POSSIBLE PHYSIOLOGICAL INDICATORS FOR NET FEED CONVERSION EFFICIENCY IN BEEF CATTLE

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SUMMARY

Angus heifers and bulls in test 2 and 3 of the Net Feed Conversion Efficiency (Net FCE) project at Trangie (Arthur *et al.* 1996) were ranked for Net FCE. Blood and faecal samples were taken from high and low Net FCE animals at the end of each test to identify possible indicators for Net FCE. Blood analysis included measurement of 12 haematological parameters and assays for insulin-like growth factor- 1 (IGF-1) and 2 (IGF-2). Feed and faecal samples were measured for alkane concentration which was used to estimate dry-matter digestibility (DMD) for each animal. Results from blood analysis indicate several significant relationships exist between Net FCE and some less labile blood constituents. Total plasma protein was significantly different between high and low Net FCE animals ($P < 0.01$). Ratio of haemoglobin/red blood cells was highly significant ($P < 0.0l$), and highly repeatable. Ratio of haematocrit/red blood cells was significant ($P < 0.05$) and number of red blood cells approached significance ($P < 0.10$). Blood samples from test 2 animals analysed for circulating concentrations of IGF-I and IGF-2 indicated no significant differences ($P > 0.05$) between high and low Net FCE animals. DMD was 1% unit higher ($P < 0.10$) in high Net FCE cattle compared to low Net FCE cattle. This study identified physiological differences between high and low Net FCE animals at the end of the efficiency tests. Further research is needed to identify differences at the start of the test, predictive of subsequent performance, to form a screening test that justifies the expense of putting animals through a Net FCE test.

Keywords: net feed efficiency, physiological indicators, beef cattle

INTRODUCTION

While most selection programmes aim to improve production systems through an increase in outputs, escalating costs of production demand that breeders produce more efficiently and cost effectively. Genetic improvement of net feed conversion efficiency (Net FCE) is a strategy to reduce the costs of inputs. Net FCE is actual feed intake net of expected requirements for maintenance and growth. High Net FCE cattle eat less than low Net FCE cattle. Preliminary results from the Net FCE project at Trangie (Arthur *et al.* 1996) indicate that large variation exists among animals for Net FCE.

The objective of this study was to examine animals being tested for Net FCE for possible physiological indicators of Net FCE. The approach taken was to compare high and low Net FCE animals for differences in feed utilisation (via digestibility), haematology and plasma insulin-like growth factor-l and 2 (IGF-1, IGF-2). Red blood cells andrelated factors were examined for their oxygen carrying capacities (to investigate any possible associations between their function and Net FCE); plasma proteins, lymphocytes and associated cells due to their connection with immune function (to explore the possibility of a connection between immune function and Net FCE); and IGFs since IGF-1 has been shown to be related to a number of traits including growth and body size, food conversion efficiency and carcass characteristics (Davis and Bishop 1994).

MATERIALS AND METHODS

Animals

This investigation used beef cattle from the second and third efficiency tests of the Net Feed Conversion Efficiency project at Trangie Agricultural Research Centre. Test 2 comprised Angus, Hereford and Shorthorn heifers from industry herds ($n = 193$). Test 3 consisted of Trangie-bred Angus heifers and bulls ($n = 194$ and 188 respectively). Individual feed intakes of a pelleted 70% luceme hay: 30% wheat mixture were recorded in an automated feeding system over a 120 day test period. Cattle in each test group were ranked for Net FCE based on the difference between. what they were expected to eat (derived from their liveweight and growth rate during each test) and what they actually consumed over that period. Further details of the test protocol are given in Arthur *et al.* (1996).

Samples were obtained from the 10 highest and 10 lowest animals as ranked for Net FCE. Test 2 and 3 animals were sampled for blood and faeces at the completion of their test. Test 3 animals were also sampled for blood 1 month before the end of the test to measure repeatability for the blood factors over time.

