PRODUCTION AND POLLEDNESS: GENETIC CORRELATIONS BETWEEN TARGET TRAITS IN BEEF CATTLE

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SUMMARY

Keeping horns or physically removing them pose economic and welfare risks, therefore, producing naturally hornless (polled) animals would make livestock production more humane and sustainable. The cattle industry is rapidly breeding polled cattle with the aid of advanced genomic technologies. However, some reluctance has been noticed due to perceived trade-offs associating polled animals with increased inbreeding and loss of production for various traits. Estimated breeding values (EBVs) of 243,330 animals, born in last 70 years, from three beef breeds (Brahman, Droughtmaster and Hereford) were obtained from BREEDPLAN. We have compared eight economically important traits for production (birth weight, mature cow weight carcase weight, retail beef yield, intramuscular fat and milk yield) and reproduction (scrotal size and days to calving). At various levels of EBVs accuracy (60%, 75%) a few significant differences of small effect sizes were found in no consistent direction of either horn or poll cohorts. Overall, we conclude that polledness had no detrimental effects on target traits of beef cattle.

INTRODUCTION

Many modern cattle are naturally horned, which pose risks to animals and workers, and management practices to remove horns are expensive, painful and unsafe (Bunter *et al.* 2013; Thompson *et al.* 2017). Alternatively, with growing support of consumers, genetic polledness is being progressively adopted, as a welfare-oriented and an effective management approach, to breed hornless (polled) cattle. Poll cattle have a long-history being kept in colder regions for easy confinement of cattle, however, commercial adoption of genetically polled cattle can sometimes face resistance because of a few perceived trade-offs associating polledness with increased inbreeding and loss of production for various traits (Schafberg and Swalve 2015). In dairy cattle, the frequency of polled bulls is so low that including this trait as selection criteria generally results in higher inbreeding and thus slower genetic improvement (Gaspa *et al.* 2015; Windig *et al.* 2015; Scheper *et al.* 2016). However no significant differences were found between horn and poll cattle in dairy traits (Onaciu *et al.* 2012) at the population level.

In beef cattle, the prevalence of natural mating and higher proportions of males in the herd suggest the need for better horn management by adapting to poll breeding. Randhawa *et al.* (2019a) noted that horn appearance and agonistic behaviour were generally male centric. Some beef cattle breeds have already achieved fixation of polledness, e.g., Angus, however, many beef breeds grow horns and entail impact assessment for poll breeding schemes. The impact of polledness on production and fertility traits of different breeds and cross-bred cattle have generally shown no significant difference for several beef traits, such as; live weight, growth rate, carcass weight and quality, dystocia, fertility and mortality rates (Frisch *et al.* 1980; Stookey and Goonewardene 1996; Kommisrud and Steine 1997; Goonewardene *et al.* 1999).

For comparison of genetic merit between animals, evaluation of genetic effects of a trait is more practical by substituting estimated breeding value (EBV) for phenotypic values. EBV is a tool of genetic evaluation between animals for a particular trait by accounting for heritability and fixed effects. EBVs for a quantitative trait capture the aggregate additive genetic value by using phenotype of an animal together with phenotypes of its relatives (Henderson 1975). EBVs denote that how an animal's genetics is different than the genetic base, for example breed averages. Accuracy of EBV predictions increases as more information become available for animal's direct performance, pedigree and progeny. BREEDPLAN (http://breedplan.une.edu.au/index.php) is an advanced genetic evaluation system, implemented for national beef recording scheme in Australia to compute EBVs, which can be used to highlight the genetic differences in various beef traits between various head-status cohorts. The aim of this study is to compare the genetic merit of naturally horned and polled animals for eight economically important traits for three breeds of Australian beef cattle.

MATERIALS AND METHODS

There were 243,330 animals from the Brahman (BRH), Droughtmaster (DRM) and Hereford (HFD) breeds from the BREEDPLAN database included in this study (Table 1). Animals were born between 1950 and 2018 and were classified into head-status cohorts as; horn (101,287), scur (5,297) and poll (131,792). BREEDPLAN EBVs are classified for interpreting accuracy, such that less than 50% = preliminary, 50-74% = medium, 75-90% = medium-high, and above 90% = high accuracy estimates of the animal's true breeding value. EBV records were obtained for eight traits where the EBV accuracy ≥ 60%. The number of EBVs for each trait and cohort are given in Table 1. Total number of samples for each breed at various accuracy of EBVs thresholds (%) and birth years were;

EBV 60% and born 1950 - 2018 (BRH: 50,392, DRM: 4,545, and HFD: 188,393) EBV 75% and born 2000 - 2018 (BRH: 4,210, DRM: 365, and HFD: 14,788).

