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ASSOCIATIONS BETWEEN RESIDUAL FEED INTAKE ON AD LIBITUM, PASTURE AND RESTRICTED FEEDING IN ANGUS COWS

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SUMMARY

Growth, feed intake and efficiency traits were recorded for 56 Angus heifers in a postweaning residual feed intake (RFI) test, and as cows in a pasture efficiency (n=41) test, then in a restricted feeding efficiency test (n=56) and a mature cow RFI test (n=56). Significant correlations between the traits were taken as evidence that heifers identified as phenotypically superior for feed efficiency at a young age were superior in size and efficiency as cows on medium-quality pasture or on unrestricted pellet feeding. These advantages were not accompanied by superior efficiency during restricted feeding. Lower values for EBV for RFI-postweaning and RFI-feedlot were associated with improved cow efficiency on pasture and on unrestricted feeding, but not with improvement in efficiency at restricted feeding.

INTRODUCTION

Residual feed intake (RFI) is a measure of feed efficiency that has been adopted by the Australian beef cattle industry for the purpose of genetic improvement. It is calculated as the difference between actual feed intake by an animal and its expected feed intake based on its average weight and growth rate over a standard test period. Thus calculated, RFI is phenotypically independent of an animal's size and growth rate, and has lead to speculation that variation in RFI may represent inherent variation in basic metabolic processes which determine production efficiency (Archer *et al.* 1999). There remains a need to study possible interactions of feed efficiency with diet quantity and quality parameters, to determine whether animals selected under *ad libitum* access to a moderate quality ration, typical of that used in RFI tests, are also superior when diet quality is altered, or feed intake is restricted, such as in animals on pasture.

This paper reports the phenotypic associations between efficiency traits measured on the same cohort of Angus females from when they were tested for RFI postweaning, then subsequently tested as lactating 3-year-old cows at pasture, then tested at restricted feeding as 4-year-old non-pregnant, dry cows, and then tested for RFI again on *ad libitum* feeding, and the associations between these efficiency traits and genetic variation in RFI.

MATERIALS AND METHODS

Cattle. The heifers were born in spring 1993 at the Trangie Agricultural Research Centre NSW. They were the progeny of Trangie Angus cows that had been joined randomly to purchased Breedplan-recorded Angus bulls. They became part of the parental population for RFI-divergent lines, but the heifers themselves were not from the selection lines. After a postweaning RFI test in 1994 the heifers were mated and first calved as 2yo cows in 1995. After they calved they were joined to have their second calf in 1996. While lactating with their second calf, cow efficiency at pasture was measured. The cows were not re-mated and following weaning in 1997 the near 4yo cows underwent a restricted feeding efficiency test, followed by a mature cow RFI test.

Efficiency tests

Postweaning RFI (RFIpw) test. After weaning in early 1994, 100 heifers underwent a 10-week RFI test on a medium-energy (10.5 MJ metabolizable energy (ME)/kg dry matter (DM)) pellet ration following standard procedures described by Arthur *et al.* (2001).

*Pasture efficiency (PAST) test***.** Fifty-six 3yo lactating non-pregnant cows (second lactation) that had previously been tested and ranked for RFIpw were available. The 22 most efficient and 22 least efficient were selected to have their pasture intakes measured. The cows were in the third month of their lactation and moved onto an ungrazed oat crop for efficiency testing. The cows and calves were weighed on four occasions: at the start, and after 11, 14 and 18 days. Pasture intake over days 7 to 14 was measured using the alkane technique as described in Herd *et al*. (1998). Data for three cows was not used as there was evidence of a malfunction with their capsule. Average digestibility of DM consumed was 63% which gave a predicted ME content of 9.3 MJ/kg DM meaning that the pasture consumed should be considered of medium-quality in regards to energy.

*Restricted feeding efficiency (RES) test***.** In 1997, six weeks after weaning their second calf, the cows were weighed and then fed at a restricted feeding level calculated as 1.1-times maintenance by equations of SCA (1990). The cows were individually-penned and fed once-daily the same pellet ration as used in RFI tests at Trangie, and weighed weekly. For the first 3 weeks about 0.5kg/head of straw was also offered each day, then the cows allowed another 2 weeks of being fed pellets alone to allow gut-fill to stabilise. Then followed a test period of 7 weeks.

Mature RFI (RFImat). Following the RES test, the cows were tested for RFI on *ad libitum* feeding. They were allowed 3-weeks to become accustomed to consuming the pellet ration before a standard 70-day RFI test.

