Contributed paper

EFFECTS OF POLL BREEDING ON REPRODUCTIVE TRAITS IN BEEF CATTLE

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SUMMARY

Efficient reproduction is considered the backbone of sustainable livestock production. This study has evaluated the estimated breeding values (EBVs) of seven beef breeds (Charolais, Hereford, Limousin, Shorthorn, Brahman, Droughtmaster and Santa Gertrudis). Intra-breed genetic merits (EBVs) were compared between the polled and horned cohorts using 548,775 animals born between 2000 and 2018 for five traits (scrotal size, gestation length, days to calving, calving ease direct and calving ease daughters). All breeds have shown genetic gain in the reproductive traits. Moreover, more traits in polled cohorts were found to have higher genetic merit as compared to horned cohorts. For example, scrotal size were found significantly higher in polled cohorts of Charolais, Hereford, Limousin, Brahman, Droughtmaster and Santa Gertrudis, and in horned cohort of Shorthorn. EBVs of gestation length were significantly lower (desirable) in polled cohorts of all breeds. All in all, this research concludes that polledness has no detrimental effects on the genetic merit of reproductive traits in beef cattle.

INTRODUCTION

Cattle breeding programs require reproductively sound animals of superior genetics. Genetic merits of the nucleus herds are routinely computed as estimated breeding values (EBVs) of recorded production and reproduction traits to rank animals and select them for various breeding programs. Reproductive traits have been generally found with low-to-moderate heritability (Meyer *et al.* 1990), and genetically favourable to neutral correlations with the production traits have been reported in beef cattle (Wolcott *et al.* 2013). Therefore, several reproductive traits, both in male and female, are measured and genetically evaluated (EBVs) for selective breeding (Barwick *et al.* 2013). In male, scrotal size (SS) is measure from scrotal circumference (cm) of bulls at 300-700 days (adjusted for 400 days of age). Higher EBVs of SS are favourable because the larger scrotal circumference is associated with more semen production and earlier age at puberty in bulls. Furthermore, heifer progeny of Brahman and Tropical Composite bulls with larger SS reached puberty earlier and had shorter days to calving (Johnston *et al.* 2013). Heifers and cows are measured for several performance traits, including gestation length (GL), days to calving (DTC), calving ease direct (CEdr) and calving ease of daughters (CEdt). EBVs of GL (days) calculated based on the number of days from the date of conception to the date of calf birth. Lower EBVs are favourable because shorter GL is generally associated with lighter birth weight, improved calving ease and improved re-breeding performance among dams. In addition, calves born with a shorter GL are often heavier at weaning due to more days of growth. For DTC, lower values are favourable for EBVs estimated from the date when the female is introduced to a bull (joining period) until subsequent calving. Note that the time taken by cows to conceive after the commencement of the joining period primarily cause variation in DTC. Moreover, cows that had early puberty as heifers and return to oestrous earlier after calving will have lower DTC EBVs. Both CEdr and CEdt are favourable at lower EBVs, which are based on the ability of a sire's calves to be born unassisted from 2-year-old heifers and ability of a sire's daughters to calve at 2 years of age without assistance, respectively. Recently, due to increased awareness of animal welfare, consumer choices and costs and risks associated with physical dehorning, commercial beef producers and feedlots have emphasized on poll breeding. Polledness has been perceived by some farmers to have negative effect on some beef traits, including reproduction. Therefore, genetic merit of reproductive traits between the polled and horned cohorts of beef cattle are compared in this study.

MATERIALS AND METHODS

Phenotypes for horn status (polled or horned) and EBVs (accuracy > 50%) of five reproductive traits (SS, GL, DTC, CEdr and CEdt) were obtained on a total of 548,775 animals (birth years: 2000 to 2018) of seven beef breeds (Charolais = 14,219, Hereford = 25,2837, Limousin = 43,351 Shorthorn = 58,603, Brahman = 81,617 Droughtmaster = 17,686 and Santa Gertrudis = 80,462) from BREEDPLAN database (https://breedplan.une.edu.au). Within each breed, dataset analyses were performed for the poll-*vs*-horn cohorts (Table 1) by using the R program (R Core Team 2021) to compute the summary statistics of Mean ± Standard Deviation (SD). Descriptive statistics for pairwise comparisons between the means were performed by the t-tests with pooled SD, and p-values were obtained by using the *t.test* function in R-package "*stats*". Effect sizes on each trait due to polledness within breeds were computed using the Cohen's d (Cohen 1977; Lakens 2013).

