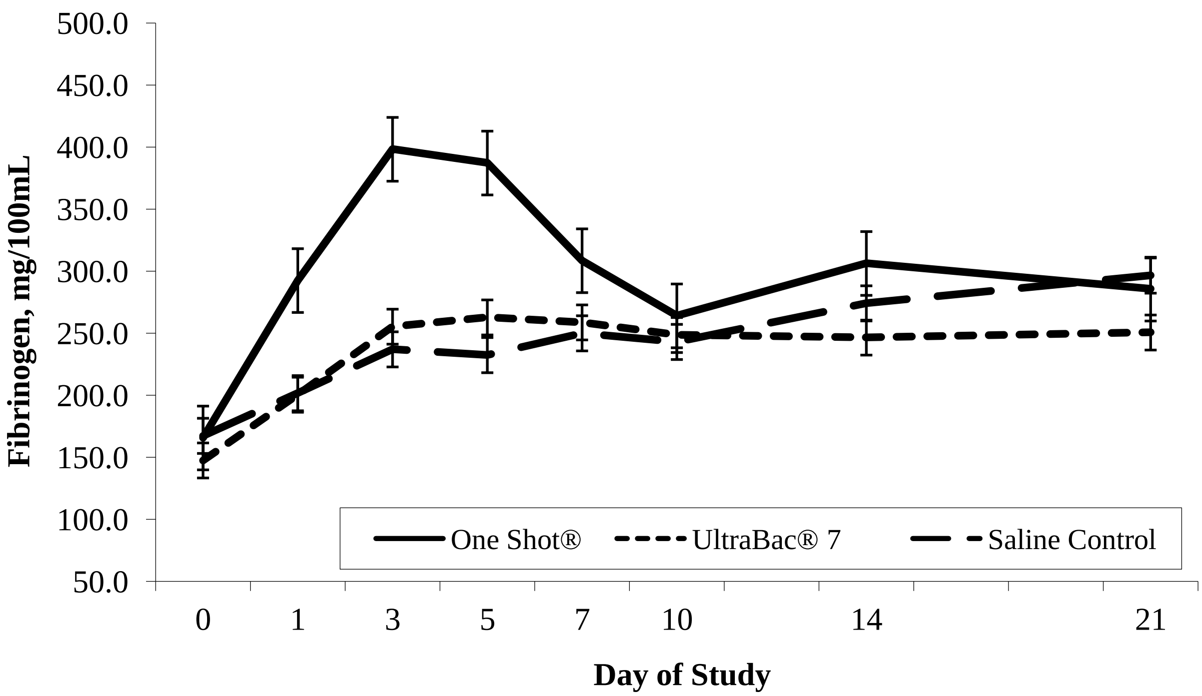

Figure 4. Plasma acid soluble protein concentrations of steers vaccinated with One Shot®, UltraBac® 7, or saline control. A vaccination treatment x day interaction was detected (P < 0.01). Daily comparison among vaccination treatments: ** One Shot® vs. Ultra Bac® 7 and saline control (P < 0.01); † One Shot® vs. Ultra Bac® 7 and saline control (P = 0.07 and 0.10, respectively).

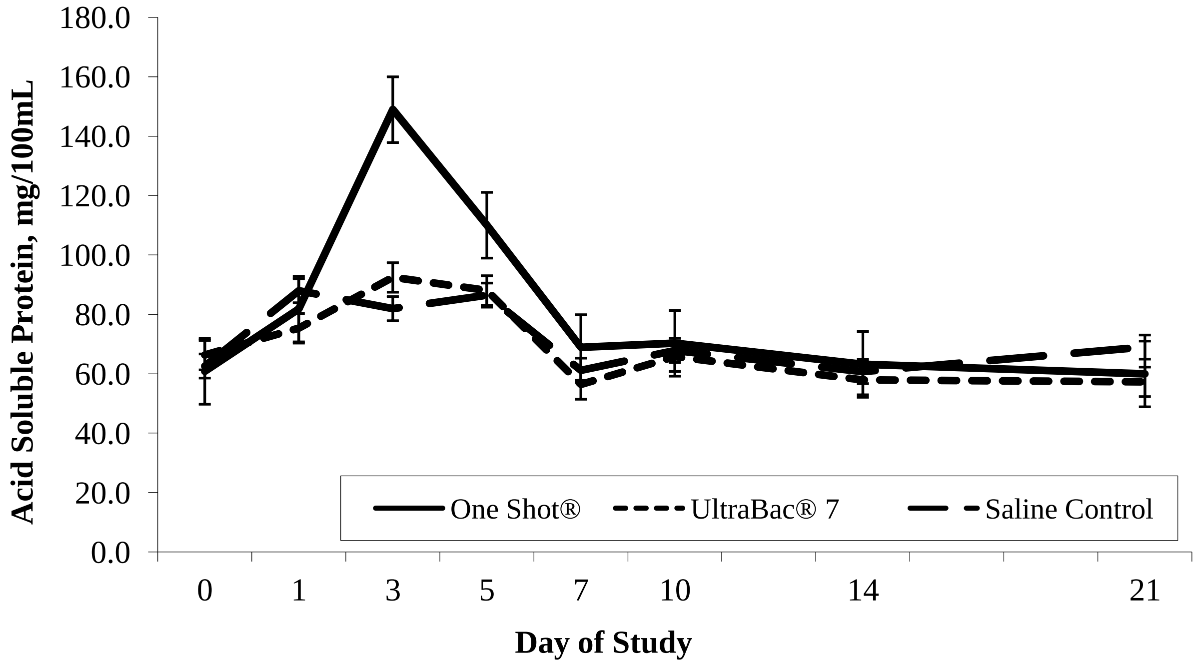

Figure 5. Plasma haptoglobin concentrations of steers vaccinated with One Shot®, UltraBac® 7, or saline control. A vaccination treatment x day interaction was detected (P < 0.01). Daily comparison among vaccination treatments: ** One Shot® vs. Ultra Bac® 7 and saline control (P < 0.01); * Ultra Bac® 7 vs. One Shot® and saline control (P < 0.05 and 0.01, respectively).