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GENETIC ASSOCIATION OF YOUNG MALE TRAITS WITH FEMALE REPRODUCTIVE PERFORMANCE IN BRAHMAN AND SANTA GERTRUDIS CATTLE

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SUMMARY

This study investigated the potential value of traits measured in young bulls as genetic indicators for female reproductive performance in two tropical beef cattle breeds. Genetic parameters for the male traits percentage of normal sperm (PNS) and scrotal circumference (SC), and their genetic relationships with first (DTC_1) second (DTC_2) and all days to calving measures (maximum of six) (DTC_{all}) were estimated in Brahman (BRAH) and Santa Gertrudis (SANTA) cattle from records submitted for BREEDPLAN evaluation. Estimated heritabilities for PNS and SC were 0.20±0.06 and 0.45±0.02 for BRAH and 0.17±0.05 and 0.43±0.02 for SANTA, respectively. Genetic correlations between PNS and DTC_1, DTC_2 and DTC_{all} were -0.67±0.28, -0.79±0.25 and -0.47±0.22 in BRAH and -0.18±0.21, -0.28±0.27 and -0.20±0.20 in SANTA, respectively. Genetic correlations of SC with DTC_1, DTC_2 and DTC_{all} were -0.26±0.12, -0.25±0.13 and -0.19±0.08 in BRAH and -0.02±0.09, -0.19±0.13 and 0.00±0.09 in SANTA. These results showed that PNS and SC measured at 18 to 24 months of age in young BRAH and SANTA bulls were moderately heritable and their genetic correlations with DTC were in the same direction in both breeds. PNS and SC had higher genetic correlations with early DTC measures compared to DTC measured in older cows, indicating that they may be more related to early reproduction than lifetime reproduction. In addition, PNS was more strongly related with all DTC measures than SC in both breeds, which suggests that PNS may be a better indicator trait than SC for improving female reproduction in tropical breeds in Northern Australia.

INTRODUCTION

Cow and bull reproductive efficiency are important for the productivity and profitability of beef cattle producers in northern Australia. Various measures of female fertility were investigated to improve female reproductive efficiency. Days to calving (DTC) is one such measure and is implemented in the BREEDPLAN genetic evaluation as the key measure of genetic merit for female reproduction. However, low heritability, low intensity of selection and observations relatively late in life, limit the capacity to improve female fertility using DTC measures only. Therefore, identification of male traits, which have high genetic associations with female fertility, could greatly assist the improvement of reproductive performance of beef cattle in Northern Australia. From a previous study (Meyer *et al.* 1991), scrotal circumference (SC) in males is used as an indicator trait for female fertility in BREEDPLAN evaluation. However, Johnston *et al.* (2014) identified percentage of normal sperm (PNS) as being strongly genetically correlated with female reproductive traits in tropical breeds, in a research data set. These findings need to be validated using industry data before PNS could be included in routine BREEDPLAN genetic evaluation. Therefore, the aim of this study was to compare the genetic correlations of PNS and SC with early and lifetime female reproduction traits in Brahman (BRAH) and Santa Gertrudis (SANTA) cattle, to discover whether there are additional or better genetic indicators to improve reproduction efficiency of beef cattle in Northern Australia.

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MATERIALS AND METHODS

Data for PNS, collected as part of the bull breeding soundness evaluation for young BRAH and SANTA bulls (of Beef CRC and industry), along with the pedigree data and performance data for other traits were obtained from respective breed society databases. The PNS data were measured between 540 to 800 days of age and for bulls with multiple PNS records, only the first record was used. Data for all DTC (DTC_{all}) and SC were submitted by members of BRAH and SANTA societies for their respective BREEDPLAN evaluations. Scrotal circumference (SC) was measured between 300 to 700 days of age. DTC for natural mating was defined as the number of days from the "bull in date" (first day of introducing bulls) until the subsequent calving of the cow (Johnston and Bunter, 1996). DTC_{all} were split into DTC from the first mating (DTC_1) and DTC from the second mating (DTC_2), to describe early reproductive measures. For BRAH, DTC_1 was measured between 650 to 925 days of age and DTC_2, the second measurement for cows with a DTC_1. For SANTA, the DTC_1 was measured between 270 to 640 days of age. All non-calver cows were included by assigning a penalty DTC record as described by Johnston and Bunter (1996).

