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GENETIC VARIATION IN GROWTH, HORMONAL AND SEMINAL TRAITS OF YOUNG TROPICALLY ADAPTED BULLS

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SUMMARY

Except for scrotal circumference there is little published information on the genetic variation of traits measured on young tropical breed bulls. The current study assesses growth, hormonal and seminal traits measured in Brahman and tropical Composite bulls (n=2212) from weaning through to 2 years. Heritability of scrotal size (39 to 75%), prepubertal serum concentration of inhibin (40 to 71%) and semen quality traits (19 to 27%) indicated potential to genetically improve these traits in both Brahman and tropical Composite populations. Genetic correlations between male traits varied (-46 to 78%), some suggesting antagonism between traits while others indicated that some traits measured in bulls early in life could potentially be indicators of post-pubertal semen quality.

INTRODUCTION

Reproductive performance of a cattle population has, arguably, the single greatest influence on beef economic returns. Reproductive performance has many components and BREEDPLAN currently provides EBVs for scrotal circumference (SC) and days to calving (DTC) to aid selection for improved herd fertility. Studies have reported favourable genetic relationships between SC and female fertility traits (Morris *et al*. 1993; Martinez-Velazquez *et al*. 2003). However, there is only sparse information published on the genetic relationships among desirable traits measured on bulls in Australian tropical beef breeds. The current study provides a preliminary report on genetic variation in early-life male fertility traits and estimates of genetic correlations.

MATERIALS AND METHODS

Animals. Data were obtained from bulls of two genotypes (908 Brahmans and 1304 tropical Composites) which were progeny of cows bred for the Beef CRC northern Australia breeding project (Johnston *et al*. 2009). Composites bulls comprised admixes of Belmont Red, Charbray, Santa Gertrudis and Senepol breeds. The bulls were bred on 5 properties across central, northern and western Queensland over 4 years using sires selected to ensure representation of industry populations and genetic linkage across years and properties within genotype. At weaning, 1494 bull calves (average of 374 per year) were relocated by road transport to Brigalow Research Station (170km SW of Rockhampton). The remaining 718 bulls were born at Belmont Research Station (25km NW of Rockhampton) and remained there post-weaning. At Brigalow and Belmont all bulls weaned in the same year were managed as a single group (defined as a cohort) until completion of data collection as 2 year olds. Breeding of a further 3 cohorts is planned.

Measurements. At ~4 months of age, blood samples were taken to measure pre-pubertal serum inhibin (INH4), a trait linked to reproductive function (Phillips 2005). When weaned at ~6 months, flight time (FLT6) was recorded. Scrotal circumference was measured at 9 (SC9), 12 (SC12) and at 24 months of age (SC24). Weights were also recorded at these intervals (WT9, WT12, WT24), and body condition score (BCS12; scored 1 to 5) was recorded at 12 months. At 15 months the bulls were scanned to measure fat depth at the P8 site (Fat15) and eye-muscle area (EMA15). An ejaculate from bulls with SC ≥ 20cm was collected by electro-ejaculation at 12 and 24 months. Traits recorded on the ejaculate included presence or absence of sperm at 12 months (Sperm12; 1 or 0), and percent morphologically normal sperm at 24 months (Norm24; 0 to 100%). Table 1 lists the descriptive statistics of the traits measured.

Table 1. Descriptive statistics of traits measured on young tropical breed bulls

Trait*	Units	Brahman			Composite		
		N	Mean	SD	N	Mean	SD
INH4	ng/ml	580	7.8	1.97	790	8.2	1.91
FLT6	seconds	908	1.17	0.59	1304	1.16	0.45
SC9	cm	796	18.0	1.76	1136	21.4	2.90
SC12	cm	902	21.6	2.95	1297	26.5	3.28
SC24	cm	892	30.4	3.19	1281	31.2	2.78
WT12	kg	904	247	33.1	1295	267	39.5
WT24	kg	898	380	42.5	1284	378	46.0
BCS12	score 1 to 5	903	2.5	0.31	1299	2.5	0.31
Fat15	mm	903	1.4	0.57	1295	1.1	0.32
EMA15	cm^2	903	46	8.4	1293	49	8.1
Sperm12	binomial	798	0.10	0.30	1130	0.52	0.50
Norm24	%	765	69	23.2	1112	74	18.9

* See text for trait definitions; INH4 not measured on first 2 cohorts; SC9 not measured on first cohort.

