# CARCASS QUANTITY TRAITS IN CROSSES OF ANGUS, SANTA GERTRUDIS AND GELBVIEH BEEF CATTLE

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## Summary

A total of 333 carcasses were evaluated for hindquarter traits: round weight, percent round, loin weight, percent loin, flank weight and percent flank. Other characteristics included: total retail, lean trim, fat trim, round steaks, rump, sirloin tip, loin steaks, percent loin steaks and flank steaks. Mating types included straightbred Angus and Santa Gertrudis, the reciprocal crosses of these two breeds and Gelbvieh × Angus. Breed of sire and breed of dam were significant for most of the traits evaluated. Calf year and slaughter group were also significant. This could be the result of environmental variations. Effect of sire within sire breed was non-significant for all the traits considered. Heterosis due to interaction between sire breed × dam breed was found significant for percent total retail cuts based on hindquarter weight. Generally, Santa Gertrudis purebreds were more desirable in cut out characteristics than all other breeding types followed by crossbreds of Angus × Santa Gertrudis.

(Key Words: Beef Cattle, Carcass, Angus, Santa Gertrudis, Gelbvieh)

## Introduction

Crossbreeding, which results in heterosis, is one way to improve livestock quickly. In addition, by crossbreeding we can incorporate complementary characteristics of different breeds in the next generation. However, evaluation of each breed and breed combination is essential to maximize production in a particular environment to reap the fruit of crossbreeding programs.

The germ plasm evaluation program at the U.S. Meat Animal Research Centre in Clay Centre, NE was conducted to evaluate a number of breed crosses for economic improvement of breed production in a northern environment. Production parameters are different in different regions of the U.S. because of climate, forages, parasites and other unknown factors. Genotype × environment interactions have their role in reranking various crosstypes under different systems of management (Butts et al., 1971; Burns et al., 1979; Gotti and Benyshek, 1988; Pahnish et al., 1983, 1985).

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This paper discusses the meat characteristics of calves from a partial diallel mating scheme utilizing straightbred Angus and straightbred Santa Gertrudis plus Gelbvieh × Angus.

## Materials and Methods

Angus (A), Santa Gertrudis (S) and Gelbvieh (G) sires were mated to Angus and Santa Gertrudis dams to produce five mating types, A × A, S × S, S × A, A × S and G × A. The design of study, number of calves and the five mating types are shown in table 1. Cattle were grouped together and then randomly alloted to two slaughter groups each year of the study. Age, weight, mating types and sex were considered in the stratified randomized procedures.

The data used in this study were obtained from a crossbreeding project at the University of Georgia Experiment Station from 1977 through 1980. The station is located in the Piedmont area of Georgia. The average rainfall for the area is 128 cm with a mean temperature of 16.3℃. Cow herds were maintained on pastures of Fescue in winter and Bermuda grass in summer and, when required, cows were supplemented with grazing (winter animals), hay and corn. The calves were born between January and March of each year of the study. Bull calves were castrated soon after

TABLE 1. CARCASSES EVALUATED

| Breed of sire | Breed of dam | | |
|---|---|---|---|
| | Angus | Santa gertrudis | Total |
| Angus (26[a]) | 96<br>(49)* | 44<br>(24) | 140<br>(73) |
| Santa Gertrudis (23) | 84<br>(50) | 46<br>(23) | 130<br>(73) |
| Gelbvieh (14) | 63<br>(37) | –<br>– | 63<br>(37) |
| Total | 243<br>(136) | 90<br>(47) | 333<br>(183) |

* Number of hindquarters evaluated.
a Number of sires used.

birth. The weaned calves were randomly allotted to feeding pens by sex.

After an adjustment period the calves were fed a free choice high energy concentrate diet consisting of steamed rolled corn (65.5%), soybean oil meal (8%), liquid molasses (0.5%), cottonseed hulls (10%), peanut hulls (10%), trace mineral salt (0.5%), defluorinated phosphate (0.5%) and limestone (0.5%).

Cattle were slaughtered at approximately 393 and 433 days of age for slaughter group 1 and 2, respectively. The cattle were slaughtered at a commercial packing plant.

One hindquarter from each steer was returned to the University of Georgia meats laboratory. The hindquarter was aged for 10 d at 4℃ to improve tenderness of the meat and the cutting began on 10th day after slaughter. The hindquarter was weighed, separated into wholesale and retail cuts and then the wholesale and retail cuts were weighed. Kidney and pelvic fat was removed and weighed. The flank was separated from the loin and round. The round was separted from the loin by cutting on a straight line from between the fourth and fifth sacral vertebrae with the cut tipping the ball joint.