In addition, a subset of 5,586 animals (BRH: 2,476, DRM: 323, and HFD: 2,787) had genomic horn and poll predictions obtained from the recently developed optimised poll testing (OPT) (Randhawa *et al.* 2019b). Samples with phenotype-genotype discrepancy (n = 374) were excluded, which were previously deemed as phenotyping and data recording errors (Randhawa *et al.* 2019b).

Table 1. List of eight traits and number of breed-wise samples for head-status for EBVs (60% accuracy)

Traits	Acronym (unit)	Brahman (N)			Droughtmaster (N)			Hereford (N)		
		Horn	*Scur*	*Poll*	*Horn*	*Scur*	*Poll*	*Horn*	*Scur*	*Poll*
Birth Weight	BW (kg)	27664	872	2818	826	295	2902	58642	3723	124066
Mature Cow Weight	MCW (kg)	41620	1054	4726	722	301	3248	28250	2021	47013
Carcase Weight	CW (kg)	18228	572	1607	417	131	1546	15632	1108	24842
Retail Beef Yield	RBY (%)	313	-	3	18	7	56	1340	164	3182
Intra Muscular Fat	IMF (%)	271	35	40	3	2	35	2277	215	5593
Milk Yield	MY (kg)	7667	127	652	760	186	2510	27965	1332	46819
Scrotal Size	SS (cm)	13213	377	1400	1025	520	3000	17318	2289	30873
Days to Calving	DTC (days)	3351	187	379	-	-	-	60	14	117

For each trait, four comparisons were made between the phenotype-based cohorts within breeds to screen the impacts of levels of medium (60%) and medium high (75%) EBV accuracy, birth years and poll test genotype-based composition of cohorts. Data analyses were conducted using the R program (R Core Team 2018). Because highest number of samples with EBVs at medium level accuracies represent extensively the available herds of beef cattle, therefore, summary statistics of Mean±SD were computed between the three cohorts (horned, scurred and polled) at 60% accuracy. The descriptive statistics including ANOVA, *p*-values by Tukey multiple comparisons of means (95%

family-wise confidence level) and pairwise comparisons using t-tests with pooled SD, and effect size (Cohen's *d*) were computed and probed for the poll-*vs*-horn cohorts.

RESULTS AND DISCUSSION

Table 2 shows the distribution of EBVs of 8 traits between within-breed cohorts of horn-status and provides an overview of significance levels and effect sizes. Of the eight traits, desirability for breeding differ for higher (MCW, CW, RBY, MY, IMF, SS) and lower (DTC) EBV values. Note that because BW is the major genetic cause of calving difficulty, small or moderate BWs are more favourable. Our results were computed for poll-*vs*-horn comparisons for trait-wise EBVs at medium to medium-high accuracies, as the number of animals with high EBVs accuracies (≥ 90%) were too low, e.g., BRH: 44, DRM: 11 and HFD: 593. At medium accuracy of 60%, comparisons of mean EBVs of several traits between poll and horn were highly significant ($p \leq .001$), however, the effect size were small ($d \sim 0.2$). As we increased the accuracies to 75%, there were a very few significant differences (Table 2).

Table 2. Descriptive statistics, effect sizes and statistical significance (t-test) of eight traits in three breeds of Australian beef cattle