Statistical analyses. Significant fixed effects were identified separately for each genotype using linear mixed model procedures of GenStat (10^{th} Edition). Models included the fixed effects of year (2004 to 2007), birth location (5 properties), post-weaning location (Brigalow or Belmont), dam age (3, 4 or 5+ years), birth month (Sep. to Jan.), their interactions and sire as a random effect. WT was included as a covariate for SC traits to adjust to a common body mass. For the Composite data, sire and dam breed groups were included to account for heterosis effects. Non-significant terms were sequentially removed from the model to yield the final model for each trait. Phenotypic variances and trait heritabilities were estimated in univariate analyses using ASReml (Release 2.0). The animal models used included the final fixed effects identified above with additional maternal random terms to model genetic and permanent environment effects of the dam. Genetic correlations among bull traits were estimated in a series of bivariate analyses between paired traits. The relationship matrix was derived from a pedigree of 6081 animals going back 5 generations.

RESULTS AND DISCUSSION

Estimates of phenotypic and genetic variance parameters for the traits measured are presented in Table 2. The direct heritability of most traits was generally moderate indicating that improvement of the traits could readily be made by selection. The low heritability estimates of

BCS12 in both breeds and Fat15 in Composites could reflect that these pasture-fed bulls did not vary greatly in body fatness. Heritability estimates of INH4, FLT6, WT12 and Fat15, although associated with high error, may suggest breed differences reflecting underlying genetic and physiological differences between Brahmans and Composites for these traits. The heritabilities for INH4 and SC24 were high in Brahmans and although no published estimates for either trait were cited, the heritability of SC24 was greater than published estimates for SC at 18months (Burrow 2001). Further data are needed to validate these estimates. Maternal genetic and non-genetic effects were important for some traits, including those measured post-weaning, indicating the need to consider maternal effects in analytical models to ensure accurate estimation of direct heritability. Martinez-Velazquez (2003) reported maternal effects of similar magnitude for SC12 in *Bos taurus* breed bulls.

Table 2. Phenotypic variance (V_p), direct heritability (h^2), maternal heritability (m^2) and permanent environment effect (c^2) estimated for traits measured on young bulls

Trait*	Brahman				Composite			
	V_p	h^2	m^2	c^2	V_p	h^2	m^2	c^2
INH4	3.17	0.71 (0.21)	0.04	0.00	2.65	0.40 (0.13)	0.23	0.06
FLT6	28.4	0.18 (0.08)	0.02	0.00	17.1	0.33 (0.11)	0.02	0.00
SC9	2.11	0.41 (0.13)	0.22	0.00	5.64	0.49 (0.12)	0.00	0.11
SC12	4.97	0.59 (0.15)	0.15	0.00	6.32	0.39 (0.10)	0.00	0.11
SC24	6.6	0.75 (0.18)	0.04	0.01	5.4	0.46 (0.11)	0.00	0.16
WT12	554	0.31 (0.12)	0.13	0.00	671	0.18 (0.07)	0.23	0.00
WT24	950	0.35 (0.12)	0.14	0.00	1104	0.39 (0.11)	0.17	0.00
BCS12	0.05	0.14 (0.07)	0.00	0.09	0.04	0.15 (0.06)	0.00	0.00
Fat15	0.310	0.21 (0.09)	0.02	0.11	0.100	0.03 (0.04)	0.04	0.00
EMA15	28.9	0.25 (0.10)	0.09	0.00	30.3	0.26 (0.09)	0.09	0.00
Sperm12	0.084	0.27 (0.11)	0.11	0.00	0.223	0.19 (0.07)	0.00	0.00
Norm24	512	0.20 (0.09)	0.00	0.00	355	0.24 (0.08)	0.00	0.01

* See text for trait definitions; standard error shown in parentheses.

Estimated genetic correlations between traits measured on the bulls are presented in Table 3. For brevity only traits of higher economic importance or heritability have been included here. High standard errors generally indicate fewer observations available for analyses. INH4 had a positive genetic correlation with SC9 and SC12 but, except with Sperm12 in Brahmans, tended to show a negative relationship with semen quality traits (Sperm12 and Norm24). These relationships suggest higher levels of inhibin at 4 months are associated with the development of larger testes in pre-pubertal bulls but, conversely, associated with poorer semen quality post-puberty. However, high standard error warrants further data before dismissing INH4 as a predictor of male fertility.