The number of records and descriptive statistics for all traits are given in Table 1. For BRAH, there were 215, 1884, 1199 and 1199 sires with progeny recorded for PNS, SC, DTC_1 and DTC_{all}, respectively. There were 128 and 816 common sires with progeny recorded for PNS and DTC_1, and SC and DTC_1, respectively. For SANTA, there were 221, 2385, 619 and 619 sires with progeny recorded for PNS, SC, DTC_1 and DTC_{all}, respectively. There were 119 and 560 common sires with progeny recorded for PNS and DTC_1, and SC and DTC_1, respectively.

Genetic variances and variance ratios were estimated by restricted maximum likelihood (REML) using a univariate animal model, and genetic correlations were estimated using a series of bivariate animal model analyses, with three generations of pedigree in WOMBAT (Meyer 2007). Models included contemporary group as a fixed effect, age of measurement as a covariate and the random additive genetic effect of animal for all traits. An additional random common environmental effect of animal was fitted for DTC_{all} to account for repeated records. Contemporary group definitions for DTC and SC were as defined in BREEDPLAN (Graser *et al.* 2005) and for PNS were formed by accounting for herd of origin, year of birth, birth type, previous weight management groups and date of measurement.

RESULTS AND DISCUSSION

Raw means by breed are presented in Table 1. For BRAH, the means for PNS, SC and DTC_{all} were 68.2, 26.2 and 358 and for SANTA, were 73.1, 32.3 and 358, respectively Estimated heritabilities were moderate for PNS and SC in both breeds (Table 1) (0.20 and 0.17 for PNS and 0.45 and 0.43 for SC in BRAH and SANTA, respectively). Estimated heritability for PNS in BRAH was of similar magnitude to the 0.25 reported by Corbet *et al.* (2013) for the Beef CRC study. Estimated heritabilities for SC in BRAH and SANTA were in agreement with the range of estimates reported by Cammack *et al.* (2009). The moderate heritability estimates for PNS and SC suggest that both traits could be improved by selection in BRAH and SANTA. Heritability estimates for all DTC measures in both breeds were low. Estimated heritabilities for DTC_2 were higher than the estimates for DTC_1 in both breeds. Estimated heritabilities for DTC_1 and DTC_2 were lower than the values of 0.22 and 0.20 reported for DTC_1 and DTC_2 of BRAH, respectively, by Johnston *et al.* (2014a) using research data.

Estimated genetic correlations between bull traits and DTC measures are presented in Table 2. Genetic correlations between PNS and DTC were in the same direction for BRAH and SANTA (Table 2). Moderate to strong negative genetic correlations were estimated between PNS and DTC measures and were of larger magnitude for BRAH than SANTA. The difference in the magnitude of the genetic relationship between PNS and all three DTC measures in the two breeds may be attributed to differences in their age at first mating. BRAH heifers were one year older than the

SANTA heifers at first mating, and it is likely that a higher proportion of BRAH than SANTA heifers would be cycling at the time of first mating. Estimated genetic correlations between PNS and DTC_2 were of higher magnitude than the correlations of PNS with DTC_1 and DTC_{all} in both breeds. For BRAH, the genetic correlations between PNS and all three DTC measures were significantly different from zero. Estimated genetic correlations between PNS and DTC_1 and DTC_2 in BRAH were stronger than the values reported by Johnston *et al.* (2014b), which ranged from -0.69 to -0.04.