Following retail cuts were obtained and weighed.

**Round**

1. Rump: Tail vertebrae and aitch bone were removed and rump separated from round.

2. Sirloin tip: This was obtained by cutting at the junction of sirloin tip and round tip.

3. Round steaks: These were obtained by cutting the round on power saw at 2.6 cm until reaching shank.

4. Shank: It was removed at knuckle and boned for ground beef.

**Loin**

Sirloin steaks were cut 2.54 cm thick. Porterhouse and T-bone steaks were cut 3.8 cm thick.

**Flank**

Steak was pulled and bone removed. Remainder was separated into lean and fat.

All retail cuts were trimmed to 2 cm of fat or less. The traits examined in this study included wholesale cuts from the hindquarter: round weight (RWT), percent round (PR), loin weight (LWT), percent loin (PL), flank weight (FWT) and percent flank (PF). Other characteristics included, total retail cuts (TRC), lean trim (LTR), fat trim (FTR), round steaks (RST), rump (RMP), sirloin tip (SLT), loin steaks (LST), percent loin steaks (PLS), and flank steaks (FST). Data were analyzed using computational procedures of the Statistical Analysis System (Barr et al., 1979). Several statistical models were used in this study which included calf year, sire breed, sire nested within breed of sire, dam breed, slaughter group, the interaction of sire breed × dam breed and a covariate for age at slaughter. The deviation of age from the average age of the slaughter group was used in this analysis. In addition to age at slaughter being used as a covariate, other models were alternately included as covariates: fat thickness, percent body fat, marbling and carcass weight nested within the slaughter groups. The random component of sires nested within sire breed was used as an error term to test for sire breed effect. The interaction of sire breed × dam breed was kept in the model to examine the effect of heterosis, which was found significant for some of the traits. The interactions of calf year × slaughter group and calf year × dam breed were found significant for most of the traits but their biological significance was not clear. Other two-way interactions were non-significant and therefore removed from the models. The three-way interaction of sire breed × dam breed × slaughter group was found to be non-significant and therefore removed from subsequent models.

## Results and Discussion

The effects of year, sire breed, sire within sire breed, dam breed, slaughter group and interaction of sire breed × dam breed on following carcass traits are discussed for all five mating types. The mating plan is given at table 1.

### Hindquarter weight

Least square means and standard error estimates are given in table 2 for hindquarter weight (HWT), percent hindquarter (PHQ), TRC, and percent retail cuts (PRC). About 48 percent of the beef carcass consist of the hindquarter. Dam breed, slaughter group, interaction of sire breed × dam breed and age at slaughter group, interaction of sire breed × dam breed and age at slaughter nested within slaughter group were significant when the later was used as a covariate in the model. Crossbreds of A × S had the heaviest HWT while S × A had the lowest. The results were in close agreement with those reported by Jenkins et al. (1981).

TABLE 2. ESTIMATES OF HETEROSIS AND LEAST SQUARE MEANS AND STANDARD ERROR FOR BREED OF SIRE, BREED OF DAM, CALF YEAR, SLAUGHTER GROUP AND BREED OF SIRE × BREED OF DAM