Traits analysed

Weight and feed intake. Start-of-test weight (STWT) and average daily gain (ADG) for the RFIpw and RFImat tests were calculated from regression of weekly WT. For the PAST test, the average of the four WT of the cows and the calves taken over 18 days was used; it was judged that the test length was too short to accurately estimate ADG. For the RES test, the weekly WT taken at the start was used as STWT; ADG was calculated by regression of weekly WTs over the test. Daily feed intake on a DM basis (DMI) was standardised to an equivalent intake of a 10MJ ME/kg DM.

Fat. Subcutaneous fat depth over the 12/13 rib was measured at the start and end of each test (start only for PAST test) using ultrasound by a trained technician.

Efficiency. RFIpw, RFIres and RFImat were calculated for each test as the residual from the multiple regression of DMI against their metabolic STWT ($STWT^{0.73}$) and ADG. Feed conversion ratio (FCR) was calculated as DMI/ADG in the RFI tests and as DMI per 500kg (cow WT plus calf WT) in the PAST test. For the RES test, ADG and gain in ribfat (FATGN) were also used as measures of efficiency on the premise that an animal gaining (or losing) weight or fat when fed just above predicted maintenance was more (or less) efficient.

Estimated breeding values (EBV). Trial Breedplan EBV for RFIpw (EBVrfi-pw) and RFIfeedlot (EBVrfi-f; extracted 30/11/2009) were used as estimates of the genetic merit for RFI. All cows had their own RFIpw record, multiple progeny RFIpw records, and some had a progeny RFIf record. Mean EBVrfi-pw was 0.10kg/day (SD 0.23; range -0.26 – 0.67; mean accuracy 76%) and mean EBVrfi-f was 0.20kg/day (SD 0.29; range -0.31 – 0.77; mean accuracy 60%).

Statistical analysis. Results for 56 cows that were tested together for RFIpw, restricted feeding efficiency and RFImat, and for 41 cows with PAST test results, were available. Descriptive statistics for the traits measured are presented in Table 1. The CV for RFI was calculated as the SD divided by mean DMI, and for ADG (as kg gained or lost) and FATGN in the RES test as SD divided by mean STWT or mean start ribfat. Correlation coefficients were calculated between

pairs of traits and statistical significance used to indicate phenotypic association. Statistically-significant regression coefficients for traits on the EBVrfi were taken as evidence for association of phenotypic variation with genetic variation in RFI.

Table 1. Means (SD) and range for weight, growth rate, rib fat, feed intake and efficiency traits for Angus heifers in a postweaning RFI (RFIpw) test and as cows in a pasture efficiency (PAST) test, a restricted feeding efficiency (RES) test and a mature RFI (RFImat) test. See text for abbreviations

	RFIpw test	PAST test	RES test	RFImat test
Number of females	56	41	56	56
STWT (kg)	321 (36)	cow: 597[1] (66; 473 – 798)	535 (54)	606 (59)
	237 – 407	calf: 107[1] (16; 69 – 136)	428 – 700	493 – 777
ADG (kg/day)	1.03 (0.14)	[2]	0.34 (0.23)	1.30 (0.21)
	0.78 – 1.35		-0.29 – 0.86	0.85 – 1.71
Start ribfat (mm)	4.2 (1.6)	11.9 (3.4)	8.5 (2.2)	7.6 (2.3)
	1 – 9	6 – 22	4 – 14	3 – 12
Ribfat gain (mm)	4.4 (2.1)		-0.9 (1.9)	8.1 (2.7)
	0 – 11		-6 – 3	3 – 14
DMI (kg/day)	11.7 (1.1)	12.1 (2.8)	5.41 (0.41)	17.0 (1.4)
	9.7 – 14.0	6.0 – 19.8	4.6 – 6.6	13.8 – 19.7
RFI (kg/day)	0.0 (0.4)		0.0 (0.07)	0.0 (1.01)
	-1.1 – 1.1		-0.18 – 0.16	-2.4 – 2.6
FCR (kg/kg)	10.6 (1.2)	8.6 (1.9)[3]		13.3 (2.0)
	8.1 – 12.8	4.7 – 13.3		10.3 – 18.4

[1]Average weight. [2]Test too short to measure with accuracy. [3]kg DMI/500kg cow WT plus calf WT.

RESULTS AND DISCUSSION

There was phenotypic variation in efficiency in these sequential tests with a CV of 4% for RFIpw, 22% for FCR at pasture; and 6% for RFImat. Variation in efficiency during restricted feeding measured as RFI was 1.3%, as ADG 2% and as RIBGN 22%.