Table 1. Number of records, descriptive statistics, additive genetic variance (σ_a^2) and heritability (h^2) with se in parenthesis for percentage normal sperm (PNS), scrotal size (SC) and first (DTC_1), second (DTC_2) and all days to calving (DTC_{all}) for Brahman and Santa Gertrudis

Trait (units)	No. of records	Mean	SD	Min	Max	σ_a^2	h^2
			Brahman				
PNS (%)	2330	68.2	26.0	1.0	99.0	119.7	0.20 (0.06)
SC (cm)	23247	26.2	4.9	13.4	41.5	2.6	0.45 (0.02)
DTC_1 (days)	11800	363.9	58.2	270.0	491.0	145.9	0.07 (0.02)
DTC_2 (days)	3349	370.6	46.6	271.0	490.0	202.4	0.13 (0.04)
DTC_{all} (days)	29552	358.6	51.8	270.0	491.0	111.3	0.06 (0.01)
			Santa Gertrudis				
PNS (%)	2078	73.1	20.2	2.0	99.0	65.7	0.17 (0.05)
SC (cm)	35663	32.3	4.1	20.0	44.0	2.9	0.43 (0.02)
DTC_1 (days)	5794	377.3	60.9	273.0	491.0	311.8	0.13 (0.03)
DTC_2 (days)	2042	360.4	47.7	273.0	491.0	228.4	0.14 (0.05)
DTC_{all} (days)	15104	358.6	53.2	270.0	491.0	156.9	0.08 (0.01)

Genetic correlations between SC and DTC measures for BRAH and SANTA were in the same direction as between PNS and the three DTC traits, except for DTC_{all} in SANTA. However, for both breeds, the magnitude of the genetic correlations with SC was lower than those estimated between PNS and DTC. Genetic correlations of SC with DTC_1 and DTC_2 were within the range of -0.35 to -0.21 reported between SC and both DTC_1 and DTC_2 for BRAH by Johnston *et al.* (2014b).

Table 2. Genetic correlations between PNS and SC with first (DTC_1), second (DTC_2) and all days to calving (DTC_{all}) of Brahman and Santa Gertrudis cattle

Trait (units)		Genetic correlation	
	DTC_1 (days)	DTC_2 (days)	DTC_{all} (days)
		Brahman	
PNS (%)	-0.67 (0.28)	-0.79 (0.25)	-0.47 (0.22)
SC (cm)	-0.26 (0.10)	-0.25 (0.13)	-0.19 (0.08)
		Santa Gertrudis	
PNS (%)	-0.18 (0.21)	-0.28 (0.27)	-0.20 (0.20)
SC (cm)	-0.02 (0.09)	-0.19 (0.13)	0.00 (0.09)

This study showed that PNS had stronger genetic correlations than SC with all DTC measures in BRAH and SANTA. This suggests that PNS is a better indicator trait than SC to improve female reproduction in these breeds, under Australian conditions. Inclusion of PNS, along with SC, in the genetic evaluation for BRAH and SANTA will improve the accuracy of prediction for DTC. Consistently higher genetic correlations were observed between PNS and DTC_2 than between PNS and DTC_1, which implied that PNS had a higher genetic correlation with lactation anoestrus interval than heifer puberty in DTC_1, in both breeds. These results are consistent with those reported by Johnston *et al.* (2014b). Although a similar pattern was observed for the genetic correlations between PNS and DTC measures in both breeds, the differences in the magnitude of the correlations for BRAH and SANTA were attributed to the physiological stage they were in at the time of recording the DTC measures. For BRAH, the first DTC record was from females mated as 2 year olds, which could have a higher proportion of heifers cycling than SANTA (which could submit results from yearling matings) at the time of measuring DTC_1.

CONCLUSIONS

PNS and SC measured in young BRAH and SANTA bulls were moderately heritable. Selecting bulls for higher PNS and SC at 2 years of age is expected to lead to a correlated response of reduced days to calving in cows in both breeds, with the effect stronger in early matings. Stronger genetic relationships between PNS and all DTC measures in both breeds suggest that PNS is a better indicator trait than SC, in terms of estimating genetic merit, and hence providing potential for improving female reproduction in tropical breeds in Northern Australia. PNS could be included in BREEDPLAN genetic evaluation as indirect selection criteria for improving female reproduction in tropical breeds. Furthermore, difference in the magnitude of the genetic correlations of PNS with DTC_1 and DTC_2 and low to moderate correlation (less than 0.6) between DTC_1 and DTC_2, suggest that DTC records in BREEDPLAN evaluation could be split into DTC_1 and DTC_2 to better describe early female reproduction.

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