Evaluation of the North American Limousin

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Evaluation of the North American Limousin

D.S. Buchanan, D.K. Darnell, R.R. Frahm and W. Vanderwert*

The choice of breeds and breeding systems has considerable impact on the efficiency of beef production. During the last quarter century numerous breeds of beef cattle have been imported into North America from many parts of the world, most notably the European continent. This smorgasbord of breeds gives the commercial cattle producer many choices but, without proper information on the roll of each breed, may also serve to confuse rather than enlighten. The Limousin breed was imported from France in 1968. Ten years later the available research information on the merits of the Limousin breed was summarized (Frahm and Belcher, 1978). At that time there was limited information available from research conducted in North America. Research was underway to evaluate the direct effects of Limousin genetics on growth, efficiency and carcass merit. More recently, additional studies have been conducted evaluating the value of the Limousin as a component of the commercial cow herd.

The primary purpose of this report is to summarize the current status of research concerning the Limousin breed in comparison with other breeds. Research conducted in North America will be emphasized. In

*AUTHORS: Professor, Animal Science Department, Oklahoma State University; Undergraduate research assistant, Animal Science Department, Oklahoma State University; Head, Animal Science Department, Virginia Polytechnic Institute and State University, Blacksburg, VA; Director of Education and Research, North American Limousin Foundation, respectively.

addition, information from analysis of the sire evaluation data will be used to evaluate the genetic progress made by Limousin breeders since the breed was imported.

A report of this nature is useful on two fronts. Commercial cattle producers will be able to use this information to assist in making rational decisions concerning the use of Limousin cattle in their breeding programs. In addition, breeders of Limousin cattle should use this summary to plan the future focus of selection programs for the breed. Strong points can be advertised and promoted, but weak points should be acknowledged and examined closely to see if additional selection pressure should be applied.

Brief History of the Limousin

The Limousin breed is native to the hills and valleys of the old province of Limousin, now the departments of Haute-Vienne and Correze, located in the south-central part of France. Ancestors of Limousin can be traced to the wild native cattle of Europe, called Aurochs. Rouse (1970) describes Limousin as the second most important beef breed of continental Europe and indicates they may have the same ancestors as the Austrian and German Yellow cattle. In the 17th and 18th centuries, Limousin were renowned as draft animals and the oxen were slaughtered for meat upon termination of their usefulness. Although many other European breeds were selected for milk production, the Limousin breed was developed for draft and meat production.

In the early 1800's efforts were intensified to improve the Limousin cattle for meat production. The Limousin herd book was established in 1886 and Limousin have since developed a reputation in France for their hardiness, ease of calving and lean meat yield. The Limousin in France is now selected and managed solely for meat production. Rouse (1970) and French et. al. (1966) described Limousin as being large (mature females that begin calving at three years of age averaging about 1350 lb and bulls 2400 lb) but somewhat smaller boned than Charolais.

Limousin cattle were introduced to North America in 1968 with importation of "Castor", renamed "Prince Pompador", from the Pompador Estate in France. Many other purebred Limousin bulls were imported to North America in the years that followed. These early Limousin cattle were very appealing to cattlemen throughout the United States and Canada and many modified their breeding programs to grade up from existing herds to produce American purebreds, 7/8 for females and 15/16 for bulls.

The Limousin breed has shown rapid growth in North America. In 1987 the North American Limousin Foundation was the fifth largest beef breed registry in the United States (48,441 registrations in 1986-87 and over 7000 lifetime members).

Materials and Methods

The major source of information for this study was the published reports of research, conducted in North America, in which Limousin cattle were directly compared with cattle of other breeds. There has also been considerable research with Limousin cattle in Europe. These results were not included in this bulletin because there are sufficient results from North America to provide ample information and management systems used in the North American research should be similar to those systems employed by the clientele of the North American Limousin Foundation. Some of the earlier European work has been summarized by Frahm and Belcher (1978).

Research was divided into two categories. The first was derived from those studies in which calves sired by Limousin bulls were directly compared to calves sired by bulls of other breeds. The dams of these calves were generally females of other breeds, frequently Hereford and/or Angus. Calf survival, calving difficulty, growth characteristics and carcass traits were generally evaluated in these studies. The second category includes those studies where females that had Limousin breeding were used. Traits associated with reproduction in the female such as age at puberty, gestation length and pregnancy rate were important in such studies as well as performance characteristics of the offspring. The location and characteristics of each research study are summarized in Appendix Summary 1.

Information from various studies was combined so that overall means could be obtained for those traits that were evaluated in a uniform

manner in different studies. Means from each study were subjected to a least-squares analysis with weighting by the number of observations for each mean. These results will be presented graphically in the body of this bulletin with individual results from each study shown in appendix tables. Caution should be used when examining these overall means. Only studies with Limousin cattle were included and, therefore, only those comparisons of each other breed with Limousin are using the complete information from the literature. These results should not be used to make comparisons among the other breeds since there may be additional research that is pertinent.

The most common design employed in research studies involving Limousin was to produce two-breed cross calves by mating bulls of the breeds to be evaluated to cows of some other breed. Frequently, either Hereford or Angus was used as the other breed. Comparing such two-breed crosses provides estimates of one-half of the additive genetic differences among the sire breeds compared for a particular trait, assuming a similar level of heterosis among the various crosses. In several studies, crossbred heifers from these matings were retained to compare breeds for cow performance.

Comparisons of Limousin crossbred females with crossbred females of other breed combinations have been accomplished at several research stations in North America. Most commonly, Hereford-Angus females were used as a "control" and crossbred females were generated using bulls of other breeds with Hereford or Angus females. These crossbred females were usually mated to bulls of another breed to produce three-breed crossbred offspring.

One particular study needs to be identified. This is the ongoing effort at the US Meat Animal Research Center at Clay Center, Nebraska. This study is commonly called the "Germ Plasm Evaluation Project". Over 20 breeds of cattle have been evaluated over a 20 year period. Numerous individual papers have been published from this project and several of these are included in this review. The best recent discussion of this project is Cundiff et al. (1986).

Performance of Limousin Sired Calves

<u>Gestation Length, Birth Weight and Calving Difficulty.</u> A comparison of gestation lengths (Figure 1, Appendix Table 1) indicated that calves sired by Limousin bulls had longer gestation periods than other breeds, except Brahman. The difference was approximately 2 days when compared to Charolais, Chianina and Simmental and ranged from 3 to 5 days for other breeds.

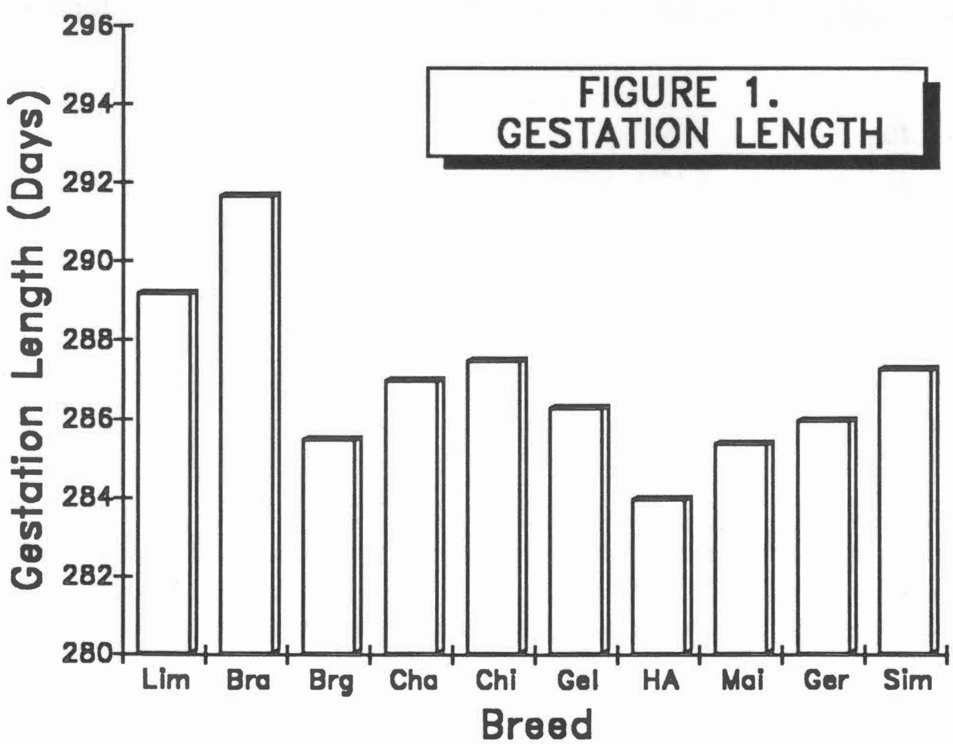
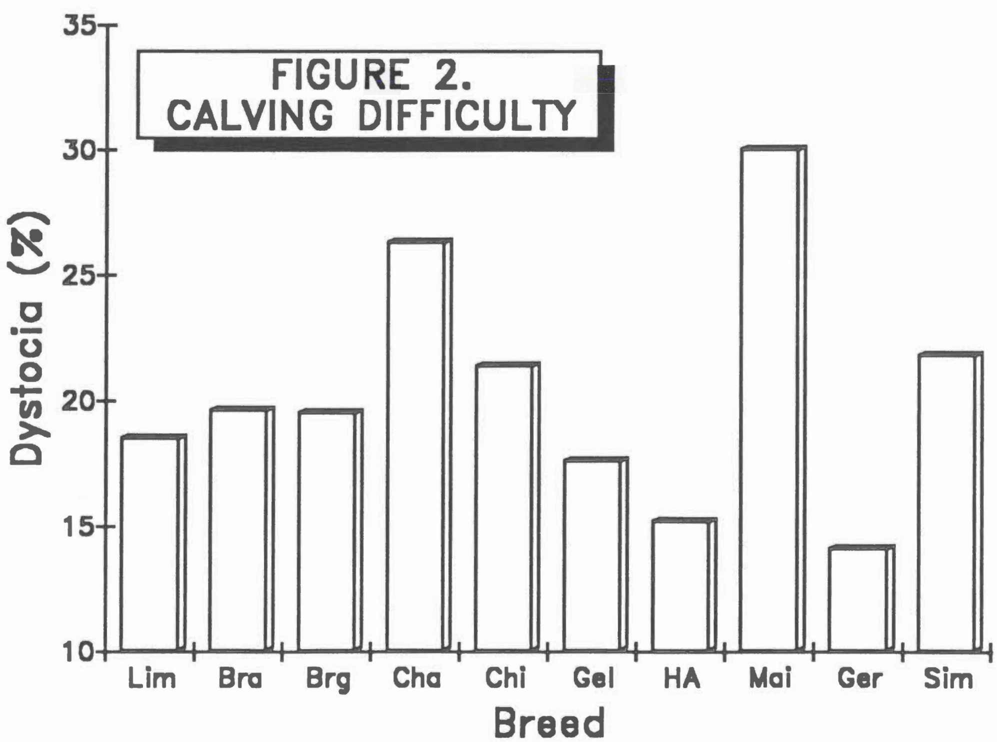


FIGURE 1.
GESTATION LENGTH
Gestation Length (Days)
296
294
292
290
288
286
284
282
280
Lim
Bra
Brg
Cha
Chi
Gel
HA
Mai
Ger
Sim
Breed

Despite the longer gestation period, Limousin sired calves were 4 to 8 pounds lighter and caused cows less calving difficulty when compared to Charolais, Chianina, Maine Anjou or Simmental sired calves (Figures 2 and 3, Appendix Tables 2 and 3). Birth weights and calving difficulty scores of Limousin sired calves were similar to Gelbvieh sired calves. Angus, Brangus and Hereford sired calves were generally smaller at birth than calves by Limousin bulls but only Hereford, Angus and Santa Gertrudis sired calves were easier calving.

These findings on birth weight and calving difficulty show a clear advantage for the Limousin in comparison with most other continental European breeds. These are the breeds most commonly recommended for a terminal sire in the three-breed crossing system. This lower incidence of calving difficulty is a distinct economic advantage, particularly for large commercial operations where close care of the cow herd is not always possible.

<u>Calf Liveability and Preweaning Growth.</u> Calf mortality from birth to weaning was generally lower for Limousin sired calves when compared with calves by Charolais, Chianina or Simmental sires (Figure 4, Appendix Table 4). Similar mortality figures were obtained for Gelbvieh and Maine Anjou sired calves and Hereford, Angus and the Brahman based breeds had generally lower mortality rates. The breeds with higher calving difficulty scores usually had higher mortality rates as well. Again, the Limousin showed an advantage, relative to most other breeds generally used as terminal cross sires.