| Mating or effect[1] | Hindquarter weight (kg) | Percent hindquarter[4] | Total retail cuts (kg) | Percent retail cuts[5] |
|---|---|---|---|---|
| AA | 63.4 ± 1.3[a] | 45.0 ± .004[a] | 44.2 ± 1.4[a] | 69.0 ± .01[a] |
| AS | 76.2 ± 1.7[b] | 47.0 ± .006[b] | 50.9 ± 1.7[b] | 66.0 ± .01[b] |
| SA | 68.4 ± 1.5[c] | 47.0 ± .004[b] | 48.0 ± 1.5[c] | 68.0 ± .01[a] |
| SS | 75.7 ± 1.9[b] | 49.0 ± .006[c] | 53.6 ± 1.8[c] | 68.0 ± .01[a] |
| GA | 68.9 ± 1.7[c] | 46.0 + .005[b] | 50.7 ± 1.5[b] | 72.0 ± .01[c] |
| A Sires | 68.9 ± 0.7[a] | 46.0 ± .004[a] | 47.4 ± 1.4[a] | 67.0 ± .01[a] |
| S Sires | 73.0 ± 0.7[b] | 48.0 ± .004[b] | 50.8 ± 1.4[b] | 68.0 ± .01[a] |
| G Sires | 74.2 ± 1.2[b] | 47.0 ± .005[ab] | 53.8 ± 1.7[c] | 71.0 ± .01[b] |
| A Dams | 67.4 ± 0.5[a] | 46.0 ± .003[a] | 47.6 ± 1.3[a] | 69.0 ± .01[a] |
| S Dams | 76.8 ± 0.1[b] | 48.0 ± .004[b] | 53.7 ± 1.5[b] | 68.0 ± .01[b] |
| 77 Calf yr | 68.2 ± 0.9[a] | 47.0 ± .004[a] | 48.7 ± 0.7[a] | 71.0 ± .00[a] |
| 78 Calf yr | 69.3 ± 0.9[a] | 47.0 ± .004[a] | 49.7 ± 0.7[a] | 70.0 ± .00[a] |
| 79 Calf yr | 74.4 + 0.9[b] | 46.0 ± .004[a] | 52.3 ± 1.0[ab] | 67.0 ± .03[b] |
| 80 Calf yr | 70.3 ± 1.2[a] | 46.0 ± .005[a] | 47.2 ± 1.0[a] | 67.0 ± .01[b] |
| SG I[3] | 68.4 ± 0.7[a] | 47.0 ± .003[a] | 47.9 ± 1.4[a] | 68.0 ± .01[a] |
| SG II | 72.7 ± 0.7[b] | 46.0 ± .003[a] | 51.0 ± 1.3[b] | 69.0 ± .01[a] |
| Heterosis[2] | 6.1 (3.9%) | −0.01 (−2.1%) | 1.25 (1.2%) | −1.5 (−2.2%) |

[1] A = Angus, S = Santa Gertrudis, G = Gelbvieh; Sires breed listed first.
[2] *Heterosis = 1/2 {(SA + AS) − (AA + SS)}.*
[3] SG I (slaughter group I) = 393 d, SG II = 433 d.
[a,b,c] Values with different superscripts are different ($p < .05$).
[4] Percentage based on half-carcass weight.
[5] Percentage based on hindquarter weight.

**Total retail cuts**

Total weight of retail cuts obtained from the hindquarter was found to be highly influenced by breed of dam slaughter group and sire breed in all types of analyses except when carcass weight was tried as covariate. In this, too, sire breed still had significant effect and dam breed was approaching significance. Moreover, heterosis due to interaction of sire breed × dam breed was also found to be significant. Highest weights of TRC were obtained from the S purebreds. The results in the present study were similar to that of Rahnefeld et al., (1983) and Adams et al. (1977).

**Round**

**a) Round weight**

Least square means and standard error estimates are given in table 3.1 and 3.2 for RWT, PR, RST, RMP and SLT. Sire breed, dam breed and slaughter group had highly significant effects on the RWT. There was no effect of heterosis on RWT. The purebreds from A breed produced the highest RWT followed by S purebreds. The SA had the smallest RWT. Clayton et al. (1979), Hedrick et al. (1975) and Urick et al. (1974)

TABLE 3.1 ESTIMATES OF HETEROSIS AND LEAST SQUARE MEANS AND STANDARD ERROR FOR BREED OF SIRE, BREED OF DAM, CALF YEAR, SLAUGHTER GROUP AND BREED OF SIRE × BREED OF DAM

| Mating or effect[1] | Round weight (kg) | Percent round[4] | Percent round[5] | Lean trim from round (kg) |
|---|---|---|---|---|
| AA | 36.4 ± .6[a] | 20.0 ± .003[a] | 43.0 ± .004[a] | 4.3 ± .2[a] |
| AS | 34.2 ± .8[b] | 21.0 ± .004[b] | 45.0 ± .006[b] | 5.5 ± .3[b] |
| SA | 31.1 + .7[c] | 21.0 ± .003[b] | 45.0 ± .005[b] | 5.0 ± .2[b] |
| SS | 35.9 ± .9[d] | 23.0 + .004[c] | 47.0 ± .006[c] | 5.6 + .3[b] |
| GA | 31.7 ± .7[c] | 21.0 ± .004[b] | 46.0 ± .005[c] | 5.0 ± .3[b] |
| A Sires | 30.9 ± .4[a] | 20.0 ± .002[a] | 44.0 ± .003[a] | 4.8 ± .1[a] |
| S Sires | 33.8 ± .4[b] | 22.0 ± .002[b] | 46.0 ± .003[b] | 5.3 ± .1[b] |
| G Sires | 35.0 ± .5[c] | 22.0 ± .003[b] | 47.0 ± .003[c] | 5.6 ± .2[b] |
| A Dams | 30.4 ± .3[a] | 21.0 ± .001[a] | 45.0 ± .001[a] | 5.0 ± .1[a] |
| S Dams | 35.9 + .5[b] | 22.0 ± .002[b] | 47.0 ± .003[b] | 5.6 ± .2[b] |
| 77 Calf yr | 31.7 ± .5[a] | 22.0 + .002[a] | 47.0 ± .003[a] | 4.9 ± .2[a] |
| 78 Calf yr | 31.7 ± .5[a] | 21.0 ± .002[b] | 46.0 ± .003[ab] | 5.1 ± .2[a] |
| 79 Calf yr | 33.6 ± .5[b] | 21.0 ± .002[b] | 45.0 ± .003[ab] | 5.8 ± .2[b] |
| 80 Calf yr | 31.3 ± .6[a] | 21.0 ± .003[b] | 44.0 ± .003[b] | 4.4 ± .2[c] |
| SG I[3] | 31.3 ± .3[a] | 21.0 ± .002[a] | 45.0 ± .003[a] | 4.9 ± .1[a] |
| SG II | 33.2 + .3[b] | 21.0 ± .002[a] | 45.0 ± .003[a] | 5.2 ± .1[a] |
| Heterosis[2] | 2.25 (3.2%) | −0.005 (−2.3%) | 0 | 0.7 (6.4%) |

