CATTLE PRODUCTION AND MEAT YIELD INTERACTIONS

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INTRODUCTION

From the birth of a calf up until it is sold at the retail outlet s beef, a great deal of effort is expended in optimising profitability. n these events the point of slaughter represents a rather abrupt reak in a sequence of activities that would be better considered s a continuum. On the growth side of this break, activities are ursued that often are not complementary to activities on the rocessing side. Such incompatible activities can produce marked conomic losses.

Very often graziers, veterinarians and husbandry advisors ork hard on the nutrition and health of the animal in order to get t to market liveweight, without close reference to the carcass equirements of the intended market. The supply of unsuitable attle for a specific market results in financial losses to the rower, or the processor or to both through cuts rejection, ncreased processing costs and loss of premiums.

At a Congress of this type we tend to hail small mprovements in livestock growth (promotants etc.), or in meat rocessing (preservation, mechanization etc.), as valuable conomic gains. They, of course, are. However it is curious that e often fail to place due emphasis on the large economic gains hat can result from producing the type of cattle (carcasses) that re suited to a specific market.

In this paper I want to discuss events that straddle the point f slaughter; I wish to relate events in the growth and finishing f the beef animal to its carcass profitability.

MODERN MARKETS

The main quantitative needs of beef markets are spelt out in erms of carcass weight and carcass fat content. Given acceptable quality", all markets tend to translate to these two quantitative equirements. This may come as somewhat of an anticlimax to any of us, with so many other exciting carcass features to be ebated. This simplicity of specification is not a bad thing for the ndustry. However it is odd how producers of cattle and carcasses o to a great deal of effort to appraise so many other characteristics which cloud the issue.

When carcass weight and fatness are specified we are utomatically catapulted into a consideration of "maturity" which is commonly regarded as the liveweight of an animal genetic type or sex) at which the deposition of fat begins in arnest (Berg and Butterfield, 1976; Price and Berg, 1976). Forty ears ago this area needed no close consideration since what was equired of cattle was that they should reach the "maturity" point nd get way past it (eg., the very generous requirements of the mithfield market). Carcass fat was virtually as saleable as red neat. Today's markets are different. Specifications now require hat cattle, at slaughter, should have reached the "maturity" point nd proceeded past it only a relatively short way depending on he market specification.

Now many of you will grimace and say "Is this the old story bout over-fatness again? We've heard it all before. We want to ear about other important attributes!" Well, we will speak of ther important attributes such as different genetic types for markets, variations in saleable beef yield, the influence of sex on ield, "muscling" and the correct conformation, but I would oint out that the amount of fat in the carcass and its distribution atterns will form an essential part of the discussion of each ttribute.

TYPES OF CATTLE

In Australia our cattle herd has a large and expanding gene pool. More importantly Australian cattlemen, especially those in the northern parts of Australia, have been as innovative in their use of these genes as any in the world.

Currently we are importing new types – Romangola, Gelbveih, Texas Longhorns, Salers, Piedmontese, Belgian Blues and perhaps Borans. Whilst a large genetic base generally is regarded as an advantage, perhaps it's time we better understood and properly utilized those types we already have.

BEEF MARKETS

(i) Maturity type

Some types of cattle fit a specific carcass market better than other types; or putting this in a more practical form, some types of cattle cannot economically satisfy a given market specification.

Growers who continue to present unsuitable cattle will lose out financially, especially under objective classification systems. At the same time they will pass problems on to the boning room at the processing works.

This is clearly illustrated in the results from two yield studies shown below. Here the influence of genotype and sex on saleable beef yield for the Japanese grass-fed, chilled beef market was investigated. Figure 1 shows details from a commercial study in a Queensland export abattoir (Ball and Johnson, unpublished data).