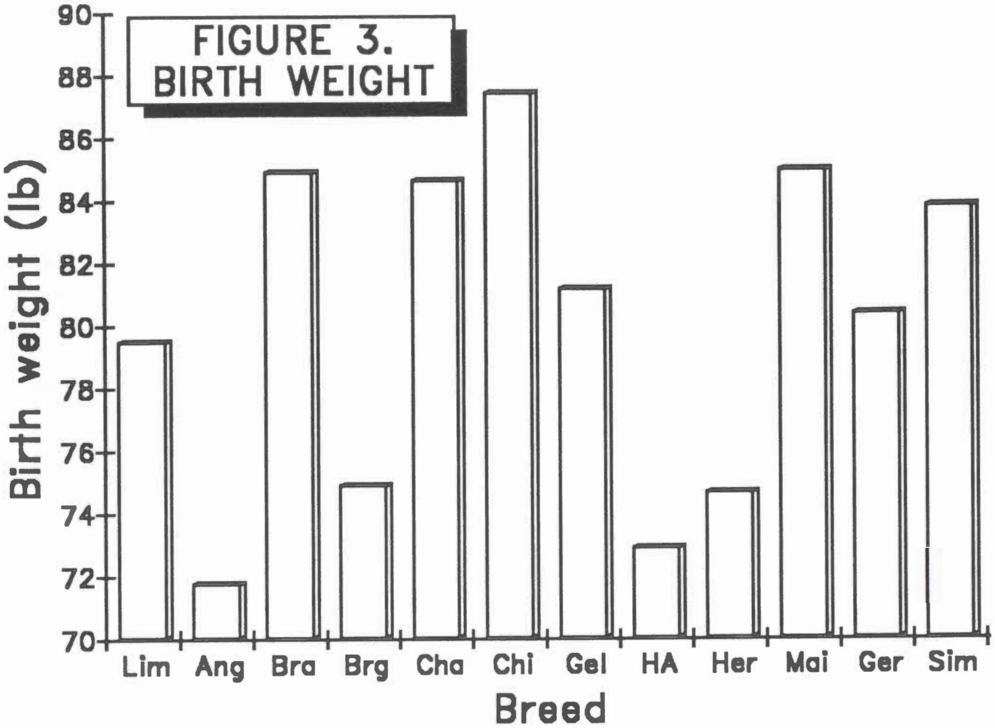


FIGURE 3.
BIRTH WEIGHT
Birth weight (lb)
90
88
86
84
82
80
78
76
74
72
70
Lim
Ang
Bra
Brg
Cha
Chi
Gel
HA
Her
Mai
Ger
Sim
Breed

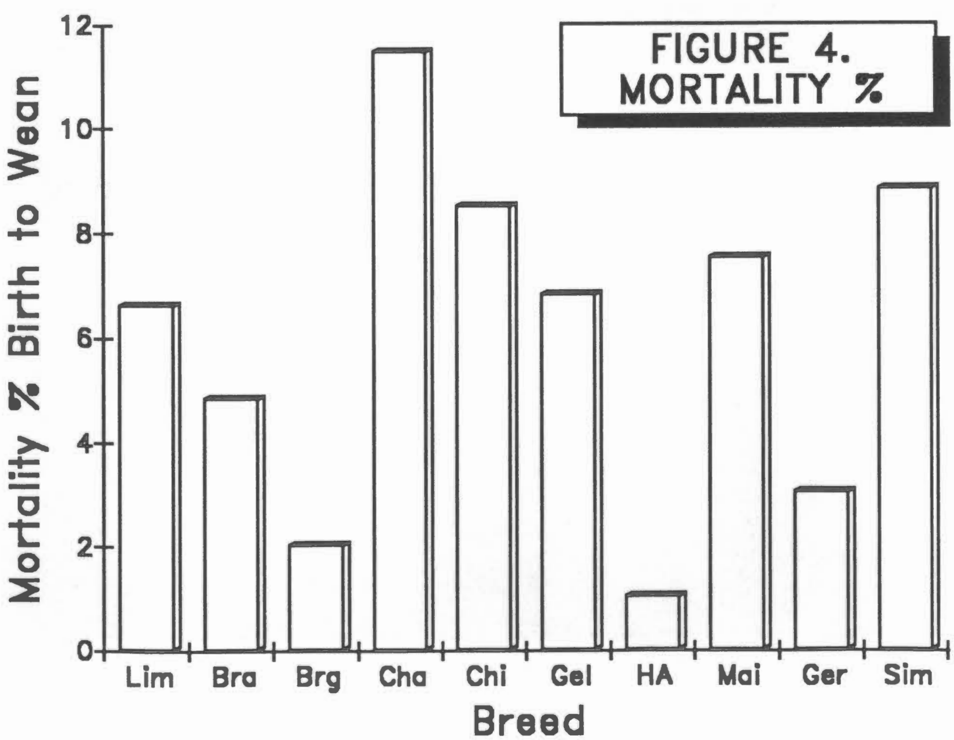
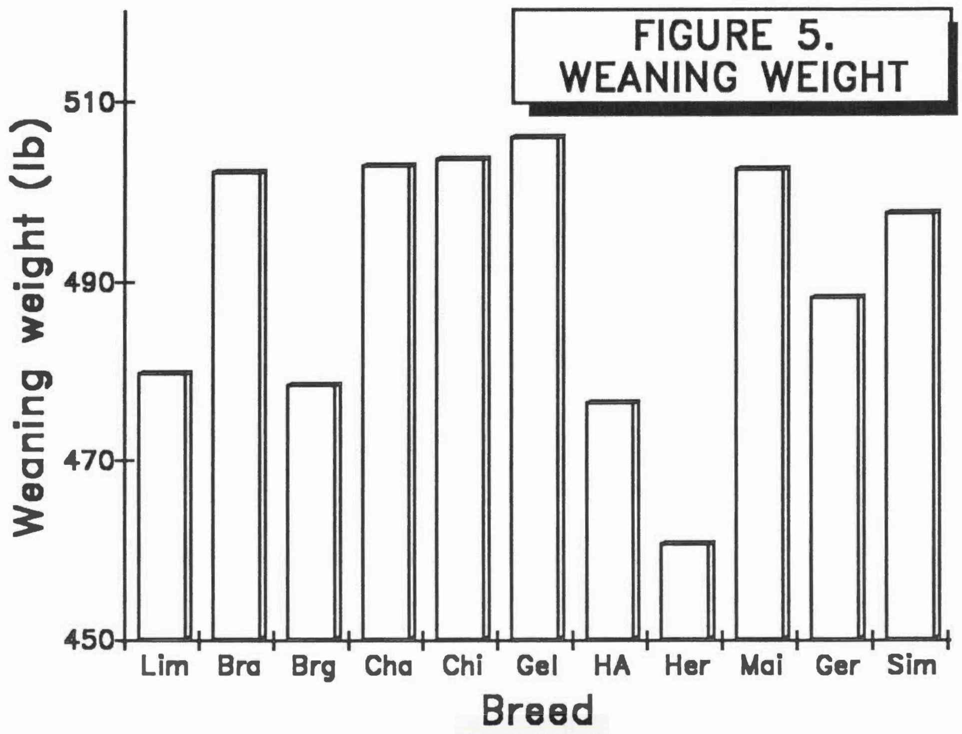


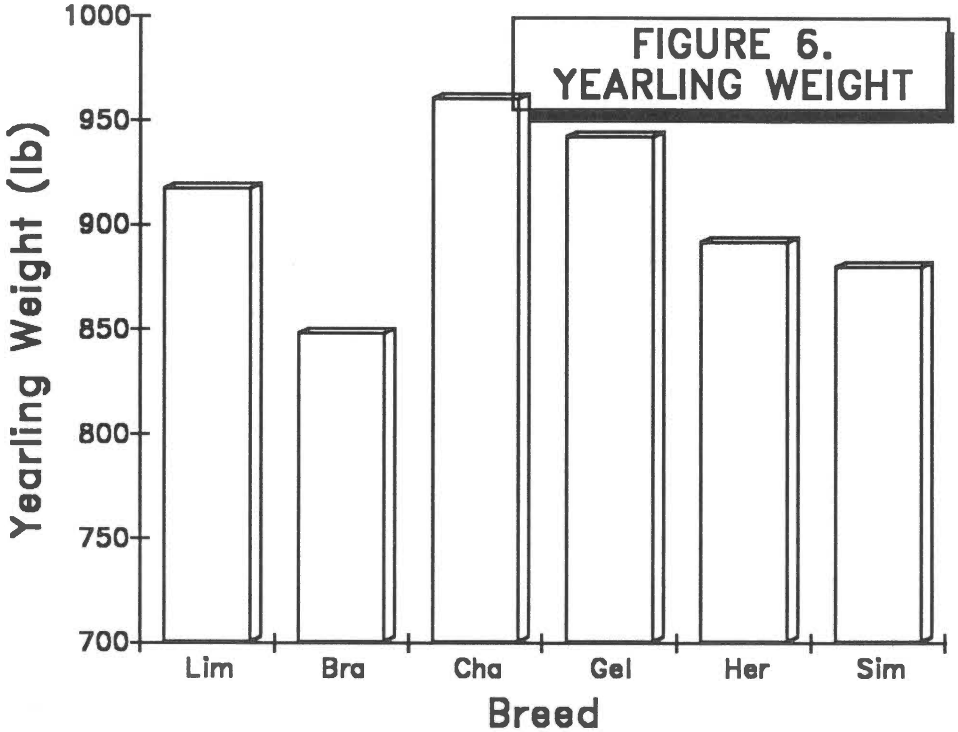
FIGURE 4.
MORTALITY %
Mortality % Birth to Wean
12
10
8
6
4
2
0
Lim
Bra
Brg
Cha
Chi
Gel
HA
Mai
Ger
Sim
Breed

Average weaning weights (Figure 5, Appendix Table 5) showed an approximate 4 percent disadvantage for Limousin sired calves, relative to Brahman, Charolais, Chianina, Gelbvieh, Maine Anjou and Simmental. Limousin sired calves were slightly larger at weaning than calves sired by Angus, Hereford or Brangus bulls.

<u>Postweaning Growth and Efficiency.</u> Yearling weights (Figure 6, Appendix Table 6) of Limousin sired calves were larger than Brangus, Hereford or Simmental sired calves and were slightly smaller than those of



Calves shown in feedlot are Limousin-cross calves born in research project at Oklahoma State University.



Charolais or Gelbvieh sired calves. However, relatively few studies actually reported yearling weight. A better estimate of postweaning growth was obtained from average daily gain in feedlot conditions (Figure 7, Appendix Table 7). Charolais, Maine Anjou and Simmental sired calves grew somewhat faster than calves sired by Limousin bulls. Limousin, Chianina and Gelbvieh sired calves had similar growth rates.

Considerable variation existed among experiments as to how feed efficiency was measured. Values summarized in Figure 8 and Appendix Table 6 used the traditional pounds of feed to pounds of gain ratio and show an advantage in feed efficiency for Limousin sired calves relative to Brangus, Brahman, Charolais and Simmental sired calves. Angus, Gelbvieh and Maine Anjou sired calves were more efficient than calves sired by Limousin bulls. Results from the Germ Plasm Evaluation project (Cundiff et al. 1986) compare breeds for feed efficiency under several different feeding intervals. Limousin sired calves were similar in feed efficiency to other continental European breeds and slightly more efficient than Hereford and Angus when a time or weight constant feeding interval was used. Feeding to a constant quality grade resulted in an advantage in feed efficiency for Limousin sired calves relative to the Chianina, but disadvantages relative to other European or British breeds.

