Understanding the effect of gender and age on the pattern of fat deposition in cattle.

*A.K. Pugh[1] *, B. McIntyre[2], G. Tudor[3] , & D.W. Pethick[1]*
[1] Division of Veterinary & Biomedical Sciences, Murdoch University, Murdoch, 6150, Western Australia, Australia.
[2] Department of Agriculture, Western Australia, South Perth, 6151, Australia.
[3] Department of Agriculture, Western Australia, Bunbury, 6231, Australia.
**Corresponence: Tel: +61893602235, FAX: +61893602235, apugh@central.murdoch.edu.au*

Summary

This experiment investigated the allometric development of intramuscular (imf), subcutaneous, and intermuscular fat in Australian Angus heifers and steers a. Steers (90) heifers (75) were fed a grain based ration and randomly allocated to a slaughter weight in the range 200kg to 450kg carcass weight. Body composition was estimated from a 6 rib dissection (5-10) and imf content was estimated on of *m. longissimus thoracis et lumborum* (LTL). Analysis of the results using general linear modelling (SAS) showed that at any given level of estimated total body fatness, steers had a significantly higher level of intramuscular fat ($P<0.0001$) when compared to heifers, though at the same carcass weight there was no significant difference ($P >0.05$). There was a significantly linear increase ($P <0.0001$) in imf of the LTL as proportion of total rib fat. As carcase weight increased there was a significant increase in the ratio of gms fat in the LTL/gms of total body fat ($P<0.0001$), although the r^2 was low ($r^2=0.121$), indicating that intramuscular fat tended to develop more strongly as the carcase weight increased. It can be concluded that steers are more efficient than heifers with respect to accumulation of imf, as they have a higher level of imf at the same total carcass fatness**.** In addition intramuscular fat accumulation occurred primarily in parallel with total body fat synthesis.

Keywords: intramuscular fat, total body fat, steers, heifers

Introduction

Within the total fat depot there are many different depots. The main fat depots are subcutaneous, intermuscular, channel and kidney and intramuscular fat (imf) and a commonly held view is that imf is the last depot to develop (Vernon 1981). However this conclusion was not supported by (Johnson, Butterfield, and Pryor 1972) who found that as a proportion of total carcass, the absolute amount of intramuscular fat develops at the same rate as intermuscular, subcutaneous, channel and kidney fat. Other work has also shown that imf, over a wide range in fatness levels, is highly correlated with total body fatness (Jones, Savell, and Cross 1990). These results suggest that within a genotype imf and other fat depots increase at the same rate as animals fatten and therefore in this study it was hypothesized that imf will develop at a constant rate, as a proportion of the total fat depot.

There have been many studies on the expression of imf in heifers and steers and in the past the trend is for higher levels of imf in heifers at a given carcass weight (Hardt, Greene, and Lunt 1995; Jones, Savell, and Cross 1990; Kazala et al. 1999). Few studies have

examined the interaction between imf, sex, and total body fatness in a serial slaughter experiment.

The primary objective of this experiment was to gain a better understanding of the allometric growth of the fat depots in steers and heifers over a wide range of carcass weights. It was hypothesized that heifers will show increased imf (%) at lower carcass weights than steers, but when corrected for total body fatness heifers and steers will show the same level of imf (%) at the same level of total body fatness. In addition intramuscular fat accumulation will accumulate at the same rate as the sum of subcutaneous and intermuscular fat depots.

Material and methods

Animals and diet

Australian Angus steers and heifers were purchased from one property and placed into intensive feeding pens (3 pen replications per gender) at an initial liveweight of 426kg and 415kg for steers and heifers respectively. The steers were castrated at 3-4 months of age by elastration. There were 25 heifers and 30 steers per replicate pen. Cattle were allocated at random to final hot carcass weight endpoints (15 of each gender per endpoint) and were slaughtered when the mean estimated carcass weight was reached for each group. The hot carcass weight endpoints were 220, 260, 300, 340, 380 and 450kg for heifers, and 230, 280, 330, 380, 430 and 480kg and for the steers.

The diet consisted of ground hay (15%), rolled barley (67.4%) and lupin grain (15%) and a mineral pre-mix with an estimated metabolisable energy and crude protein of 11.5 MJ/kg and 14% (dry matter basis) respectively. Total time on the grain based ration for the last slaughter group was 385 or 354 days for the steers and heifers respectively.