Samples and analyses

Although animals from each test were sampled at different times throughout the year (due to the different completion dates of each test), effort was made to ensure that all samples were taken from the animals mid-morning. Two tubes of blood were taken from each animal. The first used EDTA as an anti-coagulant and were sent fresh to Sydney University Rural Veterinary Clinic, Camden, for analysis of total plasma protein (TPP), fibrinogen (FIB), haemoglobin (HGB), haematocrit (HCT), red blood cells (RBC), white blood cells (WBC), lymphocytes (LYMP), neutrophils (NEUT), monocytes (MONO) and eosinophils (EOS). The second tube used heparin as the anti-coagulant for test 2. Some samples which clotted were discarded and results for a reduced number of samples are reported, EDTA was used for blood samples taken from test 3 animals. These samples were centrifuged at 4°C for 10 - 15 minutes, plasma removed, and frozen for subsequent analysis of plasma protein (PP), albumin and IGFs. PP and albumin content were determined by the CSIRO Pastoral Research Laboratory, "Chiswick", Armidale. The ratio of albumin/PP (ALBPP) was calculated on the assumption that a reduction in this ratio would be evidence of an increase in globulins (the other major fraction of PP) associated with exposure to infection. IGF-1 was analysed by the method of Hall *et al.* (1992); IGF-2, by the same procedure as IGF-1 but with rabbit anti-human IGF-2 polyclonal antisera (GroPep Pty Ltd) substituted for Tr 10 rabbit IGF-1 antisera.

To evaluate any variation in the concentrations of alkanes in faeces that might occur between days, faecal samples were sought from each animal on 4 different mornings over one week. They were dried for 2 - 3 days at 70°C, ground, stored individually, then sent to the Elizabeth Macarthur Agricultural Institute, NSW Agriculture, Camden, for alkane analysis (Dove 1992). Feed samples were also sent for alkane analysis and determination of dry matter digestibility (DMD). The extent of recovery in faeces of alkanes in feed was calculated as:

$$\text{Recovery} = (1 - \text{DMD}) \times (\text{faecal [alkane]} / \text{feed [alkane]})$$

DMD was calculated for each animal using the formula:

$$\text{DMD} = 1 - \text{feed [alkane]} \times \text{alkane recovery} / \text{faecal [alkane]}$$

To decide whether fewer than 4 samples per animal need be obtained to calculate an average value for alkane content close to that based on 4 samples, correlations were calculated between alkane content (C29+C31+C33) averaged over 4 samples, and values over 3, 2 or from 1 of these samples collected at the end of test 2.

Differences between high and low Net FCE groups in test 2 and 3 were tested in the general linear model (GLM) procedure of SAS (1990), after accounting for variation due to'the fixed effects of test and sex. Results are expressed as least squares means (LSMs) ± s.e. Results for IGF-1 and 2 were available only from test 2; differences between high and low efficiency groups were analysed using t-tests.

RESULTS

Blood samples

Many of the haematological parameters measured were very variable (in particular WBC, LYMP, NEUT, MONO and EOS). Results for some of the less labile blood constituents demonstrated they could prove useful as indicators for Net FCE. Table 1 summarises results for animals from tests 2 and 3. There were consistent, statistically significant differences between high and low Net FCE animals in their levels of TPP and in the ratios MCH and MCV. None of the remaining blood constituents differed between high and low efficient animals ($P > 0.10$).

Table 1. Blood constituents that differed between High and Low Net FCE animals at the end of tests 2 and 3

Blood constituent	High efficiency	Low efficiency	Significance [A]
MCH (haemoglobin / red blood cell)	43.45 ± 0.94	46.19 ± 0.94	**
MCV (haematocrit / red blood cell)	14.84 ± 0.26	15.86 ± 0.26	*
Total plasma protein (g/L)	65.20 ± 0.68	70.05 ± 0.68	**

[A] + $P < 0.10$; * $P < 0.05$; ** $P < 0.01$

The ratio MCH was highly repeatable over the last month of test 3 ($r > 0.9$; Table 2). MCV, TPP and RBC were moderately repeatable ($r > 0.5$). This suggests that for these haematological parameters in which differences between high and low Net FCE cattle were observed, the collection of blood samples to characterise animals might be possible before the end of a Net FCE test. Other blood parameters that were moderately repeatable included HGB in both sexes, and HCT and LYMP in bulls, but these were not associated with differences in Net FCE:

Table 2. Repeatability estimates using correlation coefficients between 2 measurements for blood constituents [Red Blood Cells (RBC), Haemoglobin (HGB), Haematocrit (HCT), MCV (HCT/RBC), MCH (HGB/RBC), Total Plasma Protein (TPP) and Lymphocytes (LYMP)] between week 15 and 19 of test 3

	RBC	HGB	HCT	MCV	MCH	TPP	LYMP
Heifers	0.86**	0.72**	0.29^{ns}	0.70**	0.94**	0.71**	0.36^{ns}
Bulls	0.78**	0.68**	0.56**	0.91**	0.95**	0.53**	0.61**

^{ns} $P>0.05$; * $P < 0.05$; ** $P < 0.01$

Plasma proteins (PP), a measurement equivalent to TPP, differed between high and low Net FCE animals at the end of the tests (68.3 ± 0.6 v 70.1 ± 0.6g/L; $P < 0.05$). However there was no difference in ALBPP between high and low Net FCE animals (0.5 14 ± 0.006 v 0.5 11 ± 0.006 g/g; $P > 0.05$), hence no evidence for an increase in globulins in one group of cattle over the other at the end of the tests.