<u>Carcass Traits.</u> Numerous carcass characteristics were evaluated in a variety of studies. These are summarized in Figures 9 to 16 and Appendix Tables 9 to 17. Limousin sired calves showed an advantage in dressing percent compared to all other breeds except the Chianina. Rib eye area and

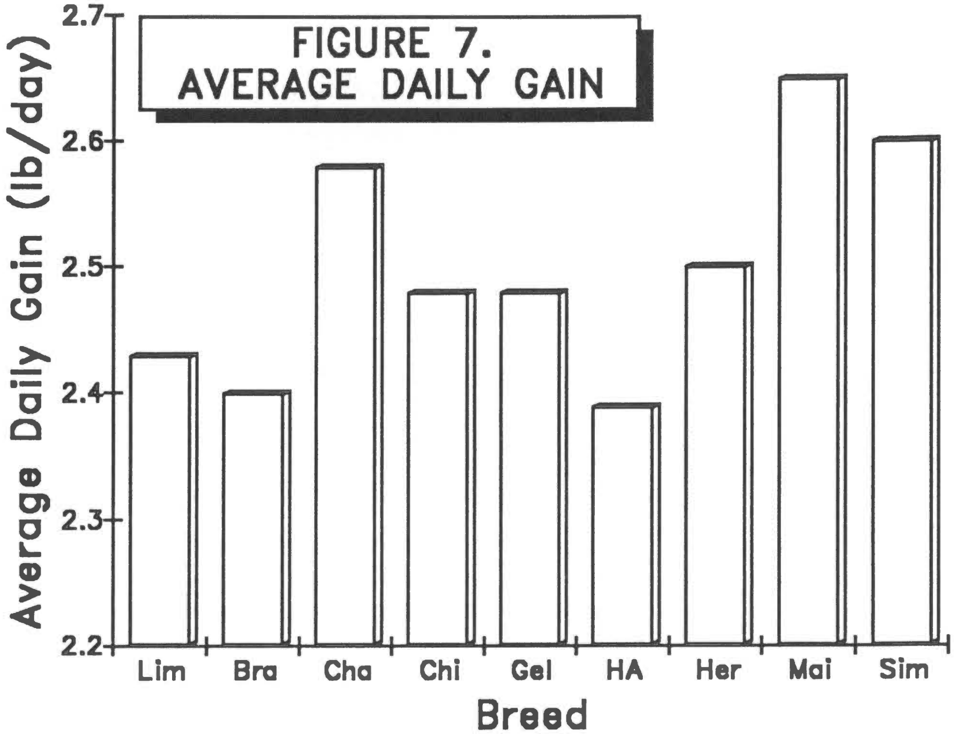


FIGURE 7.
AVERAGE DAILY GAIN
Average Daily Gain (lb/day)
2.7
2.6
2.5
2.4
2.3
2.2
Lim
Bra
Cha
Chi
Gel
HA
Her
Mai
Sim
Breed

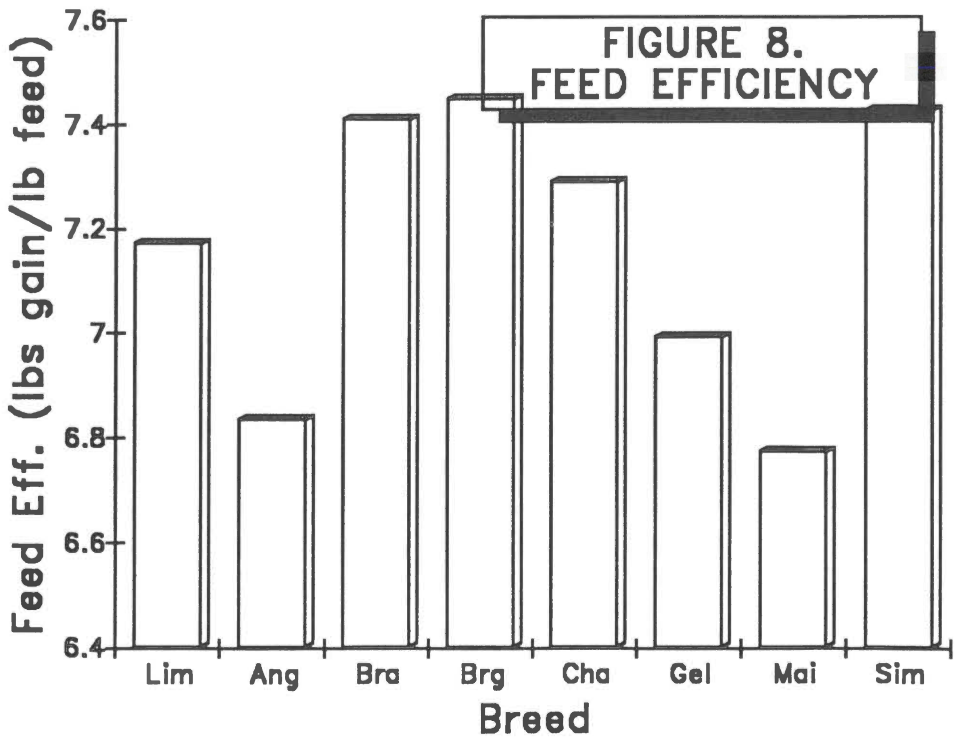
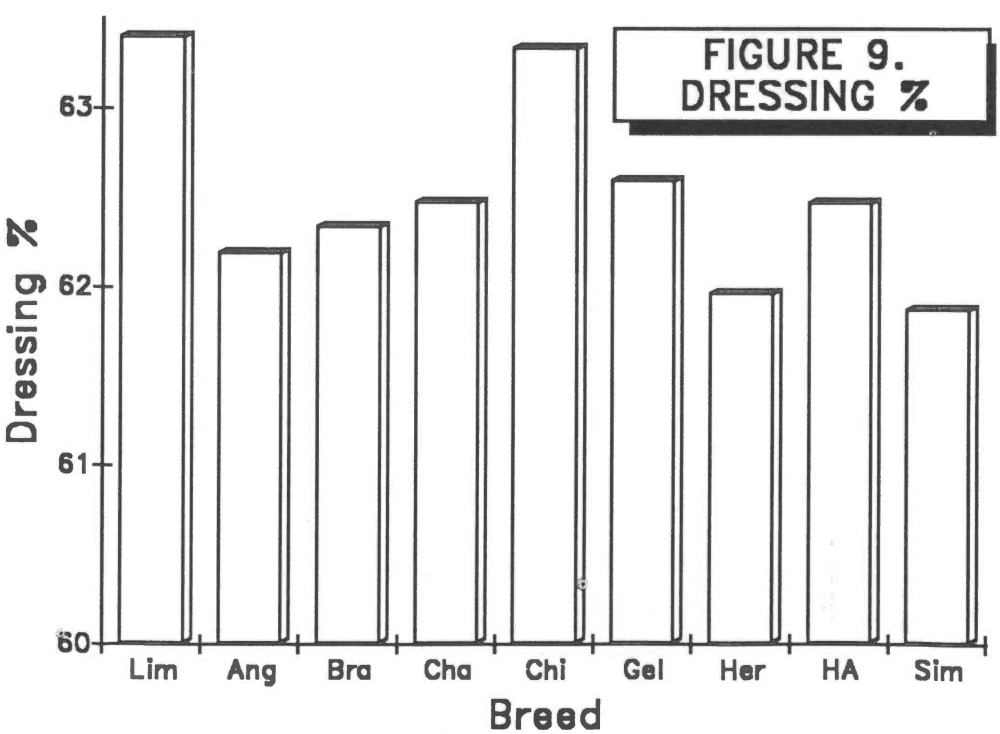


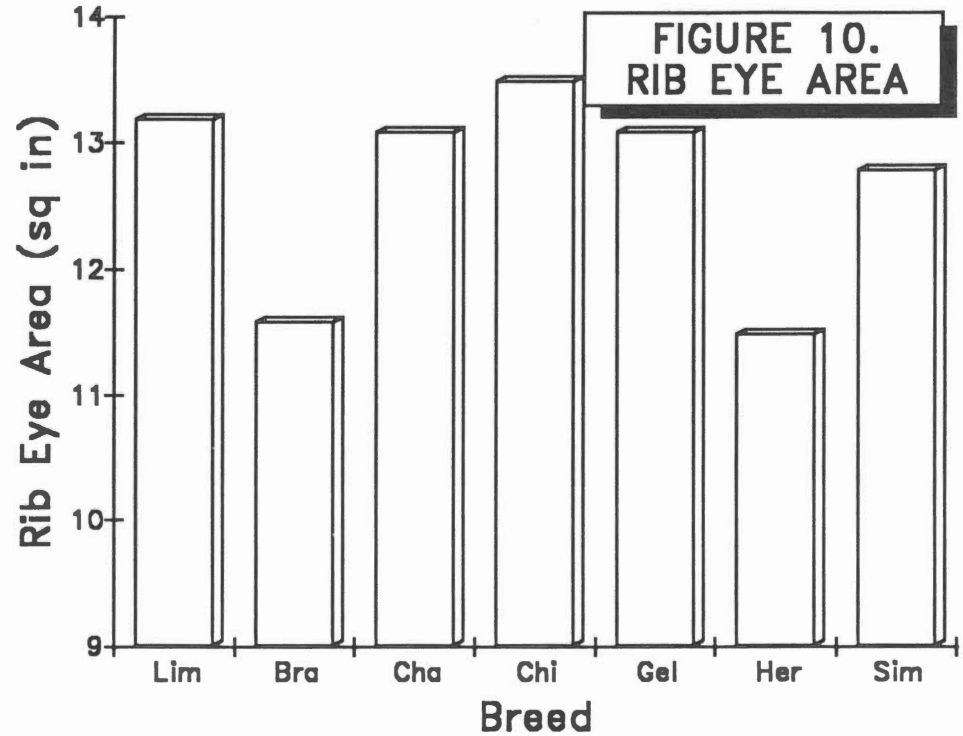
FIGURE 8.
FEED EFFICIENCY
Feed Eff. (lbs gain/lb feed)
7.6
7.4
7.2
7
6.8
6.6
6.4
Lim
Ang
Bra
Brg
Cha
Gel
Mai
Sim
Breed

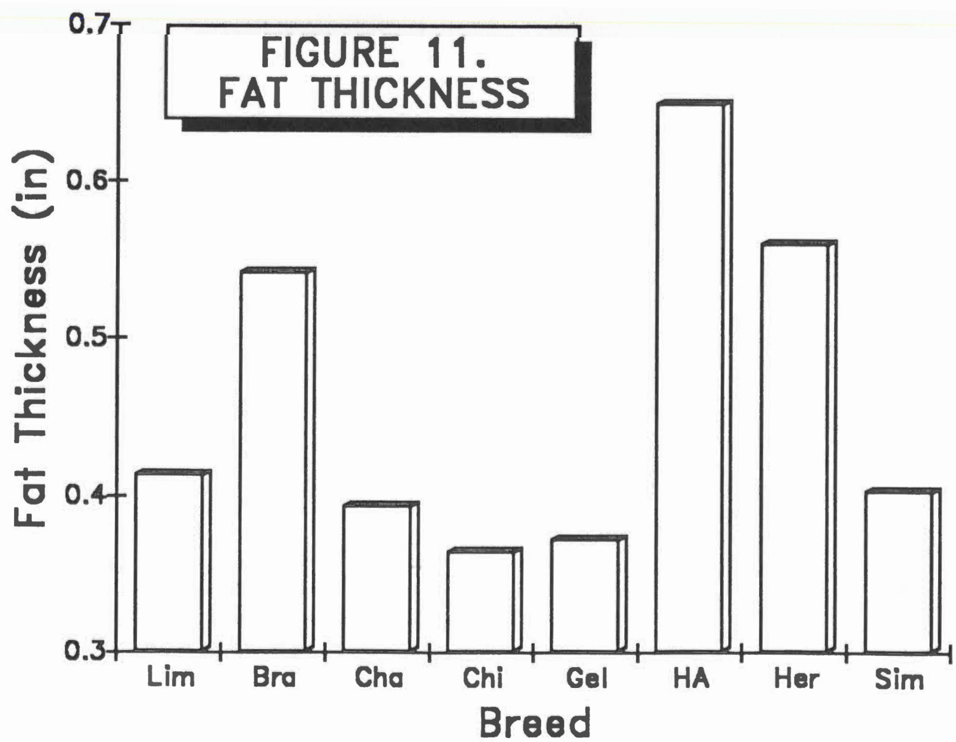
Oklahoma State University research assistant, Eugene Tinker, checks rib eye area.



fat thickness were strengths of the Limousin sired calves, as well as calves sired by Charolais, Chianina, Gelbvieh and Simmental.

Four studies evaluated taste panel results of Limousin sired calves. These showed slightly less tenderness and juiciness for Limousin and Charolais, relative to Angus, Hereford, Maine Anjou and Simmental. Taste panel flavor was similar for all six breeds with the Limousin intermediate in value.