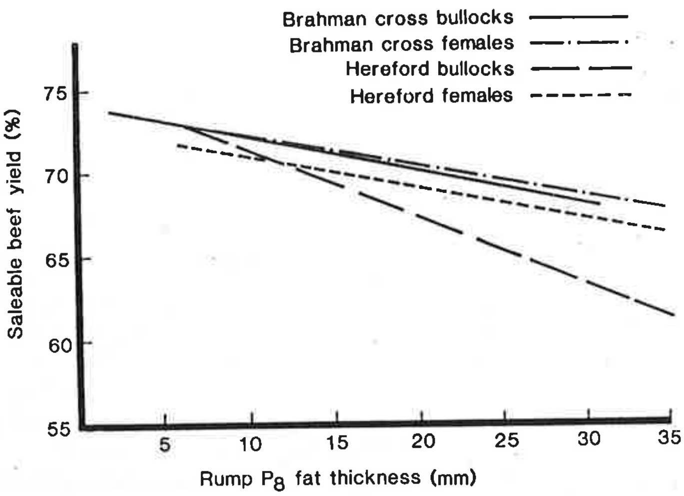


Figure 1. Influence of genotype and sex on saleable beef yield for the Japanese grass-fed, chilled beef market.

Deductions from Figure 1

(a) Brahman cross-breds (steers and females) yielded about 2 percent more than Hereford females and much more than 2 percent in Hereford steers, at all levels of fat thickness;

(b) As fat thickness increased, yield fell off rapidly regardless of breed or sex;

(c) The influence of sex on yield was not clear. While there was no significant difference in yield curves between the Brahman-cross steers and females, there was a large difference between those of the Hereford steers and females.

CONCLUSION:

Yield varied with fatness and this relationship was influenced by the genotype-sex groups, but how much by genotype and how much by sex?

The relative importance of these influences is specified in Table 1.

Table 1. Explanation of the variance accounted for in the regression of percentage saleable beef yield on rumpfat thickness

Genotype	Sex	Number of carcasses	R^2 (Variance accounted for) (%)	Sources of explained variance Fat thickness (%)	Genotye (%)	Sex (%)
Hereford	Steer A	75	63.3	-	-	-
Hereford	Female	38				
Brahman	Steer	35	46.9	83.8**	15.8**	0.1 NS
Brahman	Female	42				

A Hereford steer group deviated from constant variance and was not considered further in covariance analysis

** $p < 0.01$ NS Not significant

The fat thickness measurement explained 83.8 percent of variance, genotype 15.8 percent and sex nil. In other words when we use fat thickness to reflect yield variations there is no need to allow for sex because sex has already been accounted for in using the fat thickness measurement.

Is the 15.8 percent of yield variance tied up in genotype worth chasing? It certainly is a significant contribution but what this analysis really brings home to us is that carcass fatness is of over-riding importance in determining saleable beef yield!

The findings from this study worried us. After all the investigation was done under commercial circumstances, with all its possible inaccuracies – fast measurements, potential variations in yield standards from inconsistent trimming, etc. So our second study (Johnson and Ball, unpublished data) was carefully controlled and checked. The results are summarized in Figure 2.

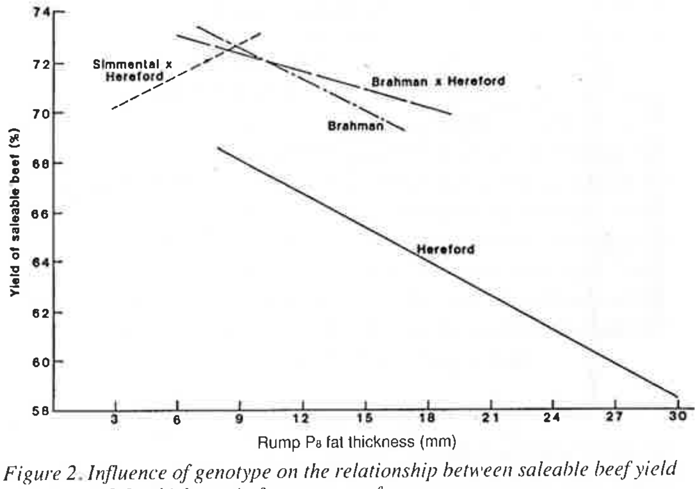


Figure 2. Influence of genotype on the relationship between saleable beef yield and rump P8 fat thickness in four groups of steers.

