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Genetic relationships among temperament, immune function, and carcass merit

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Genetic Relationships Among Temperament, Immune Function, and Carcass Merit in Beef Cattle

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Introduction

Cattle producers historically have selected for docile temperaments simply for management convenience because calmer animals are conducive to safe environments for their peers as well as their handlers. As many producers would acknowledge, there seems to be a relationship between temperament and health, and calmer cattle tend to frequent the working chute for treatment of disease less often.

Positive correlations have been found in cattle between temperament traits (chute scores, pen scores, and chute exit velocities) and cortisol concentration in the blood, suggesting that more excitable cattle are easily stressed (Curley et al., 2006; Cooke et al., 2009). In addition, Curley et al. (2007) found that easily excitable animals sustain elevated cortisol concentrations for a longer duration and had greater pituitary and adrenal responses following a stressor than calm cattle. Temperamental cattle have significantly higher mean temperament responses at all points (Oliphint, 2006). Higher basal serum cortisol concentrations may suggest that easily excitable cattle are chronically stressed (Curley et al., 2007), possibly resulting in a compromised immune system, illness, and decreased fat and protein deposition.

Common measures of cattle temperament are pen scores, chute scores, and exit velocities. Temperament appears to be moderately heritable, with estimates ranging from 0.15 to 0.44 (Burrow and Corbet, 2000; Kadel et al., 2006; Schrode and Hammack, 1971; Stricklin et al., 1980; Fordyce et al., 1988). If genetic correlations are found between temperament and production traits or immunological factors, they may aid cattle breeders in producing profitable cattle. Such relationships have been found between exit velocity and hot carcass weight (r = -0.54), exit velocity and marbling score (r = 0.10), exit velocity and yield grade (r = -0.22) (Nkrumah et al., 2007), and post-weaning weight gain and exit velocity (Weaber et al., 2006). Bovine respiratory disease (BRD) susceptibility has been estimated to be lowly heritable (Muggli-Cockett et al., 1992; Snowder et al., 2005, 2006, 2007; Schneider et al., 2008).

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This study was conducted to further investigate the genetic relationships between cattle temperament measured by chute score and exit velocity, immunological factors, and a range of economically relevant performance traits.

Experimental Procedures

The Colorado State University Animal Care and Use Committee approved all experimental procedures. Crossbred steers were provided by a single-source ranch with three locations in western Nebraska. In Year 1 (2007), 1,551 cattle were provided, and 1,319 cattle were provided in Year 2 (2008). In November of each year, cattle were shipped 333 miles to a commercial feedlot in southeastern Colorado and were processed within two days of arrival to the feedlot. Initial processing included administration of a radio frequency and visual identification tag, an oral and pour-on parasiticide, and implantation of a growth promotant. At this time, a blood sample was taken and weight was recorded. Cattle were not vaccinated in Year 1 so that all animals could be equally challenged; however, 45% of animals experienced BRD. To avoid similar costs in Year 2, cattle were vaccinated for BRD with Pyramid 2 + Type II BVD and Presponse SQ (both from Boehringer Ingelheim, St. Joseph, MO).

Cattle were processed again at the time of re-implantation (~day 74) and a third time at approximately day 140. At both of these processing points, weights of the animals were recorded.

Temperament was assessed using chute score (Grandin, 1993; BIF, 2002) and exit velocity (Burrow et al., 1988) at the first two processing dates. When the steer was restrained in the chute, two evaluators assigned a chute score to the animal. The chute score scale ranges from 1 to 6, where calmer animals were on the lower end of the scale and the most aggressive cattle were at the upper end. The two appraised chute scores were averaged, and chute score was treated as a continuous variable for analysis. Upon release from the chute, the flight time, or the time it takes an animal to cover a defined distance (6 feet), was recorded. Flight time was then converted to exit velocity in units of feet/second.

