# Improving carcase and beef quality in *Bos indicus* through crossbreeding

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**Abstract**

*The CRC for Cattle and Beef Quality is Australia's largest integrated beef research project directed at improving the eating quality of beef. Since 1992, the CRC has worked closely with the Australian beef industry to identify the main genetic and non-genetic factors affecting tenderness, marbling, retail beef yield, meat colour, the fatness traits and efficiency of feed utilisation. This paper presents results from the CRC's Northern Crossbreeding Project showing favourable opportunities to improve carcase and beef quality attributes of high* Bos indicus *content animals by crossbreeding. Non-genetic effects on meat quality arise from CRC investigations of grain (feedlot) and grass finishing and from our studies of genotype x environmental interaction between cattle bred in northern Australia and finished in temperate regions of Australia. The results provide a blueprint for improvement of beef quality traits.*

**CRC for Cattle and Beef Quality**

- Ensure consistent consumer-specified eating quality of domestic and export product by developing and implementing new pre- and post-slaughter practices;
- Achieve a consistent supply of consumer-specified product for both domestic and export markets using innovative genetic, nutritional and management technologies applicable to grass- and grain-finished cattle;
- Capture benefits from the worldwide expansion in genomics knowledge by strategic application of gene markers and functional genomics for genetic improvement of beef quality in Australian cattle herds;
- Add value to the beef carcase by striving to achieve increased returns for all beef cuts, based on their eating quality, not just their anatomical description;
- Strengthen domestic and export markets for Australian beef by developing and implementing at the production and processing tiers of the industry, new technologies directed at improving health and welfare of cattle and enhancing food safety of beef and beef products.

**CRC Core Breeding Programs**

To address these issues, the CRC developed an integrated research program to focus on the major production and processing factors affecting beef quality. Underpinning the program were two large-scale progeny testing programs used to develop quantitative and molecular genetic technologies to breed cattle better suited to new and existing markets and to design novel feeding, management and meat processing strategies to ensure eating quality of beef.

***CRC Straightbreeding Program***

The CRC's straightbreeding program involved 7 breeds in which pedigreed calves were generated in 34 commercial herds throughout eastern Australia. The calves were purchased by the CRC at weaning and were managed through a complex research protocol that enabled scientists from multi-disciplinary teams to work together to identify genetic, nutritional, management and meat processing factors that affect beef quality. Breeds in the program were from biologically diverse types of cattle and from environmentally diverse properties of origin. *Bos taurus* breeds were four British breeds (Angus, Hereford, Murray Grey and Shorthorn) and the Sanga-derived Belmont Red breed. Large European *Bos taurus* breeds were not included because cow herds of sufficient size to generate the required numbers of progeny could not be located. The Brahman breed represented *Bos indicus* breeds. The Santa Gertrudis breed represented the *Bos indicus* x British stabilised breeds. Belmont Red, Brahman and Santa Gertrudis are all tropically adapted breeds. British cattle for the program were bred in temperate areas, whilst the tropically adapted cattle were bred in tropical or sub-tropical areas of Australia.

All sires represented in the program were performance recorded through Group BREEDPLAN to allow evaluation of sires relative to industry standards. Individual collaborating breeders and the breed societies selected sires for the program. Genetic linkages were generated between herds of the same breed by use of common ('link') sires in all herds. After weaning, calves were transferred to properties under the CRC's control for growing and finishing to experimental specifications according to the CRC experimental protocol. Calves were subsequently managed together within contemporary management or cohort groups.