Deductions that could be made from this study were:

(a) Brahman and Brahman x Hereford Fl steers were higher-yielding than Hereford steers at all levels of fat thickness;

(b) Simmental x Hereford Fl steers, by careful management could be turned off at yields equal to the above two groups. This genotype was achieving maximum yield at about 750-780kg liveweight. It seems that top yield and adequate fat cover for Japanese cuts can only be achieved in this late-maturing type of cattle at very heavy weights;

(c) As fat thickness increased, yield fell off rapidly in all groups except the Simmental x Hereford steers.

CONCLUSION:

This study confirmed that the Brahman types (Taurindicus) did indeed yield well for the Japanese market, while the late-maturing Simmental x Hereford group could equal this high yielding performance provided they were taken on to a carcass weight that allowed them to develop a rump fat thickness of about 12mm. The conclusion that the Herefords appear unsuitable for the Japanese trade must not be extrapolated to the local trade where they do indeed perform well for a market that, after all, absorbs half of Australia's production.

When carcasses of similar fat distribution pattern (see next section) are compared, the highest yielding carcasses for the Japanese trade are those that have the lowest acceptable fat cover. In our studies this was about 12-15mm at the rump "P8" site (Moon, 1980). At about 12mm some types of carcasses are in real danger of having some cuts rejected for the Japanese market because of insufficient fat cover. So to satisfy market acceptability and obtain maximum yield the grower treads the tightrope between maximum profitability and cuts rejection. This was clearly evident in the AUS-MEAT National Livestock Feedback Trials conducted in Rockhampton, Queensland, in May of this year where some top-yielding carcasses had one millimetre too little fat cover on some cuts (Beasley, unpublished data).

So in our study, in addition to the effect of total carcass fatness there was an important breed effect! How this breed effect (or a large part of it) was mediated is shown in the following section, which deals with fat distribution.

(ii) Fat distribution

Until recently the influence of carcass fatness on many carcass characters including profitability, was assumed to be attributable to total carcass fatness. However the latest evidence shows that differences in fat distribution among types of cattle can influence the yield of saleable beef. This is not widely appreciated. In Tables 2 and 3 details of the fat distribution of the four genotypes in our previous study are given.

Table 2. Distribution of fat in "crude" cuts and in "beef yield" in the carcasses of four genotypes of steers

Genotype	Number of carcasses	Subcutaneous fat (% of cold carcass wt.) Crude cutsY	Beef YieldZ	Intermuscular fat (% of cold carcass wt.) Crude cutsY	Beef YieldZ
Hereford	15	12.9^a	4.6^a	18.4^a	7.2^a
Brahman	15	9.9^b	4.8^a	11.3^b	5.8^b
Brahman x Hereford (F1)	15	10.5^b	4.6^a	13.5^c	6.5^c
Simmental x Hereford (F1)	15	7.0^c	3.2^b	12.4^{bc}	6.3^{bc}

Y Crude cuts derived from the carcass before trimming to Japanese specifications.

Z Beef yield is the total weight of crude cuts of the carcass minus waste fat and waste bone which were removed according to specification.

Values not bearing the same superscripts are significantly different.

Table 3. Total fat in the "crude" cuts and in "beef yield" in the carcasses of four genotypes of steers

Genotype	Saleable beef yield (%)	Crude cuts Subcutaneous + intermuscular fat % of chilled carcass wt.	Ratio (Intermuscular fat) (Subcutaneous fat)	Beef yield Subcutaneous + intermuscular fat % of chilled carcass wt.
Hereford	64.7	31.3	1.4	11.9
Brahman	71.8	21.2	1.1	10.6
Brahman x Hereford (F1)	71.5	23.9	1.3	11.1
Simmental x Hereford (F1)	71.5	19.4	1.8*	9.5

* Ratio of 1.8 in the Simmental x Hereford group is misleading because this ratio resulted from an extremely low (underfinished) level of subcutaneous fat.