[1] A = Angus, S = Santa Gertrudis, G = Gelbvieh; Sire breed listed first.

[2] Heterosis = 1/2 [(SA + AS) − (AA + SS)].

[3] SG I (slaughter group I) = 393 d, SG II = 433 d.

[a,b,c] Values with different superscripts are different ($p < .05$).

[4] Percentage based on half-carcass weight.

[5] Percentage based on hindquarter weight.

TABLE 3.2 ESTIMATES OF HETEROSIS AND LEAST SQUARE MEANS AND STANDARD ERROR FOR BREED OF SIRE, BREED OF DAM, CALF YEAR, SLAUGHTER GROUP AND BREED OF SIRE × BREED OF DAM

| Mating or effect[1] | Fat trim from round (kg) | Round steaks (kg) | Rump (kg) | Sirloin tip (kg) |
|---|---|---|---|---|
| AA | 1.2 ± .15$^{a}$ | 11.1 ± .4$^{a}$ | 2.9 ± .2$^{a}$ | 2.5 ± .1$^{a}$ |
| AS | 1.4 ± .15$^{b}$ | 13.9 ± .5$^{b}$ | 3.5 ± .2$^{b}$ | 3.1 ± .1$^{b}$ |
| SA | 1.3 ± .15$^{b}$ | 12.6 ± .5$^{a}$ | 3.1 ± .2$^{a}$ | 2.8 ± .1$^{b}$ |
| SS | 1.6 ± .20$^{ab}$ | 14.6 ± .5$^{b}$ | 3.5 ± .2$^{b}$ | 3.4 ± .2$^{c}$ |
| GA | 0.8 ± .15$^{c}$ | 13.4 ± .5$^{b}$ | 3.4 ± .2$^{b}$ | 2.9 ± .1$^{b}$ |
| A Sires | 1.3 ± .10$^{a}$ | 12.6 ± .2$^{a}$ | 3.1 ± .1$^{a}$ | 2.9 ± .0$^{a}$ |
| S Sires | 1.5 ± .10$^{b}$ | 13.4 ± .2$^{b}$ | 3.3 ± .1$^{a}$ | 3.2 ± .0$^{b}$ |
| G Sires | 1.1 ± .10$^{c}$ | 14.5 ± .3$^{c}$ | 3.8 ± .1$^{b}$ | 3.3 ± .1$^{b}$ |
| A Dams | 1.2 + .01$^{a}$ | 12.4 ± .1$^{a}$ | 3.2 ± .1$^{a}$ | 2.9 + .0$^{a}$ |
| S Dams | 1.5 ± .10$^{b}$ | 14.7 ± .3$^{b}$ | 3.6 ± .1$^{b}$ | 3.3 ± .1$^{b}$ |
| 77 Calf yr | 1.5 ± .10$^{a}$ | 12.6 ± .3$^{a}$ | 3.8 ± .1$^{a}$ | 2.8 ± .1$^{a}$ |
| 78 Calf yr | 1.0 ± .10$^{b}$ | 14.1 ± .3$^{b}$ | 2.9 ± .1$^{b}$ | 3.2 ± .1$^{b}$ |
| 79 Calf yr | 1.6 ± .10$^{a}$ | 13.0 ± .3$^{a}$ | 3.0 ± .1$^{b}$ | 3.2 ± .1$^{b}$ |
| 80 Calf yr | 1.4 ± .15$^{a}$ | 12.9 ± .4$^{a}$ | 3.4 ± .2$^{c}$ | 2.9 ± .1$^{ab}$ |
| SG I[3] | 1.1 ± .05$^{a}$ | 12.4 ± .2$^{a}$ | 3.1 ± .1$^{a}$ | 3.1 ± .0$^{a}$ |
| SG II | 1.5 ± .05$^{b}$ | 13.7 ± .2$^{b}$ | 3.4 + .1$^{b}$ | 3.1 + .0$^{a}$ |
| Heterosis[2] | −0.1 (−3.2%) | 0.95 (1.3%) | −0.1 (−1.3%) | 0 |