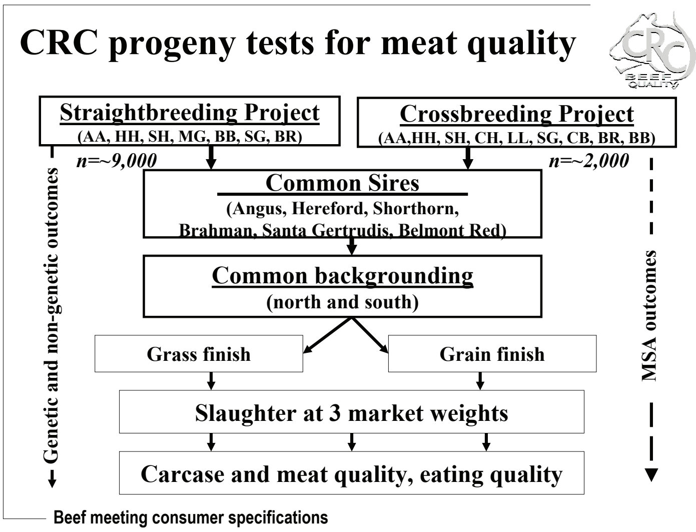



Figure 1. Design of CRC breeding program targeting meat quality traits (AA, Angus; HH, Hereford; MG, Murray Grey; SH, Shorthorn; BB, Brahman; SG, Santa Gertrudis; BR, Belmont Red; CH, Charolais; LL, Limousin; CB, Charbray)

### *Crossbreeding Program*

The CRC's northern crossbred cattle were generated in 2 Brahman herds that were under direct control of the CRC, in contrast to the contracted arrangement with cooperating breeders in the straightbreeding program. This approach allowed greater control of the more complicated mating program required to generate the contemporary crossbred calves. Northern Australian pastoral companies, individual beef producers and the Queensland Department of Primary Industries donated ~1,000 Brahman females specifically to initiate the crossbreeding program. Seven hundred cows were joined at the CRC's leased property, "Duckponds" and 300 cows were joined at Brigalow Research Station in Central Queensland over 3 years to produce comparable purebred Brahman and Brahman-crossbred calves. Calves were weaned at an average age of 6 months.

Sire breeds in the crossbreeding program represented different biological types (Figure 2) and included Bos indicus (Brahman-purebred control), Bos taurus-British (Angus, Hereford, Shorthorn), Bos taurus-European (Charolais and Limousin), Brahman x British-derived (Santa Gertrudis), Brahman x European-derived (Charbray) and Sanga-derived (Belmont Red). All sires except Charbray were performance recorded in their breed society's Group BREEDPLAN analysis. Appendix 1 shows breed average and average EBVs for growth, fertility and carcass attributes for all sires used in the CRC crossbreeding program for all breeds except Charbray. Charbray sires were $F_1$ Charolais x Brahman, whose sires were recorded in the Charolais Group BREEDPLAN analysis and whose dams were recorded in the Brahman Group BREEDPLAN analysis.

To strengthen the experimental design, genetic linkages were generated between the CRC's crossbreeding and straightbreeding projects by use of common sires across projects. For breeds common to both programs (Angus, Belmont Red, Brahman, Hereford, Santa Gertrudis and Shorthorn), only sires that had been used in the straightbreeding program were used in the crossbreeding program. Most joinings within the crossbreeding program were by AI, followed by natural mating to 'back-up' sires of a different breed. A small number of sires were naturally mated at the same time as the AI programs to ensure calves by natural mating and AI sires were born at the same time. The aim of the program was to generate about 20 steer and heifer progeny (10 of each sex) per sire for each of the sires used in the crossbreeding program.

### Crossbreeding Project Objectives

- Identify sires and sire breeds that rank highly for net feed efficiency as well as carcase and meat quality attributes;
- Identify the most profitable $F_1$ genotypes for grain and grass finishing for domestic, Korean and Japanese market specifications in northern and southern environments;
- Estimate the differences between Estimated Breeding Value (EBV) bases of different breeds so that EBVs can be compared across breeds;
- Determine the accuracy with which EBVs predict performance of crossbred offspring;
- Determine the effect of *Bos indicus* content on eating quality of cattle of known genotype, growth paths, backgrounding environment, finishing regime and slaughter process to develop Meat Standards Australia pathways for northern cattle;
- Improve the industry's ability to compete for the quality-based Asian markets;
- Deliver the above outcomes to industry through the CRC's Education and Technology transfer program, the CRC's cooperating breeders, sponsors and industry-driven Board and Advisory Committee.

