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Progress with selection to change age at puberty and reproductive rate in Angus cattle

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ABSTRACT

Trying to improve beef cow pregnancy rate by genetic selection within a breed is generally considered to be slow and difficult. In a novel approach, the present study involves selecting to change age at puberty in heifers and then exploiting the genetic correlation with lifetime pregnancy rate. Angus herds were established from a common foundation population in the early 1980s, and were then selected from 1984 (first calves born in 1985) for reduced age at puberty (AGE-) or increased age at puberty (AGE+), with a control herd for comparison. Relative to the AGE+ herd, heifers born in the AGE- herd in 1993 to 1995 were 81 days (=19%) younger at puberty ($P < 0.001$), and their half-brothers had a 1.8 cm (=6.0%) greater scrotal circumference at 8, 10 and 12 months of age ($P < 0.001$). Corresponding live weights in the AGE- herd were 18% less at puberty ($P < 0.001$), not significantly different between herds at birth, weaning or 8 months of age, and 2.4% higher as yearlings ($P < 0.05$) than in the AGE+ herd. Conception rates for the 1992 to 1996 matings were 91.4 and 64.6% ($P < 0.001$) for AGE- and AGE+ yearling heifers, but not yet significant at 89.9 and 85.6%, respectively, for older cows. Restricted maximum likelihood estimates of heritability for transformed age at puberty and scrotal circumference (mean of 3 measurements), using all herds and years of data, were 0.27 ± 0.04 and 0.48 ± 0.05 , with a genetic correlation of -0.30 ± 0.10 . Phenotypic standard deviations for age at puberty in the AGE- and AGE+ herds were 51 days for each herd. Within-herd heritabilities for age at puberty were 0.32 ± 0.11 and 0.13 ± 0.14 for the AGE- and AGE+ herds respectively.

Keywords: cattle; puberty; age; selection; scrotal circumference.

INTRODUCTION

It is generally considered that improving beef cow reproduction (live calves per cow) by genetic selection within a breed is slow and difficult, and the major trait contributing to this is pregnancy rate. The reasons for a slow response are the low heritability and the high age when records are collected. However, the rate of progress via genetic selection for age at puberty (AP) in heifers offers potential because of a medium heritability for AP (New Zealand estimates of 0.32 to 0.49, as reviewed by Morris *et al.*, 1993), and a moderate negative genetic correlation of AP with cow pregnancy rate (Morris and Cullen, 1994). In their review of the genetics of pubertal traits in beef cattle, Morris *et al.* (1993) also summarised the establishment phase of the current puberty selection experiment. Selection- and control-herd results are now revised here following the analyses of calf crops born from 1985 to 1995. Since the 1992/93 matings, much higher selection intensities have been applied to the primary trait, AP; this was achieved by applying more intensive selection among bulls. Their breeding values were derived from scrotal circumference (SC) measured on themselves and their relatives and the negatively correlated trait of AP measured on female relatives.

MATERIALS AND METHODS

Experimental design

Following an establishment phase involving the inter-mating of existing Angus lines at Waikeria (Te Awamutu),

the first experimental matings in the puberty experiment were in 1984, with first selection-herd calves being born in 1985. Details of the design were given by Morris *et al.* (1993). Briefly, three selection herds and an unselected Control were managed together at Waikeria for the 1985 to 1992 calvings. The selection herds consisted of an increased age-at-puberty herd (AGE+), a reduced age-at-puberty herd (AGE-) and an increased scrotal circumference herd. From 1992/93 when the experiment was transferred to AgResearch's Tokanui Station (Te Awamutu), the two similar herds (scrotal circumference and AGE-) were merged into a new AGE- herd. The reorganised three herds consisted of approximately 185 cows calving in 1993 (70 AGE-, 70 AGE+ and 45 Controls), rising to about 240 calving in 1996.

Calving was from mid-August, with the majority of calves born in September. SC data were recorded on all bull calves in May, July and September each year at 8, 10 and 12 months of age. Harnessed vasectomised bulls were used to identify oestrus in all heifers for AP, from May (8 months) until the following January/February, with the exception of the mating period when entire bulls were used. Mating was for 7 to 8 weeks each year, using the same mating dates for yearling heifers and all cow age groups. Selection and culling of yearlings was applied to bulls only. Yearling and/or two-year-old bulls were selected on a within-herd basis for mating, using procedures described below, combining an individual's record and data from relatives of both sexes.

