SELECTION FOR REDUCED MATURE COW WEIGHT WILL REDUCE BODY CONDITION UNLESS ACCOMPANIED BY SELECTION FOR INCREASED FAT

W.S. Pitchford[1], S.J. Lee[1], K.A. Donoghue[2] and B.J. Walmsley[3]

[1]School of Animal and Veterinary Sciences, University of Adelaide, Roseworthy SA 5371
[2]Department of Primary Industries, Trangie Agricultural Research Centre, Trangie NSW 2823
[3]Animal Genetics and Breeding Unit[*], University of New England, Armidale NSW 2351

SUMMARY

A large number of Angus cows (3,768) were ultrasound scanned for eye muscle area, rib and rump fat depth and intramuscular fat both as yearlings and at weaning of their first calf. They also had weight, height and body condition recorded. Response to selection for a number of scenarios was evaluated following current industry index weightings. Single trait selection for reduced cow weight at time of weaning her calf would result in shorter cows with less fat, muscle and condition. However, selection indices that include some positive weighting on carcass fat (low weighting on subcutaneous fat depth or large weighting on intramuscular fat) would result in increased body condition of cows even when adjusted for changes in weight or mature size. Recently updated Angus selection indices do have positive weightings on both subcutaneous and intramuscular fat.

INTRODUCTION

The Cooperative Research Centre for Beef Genetic Technologies (Beef CRC) included a large Maternal Productivity project. The Project was motivated by seedstock breeder concerns that the body composition of cows is changing in response to selection for feedlot performance which is to the detriment of the breeder herd, especially during seasons with reduced feed availability (Pitchford *et al.* 2015). These concerns were captured in a social science study of seedstock breeders (Lee *et al.* 2015a). Implicit in this concern is a lack of confidence in selection indexes at the time. The specific concern addressed in this paper is that selection for low mature weight which is designed to account for feed costs of cows will result in cows that are of lower body condition rather than being of "more moderate frame".

MATERIALS AND METHODS

One part of the Maternal Productivity Project was scanning cows that were already recorded for existing BREEDPLAN traits. The results reported herein are for 3,768 Angus cows that were measured at the time of weaning of their first calf as reported by Donoghue *et al.* (2015). The traits measured on the cows were weight (WT, kg), hip height (HT, cm), condition score (CS; 1-5 scale; Graham 2006), ultrasound scanned eye muscle area (EMA, cm^2), fat depth at the $12/13^{th}$ rib and P8 rump sites (RIB and P8, mm) and intramuscular fat (IMF, %). These cows (mature, M) were also measured as yearling (Y) heifers for 400 day WT, EMA, RIB, P8 and IMF for routine estimation of BREEDPLAN EBVs.

The effects on cow weight and composition were assessed using selection index theory (Hazel 1943). This was based on correlations rather than covariances as the relative changes were considered more important than the absolute changes. The relative value of 12 traits was a vector of weights, **v**. The vector of 7 selection weights (**b**) were calculated as:

$$\mathbf{b} = \mathbf{G_{11}^{-1}G_{12}v}$$

where G_{12} is a 7x12 matrix of correlations between the 7 cow traits and the 12 potential traits (7 cow plus 5 yearling) and G_{11}^{-1} is the inverse of the correlation matrix between the 7 cow traits.

The variance of the index (σ_I^2) and the vector of response to selection in the 7 cow traits (**R**) were calculated as:

$$\sigma_I^2 = b'G_{11}b$$

$$R = b'G_{11}/\sigma_I$$

Note that responses are in standard deviation units and should only be considered relative as they are scaled by the standard deviation of the index.

The genetic correlations between cow traits and yearling heifer traits are taken from Donoghue *et al.* (2015, Tables 4 and 8) and are presented in Table 1. The cow traits used were from time of weaning of their first calf because this time point had the most data and were very highly genetically correlated (generally >0.9) with traits recorded after this time point. Thus, the measurements used herein are assumed to represent cow condition at later ages. The correlations between heifer traits and cow traits were only reported for the same trait across time, so the correlations between heifer (yearling, Y) trait x and cow (mature, M) trait y were estimated from the same data set but have not been published previously.