[1] A = Angus, S = Santa Gertrudis, G = Gelbvieh; Sire breed listed first.
[2] Heterosis = 1/2 {(SA + AS) − (AA + SS)}.
[3] SG I (slaughter group 1) = 393 d, SG II = 433 d.
[a,b,c] Values with different superscripts are different ($p < .05$).

reported similar results to those found in this study.

b) Lean trim

Breed of dam and the covariate of age at slaughter within slaughter group had significant effects on this trait. Other coveriates had similar effects in the model, Dams of S breed were found to have influenced to have larger amounts of LTR from the round. Slaughter group two also produced more LTR than group one. Rahnefeld et al. (1983) had reported that crossbred Limousin cows had a higher LTR in the round. In the present study the crossbreds have shown some heterosis for this trait, although it was non-significant.

c) Fat trim

Fat trimmed from the round was found to have been influenced by the year of calf, sire breed, dam breed and slaughter group. The covariates, age of slaughter within slaughter group and fat thickness were also significantly different from zero. Heterosis and sire within sire group were non-significant. Highest FTR was from purebreds S and lowest from crossbreds of G × A.

d) Round steaks

Year of calf, sire breed and slaughter group and covariate carcass weight within slaughter group had significant effects on total weight of RST. Purebred S produced more RST followed by progeny from A × S. Purebred A produced the lowest amounts of RST. All covariates gave similar results.

e) **Rump**

Rump weight was found to have been influenced significantly by the year of calf, dam breed and slaughter group. Heterosis was non-significant.

f) **Sirloin tip**

SLT weight was found to be influenced by the year of calf, sire breed, dam breed, carcass weight within slaughter group. SLT was heaviest in purebred S followed by A × S. Heterosis was non-significant for SLT. Hedrick et al. (1975) reported similar results as found in the present study.

**Loin**

a) **Loin weight**

Least square means and standard error estimates are presented in table 4.1 and 4.2 for LWT, PL, LST, PLS, LTR and FTR. Dam breed and slaughter group were highly significantly affecting LWT. Purebred S dams and slaughter

TABLE 4.1 ESTIMATES OF HETEROSIS AND LEAST SQUARE MEANS AND STANDARD ERROR FOR BREED OF SIRE, BREED OF DAM, CALF YEAR, SLAUGHTER GROUP AND BREED OF SIRE × BREED OF DAM

| Mating or effect[1] | Loin weight (kg) | Percent loin[4] | Percent loin[5] |
|---|---|---|---|
| AA | 20.4 ± .5[a] | 15.0 + .002[a] | 32.0 ± .002[a] |
| AS | 24.0 ± .5[c] | 15.0 ± .003[a] | 31.0 + .003[b] |
| SA | 21.4 + .5[b] | 15.0 ± .003[a] | 31.0 ± .002[b] |
| SS | 23.7 ± .6[c] | 15.0 ± .003[a] | 31.0 ± .003[b] |
| GA | 22.0 ± .5[bc] | 15.0 ± .003[a] | 32.0 ± .002[a] |
| A Sires | 21.7 ± .3[a] | 14.0 ± .001[a] | 31.0 ± .002[a] |
| S Sires | 22.2 ± .3[b] | 15.0 ± .001[a] | 31.0 ± .002[a] |
| G Sires | 23.6 ± .4[c] | 15.0 + .002[a] | 32.0 ± .003[a] |
| A Dams | 21.2 + .2[a] | 14.0 ± .001[a] | 31.0 + .001[a] |
| S Dams | 24.0 ± .4[b] | 15.0 ± .001[b] | 31.0 ± .002[a] |
| 77 Calf yr | 21.4 ± .3[a] | 15.0 ± .001[a] | 31.0 ± .002[a] |
| 78 Calf yr | 21.5 ± .3[a] | 14.0 ± .001[a] | 31.0 ± .002[a] |
| 79 Calf yr | 23.4 ± .3[b] | 14.0 ± .001[a] | 31.0 ± .002[a] |
| 80 Calf yr | 21.8 ± .4[a] | 15.0 ± .002[a] | 31.0 ± .003[a] |
| SG I[3] | 21.3 ± .2[a] | 15.0 ± .001[a] | 31.0 ± .002[a] |
| SG II | 22.9 ± .2[b] | 15.0 ± .001[a] | 31.0 ± .002[a] |
| Heterosis[2] | 1.4 (2.9%) | 0 | −0.005 (−1.6%) |