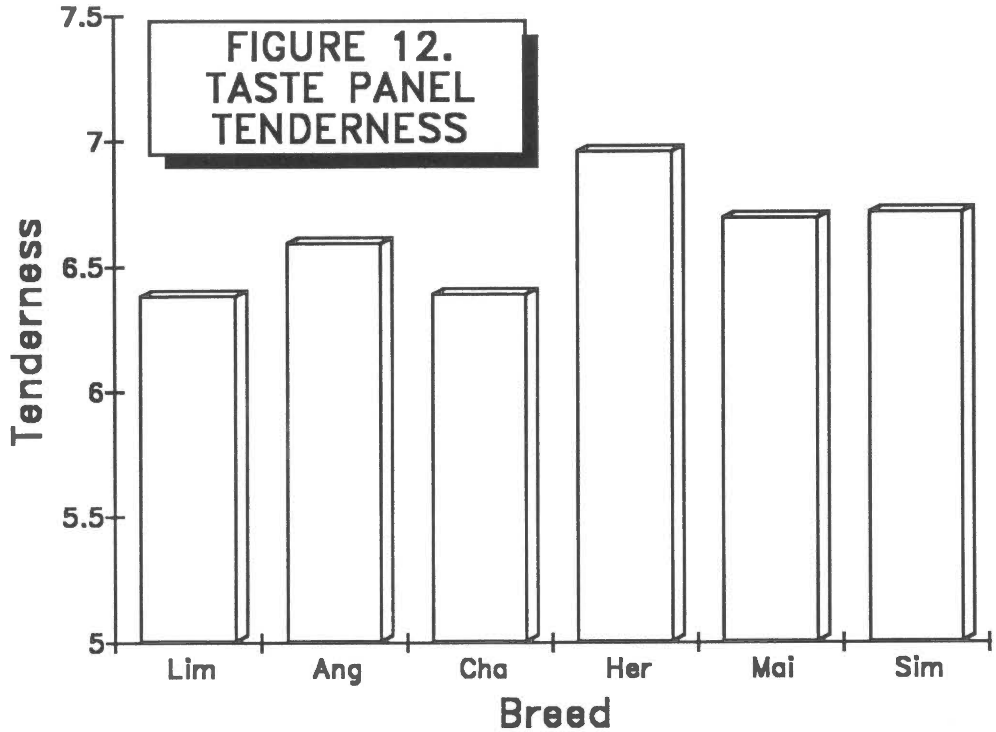


FIGURE 12.
TASTE PANEL
TENDERNESS
Tenderness
7.5
7
6.5
6
5.5
5
Lim
Ang
Cha
Her
Mai
Sim
Breed

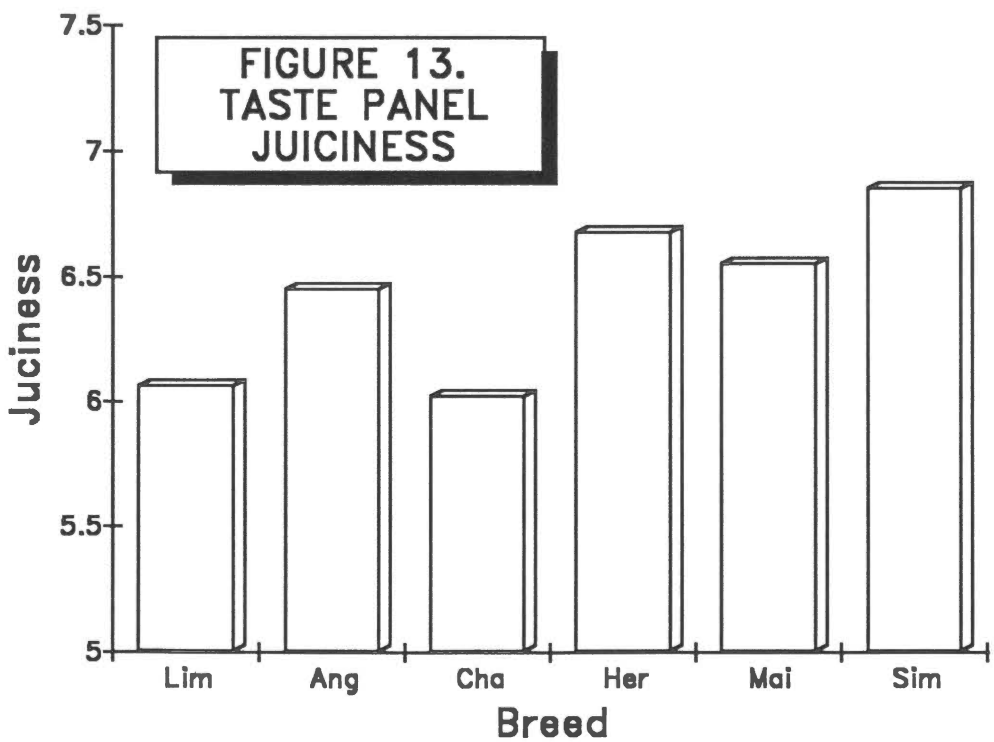


FIGURE 13.
TASTE PANEL
JUICINESS
Juciness
7.5
7
6.5
6
5.5
5
Lim
Ang
Cha
Her
Mai
Sim
Breed

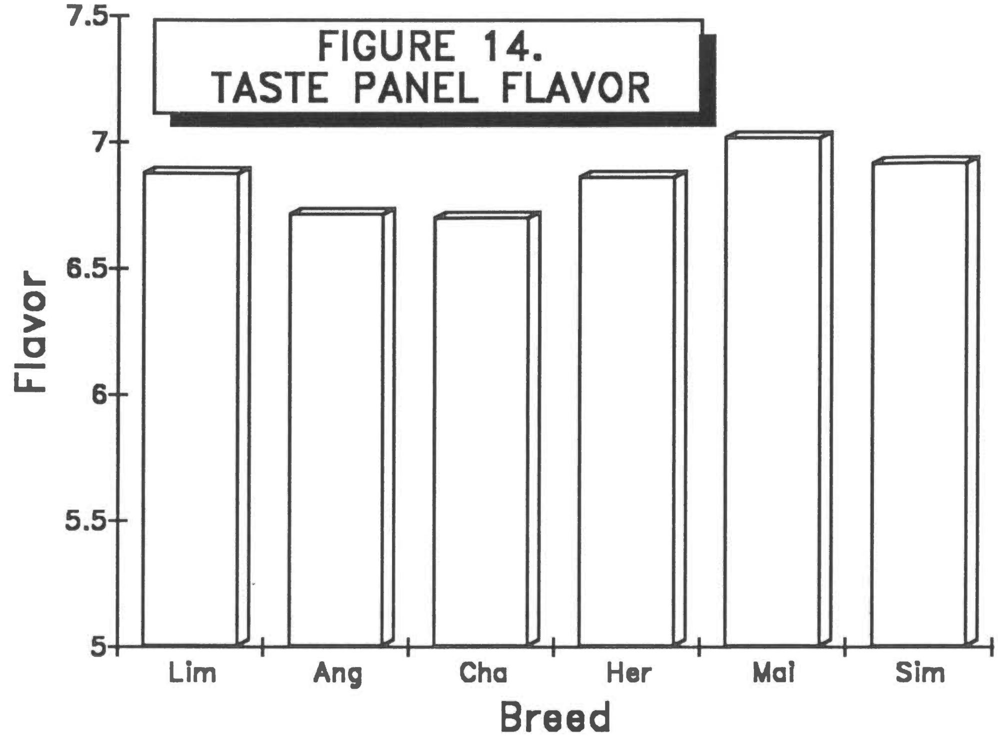


FIGURE 14.
TASTE PANEL FLAVOR
7.5
7
6.5
6
5.5
5
Flavor
Lim
Ang
Cha
Her
Mai
Sim
Breed

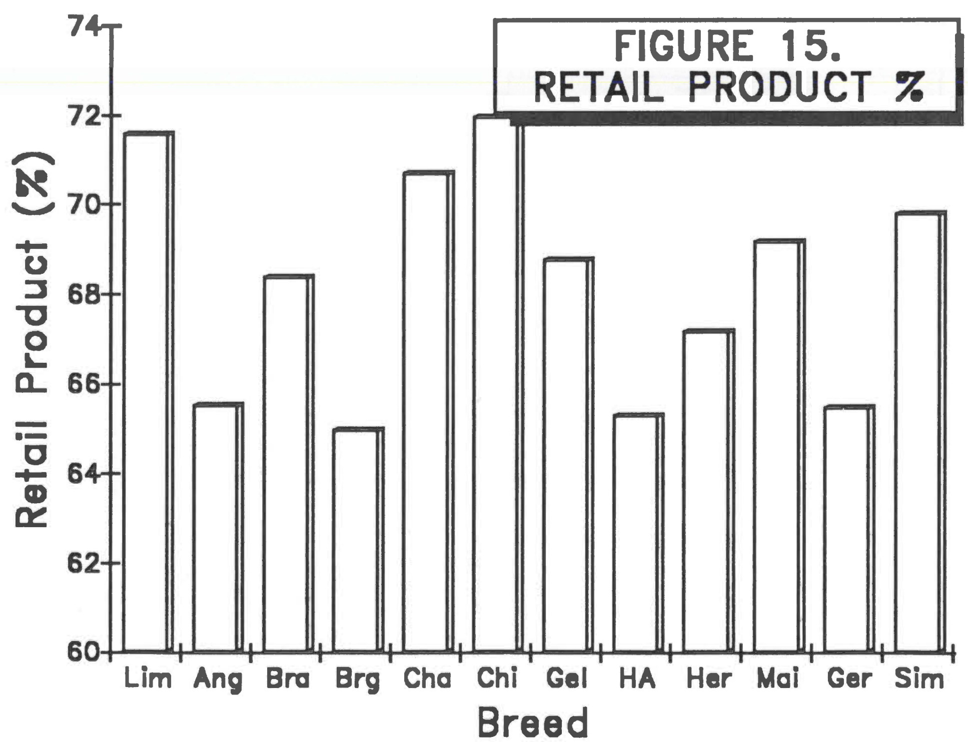
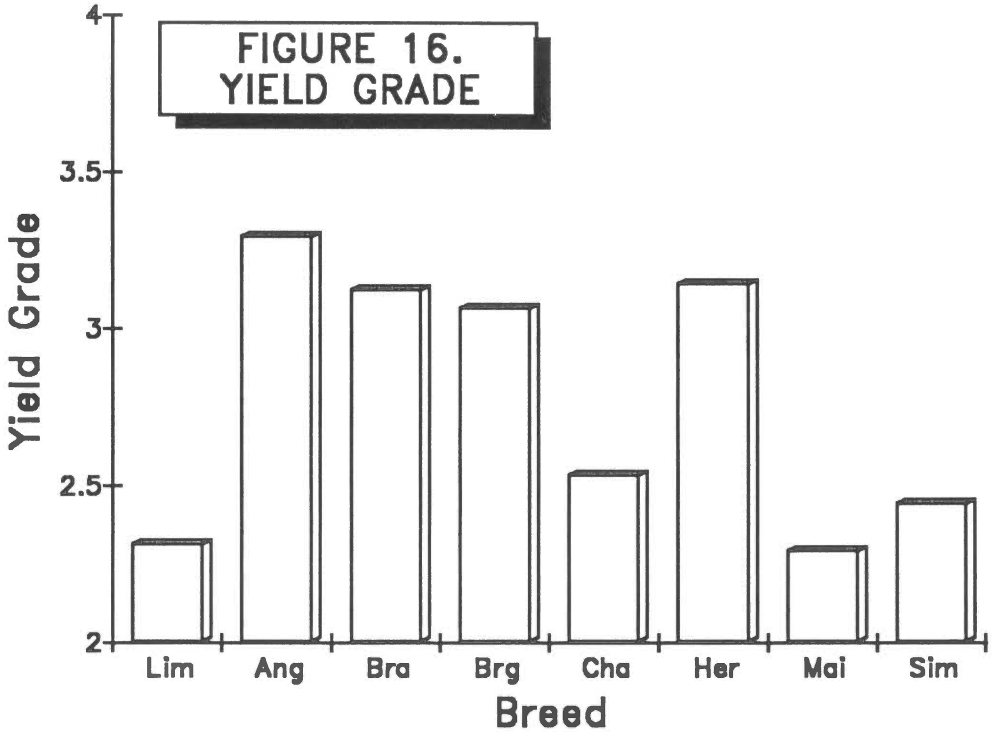


FIGURE 15.
RETAIL PRODUCT %
74
72
70
68
66
64
62
60
Retail Product (%)
Lim
Ang
Bra
Brg
Cha
Chi
Gel
HA
Her
Mai
Ger
Sim
Breed



Retail product percent and yield grade were obvious strengths of the Limousin, along with the Charolais and Chianina. These breeds had substantial advantages over all other breeds evaluated in the various studies. These studies repeatedly demonstrate the advantage the Limousin breed has in leanness and muscling relative to most other breeds of beef cattle.

Performance of Limousin Crossbred Cows

The previous summary of research concerning Limousin (Frahm and Belcher, 1978) had only scanty information concerning the breed as a contributor to the crossbred cow herd. The intervening years have provided sufficient time for several evaluations of Limousin crossbred cows.

Heifer Development, Cow Size and Reproductive Rate. Limousin crossbred heifers reached puberty at a similar age as heifers with Brangus, Charolais, Chianina and Santa Gertrudis sires (Figure 17, Appendix Table 18). Limousin sired heifers reached puberty over 40 days earlier than Brahman sired heifers but were somewhat later than Gelbvieh, Hereford, Angus, Maine Anjou or Simmental.