Deductions from these two tables

(a) In the "crude" cuts, Herefords contained by far the most subcutaneous fat and the Simmental x Hereford group the least; with intermuscular fat the Herefords, once again, contained most fat by far with the other three genotypes containing much lower levels;

In "beef yield" Simmental x Hereford contained the least subcutaneous fat and Herefords, the most intermuscular fat;

The distribution of fat (ratio of intermuscular to subcutaneous) clearly relates to degree of trim and saleable beef yield in all except the Simmental x Hereford group. In this genotype, with a ratio of subcutaneous to intermuscular fat of 1 to 1.8, the intermuscular fat was not high, but the subcutaneous fat was extremely low! The impression that the genotype had a much higher level of intermuscular fat than the other three groups was misleading. Intermuscular fat levels were about the same in all four groups. Because of the late maturity of the Simmental x Hereford steers their subcutaneous fat deposition had not proceeded very far;

Cuts from fatter carcasses (Herefords), even after a "constant" trim from an experienced trimmer, tended to contain the highest level of fat particularly in the intermuscular depot.

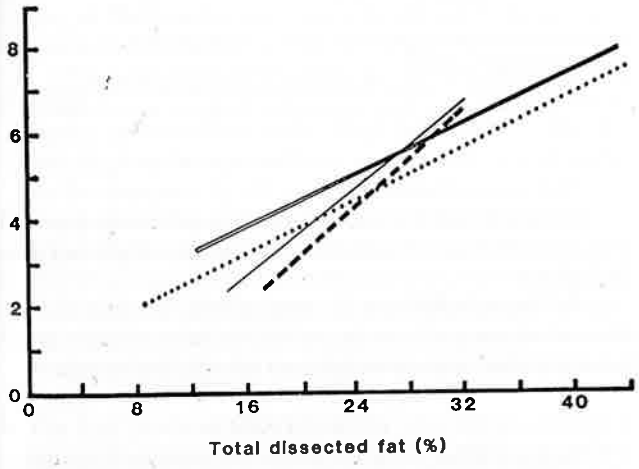
CONCLUSION:

The distribution of fat in the carcasses of different genotypes attle has an important influence on degree of trim necessary , therefore, the saleable beef yield.

Though the Simmental x Hereford group yielded highly, a nber of cuts would have been rejected for the Japanese market ause of insufficient fat cover. This problem would have been ely overcome by taking them on to heavier weights and ness.

Marbling

Marbling fat (or the fat distributed within a muscle, also ed intramuscular fat) is highly prized by some overseas kets. Beef from Australian feedlots destined for Japan attracts ıbstantial premium if it is well-marbled. It is in Australia's erests to identify mechanisms by which we can enhance rbling. Current knowledge is sketchy and the potential for reasing the tendency to marble, by genetic selection, has not n assessed. In addition the role played by nutrition, and haps the interactions between nutrition and genotype, have been defined.



ıre 3. Change in marbling fat with percentage total dissected fat in four otypes of steers
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In one recent study (Figure 3) it was established that the her marbling scores sought by certain overseas markets will be jeopardised by the use of late-maturing cattle which are nerally the more profitable types for heavier markets (Johnson, 37). For example, in Figure 3 the early-maturing Angus and refords had more marbling fat at lower carcass fatness levels n the late-maturing Friesian and Charolais x Illawarra groups. wever, as fattening increased, marbling fat was deposited at a much greater rate in the late-maturing types, until at about 27-30 per cent carcass fat, it equalled and then surpassed that of the early-maturing types. We must interpret this result cautiously. How much of the difference between these four types was attributable to physiological age, as distinct from feed and intensity of feeding, is not clear. In studies of beef marbling there are strong indications that physiological age may over-ride other important factors.

This area needs to be studied more closely and when it is I suspect we will have to ask ourselves an important question "Is the gain in premium for enhanced marbling sufficient to offset any losses that may occur from altered nutritional regime or from depressed saleable beef yield (because of overfatness)?".