Cattle were harvested at day 225 on average at JBS Swift and Company plants in Dumas, TX, and Greeley, CO, in Year 1 and 2, respectively. Data recorded at this time included hot carcass weight, calculated yield grade, USDA quality grade, a marbling score, ribeye area, and lung score. Two trained evaluators assigned a lung score of the aggregate lung. Lung scores were based on a scale of 0 to 3, where lower scores indicated less lung damage due to respiratory disease.

Assays were performed using the blood sample taken at the time of feedlot placement to determine cortisol and interleukin-8 (IL-8) concentrations in the blood. Both were measured using commercially available kits. Plasma cortisol was measured using a radioimmunoassay following the manufacturer's protocol (Coat-A-Count; Diagnostic Products, Los Angeles, CA). Interleukin-8 was measured using human ELISA kits that have been previously reported to cross-react with bovine IL-8 (Shuster et al., 1996, 1997; R&D Systems, Inc., Minneapolis, MN).

Heritabilities, genetic correlations, and repeatabilities were estimated with ASREML (Ver. 3.0, VSN International, Ltd., Hemel Hempstead, UK) on 2,871 animal records. The pedigree file included records of 7,177 animals with up to 7 generations. Data were analyzed using a multiple-trait mixed animal model with animal as a random effect to estimate additive genetic merit. Fixed effects were the same as for the phenotypic analysis with the inclusion of permanent environment to determine repeatability estimates for temperament traits.

Results and Discussion

Heritabilities and genetic correlations of blood parameters and temperament traits are shown in Table 1. Cortisol is estimated to be lowly to moderately heritable, and IL-8 seems to be more influenced by genetics, with a heritability estimate of 0.34 ± 0.07 (Table 1). The heritabilities of circulating cortisol and IL-8 concentrations have not been previously reported. Cortisol showed no significant genetic relationship with any of the temperament measures, nor with IL-8. Interleukin 8 had a negative correlation with exit velocity at both time points, suggesting that cattle with genetics to be more temperamental will have genetics for decreased circulating IL-8 concentrations.

Temperament has been previously reported to be moderately heritable (Shrode and Hammack, 1971; Stricklin et al., 1980; Fordyce et al., 1988). Previous heritability estimates for chute score specifically range from 0.15 to 0.30 (Burrow and Corbet, 2000; Kadel et al., 2006), whereas previous heritability estimates for exit velocity range from 0.21 to 0.49 (Burrow and Corbet, 2000; Kadel et al., 2006; Nkrumah et al., 2007; Sant'Anna et al., 2012). The current study has estimates for the heritability of chute score and exit velocity at each of the first two processing times, and all estimates except exit velocity at the time of feedlot placement fall within the respective previously estimated ranges (Table 1). Chute score appraised at the initial processing had a significant genetic correlation with exit velocity at feedlot placement and chute score at re-implantation, but not with exit velocity at re-implantation (Table 1). The chute score from the second processing was genetically correlated with exit velocity at both time points as well (Table 1).

Table 2 shows estimated genetic correlations among temperament, immune function, and carcass traits. Cortisol had a negative genetic correlation with both hot carcass weight and ribeye area, suggesting that cattle exhibiting genetic potential for elevated cortisol levels will have decreased hot carcass weight and ribeye area (Table 2). Interleukin 8 was positively genetically associated with hot carcass weight, marbling score, and yield grade (Table 2). Cortisol had a strong negative genetic relationship with BRD incidence in the feedlot segment, whereas IL-8 had a positive relationship with feedlot BRD incidence (Table 2). This indicates that cattle with genetics for greater cortisol concentrations upon feedlot placement may be inherently less susceptible to BRD, whereas those with genetics for greater IL-8 levels may be genetically predisposed to BRD. No previous literature has reported genetic relationships between carcass or immune traits and IL-8 or cortisol.