Table 1. Heritabilities, genetic standard deviations and genetic correlations between 5 heifer (Y) and 7 cow (M) traits (G_{12}')

Trait	h^2	σ_A	MWT	MP8	MRIB	MEMA	MIMF	MCS	MHT [A]
MWT	0.45	22.5	1	0.22	0.19	0.53	0.18	0.39	0.70
MP8	0.44	1.33	0.22	1	0.96	0.46	0.71	0.87	-0.15
MRIB	0.46	0.97	0.19	0.96	1	0.45	0.73	0.87	-0.14
MEMA	0.26	3.07	0.53	0.46	0.45	1	0.33	0.65	0.17
MIMF	0.32	0.84	0.18	0.71	0.73	0.33	1	0.71	0.07
MCS	0.14	0.17	0.39	0.87	0.87	0.65	0.71	1	-0.25
MHT [A]	0.57	2.61	0.70	-0.15	-0.14	0.17	0.07	-0.25	1
YWT	0.31	16.6	0.71	-0.07	-0.04	0.03	-0.05	-0.01	0.57
YP8	0.46	1.37	-0.21	0.49	0.47	-0.10	0.28	0.39	-0.24
YRIB	0.45	0.98	-0.16	0.45	0.57	0.05	0.37	0.43	-0.21
YEMA	0.35	3.49	0.15	-0.04	-0.04	0.59	0.04	0.11	0.15
YIMF	0.29	0.81	-0.26	0.23	0.32	-0.04	0.65	0.16	-0.12

[A] Actually measured prior to calving but extremely repeatable so assumed same trait.

Thirteen scenarios were tested for the effect of selection pressure on cow weight and body composition. The relative weightings used in the scenarios were based on a subset of those in the current Angus Breeding Index (Angus Australia 2014). The traits of importance herein are yearling weight, P8 fat, eye muscle area, intramuscular fat and mature cow weight and the relative emphasis has been assumed to be +19%, +6%, +2%, +11% and -4% respectively. In the Angus Breeding Index it is actually 600d weight that is +19% and 400d weight is only +3%. However, for the purposes of modelling herein, it was assumed that yearling weight was the trait with the greatest selection pressure at +19%. All current Angus indexes are highly correlated with each other so the choice of which specific index to use is unlikely to impact on the conclusions herein.

The first series of scenarios (Table 2) were based on single trait selection for decreasing mature weight, increasing cow condition score or decreasing cow height (frame). Selection using combinations of these cow traits were then tested in scenarios 4 and 5. Scenario 6 assumed the sole focus was to "bend the growth curve" with high yearling and low mature weight. Various carcass quality measures were added to this in the remaining scenarios with scenario 13 being interpreted as similar to the Angus Breeding Index.

Table 2. Weighting on objective traits for selection scenarios tested.

Scenario	YWT	YP8	YEMA	YIMF	MWT	MCS	MHT
1. ↓MWT					-4		
2. ↑MCS						+4	
3. ↓MHT							-4
4. ↓MWT+↑MCS					-4	+4	
5. ↓MHT+↑MCS						+4	-4
6. ↑YWT+↓MWT	+19				-4		
7. ↑YWT+↓MWT+↑YP8	+19	+6			-4		
8. ↑YWT+↓MWT+↑YEMA	+19		+2		-4		
9. ↑YWT+↓MWT+↑YIMF	+19			+11	-4		
10. ↑YWT+↓MWT+↑YEMA+↑YP8	+19	+6	+2		-4		
11. ↑YWT+↓MWT+↑YEMA+↓YP8	+19	-6	+2		-4		
12. ↑YWT+↓MWT+↑YEMA+↑YIMF	+19		+2	+11	-4		
13. ↑YWT+↓MWT+↑YEMA+↑YP8+↑YIMF	+19	+6	+2	+11	-4		

RESULTS AND DISCUSSION

In this project, mature cow condition score was highly genetically correlated with mature fat depth (0.87) and strongly correlated with MEMA and MIMF (0.65, 0.71; Table 1). Some producers had concerns about cows that could be the same weight, but some are tall with low condition and others are of modest stature with high condition score. Height and MEMA were more strongly correlated with MWT (0.70 and 0.53, respectively) than fat (0.18-0.22) and condition score (0.39) with MWT. Mature cow condition score was lowly correlated with yearling measurements of WT, EMA and IMF and moderately correlated with fat depth (P8 and RIB).

Selection for solely decreased mature weight resulted in cows that had less fat, less muscle and were shorter (Scenario 1, Table 3). This result supports the concerns of some breeders that selection pressure for lower mature weight is associated with cows that have poorer condition. This is important as cow energy reserves influence reproductive performance (Osoro and Wright 1992) and, therefore time retained in the herd. A potential strategy could be to select for increased cow condition rather than weight *per se*. This resulted in cows that were heavier but shorter and, as expected, had more muscle and fat (Scenario 2, Table 3). Height was negatively correlated with condition (Table 1) so selecting for shorter cows resulted in decreased weight (assumed favourable for reducing feed requirements) and increased condition (also considered favourable; Scenario 3, Table 3). Viewed simply, selection for reduced height could be more favourable than selecting for decreased weight. Scenarios 4 and 5 demonstrate that placing a positive weight on MCS ensures greater increase in cow condition. However, selection for cow traits needs to be in the context of a broader selection index.