RESULTS AND DISCUSSION

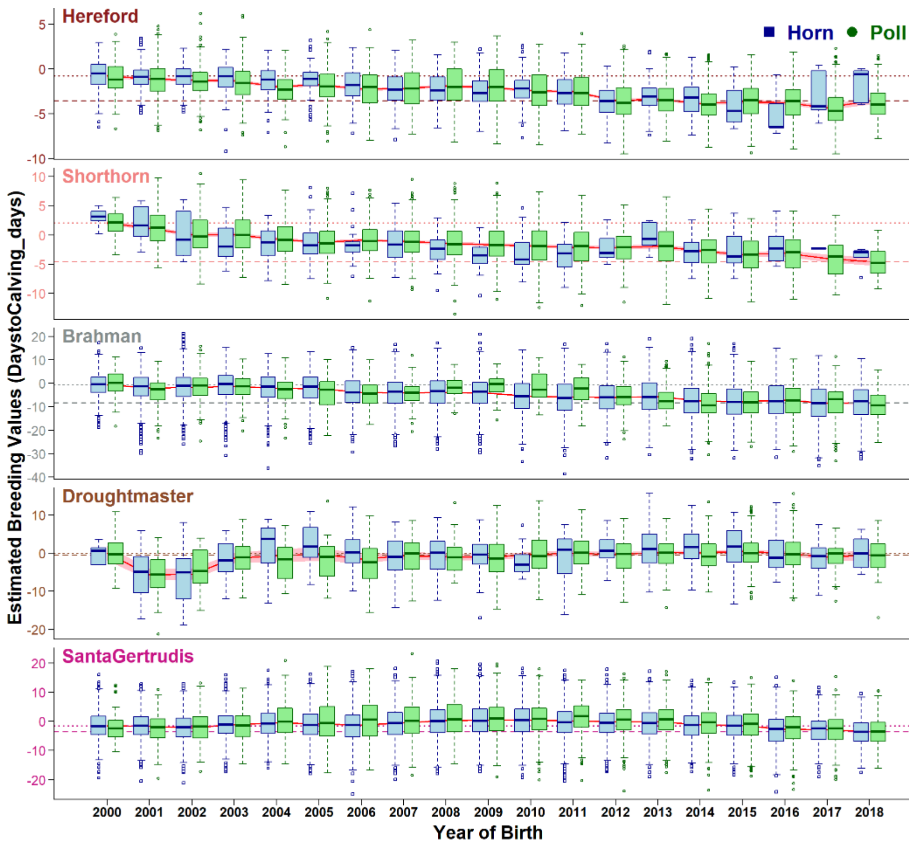

Figure 1. Boxplots of EBVs of Days to Calving for horn and poll cohorts. Red lines in the background show overall annual averages (pink: 95% confidence intervals). Dotted (….) and dashed (----) lines refer to breed-averages at the start (2000) and end (2018) of the selected period

Genetic merit for reproductive traits of the seven beef breeds have been consistently improving since 2000 though at variable rates. For example, Figure 1 shows EBVs of DTC for five breeds with decreasing trends depicting that all breeds have achieved shorter calving intervals. Intra-breed comparisons showed that genetic merit of DTC in the polled animals improved at significantly ($p < 0.05$) higher rates in Hereford and Brahman than horned cohorts, and vice versa in Shorthorn and Santa Gertrudis (Table 1). EBVs of SS were significantly higher with high effect sizes (d = 0.14-0.65) in polled cohorts of all breeds except Shorthorn (d = -0.1). The favourably decreasing trends for GL of polled animals in five breeds showed significantly better genetic gains (d = -0.11 to -0.77) except for Brahman (d=0.17), while Shorthorn were non-significant. Both CEdr and CEdt have genetically improved as measured in polled cattle. However, Hereford and Limousin have shown significantly lower EBVs for calving difficulty in their polled cohorts. It is also evident that the number of polled animals were higher in five breeds (Charolais, Hereford, Limousin, Shorthorn and Droughtmaster) as compared to Brahman and Santa Gertrudis (Table 1). While the polled and horned cohorts were generally represented by higher sample sizes, Shorthorn (horned = 5-7%) and Brahman (polled = 7-13%) had uneven representation for horned and polled respectively, and therefore both breeds may have shown discordant trends of EBVs from 2000 to 2018 born animals.

Table 1. Sample sizes, descriptive statistics, effect size (Cohen's *d*)and p-values of the comparison between polled and horned cohorts for five reproduction traits in beef breeds