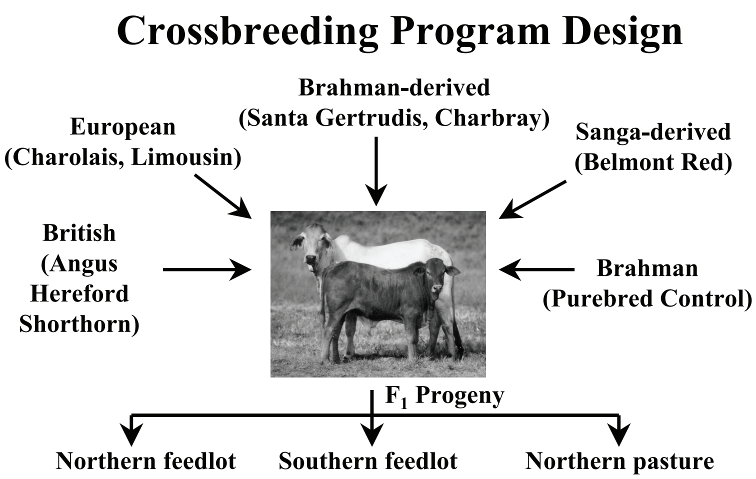



Figure 2. Design of the CRC's northern crossbreeding program

## Results of the Crossbreeding Program

### *Results of the Breeding Program*

About 1,000 Brahman cows that were donated to the CRC by northern Australian pastoral companies, individual beef producers and the Queensland Department of Primary Industries were joined at "Duckponds" and Brigalow Research Station over 3 joining periods to produce comparable pure-bred Brahman and Brahman crossbred calves that were weaned in 1996, 1997 and 1998 at an average age of 6 months.

In spite of the effects of drought over the three breeding seasons at "Duckponds", a total of 1,950 observations (matings) were recorded in the three joining periods with a herd average pregnancy rate of 75%. Gestation length averaged 285 days and a reproductive loss from positive pregnancy test to weaning average 9% of all cows mated. This is similar to long-term loss rate recorded at other sites in Central Queensland. There were no significant differences between the properties of origin of the cows for the reproductive and mortality traits studied. Mating group, lactation status, paddock mated and year of mating were significant sources of variation on reproductive traits, and all of these effects were largely a function of nutrition and body condition.

Gestation length, combined with post-partum anoestrus (the period from birth of calf to when the cow next comes in heat), measures calving interval. A shorter gestation period allows the cow more time to begin cycling before the next mating season. This trait is important in terms of maximizing pregnancy rates when restricted joining is practiced. Property of origin of the cows was not a significant source of variation in gestation length. The trait was significantly affected by year, sire breed, date of calving, calf sex (bull calves were in utero on average two days longer than heifer calves) and was significantly related to calf birth weight (heavier calves were generally associated with longer gestation lengths). Table 2 shows the effect of sire breed on gestation length of calves conceived by artificial insemination. Charolais, Limousin, Charbray and Brahman bulls sired calves with longer gestation length than the British breeds (Angus, Hereford and Shorthorn). Tropically adapted composite bulls (Belmont Red and Santa Gertrudis) sired calves with intermediate gestation lengths.

Table 1. Effects of sire breed on gestation length
*To be significantly different, gestation lengths for sire breeds should differ*

| Sire Breed | No. of calves | Gestation length (days) |
|---|---|---|
| Angus | 98 | 282 |
| Belmont Red | 260 | 285 |
| Brahman | 197 | 288 |
| Charbray | 29 | 289 |
| Charolais | 186 | 286 |
| Hereford | 100 | 281 |
| Limousin | 228 | 287 |
| Santa Gertrudis | 103 | 285 |
| Shorthorn | 87 | 283 |
| Total numbers | 1,290 | 285 |

*by 3days*

Origin of the dam, year, sire breed, calf sex and day of birth significantly affected calf birth weight. Year differences accounted for most of the variation in calf birth weight and indicated that older, heavier cows with longer gestations on average produced heavier cows at birth. With the exception of the Angus-sired calves, sire breed differences in birth weight showed that *Bos taurus* sires unrelated to the dam breed *(Bos indicus)* generally produced calves ($F_1$s) with heavier birth weights (Figure 3). Progeny of Charolais sires were 9% heavier at birth than the average of all the population, but because of the Brahman uterine environments that are known to restrict calf birth weights, calving difficulties were not a problem. Progeny of Angus sires were lightest at birth, suggesting Angus sires may have been selected for low EBV for birth weight and/or low EBV for gestation length. It should be noted that calves by sires with any amount of *Bos indicus* in their genotype (Charbray, Santa Gertrudis and some Belmont Red sires) mated to Brahman dams are not strictly $F_1$ crosses, but are probably more appropriately described as back-crosses.