(iv) Muscling, conformation, "more" muscle

These three terms are listed here under the one heading because they are often ill-defined, poorly understood, frequently mis-understood and confounded, one with the other.

Having presented them as a mixed bunch of characters let us now try to discuss them individually.

1. Muscling

When "muscling" is spoken of in the cattle and beef industries it can mean many things. Its most common meaning seems to be a suggestion that parts of the beef animal or its carcass are well muscled relative to other parts. Furthermore it is invariably the rump, loin or butt that is observed to be "well-muscled" relative to other areas. It is never the brisket, flank or chuck.

The fact is that muscle weight distribution of normal cattle, same sex, same maturity, is relatively fixed between types (Berg and Butterfield, 1976). Many separate studies support the contention that muscle weight distribution does not vary much between types (Butterfield, 1963, 1965; Bergstrom, 1968, 1978; Mukhoty and Berg, 1973; Charles and Johnson, 1976).

Some of the most incontrovertible evidence in the world began to be accumulated by Professor Rex Butterfield here in Australia in the early 1960's (Butterfield, 1963). His findings have been confirmed a dozen times since.

At an EEC Conference in Ghent in 1977 great debate led to the following question: "Is there sufficient genetic variation in cattle to make the study of muscle weight distribution a fruitful line of endeavour?" (Oslage, 1978).

Tony Kempster (1978), one of Britain's foremost meat scientists, placed the question in proper perspective. He said "... here we are talking about a character such as lean distribution which, in overall economic terms, is one sixteenth as important as fat distribution, and one quarter as important as lean/bone ratio." Moreover identification of muscling is often confounded by other carcass tissues, particularly subcutaneous and intermuscular fat (Harrington, 1971, 1972; Dumont, 1978).

Despite our clearer understanding of muscling since the 1960's, carcass evaluation systems and carcass competitions have included, still include and will continue to include scores or evaluations for "muscling".

2. Conformation

Conformation (or shape) and muscling, to most people in the cattle and beef industries, are synonymous (Yeates, 1959; Berg and Butterfield, 1976). Whilst both terms are commonly used there is a great deal of scientific evidence to show that both conformation and muscling owe much of their points-scoring success to the unwitting appraisal of associated fat deposits (Briskey and Bray, 1964; Martin et al. 1966; Harrington, 1971, 1972; Dumont, 1978). Indeed by the very nature of anatomical changes associated with growth in the beef animal's body it is very difficult for a person to discern in the live animal or its carcass exactly what is muscle and what is fat.

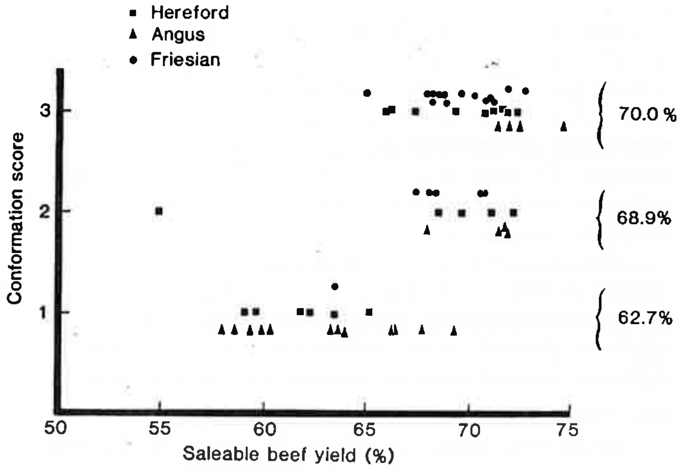

Figure 4. Relationship between conformation score and percentage saleable beef yield
Score 1 = "Superior" conformation
Score 3 = "Inferior" conformation

Conformation is regarded as a point of excellence with better conformation generally implying better yields (Martin, et al. 1966). Repeated studies at Queensland University have shown that better conformation is associated with inferior yields (Figure 4) (Johnson, 1984) and detailed anatomical study of many different types of conformation, or changing conformation, shows that muscle weight distribution remains stable. Scientific evidence from other parts of the world shows that conformation does not have a strong positive influence on saleable beef yield (Butler et al. 1956; Butler, 1957; Kidwell et al. 1959; Branaman et al. 1962; Cole et al. 1964; Hedrick et al. 1969).