Selection with a strong emphasis on increased yearling weight but with lowered emphasis on reducing mature cow weight (Scenario 6) resulted in the opposite response to Scenario 1 where cow weight and height increased but all measures of condition still decreased. Cow body condition is a function of both muscle and fat (Graham 2006). However, as heifer EMA and IMF were lowly correlated with cow condition (Table 1), only scenarios with a positive emphasis on fat

depth resulted in increased cow condition. Scenarios 9 and 12 with significant emphasis on increasing IMF did result in maintained MCS..

Table 3. Correlated changes in cow weight and composition resulting from various selection scenarios and expressed as multiples of σ_A.

	Scenario	MWT	MP8	MRIB	MEMA	MIMF	MCS	MHT
1.	↓MWT	-1.00	-0.22	-0.19	-0.53	-0.18	-0.39	-0.70
2.	↑MCS	0.39	0.87	0.87	0.65	0.71	1.00	-0.25
3.	↓MHT	-0.70	0.15	0.14	-0.17	-0.07	0.25	-1.00
4.	↓MWT+↑MCS	-0.55	0.59	0.62	0.11	0.48	0.55	-0.86
5.	↓MHT+↑MCS	-0.20	0.65	0.64	0.30	0.40	0.79	-0.79
6.	↑YWT+↓MWT	0.79	-0.18	-0.13	-0.13	-0.14	-0.15	0.67
7.	↑YWT+↓MWT+↑YP8	0.68	0.06	0.11	-0.18	0.00	0.05	0.55
8.	↑YWT+↓MWT+↑YEMA	0.84	-0.20	-0.14	-0.03	-0.14	-0.13	0.71
9.	↑YWT+↓MWT+↑YIMF	0.63	0.03	0.19	-0.19	0.52	0.00	0.64
10.	↑YWT+↓MWT+↑YEMA+↑YP8	0.75	0.06	0.11	-0.09	0.01	0.07	0.61
11.	↑YWT+↓MWT+↑YEMA+↓YP8	0.88	-0.42	-0.35	0.02	-0.26	-0.31	0.78
12.	↑YWT+↓MWT+↑YEMA+↑YIMF	0.69	0.02	0.19	-0.08	0.55	0.02	0.69
13.	↑YWT+↓MWT+↑YEMA+↑YP8+↑YIMF	0.49	0.27	0.41	-0.12	0.63	0.22	0.48
14.	13 Conditional on MWT	0.00	0.25	0.39	-0.26	0.61	0.15	0.24

Lee *et al.* (2015b) distinguished between fat depth and fatness, which they defined as fat depth with weight fitted as a covariate. Scenario 13 resulted in increases in all cow traits except EMA with the relative increase in height being smaller than weight and carcass composition. This raises the question as to whether the carcass traits just increased with weight or whether cow composition was genuinely improved. In theory, condition score should address this, but given it is subjective it seemed sensible to assess changes independent of those in weight (Scenario 14). The result was a greater reduction in EMA (-0.26), reduced change in height (0.24) and similar changes in fat traits. In conclusion, as yearling IMF and EMA were lowly correlated with cow condition score, a small positive weighting on yearling fat depth or large weighting on IMF is required to avoid selection leading to reduced body condition of cows below that necessary for production.

ACKNOWLEDGEMENT

REFERENCES

Angus Australia (2014) http://www.angusaustralia.com.au/images/ Detailed_Guide_to_Angus_Selection_Indexes.pdf Accessed April 2015.
Donoghue, KA, Lee, SJ, Parnell, PF and Pitchford WS (2015) *Anim. Prod. Sci.* Accepted.
Hazel, LN (1943) The genetic basis for constructing selection indexes. *Genetics* 28, 476-490.
Graham JF (2006) Condition scoring of beef cattle. Department of Primary Industries Victoria. Available at http://www.depi.vic.gov.au/agriculture-and-food/livestock/beef/handling-and-management/condition-scoring-of-beef-cattle Accessed April 2015
Lee SJ, Nuberg IK and Pitchford WS (2015a) *Anim. Prod. Sci.* Accepted.
Lee SJ, Donoghue KA and Pitchford WS (2015b) *Anim. Prod. Sci.* Accepted.
Osoro K and Wright IA (1992) *J. Anim. Sci.* 70,1661-1666.
Pitchford WS, Accioly JA, Banks RG, *et al.* (2015) *Anim. Prod. Sci.* Accepted.