Estimation of breeding values

The breeding objective was to change heifer AP (as represented by standardised age at first oestrus, SFO). The standardisation process, described originally by Gianola and Norton (1981), was particularly important at bull selection time in October, when puberty had only been reached by a biased sample of the yearling heifers (who were relatives of the candidate bulls). The breeding value for SFO was obtained from performance records for SFO and mean SC, using a two-trait animal-model restricted maximum likelihood (REML) analysis (Johnson and Thompson, 1995), and taking account of the negative genetic correlation between SC and SFO. There was greater opportunity to increase the selection intensities applied to bulls from the mating of 1992 onwards, than in earlier years. This corresponded with the time of transfer to Tokanui, because constraints to bull selection at Waikeria no longer applied (no small bulls had been allowed, nor bulls with small testes). This paper presents the results of the experiment for matings from 1992 to 1996, and calf crops born in 1993 to 1995.

Statistical Methods

Least squares analyses were applied to calf and yearling traits (1993 to 1995) and to cow calving date (1993 to 1996), fitting herd, year of birth and other significant fixed effects (age of dam, date of birth (covariate), and sex of calf (for calving date and weights only)). The heritabilities of mean SC and SFO and the genetic correlation between them were estimated from the two-trait REML analyses above, where herd was not fitted but all data back to the establishment phase were included. This statistical procedure provided estimates of herd differences without bias, by subsequently averaging breeding values of animals from each year x herd group. The long-term objective of the experiment, measuring response in cow

reproductive rate to AP selection, was monitored at this stage from 1992 to 1996 mating-year conception rates, and the difference between herds was tested by chi-square analysis.

RESULTS

Table 1 shows the least squares means for each herd, from the most recent years of data recorded (1993 to 1995 calf crops). Phenotypic standard deviations for AP, SFO, individual and mean SC were 51 days, 0.957, 2.44 cm and 2.21 cm, respectively. AP differed by 81 days ($P < 0.001$) between the AGE- and AGE+ herds, representing 1.6 phenotypic standard deviations of herd divergence. SC was 1.7 cm to 1.9 cm greater (5.7 to 6.5% greater) in AGE- than AGE+ bulls between 8 and 12 months of age ($P < 0.001$). There was a single year of 20-month SC data, where differences were non-significant, suggesting that the AGE-bulls had early pubertal development, rather than permanent SC differences.

Live weights at birth, weaning (5 months) and at 8 months of age did not differ between herds, but there was a small increase (6.2 kg or 2.4%) in yearling weight in the AGE- over the AGE+ herd mean ($P < 0.05$). With only these small differences in weight-for-age, the AGE- herd was considerably lighter at puberty (by 52 kg or 18%) than the AGE+ herd.

Calving date in 2-year-olds was directly affected by puberty. However, calving date to unsynchronised natural mating in cows of 3 years of age or more (and born no earlier than 1990) did not differ significantly among herds. Pregnancy rates in yearling heifers mated in the five years 1992 to 1996 were also directly affected by puberty ($P < 0.001$). In older age groups mated in the same five years, pregnancy rates tended to favour the AGE- herd, although the difference was not significant. The AGE-

TABLE 1: Response in the 'AGE minus', Control and 'AGE plus' herds since selection began in 1984/85.

Trait	Years ¹	'AGE minus' herd	Control herd	'AGE plus' herd	Average SED	Signif. test ¹
Age at puberty, d	1993-95	348.4	387.6	428.9	7.2	***
Weight at puberty, kg	1993-95	238.7	263.1	290.5	5.0	***
Scrotal circumference, cm, 8 mo	1993-95	27.9	26.7	26.2	0.4	***
10 mo	1993-95	31.8	30.9	30.1	0.4	***
12 mo	1993-95	35.0	34.2	33.1	0.4	***
20 mo	1993	36.8	35.9	36.2	0.6	n.s.
Birth weight, kg	1993-95	31.9	31.3	32.1	0.4	n.s.
Weaning weight, kg	1993-95	162.7	161.3	163.4	1.8	n.s.
May (8-month) wt, kg	1993-95	201.9	198.5	196.8	2.3	n.s.
Sept (12-month) wt, kg	1993-95	266.6	260.0	260.4	2.8	*
Calving date (3yo+), julian d	1993-96	246.2	244.5	249.3	2.2	n.s.
Pregnancy rate ² (yrlngs),%	1992-96	91.4	90.2	64.6	5.0	***
(2yo+),%	1992-96	89.9	86.7	85.6	2.8	n.s.
(all), %	1992-96	90.3	87.6	80.3	2.5	***