Phenotypically, lower RFI during the RFIpw test was associated with heavier cow WT during lactation 2-years later, with no associated increase in pasture intake, and with a trend to lower (better) FCR at pasture (Table 2). However postweaning RFI was not associated with variation in efficiency (RFI, ADG or FATGN) during the restricted feeding test. Lower (better) RFIpw was associated with heavier cow WT and lower RFI, but not FCR, in 4-year-old dry cows on *ad libitum* feeding. Superior efficiency at pasture (lower FCR) was associated with lower ADG but not with variation in FATGN or RFI in the subsequent restricted feeding test, and not associated with efficiency in the mature cow RFI test. Efficiency in the restricted feeding test (ADG, FATGN, RFI) was not associated with efficiency, as either RFI or FCR, in the mature cow RFI test. However FATGNres negatively correlated with FATGNmat meaning that cows that lost most fat during restricted feeding had higher fat gain on *ad libitum* feeding. In summary, there was evidence that heifers identified as phenotypically superior in feed efficiency on *ad libitum* feeding postweaning are also superior as lactating cows on medium-quality pasture and as dry cows re-tested on *ad libitum* feeding, but not when tested for efficiency on restricted feeding at a level just above maintenance. Superior efficiency at restricted feeding was not phenotypically associated with superior efficiency in the other three efficiency tests.

At the genetic level, lower (better) postweaning RFI (EBVrfi-pw) was associated with heavier lactating cow WT at pasture but not with superior FCR; was not associated with superior efficiency during restricted feeding; and was associated with lower (better) FCR and RFI in the

mature cow RFI test (Table 2). Lower feedlot RFI (EBVrfi-f) was not associated with improved cow efficiency on pasture or during restricted feeding, but was associated with superior FCR (but not RFI) in the mature cow test. Therefore in this experiment, EBVrfi-f computed on the basis of RFIpw and some RFIf records was not a good predictor of cow RFI on *ad libitum* feeding.

Table 2. Correlation coefficients (*r*-values) between growth, feed intake and efficiency traits and their regression coefficients (*b*-values) on EBVrfi for Angus heifers in a postweaning RFI and as cows in a pasture efficiency test, a restricted feeding efficiency test and a mature cow RFI test. See text for abbreviations; units in Table 1. Bold: P<0.05; italic: P<0.1; else not different from 0 at P>0.1

	Pasture test			Restricted feeding test					Mature RFI test					
	Cow WT[1]	DMI	FCR[2]	STWT	DMI	ADG	FATGN	RFI	STWT	DMI	ADG	FATGN	FCR	RFI
STWTpw	**.77**	.19	-.15	**.76**	**.80**	.01	.02	*.23*	**.79**	**.62**	**.38**		-.11	.13
ADGpw	**.63**	-.11	**-.39**	**.60**	**.63**	-.20	.07	**.28**	**.61**	**.40**	**.32**		-.12	-.03
DMIpw	**.65**	.12	-.17	**.66**	**.70**	-.06	.07	**.29**	**.70**	**.65**	**.39**		-.08	.21
FCRpw	-.23	**.31**	**.41**	-.13	-.14	.19	.00	-.12	-.10	.17	-.05		.13	**.34**
RFIpw	**-.34**	.12	*.28*	**-.27**	*-.25*	.09	.04	.02	*-.23*	.16	-.02	-.04	.14	**.38**
FCRpast[2]				-.15	-.14	*.27*	-.22	-.01	-.15	-.07	-.03	.13	.00	.01
ADGres									-.05	.03	-.05	-.06	.10	.12
FATGNres									-.09	.06	.16	**-.38**	-.16	.04
RFIres									.08	.20	.22	-.03	-.14	.09
EBVrfi-pw	*-76*	1.2	1.8	*-61*	-0.4	0.20	-0.5	0.04	-56	0.91	-0.12	-1.0	*2.3*	**1.9**
EBVrfi-f	-43	-1.2	-0.14	-29	-0.2	0.12	-0.8	0. 2	-23	0.06	-0.16	-0.6	**2.1**	0.83

[1]Average weight. [2]kg DMI/500kg cow WT plus calf WT.

The results of this experiment indicate that selection for lower postweaning RFI should be effective in improving cow efficiency on medium-quality pasture and on unrestricted pellet feeding, but that further research is required into the effectiveness of selection for lower RFI to improve efficiency of cows on restricted nutrition typical for much of the year in pasture-based production systems.

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