Breed	Trait	Avg.[§]	Mean ±SD within cohorts at 60%[¶]			d[^] and p[°] values between Poll-Horn		
			Horn	*Scur*	*Poll*	60%[¶]	2K[†],75%	OPT[‡]
BRH	BW	2.5	2.37±1.95	1.73±1.85	1.83±1.77	-0.29 ***	-0.24 *	0.09
	MCW	41	32.4±22.6	33.9±22.3	30.2±22.4	-0.10 ***	-0.01	0.09
	CW	22	17.0±9.82	16.6±9.10	15.8±9.34	-0.12 ***	-0.41	-0.02
	RBY	0.6	0.13±0.86	-	-0.10±0.46	-0.33	-	0.22 **
	IMF	-0.1	-0.02±0.29	-0.13±0.27	-0.10±0.25	-0.29 *	-1.15	0.07
	MY	-1.0	-0.72±2.83	-1.40±2.91	-0.65±2.85	0.02 *	-0.19	0.27***
	SS	0.7	0.71±1.28	1.23±1.42	0.95±1.17	0.20 ***	0.18 **	0.12***
	DTC	-0.9	-5.09±7.40	-5.28±6.72	-5.41±7.54	-0.04	0.45 *	-0.01
DRM	BW	0	-0.43±1.56	-0.22±1.34	-0.23±1.34	0.13 **	0.32 *	0.01
	MCW	25	25.3±17.8	22.4±18.4	23.0±20.3	-0.12 *	0.05	0.24
	CW	14	14.8±6.22	14.4±6.35	13.9±6.18	-0.16 *	-0.21	0.01
	RBY	0.6	0.76±1.09	0.69±0.63	0.68±0.70	-0.09	-	-0.36
	IMF	0.0	0.20±0.87	0.00±0.00	0.01±0.48	-0.26	-	0.04
	MY	4.0	6.00±3.52	5.32±3.49	5.17±3.38	-0.24 ***	-0.34	0.11
	SS	1.3	1.15±1.03	1.36±1.12	1.36±1.04	0.20 ***	0.58	0.35 *
HFD	BW	4.4	4.25±2.20	4.7±1.97	4.12±1.97	-0.07 ***	-0.24 ***	-0.20***
	MCW	68	56.3±22.7	66.9±22.6	58.8±22.7	0.11 ***	0.08	0.14 *
	CW	50	32.0±14.8	42.9±16.0	35.7±15.9	0.24 ***	0.06	0.54***
	RBY	0.8	0.95±0.91	0.79±0.87	0.72±0.89	-0.25 ***	-0.78 *	-0.37***
	IMF	0.4	0.15±0.61	0.43±0.67	0.23±0.68	0.13 ***	0.00	0.54***
	MY	16	9.86±5.11	10.9±5.93	8.69±5.78	-0.21 ***	-0.29 ***	0.09 *
	SS	2.0	1.37±0.90	1.79±1.02	1.69±0.97	0.34 ***	0.27 ***	0.65***
	DTC	-2.7	-1.10±2.14	-2.07±3.13	-1.92±2.57	-0.34	-0.71	-0.62***

[§] Avg. is breed averages of each trait EBVs for the 2017 born calves (Source: BREEDPLAN).
[¶] EBVs were used at accuracies ≥ 60% and 75% thresholds.
[†] EBVs were used from animals born between 2000 and 2018.
[‡] EBVs were used from animals which were also genotyped with OPT (optimized poll testing).
[^] Cohen's *d* represents effect size in pair-wise trait comparison (Sawilowsky 2009), and 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.
° Significance differences between Poll and Horn cohorts were calculated by t-test and *p*-values results are denoted by $p \leq 0.001$: ***, $p \leq 0.01$: **, and $p \leq 0.05$: *.

Genetic merit for most traits in the 3 breeds experienced significant changes within the last two decades. Therefore, by using cohorts born since 2000 and EBVs' accuracy ≥ 75% might have reliably found very few significant differences of small effects. For instance, the effect of head-status on BW (kg) was significant across 3 breeds, however small effect sizes suggesting that on average poll animals were -0.47kg (BRH), 0.45kg (DRM) and -0.48kg (HFD) different than horn animals at birth. Another significant difference was noted for SS (cm), higher SS is associated with increased semen production, and results showed that poll cohorts were better by 0.24cm (BRH), 0.68cm (DRM) and 0.28cm (HFD). DTC (days) is another important trait, measured from female introduced to bull until subsequent calving and is mainly affected by the time taken to conceive. DRM are not recorded for DTC, while poll BRH and HFD showed 3.94 (p=0.05) and -1.92 DTC, respectively. Although, BRH showed significant difference for DTC, however, opposite trends in BRH and HFD suggested that the polledness may not be directly involved. Our results by using OPT genotypes to classify poll and horn cohorts were consistent, except for HFD which may have been affected by relative very small cohort-size of horned animals. Overall, our results coincide with previous findings (Frisch *et al.* 1980; Stookey and Goonewardene 1996; Kommisrud and Steine 1997; Goonewardene *et al.* 1999). A few significant differences of small effects were found in some beef traits for horned animals however the claims were not sustained with EBV estimates at high accuracies (≥ 75%). On the other hand, the polled animals were consistently significantly better for fertility traits (SS) than the horned animals in three breeds. This study concludes that poll and horn animals have equal genetic potential for production, carcass and fertility traits.

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