Developing Limousin crossbred heifers were somewhat smaller than either Charolais or Simmental crossbred heifers, but were larger than Hereford-Angus crossbred heifers (Figure 18, Appendix Table 19). As mature cows, Limousin breeding produced cows that were similar in size to

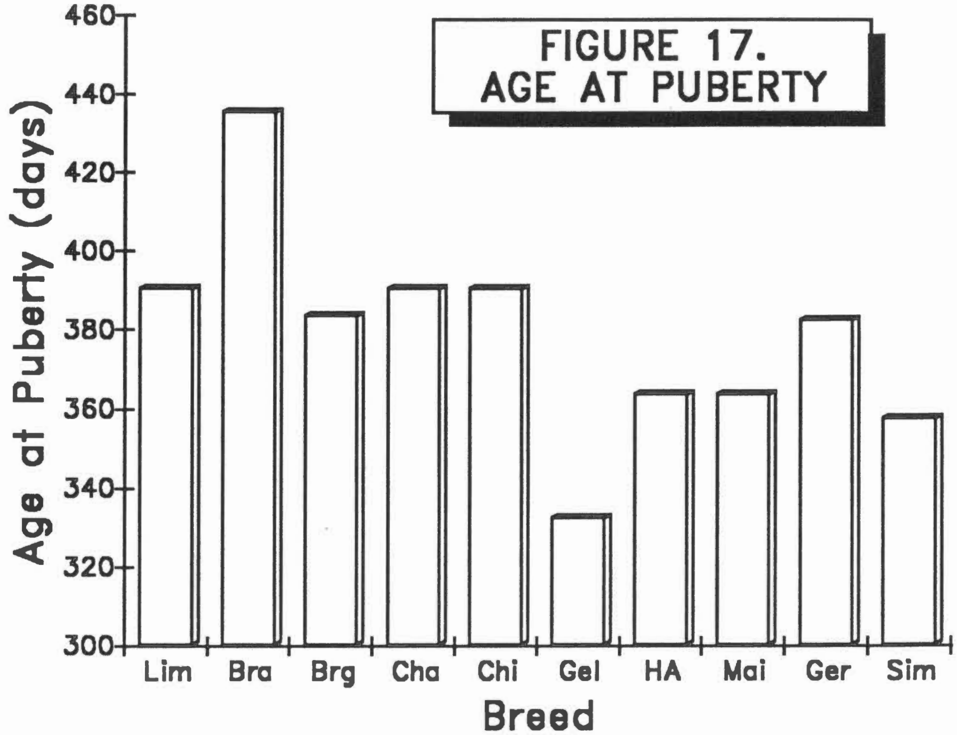
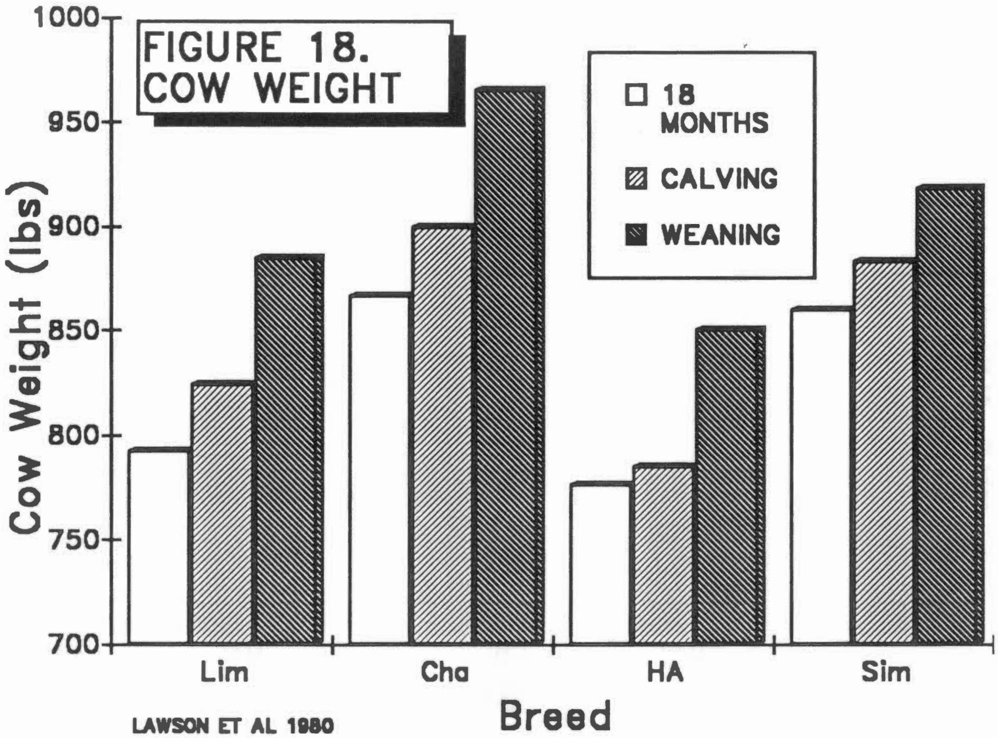


FIGURE 17.
AGE AT PUBERTY
Age at Puberty (days)
460
440
420
400
380
360
340
320
300
Lim
Bra
Brg
Cha
Chi
Gel
HA
Mai
Ger
Sim
Breed



Brangus, Hereford and Angus (Figure 19). Limousin crossbred cows were somewhat smaller than Brahman, Gelbvieh, Santa Gertrudis and Simmental crossbred cows and were much smaller than Charolais, Chianina and Maine Anjou crossbred cows.

A trait that needs improvement in the Limousin is conception rate. Limousin and Charolais crossbred cows had similar pregnancy rates and were somewhat lower than all other breeds evaluated (Figure 20, Appendix Table 20). It should be pointed out that recent research with purebred cows has shown Limousin cows to have a higher number of calves born and weaned per cow exposed than Simmental, Hereford and Brahman (Comerford et al, 1987). These results may reflect more attention paid to fertility among breeders of Limousin cattle in recent years.

<u>Gestation Length, Calving Difficulty and Birth Weight.</u> Gestation length of Limousin crossbred cows has not been extensively studied. Available results are shown in Figure 21 and Appendix Table 21. Only small differences among the breeds were observed.

Calves out of Limousin crossbred cows were moderate in size and those cows experienced moderate levels of difficulty in calving (Figures 22 and 23, Appendix Tables 22 and 23). Calves from Limousin crossbred cows were somewhat smaller than from Charolais, Chianina, Maine Anjou and Simmental and Limousin crossbred cows experienced less difficulty calving than Charolais and Simmental cows. They had somewhat larger calves than Brahman crossbred cows and experienced more difficulty calving than

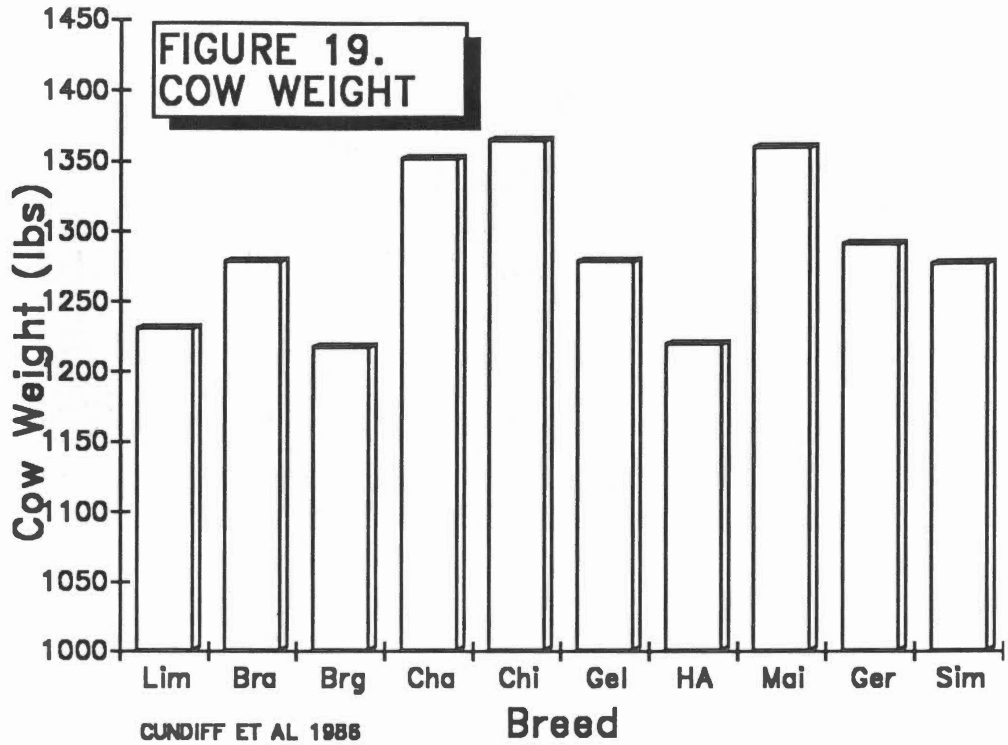


FIGURE 19.
COW WEIGHT
1450
1400
1350
1300
1250
1200
1150
1100
1050
1000
Cow Weight (lbs)
Lim
Bra
Brg
Cha
Chi
Gel
HA
Mai
Ger
Sim
CUNDIFF ET AL 1986
Breed

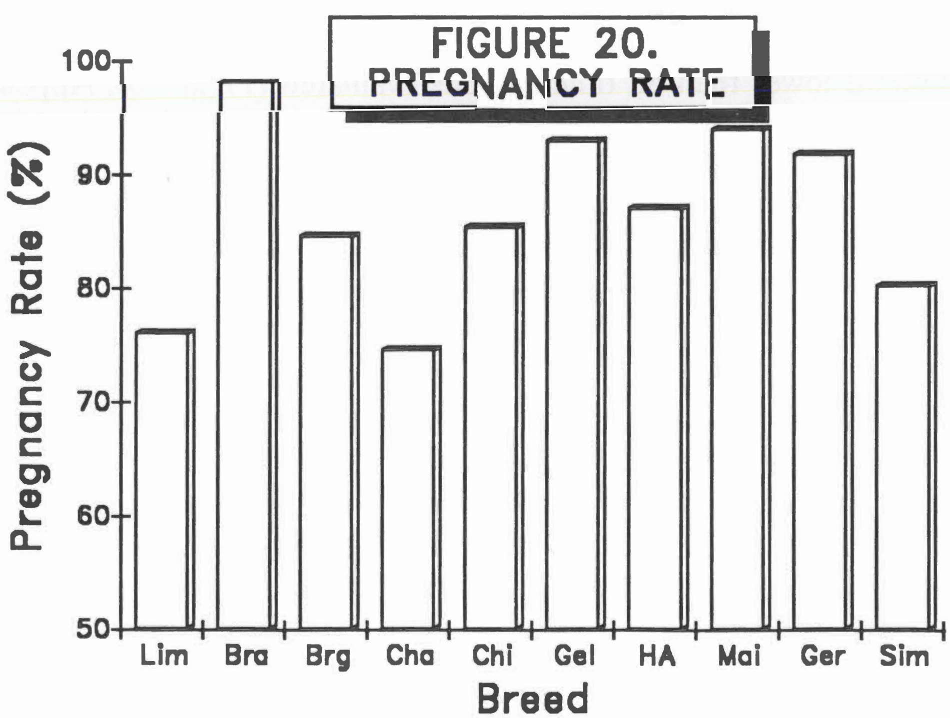


FIGURE 20.
PREGNANCY RATE
100
90
80
70
60
50
Pregnancy Rate (%)
Lim
Bra
Brg
Cha
Chi
Gel
HA
Mai
Ger
Sim
Breed

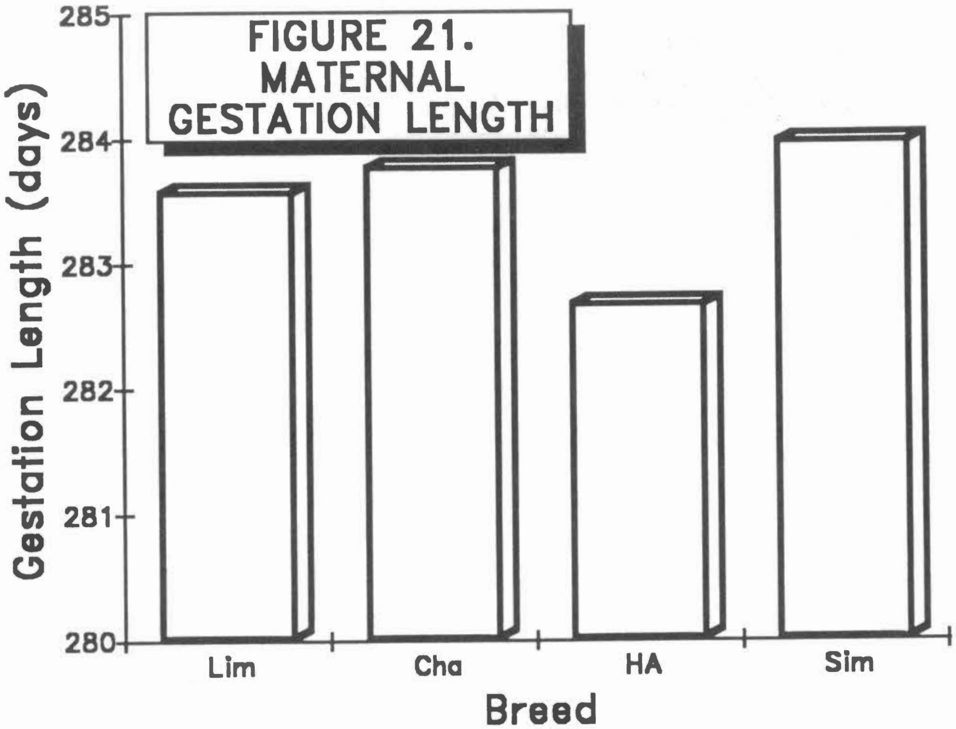


FIGURE 21.
MATERNAL
GESTATION LENGTH
Gestation Length (days)
285
284
283
282
281
280
Lim
Cha
HA
Sim
Breed