Measurements

Liveweight was measured every 2 weeks and feed intake was measured by weighing the residues weekly. The animals were slaughtered when the cattle reached the appropriate estimated carcass weights. An estimate of carcass composition was obtained via a 6 rib set dissection (rib 5-10) (Johnson and Charles 1981). The joint was dissected into subcutaneous and intermuscular fat (total rib fat), muscle, bone and connective tissue (ligamentous nuchae only). Intramuscular fat (% fresh weight) was estimated by Soxhlet extraction (Tume 1984) in *m. longissimus thoracis et lumborum* (LTL) at the level of the 10^{th} rib.

Statistical analysis

All analyses were performed using the software package SAS, using generalised linear models, with sex as a fixed effect, (SAS 1997). For all of the models non-significant interactions were sequentially removed from the model until the most significant model ($P<0.05$) was obtained (e.g. linear, quadratic, cubic).

The dependant variable percentage total rib fat was tested using a model which comprised terms for sex, hot carcass weight and percentage imf of the LTL (linear and curve linear) and all first order interactions. The dependant variable percentage imf of LTL was tested using a model, which comprised terms for sex, hot carcass weight and percentage total rib fat and all first order interactions. The dependant variable imf of the LTL/total rib fat, was tested using a

model which comprised of terms for sex and hot carcass weight and all first order interactions.

Results

The heifers grew at 1.5kg/day on 0-30days on feed which decreased down to 0.9kg/day in 260-300 days on feed, and the steers grew 2.0kg/day on days 0-37 which also decreased down to 0.92kg/day on days 280-343 on feed.

Carcass weight was a significant predictor of imf (%), total rib fat (%) and gms imf in the LTL/gms total rib fat (Figures 1(*i), (ii) and (iii)).* However, there was no significant difference between imf (%) content of the LTL and gms imf in the LTL/total rib fat in heifers and steers ($P>0.05$) (Figures 1(*i) and (ii)*). There was a positive linear relationship between imf of the LTL and carcass weight (Figures 1 *(ii)*).

Heifers were significantly fatter at all carcass weights when compared to steers ($P<0.0001$), but there was no significant difference in the rate of fattening as they grew to maturity (Figure 1*(i)*). There was a weak ($r^2=0.12$) but significant linear relationship ($P<0.0001$) between carcass weight (kg) and gms of imf in the LTL/ gms total rib fat but there was no significant difference between heifers and steers ($P>0.05$) (Figure 1*(iii)*). The percentage of total rib fat was a significant predictor of imf (%) with steers (Figure 1*(iv)*).

Discussion

We conclude that there is a significant increase at the imf site compared to subcutaneous and intermuscular fat. This is not consistent with findings by (Johnson 1975) who found that LTL imf does increase largely with other depots i.e. that LTL imf is not late maturing. However the relationship is relatively weak (slope = 0.000035, $R^2= 0.121$), indicating the trend for late maturing is not strong. Given this data we would suggest that in general, fat development is relatively similar across the 3 depots studies (intramuscular versus the sum of subcutaneous and intermuscular).

Heifers were fatter than steers at any given carcass weight. This is consistent with the findings of (Jones, Savell, and Cross 1990), however heifers did not express more imf at this same carcass weight (The fitted model was linear (Figure 1 (ii)) which suggests that imf (%) would have continued to increase with further increases in carcass weight. This finding is consistent with findings for British breed cattle (Duckett et al. 1993) and Japanese Black x Holstein cattle (Aoki et al. 2001).

When plotted against total rib fat heifers show a lower imf (%) than steers (Figure 1*(iv)*). Given the high energetic demands associated with fat synthesis (NRC), steers will represent a more efficient production system for the development of marbled beef.