[1] A = Angus, S = Santa Gertrudis, G = Gelbvich; Sire breed listed first.
[2] Heterosis = 1/2 {(SA + AS) − (AA + SS)}.
[3] SG I (slaughter group I) = 393 d, SG II = 433 d.
[a,b,c] Values with different superscripts are different ($p < .05$).
[4] Percentage based on half-carcass weight.
[5] Percentage based on hindquarter weight.

TABLE 4.2 ESTIMATES OF HETEROSIS AND LEAST SQUARE MEANS AND STANDARD ERROR FOR BREED OF SIRE, BREED OF DAM, CALF YEAR, SLAUGHTER GROUP AND BREED OF SIRE × BREED OF DAM

| Mating or effect[1] | Loin steaks (kg) | Percent loin steaks | Lean trim from loin (kg) | Fat trim from loin (kg) |
|---|---|---|---|---|
| AA | $17.1 \pm .4^a$ | $13.0 + .002^a$ | $0.16 \pm .14^a$ | $2.63 \pm .18^a$ |
| AS | $20.5 \pm .5^b$ | $13.0 \pm .002^a$ | $0.18 \pm .18^a$ | $2.68 \pm .23^a$ |
| SA | $18.3 \pm .4^c$ | $13.0 \pm .002^a$ | $0.29 \pm .15^a$ | $2.45 \pm .23^a$ |
| SS | $20.3 \pm .5^b$ | $13.0 \pm .002^a$ | $0.54 \pm .18^b$ | $2.36 \pm .27^a$ |
| GA | $19.6 \pm .5^b$ | $13.0 \pm .002^a$ | $0.29 \pm .16^a$ | $1.68 \pm .02^b$ |
| A Sires | $18.3 \pm .2^a$ | $12.0 \pm .001^a$ | $0.20 \pm .15^a$ | $2.59 \pm .11^a$ |
| S Sires | $19.2 \pm .2^b$ | $12.0 \pm .001^a$ | $0.40 \pm .15^b$ | $2.49 \pm .11^a$ |
| G Sires | $20.9 \pm .4^c$ | $13.0 + .002^b$ | $0.36 \pm .17^b$ | $1.81 \pm .18^b$ |
| A Dams | $18.1 \pm .2^a$ | $12.0 \pm .001^a$ | $0.25 \pm .13^a$ | $2.31 \pm .09^a$ |
| S Dams | $20.8 \pm .3^b$ | $13.0 \pm .001^a$ | $0.39 \pm .16^a$ | $2.27 \pm .15^a$ |
| 77 Calf yr | $18.1 \pm .3^a$ | $13.0 \pm .001^a$ | $0.49 \pm .07^a$ | $1.91 \pm .13^a$ |
| 78 Calf yr | $18.5 \pm .3^a$ | $12.0 \pm .001^a$ | $0.35 \pm .07^a$ | $1.95 \pm .13^a$ |
| 79 Calf yr | $20.0 \pm .3^b$ | $12.0 \pm .001^a$ | $0.34 \pm .50^a$ | $3.00 \pm .13^a$ |
| 80 Calf yr | $18.9 \pm .4^a$ | $13.0 \pm .002^a$ | $0.38 + .09^a$ | $2.68 \pm .19^a$ |
| SG I[3] | $18.1 + .2^a$ | $13.0 \pm .001^a$ | $0.32 \pm .15^a$ | $2.13 + .10^a$ |
| SG II | $19.1 \pm .2^a$ | $12.0 + .001^a$ | $0.26 \pm .14^b$ | $2.68 \pm .10^b$ |
| Heterosis[2] | 1.4* (2.9%) | 0 | −0.26 (−0.33%) | 0.1 (2.7%) |

[1] A = Angus, S = Santa Gertrudis, G = Gelbvieh; Sire breed listed first.
[2] Heterosis = 1/2 {(SA + AS) − (AA + SS)}.
[3] SG I (slaughter group I) = 393 d, SG II = 433 d.
[a,b,c] Values with different superscripts are different ($p < .05$).
* $p < .05$.

group two were found to have affected this trait greatly. Heterosis had no effect on LWT. Loin as a proportion of half carcass weight was influenced only by dam breed. Fatter animals were found to have larger LWT. Adams et al. (1977) reported similar results in their study.