Blood samples from test 2 animals showed no difference ($P > 0.05$) in circulating levels of IGF-1 (276 ± 7 v 249 ± 17μg/mL) and IGF-2 (174 ± 5 v 180 ± 9μg/mL) between high and low Net FCE animals.

Digestibility

Only 12 animals from test 2 had a total of 4 samples collected. For these 12 animals correlation coefficients calculated between alkane content averaged over all 4 samples, and values from 1 and 2 samples, were less than 0.5. This suggested that values from less than 3 samples would give an inaccurate estimation of average alkane content based on 4 samples. The correlation coefficient of 0.67 (for the averages of 3 versus 4 samples) was high enough to place confidence in averages of 3 samples. Consequently only those animals with 3 or more samples were included in the analysis of DMD in test 2 and 3 ($n = 18$ and 40 respectively).

The ration in test 2 contained 105, 384 and 32 mg/kg DM of C29, C31 and C33 alkane. In test 3 the ration contained 144,352 and 37 mg/kg DM of each alkane. DMD was reported to be 66% in test 2 and 69% in test 3. Faecal recoveries were calculated to be 73, 76 and 83% for C29, C3 1 and C33 in test 2, and 58, 64 and 80% in test 3. Because of its relatively higher and more consistent recovery, only values for C33 were used to calculate DMD. Over the 2 tests, high Net FCE animals tended to be slightly more able to digest feed than low Net FCE animals (DMD = 68.1 ± 0.5% and 67.1 ± 0.5%, respectively: $P<0.10$).

DISCUSSION

Only limited research has been performed on the use of blood factors as indicators for production characteristics. Kitchenham *et al.* (1977) found globulin to be negatively correlated to growth rate and body weight, and albumin to be positively correlated to growth rate during summer. In this study there was no evidence for an increase in globulins in one group of cattle over the other at the end of the tests and therefore no evidence of greater exposure to infection in one group of cattle over the other. The higher TPP and PP levels found in low Net FCE cattle would appear not to be of immunological origin and may reflect metabolic differences, for example in rates of protein synthesis and degradation.

Results illustrated a tendency for high Net FCE animals to have more RBCs in their blood, and their RBCs to have a lower haemoglobin content than the low Net FCE animals. The lower ratio of haematocrit to RBCs (MCV) in high Net FCE animals suggests that they had more RBCs and fewer other cells, i.e. white blood cells, in their HCT (or packed cell volume) than low Net FCE animals. These differences may be associated with capacity for transporting oxygen.

The tendency towards higher DMD by high Net FCE animals suggests a concomitant improvement in feed utilisation. The difference of 1% unit in DMD might appear small but it is not trivial. Simple calculations reveal that a 1% unit improvement in DMD could reduce by 2.3% the feed required per day for 450 kg cattle growing at 1.3 kg/day and eating feed with a DMD of 69%, typical of cattle in these tests (MAFF 1984). The difference in average feed intake between the high and low Net FCE cattle during the

week preceding and week of faecal sampling, in tests 2 and 3, was about 16%. This 1% unit difference in DMD could account for about 14% (2.3/16) of the observed difference in feed eaten.

No significant differences were found in levels of circulating IGF-1 and IGF-2 between high and low Net FCE cattle. Previous research has found associations between IGF-1 and many growth related measurements, including feed conversion ratio (Davis and Bishop 1994). Net FCE is calculated to be independent of liveweight and growth rate and this may explain its apparent poor association with IGF- 1. IGFs circulate bound to binding proteins, which restricts the actions characteristic of free IGF and restricts permeability of IGF through capillaries, inhibiting access to membrane receptors and regulating biological activity (Zapf and Froesch 1986). Therefore failure to demonstrate strong association between simple measures such as total plasma IGF-1 and IGF-2 with Net FCE should not discount a role for hormones of the growth axis in influencing Net FCE.

In conclusion, ideally it should be possible to take measurements at the start of the test and to use those results as predictors of subsequent performance, so that they could form a screening test that justifies the expense of putting animals through the Net FCE test. So far results are only from samples taken at the end of the 120 day test. While these may explain differences in Net FCE over the test, these differences might well be a consequence of performance in the test, rather than being related to Net FCE directly. However this study has identified physiological differences in high and low efficient animals, and indicates areas where research could be intensified.

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