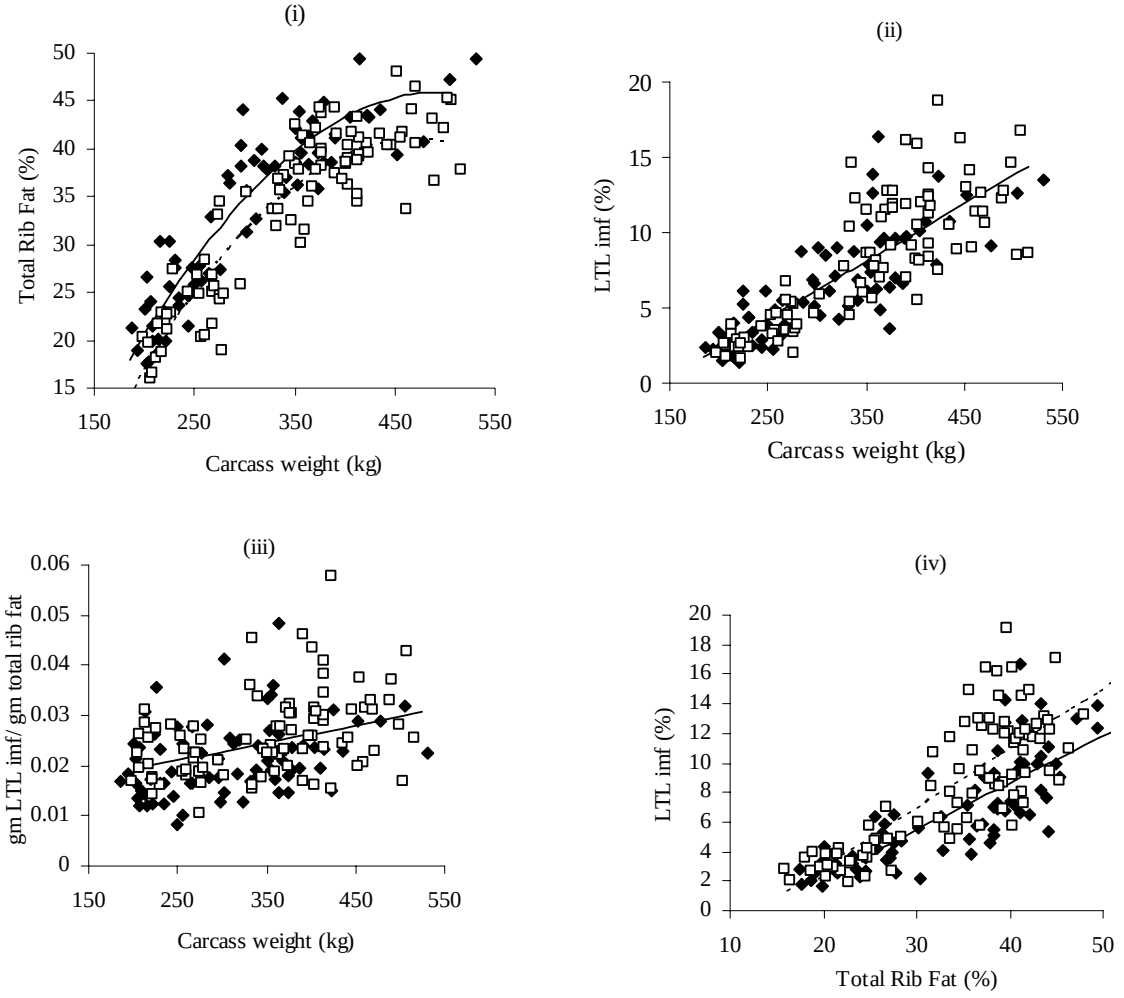

Figure 1. The relationship between carcass weights and (i) percentage total rib fat (heifers $y=-24.81+0.284x - 0.000287x^2$; steers $y=-28.51+0.284x - 0.000287x^2$ $R^2= 0.837$, $P<0.0001$) (ii) percentage chemical imf of LTL (LTL imf%, $y= -4.99+0.038x$ $R^2= 0.67$, $P<0.0001$) (iii)gms of imf in the LTL/ gms total rib fat ($y=0.012 + 0.000035x$, $R^2= 0.121$, $P<0.0001$) and the (iv) relationship between total percentage total rib fat and percentage chemical imf of LTL, (LTL imf%, Heifers $y = -4.07+ 0.32x$; Steers $y = -5.25 + 0.40x$, $R^2 = 0.658$, $P< 0.0001$) (□----□ Steers ♦——♦Heifers).

Conclusion

We can conclude that the development of imf, within a gender, is driven primarily by total body fatness of the animal, There is a gender effect for imf (%) development when total carcass fatness is accounted for such that steers have significantly higher levels of imf (%) at the same percentage total rib fat (body fatness).

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