For PL, sire nested within sire breed was highly significant in all the models used with different covariates. Other factors affecting significantly PL were heterosis and slaughter group. The results reported here agree with Gregory et al. (1978).

b) Loin steaks

This trait was significantly influenced by sire breed, dam breed and slaughter group. The heterosis was approaching significance. When LST were considered as a percentage of half carcass weight the results were the same. Crossbred progeny of A × S were superior with respect to more loin steak production followed by purebred S progeny. Purebred Angus and S × A were inferior in this respect. Since loin steaks have a direct relationship with LWT, the results were similar for both traits. Rahnfeld et al. (1983) had reported that crossbreds of Limousin cows had the highest proportion of long loin.

c) Lean trim

For LTR, non of the variables were found to be significant.

d) Fat trim

This trait was influenced by sire breed, slaughter group, age at slaughter, fat thickness, percent body fat and carcass weight within slaughter group. Lowest FTR from the loin was obtained from crossbred progeny of G × A. The heterosis was found to be non-significant for FTR.

**Flank**

a) Flank weight

Least square means and standard error estimates are presented in table 5.1 and 5.2 for FWT, PF, LTR from flank, FTR from flank and FST. Sire breed, dam breed, slaughter group, heterosis and the covariate age at slaughter were significant for FTW. Progeny of A × S had the heaviest FWT while the progeny of G × A yielded the lowest FWT among the five breeding types. PF based on half carcass weight was in-

TABLE 5.1 ESTIMATES OF HETEROSIS AND LEAST SQUARE MEANS AND STANDARD ERROR FOR BREED OF SIRE, BREED OF DAM, CALF YEAR, SLAUGHTER GROUP AND BREED OF SIRE × BREED OF DAM

| Mating or effect[1] | Flank weight (kg) | Percent flank[4] | Percent flank[5] |
|---|---|---|---|
| AA | $10.8 \pm .3^a$ | $7.0 \pm .002^a$ | $17.0 \pm .002^a$ |
| AS | $12.3 \pm .4^b$ | $7.0 \pm .002^a$ | $16.0 \pm .003^b$ |
| SA | $10.8 + .4^a$ | $7.0 \pm .002^a$ | $16.0 \pm .002^b$ |
| SS | $10.7 + .5^a$ | $7.0 \pm .003^a$ | $14.0 \pm .003^c$ |
| GA | $9.9 \pm .4^c$ | $6.0 \pm .002^b$ | $14.0 + .003^c$ |
| A Sires | $11.3 \pm .2^a$ | $7.0 \pm .001^a$ | $16.1 \pm .002^a$ |
| S Sires | $11.4 \pm .2^a$ | $7.0 \pm .001^a$ | $15.1 \pm .002^b$ |
| G Sires | $10.5 \pm .3^b$ | $7.0 \pm .001^b$ | $14.0 \pm .003^c$ |
| A Dams | $10.7 \pm .1^a$ | $7.0 \pm .001^a$ | $16.0 \pm .001^a$ |
| S Dams | $11.4 \pm .2^b$ | $7.0 \pm .001^a$ | $15.0 \pm .002^b$ |
| 77 Calf yr | $10.3 \pm .2^a$ | $7.0 + .001^a$ | $15.0 \pm .002^a$ |
| 78 Calf yr | $10.4 \pm .2^a$ | $7.0 \pm .001^a$ | $15.0 \pm .002^a$ |
| 79 Calf yr | $12.0 \pm .2^b$ | $8.0 \pm .001^b$ | $16.0 \pm .002^b$ |
| 80 Calf yr | $11.8 \pm .3^b$ | $8.0 \pm .001^b$ | $17.0 + .003^b$ |
| SG I[3] | $10.7 \pm .2^a$ | $7.0 \pm .001^a$ | $16.0 \pm .002^a$ |
| SG II | $11.5 \pm .2^b$ | $7.0 \pm .001^b$ | $16.0 \pm .002^a$ |
| Heterosis[2] | 1.6* (6.7%) | 0 | 0.005 (−3.2%) |

[1] A = Angus, S = Santa Gertrudis, G = Gelbvieh; Sire breed listed first.

[2] Heterosis = 1/2 {(SA + AS) − (AA + SS)}.

[3] *SG I (slaughter group I) = 393 d, SG II = 433 d.*

[abc] Values with different superscripts are different ($p < .05$).

[4] Percentage based on half-carcass weight.