Conformation, like muscling is evaluated in many carcass appraisal systems throughout the world despite the fact that it is not associated with increased yields. If conformation is included in appraisal systems for reasons other than yield then it may be a commercially valuable character. However, it should be understood that "superior" conformation is unlikely to be associated with increased yields of saleable beef and is more likely to be associated with decreased yields.

Despite the volume of evidence showing that "superior" conformation is not associated with increased yields, it is still commonly regarded as a point of excellence in the evaluation of cattle and carcasses. Perhaps we should simply despair and seek solace in the statement by Heusner (1985) who said "a false conclusion once arrived at and widely accepted is not easily dislodged and the less it is understood the more tenaciously it is held".

3. Total muscle

If two carcasses of the same weight and fatness are compared for total muscle, the one with the most muscle will have the highest muscle/bone ratio. This sort of muscling, muscle relative to bone, does vary genetically and is potentially worth pursuing (Hankins et al. 1943; Berg and Butterfield, 1966; Broadbent et al, 1976). However any selection for improved muscle/bone ratio should be placed in perspective:

(a) Progress is slow and gains are relatively small;

(b) If the only criterion sought is a high muscle/bone ratio, selection could lead to a higher incidence of the dubious "double-muscled" genes;

(c) Any production gains from successful selection for higher muscle/bone ratio will invariably be dwarfed by gains resulting from fitting cattle of optimum fatness to the specific market (Kempster, 1978). This latter (simple) management technique is attended by immediate economic benefits in the form of more economic production and increased carcass premiums.

Anyone wishing to select for improved muscle/bone ratio is immediately confronted with a major practical problem. How do you measure muscle/bone ratio?

For scientists in the laboratory the answer is to (painstakingly) dissect a side of the carcass in question into its component tissues, muscle, bone, fat and connective tissue. They then have muscle/bone ratio. Commercially there is no equivalent technique and if you take the best available information, the ratio of saleable beef yield to waste bone, there remains the problem of the lean/fat mix in the beef yield.

What about visual techniques? Is it possible to develop a meaningful visual method?

"Muscling" has been traditionally evaluated on the butt of the hindquarter. However a number of people, including scientists, who have come to realize the potential influence of fat (within and over the musculature of the hindquarter) have shrewdly moved to the shin for evaluation. The reason given is that the shin contains very little subcutaneous or intermuscular fat, and "muscling" can be assessed here unimpeded by fat. An additional advantage, it is stated, is that in the live animal muscling can be readily assessed through the skin, without being confounded by fat. On the surface this all seems reasonable.

At the University of Queensland both shin and shank have been carefully studied to evaluate their usefulness in predicting the amount of total muscle and yield of saleable beef in the carcass. The results are shown in Table 4.

Table 4. Prediction of total muscle weight and saleable beef yield weight from shin and shank measurements

Prediction	Predictor A	Significance	R^2 (percentage variance accounted for)	Standard error of estimate (g)
Total muscle wt.	Shin circ. B	***	16	9718
	Shin circ. B + HCW	***	55	7109
	Shin circ.	***	16	9634
	Shin circ. + shin len.	***	21	9387
	Shank circ.	**	15	9744
	Shank circ. + shank len.	***	21	9454
Saleable beef yield wt.	Shin circ. B	***	13	10894
	Shin circ. B + HCW	***	70	6448
	Shin circ.	**	11	10779
	Shin circ. + shin len.	**	13	10641
	Shank circ.	**	15	10515
	Shank circ. + shank len.	***	22	10109

A Measurements used were shin circumference, shin length, shank circumference, shank length and hot carcass weight.
B This measurement was made on the hanging carcass before the hide was removed ie., skin-on. All other measurements shown were made on the dressed carcass ie., skin-off.
** $p < 0.01$ *** $p < 0.001$

Deductions from Table 4

(a) Shank and shin measurements made on the dressed beef carcass were poorly related to total muscle weight and saleable beef yield;

(b) Shin circumference, measured in the skin-on carcass, like the measurement made on the dressed carcass, was poorly related to total muscle weight and saleable beef yield.