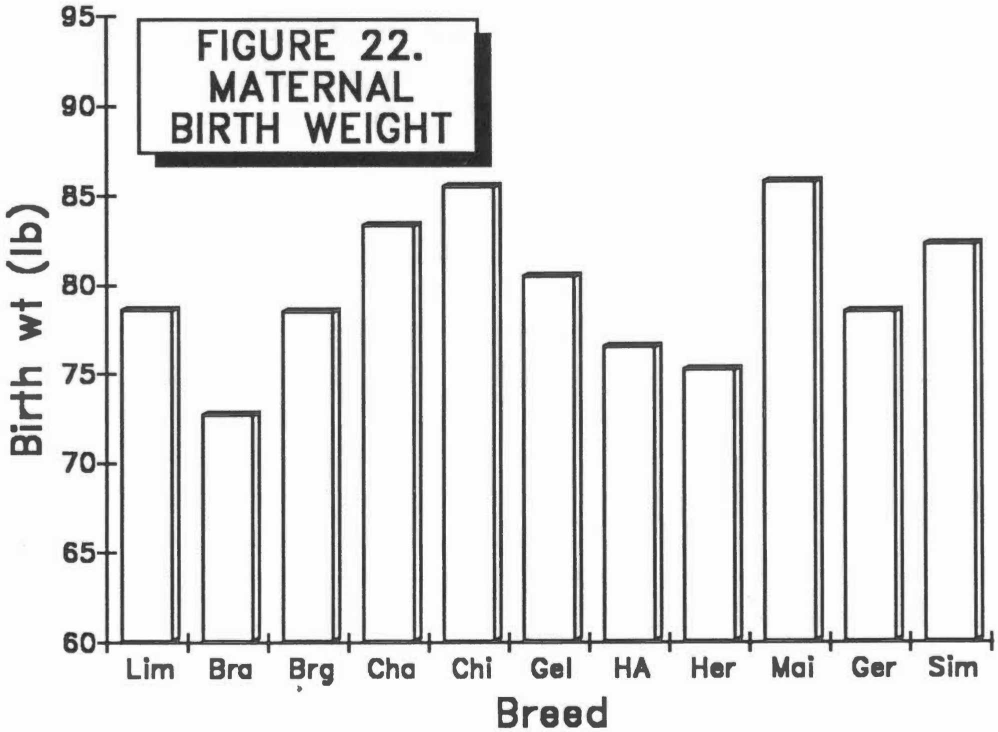
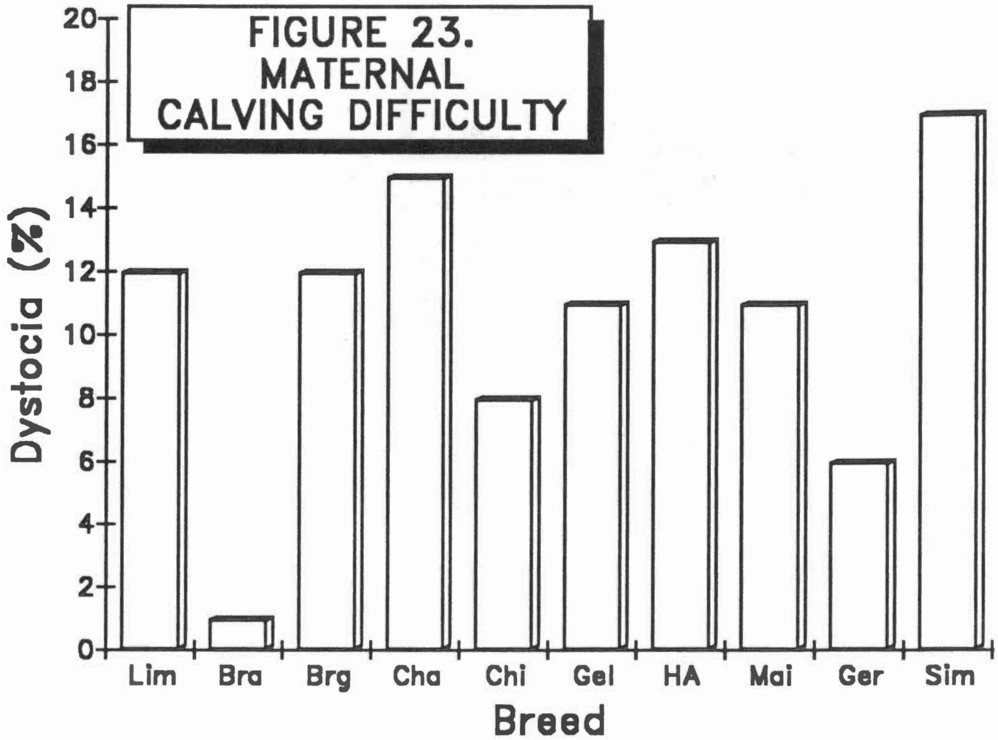


FIGURE 22.
MATERNAL
BIRTH WEIGHT
Birth wt (lb)
95
90
85
80
75
70
65
60
Lim
Bra
Brg
Cha
Chi
Gel
HA
Her
Mai
Ger
Sim
Breed



Brahman, Chianina or Santa Gertrudis crossbred cows. Relatively small differences between breeds were observed in mortality of calves out of crossbred cows (Figure 24, Appendix Table 24). Limousin crossbred cows were about average for this characteristic.

Milk Production and Weaning Weight. Milk production provides another opportunity for improvement in the Limousin breed, if the breed is to become widely accepted for use in the crossbred cow herd. Average milk production was similar to the Charolais, slightly lower than the Chianina, Hereford-Angus and Maine Anjou and was substantially lower than Brahman, Gelbvieh and Simmental (Figure 25, Appendix Table 25). Of course, maximum milk production is not necessarily optimum, but some increase would be desirable.

The moderate size of the Limousin, coupled with the fairly low level of milk production resulted in calves from Limousin crossbred cows that were larger at weaning than those from Hereford and Angus, similar in size to calves from Brangus and Charolais crossbred cows and somewhat smaller than calves from Brahman, Chianina, Gelbvieh, Maine Anjou and Simmental crossbred cows (Figure 26, Appendix Table 26).

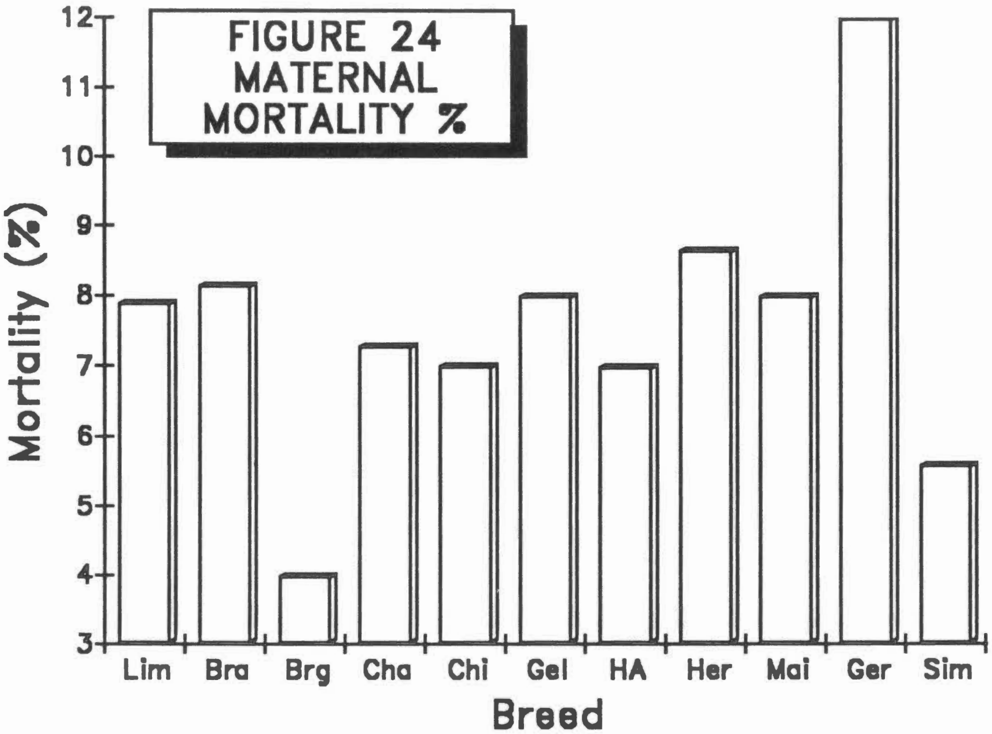


FIGURE 24
MATERNAL
MORTALITY %
Mortality (%)
12
11
10
9
8
7
6
5
4
3
Lim
Bra
Brg
Cha
Chi
Gel
HA
Her
Mai
Ger
Sim
Breed

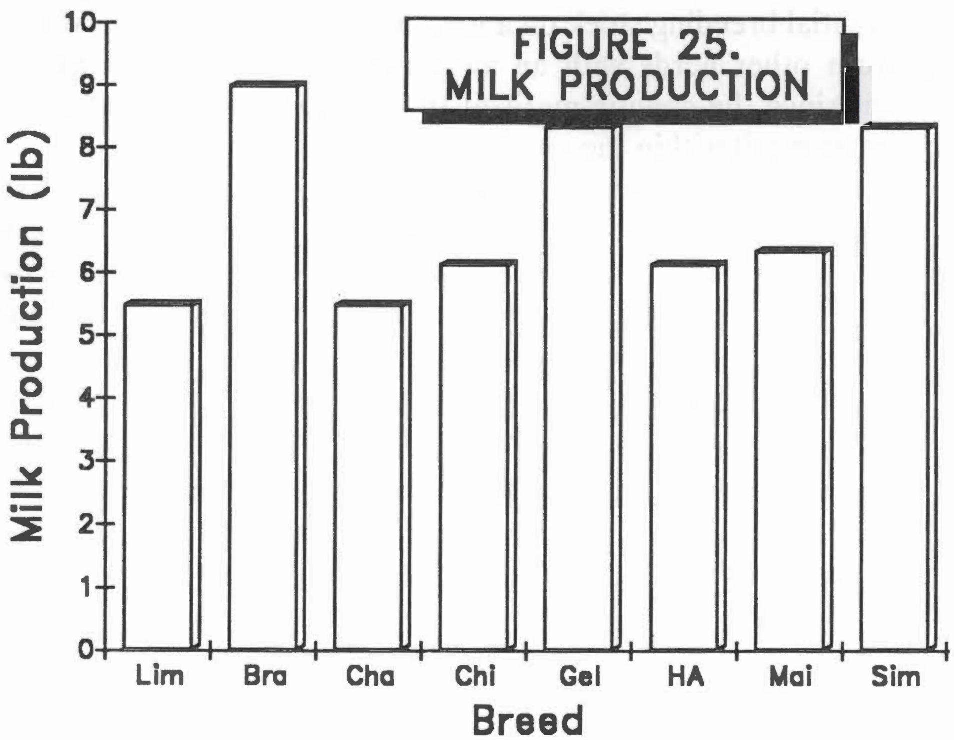
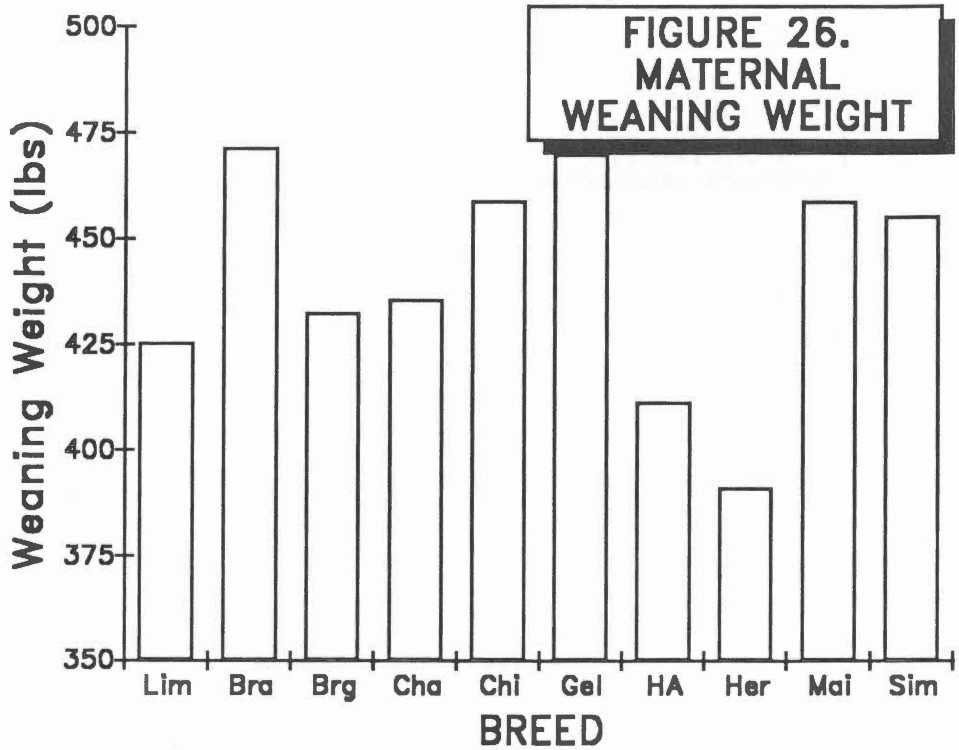


FIGURE 25.
MILK PRODUCTION
Milk Production (lb)
10
9
8
7
6
5
4
3
2
1
0
Lim
Bra
Cha
Chi
Gel
HA
Mai
Sim
Breed



Genetic Change in the Limousin Breed

The advent of National Cattle Evaluation makes it possible to evaluate potential breeding stock on a national basis. Purebred producers can use bulls from other herds with an awareness of the potential for genetic improvement since the genetic merit of those bulls can be compared to the average genetic merit within the producer's own herd.