[5] Percentage based on hindquarter weight.

* $p < .05$.

TABLE 5.2 ESTIMATES OF HETEROSIS AND LEAST SQUARE MEANS AND STANDARD ERROR FOR BREED OF SIRE, BREED OF DAM, CALF YEAR, SLAUGHTER GROUP AND BREED OF SIRE × BREED OF DAM

| Mating or effect[1] | Lean trim flank (kg) | Fat trim from flank (kg) | Flank steak (kg) |
|---|---|---|---|
| AA | $4.8 \pm .2^{a}$ | $5.3 \pm .2^{a}$ | $0.6 \pm .05^{a}$ |
| AS | $4.6 \pm .3^{a}$ | $6.6 \pm .3^{b}$ | $0.7 \pm .05^{a}$ |
| SA | $4.5 + .2^{a}$ | $5.3 + .3^{a}$ | $0.7 \pm .05^{a}$ |
| SS | $4.6 \pm .3^{a}$ | $5.3 \pm .3^{a}$ | $0.8 \pm .05^{b}$ |
| GA | $4.6 \pm .2^{a}$ | $4.3 \pm .3^{c}$ | $0.8 \pm .05^{b}$ |
| A Sires | $4.6 \pm .1^{a}$ | $6.1 \pm .1^{a}$ | $0.6 \pm .02^{a}$ |
| S Sires | $4.6 \pm .1^{a}$ | $6.0 \pm .1^{a}$ | $0.7 \pm .02^{b}$ |
| G Sires | $4.6 \pm .2^{a}$ | $4.9 \pm .2^{b}$ | $0.8 \pm .03^{c}$ |
| A Dams | $4.6 \pm .1^{a}$ | $5.2 \pm .1^{a}$ | $0.7 \pm .01^{b}$ |
| S Dams | $4.6 + .2^{b}$ | $6.0 \pm .2^{b}$ | $0.7 + .01^{b}$ |
| 77 Calf yr | $4.9 \pm .1^{a}$ | $4.4 \pm .2^{a}$ | $0.8 \pm .02^{a}$ |
| 78 Calf yr | $4.4 \pm .1^{a}$ | $5.2 \pm .2^{b}$ | $0.7 \pm .02^{a}$ |
| 79 Calf yr | $5.1 \pm .1^{b}$ | $6.2 \pm .2^{c}$ | $0.7 \pm .02^{a}$ |
| 80 Calf yr | $3.8 \pm .2^{b}$ | $6.8 \pm .2^{d}$ | $0.7 \pm .03^{a}$ |
| SG I[3] | $4.6 \pm .1^{a}$ | $5.3 \pm .1^{a}$ | $0.7 \pm .02^{a}$ |
| SG II | $4.6 \pm .1^{a}$ | $6.1 \pm .1^{b}$ | $0.7 \pm .02^{b}$ |
| Heterosis[2] | −0.3 (−3.4%) | 1.5* (12.7%) | 0 |

[1] A = Angus, S = Santa Gertrudis, G = Gelbvieh; Sire breed listed first.
[2] Heterosis = 1/2 {(SA + AS) − (AA + SS)}.
[3] SG I (slaughter group I) = 393 d, SG II = 433 d.
[a,b,c] Values with different superscripts are different ($p < .05$).
* $p < .05$.

fluenced by the sire breed and dam breed only when age at slaughter was used as covariate. PF based on hindquarter weight had similar results as on the basis of half carcass weight. Rahnefeld et al. (1983) had reported similar results.

b) Lean trim

Calf year, sire breed, sire within sire breed, dam breed, slaughter group, heterosis and covariates had no effect on this trait. However, using carcass weight within slaughter group as a covariate had highly significant effect on LTR from the flank. In this case the effects of dam breed and heterosis were also found to be highly significant. This suggests that adjustment of the data to a constant carcass weight is more important from the standpoint of looking into effects of different variables. Crossbreds from S × A produced the least amounts of LTR followed by purebred of S progeny. Purebred A progeny produced the highest amount of LTR among the five groups.

c) Fat trim

Sire breed, dam breed, slaughter group and age at slaughter group were important for FTR. Effect of all the covariates were also significant for FTR. Heterosis had also significant effect on this trait. Crossbred progeny from A × S produced the heaviest amount of fat while the crossbred of G × A produced the least. Differences in other groups were non-significant.

d) **Flank steaks**

Sire breed, dam breed, slaughter group and carcass weight within slaughter group were the main effects found to be significant for FST. Purebred S produced the largest amount of FST and purebred A the least. Heterosis was found to be non-significant.

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