¹ Years of birth for calves and yearlings; mating years for pregnancy data; the significance test is for the AGE- versus AGE+ contrast; *** = $P < 0.001$; * = $P < 0.05$; n.s. = not significant.

² Seven-week mating period; for heifers this corresponds to the approximate mean age range from 14.2 to 15.8 months (= 432 to 481 days), by which ages some of the AGE+ herd have not reached puberty. Number of heifer records = 317, cow records = 931.

herd had significantly higher pregnancy rates than the AGE+ herd, over all age groups combined ($P < 0.001$).

Bivariate heritability estimates for SFO and mean SC over all herds were 0.27 ± 0.04 and 0.48 ± 0.05 respectively, and the genetic correlation between them was -0.30 ± 0.10 . In contrast to mean SC, the heritability of single SC records was 0.41 ± 0.04 , with a repeatability over time of 0.75 ± 0.01 . For the AGE- and AGE+ herd data analysed separately, the phenotypic standard deviations for AP were the same, at 51 days. Heritabilities for SFO over the last 7 years were 0.32 ± 0.11 for the AGE- herd and 0.13 ± 0.14 for the AGE+ herd.

DISCUSSION

A large difference in AP has been generated between the AGE- and AGE+ herds, amounting to 19% of the AGE+ herd mean. Plots of weight-for-age indicate only a small difference in growth curve between herds, although weight at puberty in the AGE- herd was substantially (18%) lower than in the AGE+ herd. In addition to a change in sexual maturity, it may also be relevant to look for other differences in maturity, such as body composition. Cow weights will also be monitored when the 1993-95 calf crops of heifers reach maturity in the herd.

The realised genetic changes in pubertal traits are consistent with paternal half-sib estimates of genetic correlation from Goudies Station for pubertal traits across sexes (Morris *et al.*, 1992) and for SC in bulls and lifetime reproduction (pregnancy rate) in cows (Morris and Cullen, 1994). Because the experiment has involved combined selection using male and female pubertal traits, it is difficult to determine how much of the female response (preg-

nancy rate) has resulted from each component.

Data (not shown) for yearlings reaching puberty in successive 3-week periods reveal two distinct distributions for each herd, which is consistent with expression of a major gene. The cause(s) of these responses in each herd have not been studied yet but there could be differential responses to photoperiod and/or to changes in seasonal feed supply during winter/spring. Alternatively, the selection responses could be occurring without any differential response to such environmental stimuli.

ACKNOWLEDGEMENTS

We wish to thank Mr K.R. Jones and staff for care of animals and for puberty data collection. This work was funded by the Foundation for Research, Science and Technology.

REFERENCES

- Gianola, D. and Norton, H.W. 1981. Scaling threshold characters. *Genetics* **99**: 357-364.
- Johnson, D.L. and Thompson, R. 1995. Restricted maximum likelihood estimation of variance components for univariate animal models using sparse matrix techniques and average information. *Journal of Dairy Science* **78**: 449-456.
- Morris, C.A., Baker, R.L. and Cullen, N.G. 1992. Genetic correlations between pubertal traits in bulls and heifers. *Livestock Production Science* **31**: 221-234.
- Morris, C.A., Bennett, G.L. and Johnson, D.L. 1993. Selecting on pubertal traits to increase beef cow reproduction. *Proceedings of the New Zealand Society of Animal Production* **53**: 427-432.
- Morris, C.A. and Cullen, N.G. 1994. A note on genetic correlations between pubertal traits of males or females and lifetime pregnancy rate in beef cattle. *Livestock Production Science* **39**: 291-297.