An evaluation of the breeding values also permits an evaluation of the genetic change that has occurred in the breed. Average breeding values for cattle born in the years 1971 to 1986 was provided by Dr. Larry Benyshek, University of Georgia, and the North American Limousin Foundation. Results are summarized in Figure 27.

The average genetic merit for weaning weight and yearling weight increased rapidly from 1971 through 1977. There was little change in these two traits until 1984 when both began to increase again. Average genetic merit for birth weight has remained fairly constant throughout the existence of the Limousin breed in North America. This reflects the interest among Limousin breeders in maintaining the easy calving of the breed while increasing weight gain after birth. Average genetic merit for milk level has decrease slightly since 1973. There is some evidence of an increase since 1984. Accurate estimates for genetic milk level were not available for any breed until the use of the Reduced Animal Model became available in 1984.

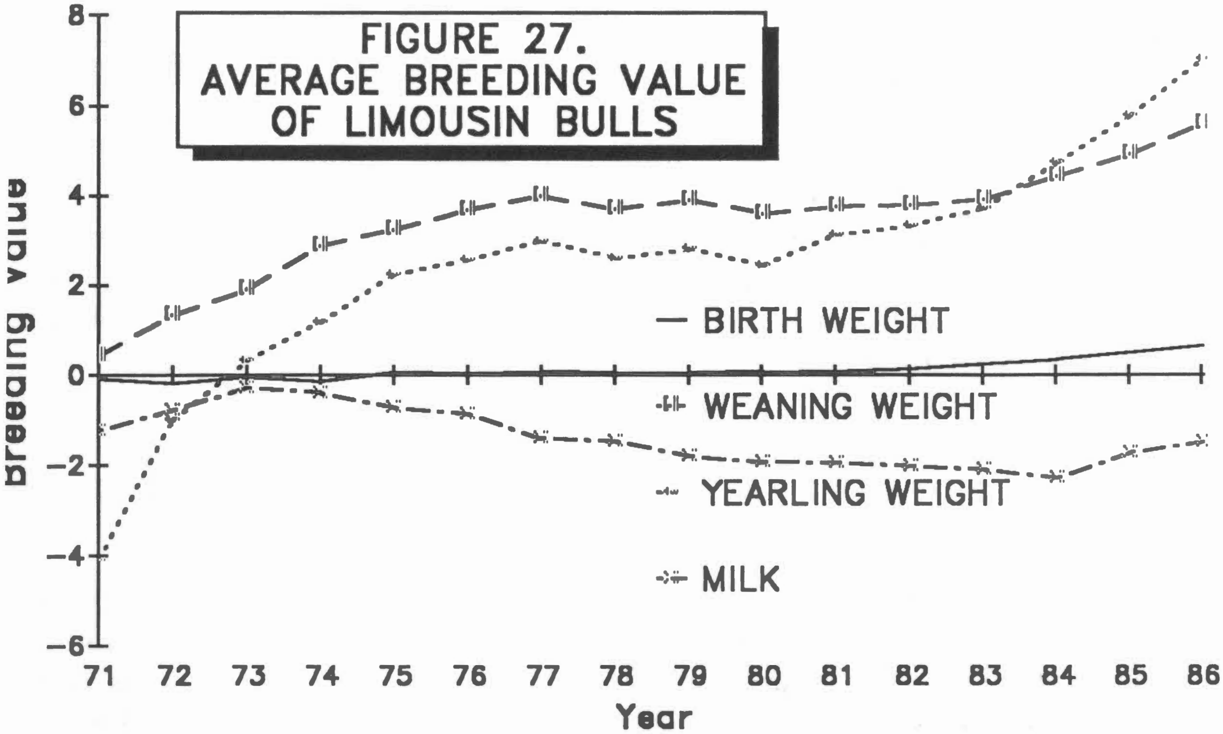
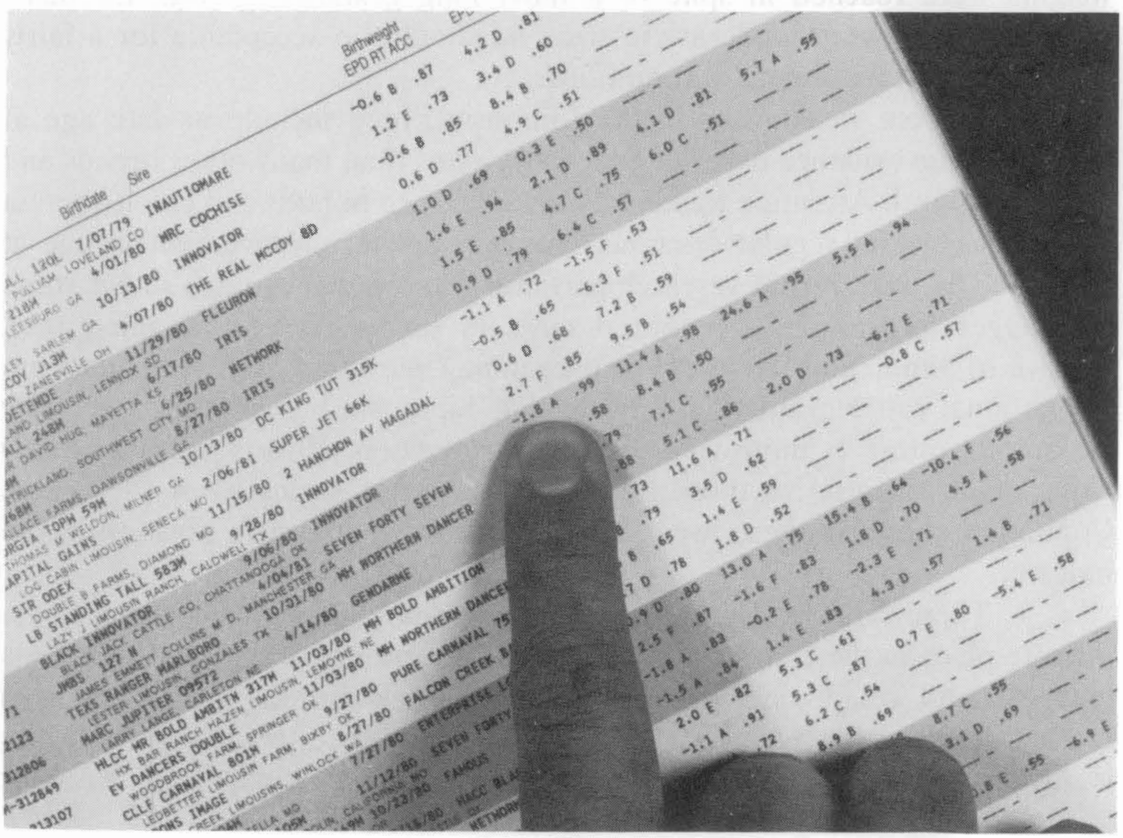


FIGURE 27. AVERAGE BREEDING VALUE OF LIMOUSIN BULLS



The increase in genetic milk level after 1984 may have resulted from use of this information.

Distributions of sire's EPD values published in the annual sire summary of the Limousin breed, as well as several other breeds of beef cattle, reveal that there is considerable genetic uniformity within the Limousin breed. This has some advantage as well as some disadvantage. The uniformity should enable the commercial producer to buy Limousin bulls with the anticipation that the calves from various bulls will perform in a consistent manner. On the other hand, genetic uniformity means that less selection intensity can be used to make rapid improvements in the breed.

Summary and Conclusions

There has been sufficient research on the Limousin breed to characterize its strengths and weaknesses for the North American cattle producer. The primary strength of the breed is its superior leanness and muscling, dressing percent and retail yield. The Limousin is superior to almost all other breeds in these characteristics. In addition, the Limousin couples a moderate to rapid growth rate with small birth weight, low calving difficulty and good livability, especially for a breed that has been traditionally thought of as a terminal sire in a crossbreeding program. These low birth weights were reached in spite of a fairly long gestation period. Limousin crossbred cows were moderate in size and should be acceptable for a fairly wide range of environmental conditions.

Current weaknesses in the Limousin breed include its late age at puberty, some evidence of lower pregnancy rates than many other breeds and a low milk level. Attention to scrotal circumference in bulls and care to retain cows that calve at regular intervals should result in improvement in age at puberty. The most recent research pertaining to pregnancy rates shows some advantages for Limousin purebred cows in pregnancy and weaning rate, relative to Simmental, Hereford and Brahman purebred cows. Results from the national cattle evaluation indicate that Limousin breeders are currently making an effort at improving the milk production. Efforts are apparently being made to improve those traits which are not strengths of the breed. Continued efforts in these areas should improve the breed's position in the industry.

These relative strengths and weaknesses suggest a breed that has a definite place in the commercial industry as a terminal sire. Superior carcass leanness and retail yield are important characteristics, particularly as a market develops for "lean" or "lite" beef. The moderate to rapid growth rate is advantageous as good feedlot performance should be expected. Another important consideration when choosing a terminal sire breed is the effect that the breed of sire will have on calving conditions in the cow herd. The evidence suggests that Limousin sired calves should cause less calving difficulty than most other breeds that are commonly recommended as terminal sires.

Recommendation of the Limousin as a component of a crossbred cow herd will depend upon the management conditions of the herd and further improvement in Limousin cattle for reproductive and maternal characteristics. Apparent efforts among breeders of Limousin cattle to improve these traits is encouraging. Moderate size and relatively easy calving suggest a place in a rotational crossbreeding program with other breeds of similar size. Producers that use Limousin crossbred cows should be prepared to manage heifers to reach sexual maturity as quickly as possible. However, with proper care in choosing sires of replacement heifers and appropriate management of those females, the Limousin breed should have a place as a component of a crossbred cow herd.

The North American Limousin Foundation is to be commended for its efforts in developing a clearer understanding the breed and in making appropriate improvements. Cooperation with several universities in genetic evaluation and research pertaining to meat palatability, cholesterol content, muscling's influence on retail yield and the relationship between scrotal circumference and female reproductive performance should yield results which Limousin breeders can use to improve the breed.

The Limousin Sire Summary is an excellent example of the North American Limousin Foundation's efforts to make up-to-date genetic information available to cattle producers. Expected Progeny Differences (EPD) on individuals (bulls and cows) not in the Sire Summary are also available on request from the NALF. The Foundation also made Interim EPD's available in 1988 for young animals that did not have individual performance information recorded at the time the yearly EPD analysis was conducted. As soon as individual performance information is recorded with NALF an Interim EPD is calculated using that performance information along with the pedigree values. These techniques allow breeders of Limousin cattle the opportunity to make genetic evaluations of their cattle in a most timely manner.

Limousin breeders are encouraged to use the available information in the Sire Summary to make additional improvement in genetic merit for milk production. Strong efforts should be made to improve reproductive development and performance, not only for the commercial producers that wish to use the Limousin in their cow herds, but also to improve reproductive efficiency in purebred Limousin herds. These improvements should be made with a watchful eye toward those traits for which the Limousin already excels. The superiority in leanness is particularly important in these times of concern over fat in the human diet. This single characteristic probability assures the Limousin breed a place in the future array of breeds used in North America. Improvements in reproductive and maternal performance will enable the breed to increase the size of its place in the beef cattle industry.