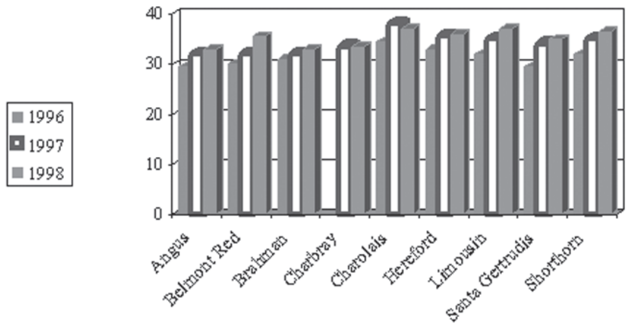


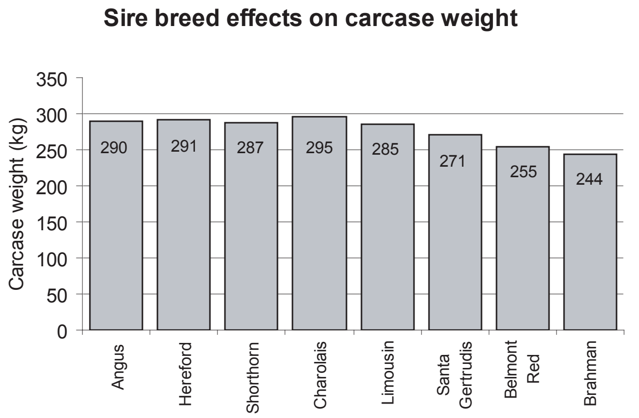

Figure 3. Sire breed and year effects on calf birth weights

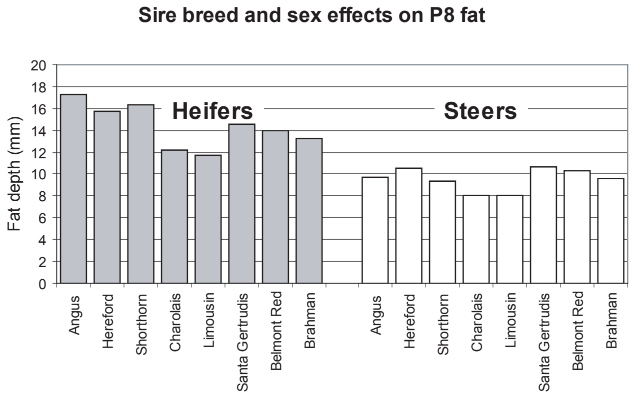
### *Carcase and beef quality attributes*

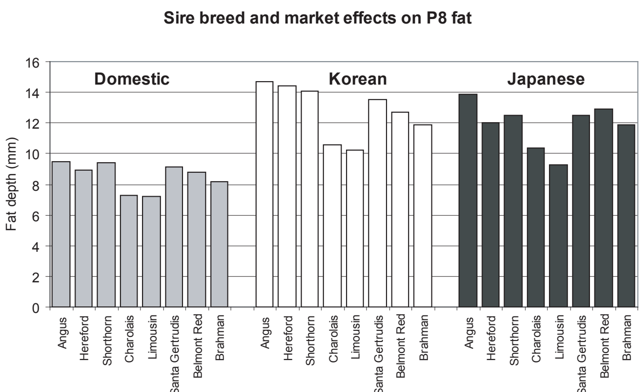
Except for carcase weight, all carcase and meat quality attributes were adjusted to a common carcase weight. Unadjusted carcase weight was calculated from those calves born during a common mating period following simultaneous AI and natural mating periods. Sire breed effects were important for all traits in the CRC's crossbreeding project. European crossbreds were significantly leaner than the tropically adapted crossbreds, which were significantly leaner than the British crossbreds. Angus-sired progeny had the highest amount of subcutaneous fat cover, while Limousin-sired progeny were the leanest. Angus, Belmont Red and Shorthorn sires produced progeny with the highest intramuscular fat percentage (marbling). Brahman, Santa Gertrudis, Charolais and Limousin sired progeny had similar levels of marbling. Generally, breeds that had the greatest subcutaneous fat cover also had the highest amount of marbling. The exception was the Belmont Red-sired progeny, which scored intermediately for fat cover and high for marbling. European-sired progeny had the greatest retail beef yields. Purebred Brahman progeny had the toughest meat, whether measured objectively by shear force and instron compression measurements, or subjectively by untrained consumer taste panels. There was no major re-ranking of sire breeds or sexes across markets or finishing regimes for any weight or carcase attribute.