FLT6 was positively correlated with SC in both breeds and Norm24 in Brahmans indicating that selection for less flighty bulls (longer flight time) would improve SC in both breeds and improve percent normal sperm in Brahmans. In Composites, however, there was no relationship between flight time and percent normal sperm. The genetic relationships between WT12 and semen traits were negative suggesting genetic antagonism between growth and semen quality. The relationships of Fat15 and EMA15 with SC12 and Sperm12 were also negative and, although behavioural studies were not incorporated for confirmation, may be influenced by depletion of body tissue reserves due to mounting activity of bulls reaching puberty. However, negative relationships between EMA15 and Norm24 in Composites and between WT12 and Norm24 in both breeds are of concern if selection emphasis is on improved EMA and weight.

Table 3. Estimates of genetic correlation (and standard error) among bull traits

Trait	INH4	FLT6	WT12	Fat15	EMA15	Sperm12	Norm24
Brahman							
SC9	0.50 (0.20)	0.42 (0.25)	0.23 (0.25)	-0.28 (0.28)	-0.01 (0.25)	0.36 (0.25)	-0.11 (0.29)
SC12	0.39 (0.20)	0.62 (0.19)	0.29 (0.23)	-0.22 (0.26)	-0.16 (0.24)	0.76 (0.14)	0.36 (0.24)
Sperm12	0.26 (0.26)	0.10 (0.40)	-0.01 (0.43)	-0.46 (0.26)	-0.21 (0.29)	-	-
Norm24	-0.33 (0.28)	0.32 (0.31)	-0.41 (0.28)	0.02 (0.34)	0.03 (0.32)	0.13 (0.33)	-
Composite							
SC9	0.21 (0.22)	0.34 (0.20)	-0.01 (0.26)	0.05 (0.46)	-0.20 (0.23)	0.49 (0.20)	0.40 (0.22)
SC12	0.29 (0.23)	0.31 (0.22)	0.21 (0.25)	-0.24 (0.48)	-0.35 (0.24)	0.64 (0.18)	0.32 (0.23)
Sperm12	-0.28 (0.26)	0.17 (0.31)	-0.29 (0.29)	-0.80 (0.60)	-0.39 (0.26)	-	-
Norm24	-0.15 (0.29)	-0.06 (0.27)	-0.27 (0.31)	0.22 (0.55)	-0.40 (0.26)	0.45 (0.25)	-

* See text for trait definitions.

The moderate genetic correlations between SC (particularly SC12) and semen quality traits indicated that improved SC in Brahman and tropical Composite bulls is genetically associated with more animals producing sperm at 12 months and higher percent normal sperm at 24 months. These genetic correlations are important given that percent normal sperm is one of the better predictors of calf output by bulls in multiple sire mating groups (Holroyd *et al*. 2002).

CONCLUSION

As a result of moderate heritability and favourable genetic association with semen quality traits, yearling SC could be flagged as an indicator trait for desirable male reproductive traits in tropical breeds. High standard errors associated with most genetic parameters estimated warrant the collection of more data to test the validity of these genetic associations.

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REFERENCES

Burrow, H.M. (2001) *Livest. Prod. Sci.* **70**:213.

Holroyd, R.G., Doogan, V.J., De Faveri, J. Fordyce, G., McGowan, M.R., Bertram, J.D., Vankan, D.M., Fitzpatrick, L.A. Jayawardhana, G.A. and Miller, R.G. (2002) *Anim. Reprod. Sci.* **71**:67.

Johnston, D.J., Barwick, S.A., Corbet, N.J., Fordyce, G.M., Holroyd, R.G., Williams, P.J and Burrow, H.M. (2009) *Anim. Prod. Sci.* **49**:399.

Martinez-Velazquez, G., Gregory, K.E., Bennett, G.L. and Van Vleck, L.D. (2003) *J. Anim. Sci.* **81**:395.

Morris, C.A., Bennett, G.L. and Johnson, D.L. (1993) *Proc. New Zeal. Soc. An.* **53**:427.

Phillips, D.J. (2005) *Domest. Anim. Endocrin.* **28**:1.