CONCLUSION:

Shin and shank, even when their circumferences are appraised by careful measurement and combined with other carcass measurements, are poor predictors of carcass muscling.

GENERAL CONCLUSIONS:

The beef industry's profitability can be greatly enhanced if the beef producer extrapolates the beef processor's requirements back to characteristics in the live animal.

The quantitative requirements of modern beef markets are usually spelt out quite simply in terms of carcass weight and fat content. "Maturity type" therefore becomes a character of primary concern. Whilst "maturity type" is genetically based its commercial effects are mediated, in practical terms, through the growth and deposition of fat.

In the studies on Japanese grass-fed chilled beef discussed in this paper, the regression, percentage saleable beef yield on rump fat thickness, accounted for about 50 per cent of the variance. Of this, 84 per cent was explained by the fat thickness measurement, 16 per cent by genotype and nil by sex. Fat thickness (total carcass fat), therefore, accounted for most of the explained variance, and genotype a significant but much lower amount. Sex accounted for nil, its effect having already been accounted for by the use of the fat thickness measurement. Evidence showed that the genotypic effect was due, at least partly, to differences in fat distribution between types.

Early maturing cattle showed greater marbling fat deposits at lighter weights than late maturing cattle. However when late maturing cattle were grown on for heavier export markets their percentage marbling fat reached and even surpassed that of early maturing cattle at the heavier weights required. The genetic and nutritional influences on ability to marble appear to be an important commercial area that, to date, has been largely ignored.

Commercially important differences in muscle weight distribution ("muscling") do not exist among types of cattle and selection directed along this line will be non-productive.

Muscle/bone ratio and total muscle percentage differences do exist in cattle and are potentially worth pursuing. However techniques require elucidation and progress will be relatively slow. Much greater commercial gains can be made simply and quickly by attention to carcass fat.

Conformation in cattle and carcasses has become entrenched as a valued character. Whilst conformation is used to score points in commercial carcass evaluation systems and in carcass competitions it is poorly, or negatively, related to important quantitative characters such as saleable beef yield and total carcass muscle.

In this paper I have published data on the suitability of specific genotypes of cattle for specific markets. As a scientist I believe that I have acted responsibly. However it would be very wrong if we took data from this study of certain types of cattle for a pre-determined market and extrapolated them to other types and other markets. The principles of production must not be compromised here by petty breed arguments.

If we use the specific examples of this paper to define principles of beef production I believe the cattle breeder and cattle producer will be best served. The principles on which we should model our beef production are, to my mind, clearly established:

(i) Market specifications exist. They have been defined for both local and export markets, and must be interpreted in the first instance by the meat processor.

(ii) The quantitative side of these specifications is spelt out largely in terms of carcass weight and fat thickness.

(iii) Objective carcass classification schemes, like AUS-MEAT (Anonymous, 1987), provide the descriptive "bridge" between the market and the grower. Once again the meat processor's role in the transmission of this information is vital.

(iv) The beef producer should use the information offered to him by the processing industry and AUS-MEAT in order to fit types to markets. The defence of a breed based on tradition or history may well compromise profitability for modern markets. A specific genotype may be totally unsuited to a specific market whilst a given market may be satisfied, with equal profitability, by a number of genotypes.

In Australia the stage has been reached where cattle production and a consideration of the quantitative and qualitative aspects of beef production can no longer proceed independently without jeopardising profitability. Information is now available to the cattleman which enables him to utilize the adequate gene pool available to him.

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