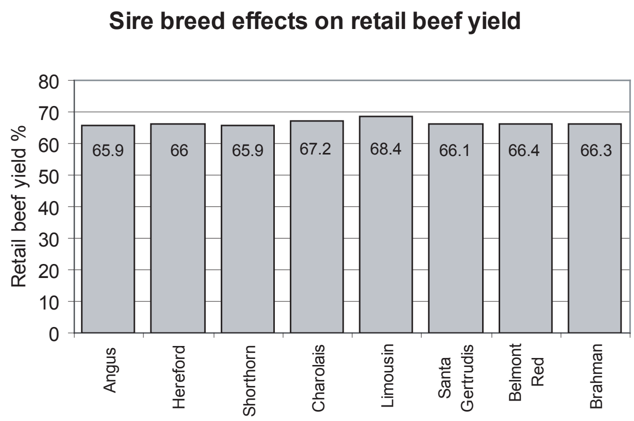
## Take-home Messages

- Sire breed had large effects on growth and most carcase and beef quality attributes
- European sires had progeny with heaviest, leanest and highest yielding carcases
- Angus, Belmont Red and Shorthorn sires had progeny with highest intramuscular fat percentages (marbling)
- Animals of high *Bos indicus* content fell below the MSA 3-star cut-off point
- Most crosses achieved MSA 3-star, with significant advantages to feedlot-finished crosses
- Pasture finished animals were significantly tougher than feedlot-finished animals
- Heifers had consistently lower MQ4 scores than steers across markets and finish, with pasture-finished heifers not reaching MSA 3-star cut-off
- Contrary to expectations, meat toughness did not increase with increasing age or carcase weight to 3-3.5 years or Japanese weight carcases
- Grain finishing increased IMF% relative to pasture finishing in the north; IMF% was highest in animals grain-finished in the south
- Progeny finished at pasture in the north were older, leaner, had highest retail yield percentages, greatest weight of retail primal cuts and consistently toughest meat
- No major re-ranking of sire breeds occurred across market (domestic, Korean, Japanese), finish (grain *versus* grass) or environment (north *versus* south) for carcase and beef quality attributes.