Trait	Breed	Polled	Horned	Mean±SD^P	Mean±SD^H	*d* *	*p*-value
SS (cm)	Charolais	8,742	4,461	1.20±0.87	0.65±0.83	0.65	<0.0001
	Hereford	159,151	86,357	1.71±0.85	1.43±0.72	0.36	<0.0001
	Limousin	16,424	5,851	1.06±0.70	0.73±0.67	0.48	<0.0001
	Shorthorn	55,626	2,761	1.26±0.70	1.33±0.67	-0.10	<0.0001
	Brahman	5,783	71,526	1.20±1.11	0.75±1.22	0.39	<0.0001
	Droughtmaster	12,258	3,592	1.53±0.86	1.41±0.81	0.14	<0.0001
	Santa Gertrudis	20,875	57,317	0.69±0.88	0.41±0.93	0.31	<0.0001
GL (days)	Charolais	9,211	4,635	-3.36±2.11	-1.77±2.04	-0.77	<0.0001
	Hereford	115,106	41,739	-0.45±1.77	-0.27±1.56	-0.11	<0.0001
	Limousin	26,928	15,292	-2.66±2.19	-0.93±2.05	-0.81	<0.0001
	Shorthorn	28,806	1,497	-1.45±1.49	-1.40±1.44	-0.03	0.22
	Brahman	600	4,458	-0.03±1.06	-0.24±1.35	0.17	<0.0001
	Droughtmaster	538	401	0.32±1.78	0.67±1.63	-0.20	0.002
DTC (days)	Hereford	8,064	1,602	-2.53±2.27	-1.78±1.93	-0.36	<0.0001
	Shorthorn	6,077	421	-1.26±3.29	-1.90±3.11	0.20	<0.0001
	Brahman	2,541	34,293	-5.87±6.89	-4.45±7.28	-0.20	<0.0001
	Droughtmaster	1,885	840	-0.65±4.76	-0.47±5.60	-0.03	0.43
	Santa Gertrudis	8,975	23,820	-0.66±5.74	-0.87±5.47	0.04	0.0028
CEdr (%)	Charolais	4,426	2,272	2.65±7.32	-0.90±6.18	0.52	<0.0001
	Hereford	56,827	18,933	-0.32±5.85	-2.34±6.42	0.33	<0.0001
	Limousin	7,759	3,541	1.59±3.61	-0.16±4.03	0.46	<0.0001
	Shorthorn	21,511	1,152	0.23±5.93	0.10±6.48	0.02	0.51
CEdt (%)	Charolais	2,028	1,333	-0.26±6.73	-0.30±6.73	0.01	0.89
	Hereford	17,689	3,516	0.74±4.34	-1.39±4.74	0.47	<0.0001
	Limousin	4,588	2,484	1.28±3.37	0.31±4.50	0.24	<0.0001
	Shorthorn	7,500	459	-0.33±5.22	-0.33±5.29	0.01	0.99

* Cohen's *d* (effect sizes) are interpreted as; *d* 0.01: very small, *d* 0.20: small, *d* 0.50: medium, *d* 0.80: large, *d* 1.20: very large, *d* 2.0: huge (Sawilowsky 2009).

Overall, the results suggest that genetic improvements in reproductive traits and selection for polledness have been favourably in action in the nucleus herds of beef cattle during the last two decades. Given the positive associations between polledness, production (Randhawa *et al.* 2021) and studied traits, selection could be undertaken to improve them simultaneously to achieve sustainable beef production. Breeding polled animals can continually improve fertility and pregnancy traits at a rate governed by the respective trait's heritability. However, generalization of genetic potentials for some breeds with significantly unequal samples represented in their polled and horned cohorts may be substantially biased. In addition, phenotyping accuracy of head-status and subsequent recording in the BREEDPLAN database may have confounded the comparisons of this study (Connors *et al.* 2018). Poll gene testing assays can not only eliminate the impacts of phenotyping bias, but can also exclude genetically heterozygous animals (i.e., carry a horn allele but phenotypically polled (Randhawa *et al.* 2020). With widespread gene diagnostics tools and high-density genotyping being implemented into nucleus and commercial herds, larger proportion of genomic evaluated breeding animals will become available for future investigations based on genotype-phenotype concordant head-status to account for the perceived bias.

CONCLUSIONS

This study shows that reproductive traits in beef cattle have generally improved along with the proportion of polled animals and their genetic merits in most of the studied breeds. Selection for polledness and reproductive traits could be undertaken simultaneously to achieve sustainable beef production. However, the findings require caution, as bias may be introduced through limited sampling, phenotyping inaccuracy and underlying genetic heterogeneity in the polled phenotypes. Further investigations by using recently developed poll diagnostic assays in genome-evaluated larger populations will enhance our understanding about the true genetic merit of polled cattle.

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REFERENCES

Barwick S.A., Johnston D.J., Holroyd R.G., Walkley J.R.W. and Burrow H.M. (2013) *Anim. Prod. Sci.* **54**:97.

Cohen J. (1977) *Statistical power analysis for the behavioral sciences.* . Routledge, New York.

Connors N.K., Tier B. and Johnston D.J. (2018) Current status of Australia's diagnostic poll haplotype test. In: *World Congress on Genetics Applied to Livestock Production*, p. 344.

Johnston D.J., Corbet N.J., Barwick S.A., Wolcott M.L. and Holroyd R.G. (2013) *Anim. Prod. Sci.* **54**:74.

Lakens D. (2013) *Frontiers in psychology* **4**:863.

Meyer K., Hammond K., Parnell P.F., MacKinnon M.J. and Sivarajasingam S. (1990) *Livest. Prod. Sci.* **25**:15.

R Core Team (2021) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Randhawa I.A.S., Burns B.M., McGowan M.R., Porto-Neto L.R., Hayes B.J., Ferretti R., Schutt K.M. and Lyons R.E. (2020) *G3-Genes Genom. Genet.* **10**:539.

Randhawa I.A.S., McGowan M.R., Porto-Neto L.R., Hayes B.J. and Lyons R.E. (2021) *Animals* **11**:870.

Sawilowsky S.S. (2009) *Journal of Modern Applied Statistical Methods* **8**:467.

Wolcott M.L., Johnston D.J. and Barwick S.A. (2013) *Anim. Prod. Sci.* **54**:60.