Chute score at the time of the first processing had a significant positive genetic correlation with hot carcass weight and bovine respiratory disease (Table 2). Exit velocity measured at the time of re-implantation also had a negative genetic relationship

with hot carcass weight. Similar genetic relationships have been previously reported; Nkrumah et al. (2007) found moderate negative genetic associations between exit velocity and hot carcass weight (r = -0.54). Exit velocity at the time of feedlot placement and chute score at the second processing both had significantly positive correlations with ribeye area (Table 2). Such results might indicate that innately more temperamental cattle will generally have genetics for larger ribeye area. Temperament measures from the second processing point were negatively genetically correlated with marbling score; however, this was not true for temperament measures at the time of feedlot placement (Table 2). Exit velocity has previously been reported to have a genetic correlation with marbling score of 0.10 (Nkrumah et al., 2007). All measures of temperament were negatively genetically associated with yield grade (Table 2).

Exit velocity measured at the first processing date had a positive genetic correlation with lung score, but other measures of temperament did not show similar significant relationships (Table 2). Temperament appraised at the second processing had negative genetic correlations with BRD incidence in the feedlot segment, suggesting that cattle with genetics to be more temperamental by the time of re-implantation will be less inherently susceptible to BRD than their peers.

Implications

Results from this study indicate that blood parameters (with the exception of IL-8) and temperament measures all have negative genetic relationships with BRD susceptibility in beef cattle, and more temperamental cattle do not seem to be inherently more susceptible to BRD incidence in the feedlot segment. Measures of temperament are genetically correlated with one another, and exit velocity is estimated to be more repeatable that chute score. Genetic correlations indicate that cattle with genetic potential to be more aggressive or fearful will have genetics for greater ribeye area, reduced marbling score, and reduced yield grade.

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Table 1. Heritabilities (on diagonal ± SE) and genetic correlations (above diagonal ± SE) among temperament and immune traits in beef cattle

Trait	Cortisol	Interleukin 8	Chute score 1	Chute score 2	Exit velocity 1	Exit velocity 2
Cortisol	**0.23**	-0.01	0.07	0.09	-0.11	0.11
	(0.06)	(0.16)	(0.17)	(0.19)	(0.19)	(0.16)
Interleukin 8		**0.34**	-0.04	-0.08	-0.31	-0.22
		(0.07)	(0.15)	(0.17)	(0.17)	(0.15)
Chute score 1			**0.23**	0.37	0.31	-0.02
			(0.05)	(0.17)	(0.17)	(0.17)
Chute score 2				**0.19**	0.23	0.27
				(0.05)	(0.19)	(0.17)
Exit velocity 1					**0.17**	0.73
					(0.05)	(0.11)
Exit velocity 2						**0.27**
						(0.06)

Table 2. Genetic correlations (± SE) among temperament, immune function, and carcass traits in beef cattle

Trait	Hot carcass weight	Marbling score	Ribeye area	Yield grade	Lung lesion score	Bovine respiratory disease
Cortisol	-0.34	-0.06	-0.19	0.08	0.16	-0.68
	(0.17)	(0.14)	(0.18)	(0.16)	(0.31)	(0.22)
Interleukin 8	0.40	0.35	-0.01	0.37	-0.44	0.35
	(0.15)	(0.11)	(0.16)	(0.14)	(0.32)	(0.20)
Chute score 1	0.18	-0.01	0.39	-0.21	-0.23	-0.01
	(0.17)	(0.13)	(0.18)	(0.16)	(0.33)	(0.22)
Chute score 2	0.05	-0.16	0.28	-0.30	-0.28	-0.60
	(0.20)	(0.15)	(0.20)	(0.17)	(0.35)	(-0.22)
Exit velocity 1	-0.12	-0.01	0.43	-0.46	0.36	-0.09
	(0.19)	(0.15)	(0.19)	(0.16)	(0.34)	(0.24)
Exit velocity 2	-0.24	-0.14	0.17	-0.29	0.16	-0.34
	(0.17)	(0.13)	(0.17)	(0.14)	(0.29)	(0.21)