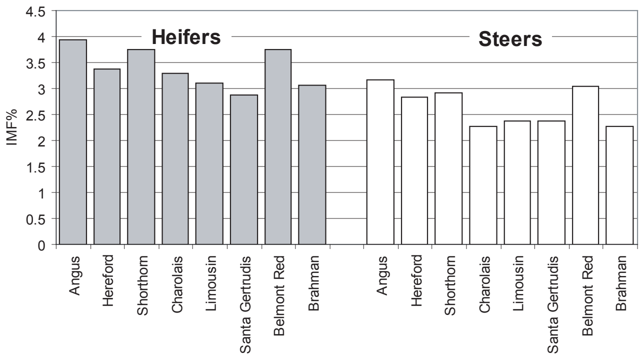


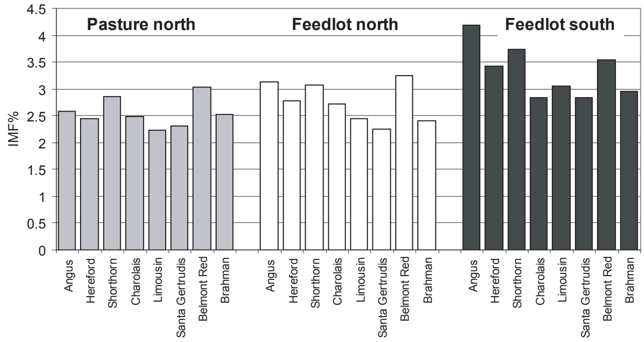



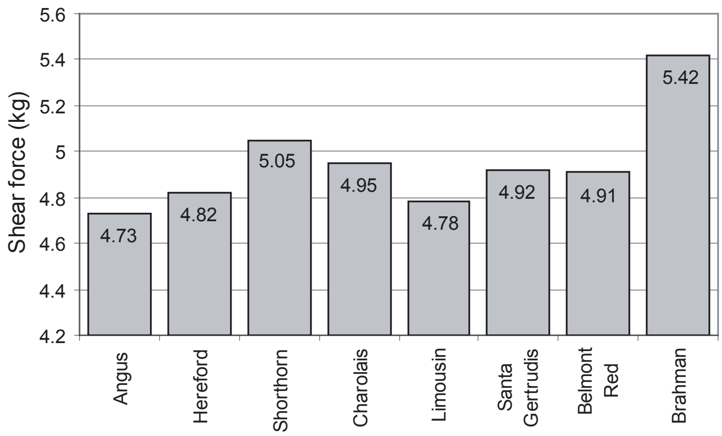
Sire breed and sex effects on IMF%



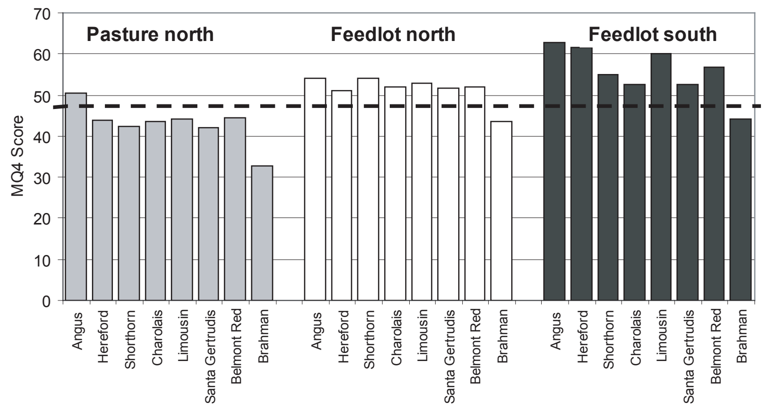

Sire breed and finish effects on IMF%



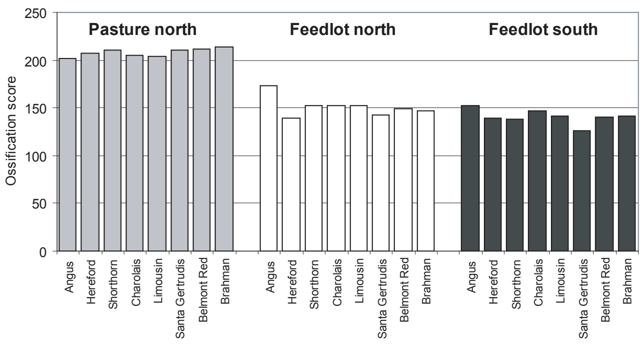

## Sire breed effects on shear force



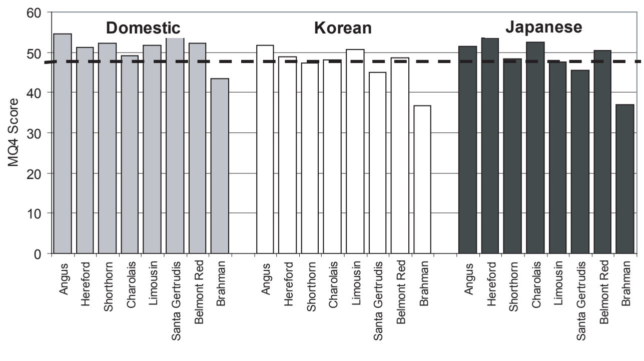

Sire breed and finish effects on MQ4




Sire breed and finish effects on ossification




Sire breed and market effects on MQ4



Appendix 1. Average Estimated Breeding Values (EBVs) for growth, fertility and carcass attributes for all sires used in the CRC crossbreeding program (breed average EBVs for animals born in 1997 for each of the traits are shown in brackets; EMA, eye muscle area; IMF, intramuscular fat percentage; RBY, retail beef yield percentage)

| Breed | Birth weight (kg) | 200-day milk (kg) | 200-day weight (kg) | 400-day weight (kg) | 600-day weight (kg) | Mature weight (kg) | P8 fat depth (mm) | Rib fat depth (mm) | EMA ($cm^2$) | IMF (%) | RBY (%) | Scrotal size (cm) | Days to calving (days) | Calving ease (d) (units) | Calving ease (m) (units) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angus | 3.4 | 7.2 | 28 | 57 | 74 | 78 | 0.0 | 0.0 | 1.8 | 0.3 | 0.2 | 0.9 | -1.6 | 1.1 | 1.9 |
| | (3.8) | (7.0) | (25) | (46) | (61) | (61) | (-0.1) | (-0.1) | (0.6) | (0.0) | (0.1) | (0.7) | (-0.6) | (-0.3) | (0.1) |
| Belmont Red | 2.9 | 0.1 | 10 | 13 | 19 | | 0.2 | 0.0 | 0.8 | 0.1 | 0.0 | 0.6 | | | |
| | (1.6) | (1.0) | (7) | (9) | (14) | | (0.0) | (0.0) | (1.5) | (0.1) | (0.1) | (0.2) | | | |
| Brahman | | 0.0 | 12 | 16 | 23 | | -0.4 | -0.4 | 1.5 | 0.1 | 0.3 | 1.4 | | | |
| | | (-1.0) | (10) | (14) | (18) | | (0.1) | (0.1) | (1.6) | (0.1) | (0.2) | (0.4) | | | |
| Charolais | 0.8 | 2.7 | 10 | 17 | 28 | | -0.1 | -0.1 | 0.1 | | -0.3 | 0.6 | | -0.2 | |
| | (0.7) | (2.0) | (6) | (11) | (14) | | (0.0) | (0.0) | (0.9) | | (0.0) | (0.2) | | (-0.3) | |
| Hereford | 6.1 | 8.9 | 27 | 46 | 68 | 73 | -0.2 | -0.3 | 1.0 | -0.3 | 0.4 | 1.4 | -1.1 | -4.7 | 0.1 |
| | (3.6) | (5.8) | (18) | (28) | (42) | (43) | (0.0) | (0.0) | (0.3) | (-0.1) | (0.1) | (0.7) | (-0.7) | (-0.8) | (-0.1) |
| Limousin | 1.7 | 0.9 | 9 | 16 | 24 | 25 | -0.1 | -0.1 | 0.9 | 0.0 | 0.2 | 0.3 | 0.3 | -2.3 | -0.5 |
| | (1.2) | (1.0) | (10) | (16) | (22) | (21) | (0.0) | (0.0) | (0.5) | (0.0) | (0.0) | (0.2) | (0.0) | (-1.1) | (0.0) |
| Santa Gertrudis | | -1.8 | 6 | 9 | 8 | 7 | -0.1 | 0.1 | 0.5 | 0.1 | 0.1 | 0.3 | | | |
| | | (0.0) | (2) | (2) | (2) | (2) | (0.0) | (0.0) | (0.6) | (0.0) | (0.2) | (0.0) | | | |
| Shorthorn | 1.8 | 3.9 | 12 | 14 | 19 | | -0.5 | -0.4 | 0.2 | 0.0 | 0.1 | 0.5 | | | |
| | (1.9) | (3.0) | (12) | (17) | (24) | | (-0.5) | (-0.5) | (1.6) | (0.0) | (0.2) | (0.5) | | | |