Appendix Summary 1. Description of Experiments Summarized in this Review.

Alabama

Patterson et al 1984

A study at Black Belt Substation, Marion Junction, Alabama using Hereford, Hereford x Angus, Charolais x Hereford and Charolais x (Hereford x Angus) cows artificially inseminated to Hereford and Limousin bulls to produce 220 calves from 1973 to 1977. Hereford bulls were used as cleanup. Two systems were used to grow steers to slaughter weight. System I: steers placed directly in feedlot at weaning and full fed 30% roughage/70% concentrate for an average of 191 days. System II: steers remained on permanent pasture of dahlisgrass after weaning for an average of 117 days. They were supplemented with hay, corn, and cotton seed meal when necessary. When winter pasture became available, steers were transferred to winter annual pasture of wheat and ryegrass mixture for an average of 114 days. Next, steers were placed in a feedlot for an average of 75 days and fed the same ration as system I. Finished steers were slaughtered from both systems and data obtained on carcass weight, ribeye area, fat thickness, kidney fat, and USDA quality and yield grades.

California

Adams et al 1973

A study at the University of California, Davis used calves produced from Hereford cows and Simmental, Limousin, Maine-Anjou, Lincoln Red, Brown Swiss, Charolais, Angus and Hereford bulls. Ten steer calves of each crossbred group were obtained for evaluation of feedlot performance. The steers received a 30 mg implant of DES and all groups were on feed 132 days before slaughtering started and were slaughtered at a commercial plant when an anticipated low choice grade had been attained.

Canada

Fredeen et al 1974

Reproductive performance of hybrid heifers produced by mating Charolais, Limousin, and Simmental bulls with Angus, Hereford, and Shorthorn cows was evaluated. The resulting nine F1 crosses were: Charolais x Hereford, Limousin x Hereford, Simmental x Hereford, Charolais x Angus, Limousin x Angus, Simmental x Angus, Charolais x Shorthorn, Limousin x Shorthorn, Simmental x Shorthorn. In addition, Hereford x Angus heifers were used. At the age of 14 months the heifers were allocated at random to two contrasting environments for maintenance and evaluation of reproductive performance through at least five calf crops. The environments were the semi-arid, shortgrass rangeland of Southeastern Alberta (Manyberries) and the semi-intensive cultivated pasture management characteristic of Southwestern Manitoba (Brandon). The heifers produced their first calves in 1972, 1973 and 1974. Summaries for breeding, conception, and calf performance to weaning for 1972 and 1973 first-calf production from 1000 heifers at both locations are given. Heifers were bred to Beefmaster and Red Angus bulls.

Rahnefeld et al 1977

Seven Hundred Eighty Eight calves from F1 (first parturition) heifers (Fredeen et al 1974) were evaluated for postweaning growth and carcass traits. At weaning the calves were moved into a feedlot and brought to full feed in about four weeks. The calves remained on feed for 140 days. No hormone treatments were administered. Slaughter was chiefly determined by weight and degree of finish. Average daily gain for the first 140 days, dressing percentage, ribeye area and average fat thickness over the ribeye were measured.

Blakely et al 1978

The effect of breed of sire on beef production and carcass characteristics on 222 males calves born from 1970 to 1974 in nine separate trials was evaluated. The trials included several housing and management systems and feeding regimes, depending on space and feedstuff availability. Nine breeds of sires were used including: British (Angus, Hereford and Shorthorn combined), Charolais, Chianina, Limousin and Maine-Anjou. Each animal was slaughtered when an average of .4" of fat cover at points 1/4, 1/2 and 3/4 of the distance along the longitudinal axis of the longissimus cross section at the 11th-12th rib junction had accumulated as measured by ultrasound. Average daily gain, dressing percent and carcass composition were measured.

Fredeen et al 1979

Postweaning growth and carcass traits of 2092 calves (second and subsequent parturitions) born from 1973 to 1976 to the 1150 F1 cows (Fredeen et al 1974) for . These calves were by Charolais, Simmental, Limousin and Chianina sires with the mating plan designed to produce 3-way crosses only.

Lawson et al 1980

Performance of two year old cows and their calves in two environments (Fredeen et al 1974) was evaluated. This study included the first calf crop from 1150 hybrid females. The heifers were all bred to either Red Angus or Beefmaster bulls as yearlings.

Fredeen et al 1981

A study was conducted from 1972-1978 comparing lifetime (all parturitions) reproductive performance of 1150 F1 cows under two contrasting environments (Fredeen et al 1974).

Fredeen et al 1982a

Calving ease and calf mortality for 4034 calves from second and later parturitions produced from ten F1 cross females (Fredeen et al 1974) bred to Charolais, Chianina, Simmental and Limousin bulls were evaluated. Data for this study accrued during the course of an experiment to evaluate the lifetime performance of breeding females under two contrasting environments (Fredeen et al 1974).

Fredeen et al 1982b

Environmental and genetic effects on pre-weaning growth traits were evaluated for 4034 calves born and 3732 calves weaned. (Same calves as Fredeen et al 1982a)

Rahnefeld et al 1983a

Breed of sire and breed of dam of cow effects on carcass characteristics of 3673 steers and heifers produced by 1150 F1 females from 1973-1978 were evaluated.

Rahnefeld et al 1983b

Breed of terminal sire effects on carcass characteristics of 3673 steers and heifers born to 1150 F1 females was evaluated. Both sexes were fed identical rations and no hormones or growth stimulants were administered.

Newman et al 1985

Calving and pre-weaning data from contracted herds of Hereford, Angus or Shorthorn breeding producing Charolais, Simmental and Limousin sired calves were studied. A total of 3939 calves were born from 48 herds during 1970-1972. No attempt was made to standardize or change management practices of participating herds except that A.I. and seasonal calving were obligatory.

Clay Center, Nebraska

This series of studies was part of the long term Germ Plasm Evaluation Project in which over 20 breeds of beef cattle have been evaluated. The project is divided into cycles of breeds. The Limousin breed was evaluated in Cycle I.

Laster et al 1972

Age and weight at puberty and conception rate of 337 heifers from cycle I were studied.

Laster and Gregory 1973

Parturitions from cycle I, Brown Swiss, Red Poll, (Charolais x Hereford) x Charolais, (Charolais x Angus) x Charolais, Hereford, Angus, Hereford x Angus and Angus x Hereford produced a total of 5064 calves from 1967 to 1972. The effects of dystocia, breeding group, cow age and calf sex on pre- and early post-natal mortality were studied.

Laster et al 1973

Calving and subsequent breeding information was obtained on 1889 Hereford and Angus cows from 1967 to 1970. Cows calved first at two years of age. Genotypes of calves born in 1967 were: Hereford x Angus and Angus x Hereford; in 1968 and 1969: Hereford, Angus, Hereford x Angus and Angus x Hereford; in 1970: {Hereford, Angus, Jersey, South Devon, Limousin, Simmental and Charolais} x {Hereford and Angus}.

Koch et al 1976

Composition and quality characteristics of 1121 steer carcasses from cycle I were recorded.

Laster et al 1976

Post-weaning growth and puberty traits in 945 female calves produced in cycle I were evaluated.

Smith et al 1976

Gestation length, birth weight, dystocia %, calf mortality, pre-weaning growth and 200 day weight on 2368 calves from cycle I were studied.

Smith 1976

Economic efficiency of the terminal cross production system in cycle I was evaluated. Consideration was given to level of calving difficulty, pre-weaning survival, growth rate, feed efficiency, carcass composition and quality grade.

Koch and Dikeman 1977

Wholesale cut composition of 1121 steer carcasses from cycle I was analyzed.

Notter et al 1978a

Birth weight, gestation length, dystocia % and mortality in 653 2-year-old and 622 subsequent 3- year-old calvings were studied. The dams were the heifer calves from cycle I. Yearling heifers were bred to Hereford, Angus, Brahman, Holstein and Devon bulls and calved as 2-year-olds in 1972, 1973 and 1974. Two-year-old cows were bred to Hereford, Angus, Maine Anjou, Chianina and Gelbvieh bulls and calved as 3 year olds in 1973, 1974 and 1975.

Cundiff et al 1986

A summary of cycles I, II and III from the Cattle Germ Plasm Evaluation at the U.S. Meat Animal Research Center (MARC) was given.

The Cattle Germ Plasm Evaluation Program was conducted in three cycles. Cycle I involved breeding Hereford, Angus, Jersey, South Devon, Limousin, Simmental and Charolais bulls by AI to Hereford and Angus cows to produce three calf crops in the spring of 1970, 1971 and 1972.

Cycle II, initiated with the 1972 breeding season, involved the Hereford and Angus cows used in the first cycle. These cows were bred by AI to Hereford, Angus, Red Poll, Brown Swiss, Gelbvieh, Maine Anjou and Chianina sires to produce two calf crops in the spring of 1973 and 1974. In addition, in cycle II, Red poll and Brown Swiss cows were added to the program and mated to Hereford, Angus, Red Poll and Brown Swiss sires.

Cycle III was initiated during the 1974 breeding season. In cycle III, the Hereford and Angus cows used to initiate Cycles I and II were mated by AI to Hereford, Angus, Brahman, Sahiwal, Pinzgauer and

Tarentaise sires to produce two calf crops in the spring of 1975 and 1976.

Florida

Crocket et al 1979, 1981

A study at the University of Florida from 1972-1976 mated Angus, Brangus and Hereford dams to Brahman, Brangus, Limousin, Maine Anjou, Beefmaster and Simmental sires. Only one sire per breed was used each year except for Beefmaster (used for cleanup). A total of 755 pre-weaning observations and 207 for feedlot and carcass observations were recorded. Feedlot and carcass data came from steers representing the 1973 and 1976 calf crops.

Georgia

Comerford et al 1987a, b and c

A study at Wilkins unit, University of Georgia Experiment Station from 1978-1982 produced 699 calves. The study began in 1977 with approximately 50 yearling heifers each of the Simmental, Limousin, Polled Hereford, and Brahman breeds. A total of 106 sires were used. Females of each breed were randomly allotted to breeding groups of approximately 25 head. Single-sire groups in eight separate breeding pastures were maintained each year to insure sire identification; bulls were replaced every year. Traits studied included: birth weight, calving ease, 24-hour survival, growth, hip height, pelvic size, feedlot, weaning weight and carcass traits. Cattle were slaughtered at a mean age of 445 days.

Illinois

Vanderwert et al 1985

A study was conducted at the University of Illinois using 29 head each of Limousin and Angus weanling bull calves. Five bulls of each breed were randomly assigned to an initial slaughter group. The remaining 24 head of each breed were allotted to implant (zeranol vs. control) and male status (bull vs. steer) treatments. Initial implantation with 36 mg of zeranol was done on day 1. Zeranol treated cattle were reimplanted at approximately 70 day intervals. All cattle were fed an 83% concentrate and 17% ground corn cob diet. A fat thickness of .76 cm was selected as an experimental end point.

Kansas

Dikeman and Crouse 1975

A study was conducted at Kansas State University mating Hereford, Simmental and Limousin bulls to Angus cows to produce nine steers of each breed cross. After weaning, the steers were fed a 71% TDN ration. They were slaughtered in three equal groups after an average of 200, 242 and 284 days of feed. Detailed carcass data were given as well as taste panel results.

May 1976

A study at Kansas State University utilized 12 Simmental X Aberdeen-Angus (AA), 12 Hereford X AA, and 12 Limousin X AA steers. Four steers per crossbred group were slaughtered 200, 242, and 284 days after weaning. Detailed carcass data were reported.

Louisiana

Loyacano et al 1974

In a study at Louisiana State University, Hereford, Brahman, Simmental, Limousin and Maine Anjou bulls were mated to Hereford dams to produce 24, 18, 11, 13 and six calves of each breed group respectively. The calves were weighed, wormed and put on wheat-ryegrass pasture for 150 days from December to May. They were wormed again coming off of the pasture into drylot where they remained for 140 days (October). At this time they were weighed and trucked to Shreveport where they were slaughtered at a commercial slaughtering house the following morning. Hot carcass weight, conformation grade, overall grade, fat thickness measurement and ribeye area measurement were obtained. Yield grade was calculated.

Knox et al 1982

A study was conducted at Louisiana State University mating Brahman, Limousin, Maine Anjou and Simmental bulls to Hereford cows via A.I. Hereford bulls were used as cleanup sires. A total of 233 calves were born during three fall calving seasons from 1971 to 1973. Calves were not given growth stimulants. They were turned on to sorghum-sudangrass pastures, then on to Coastal bermudagrass pastures. Animals were not fed supplemental protein or grain.
Phase II: The heifers produced in phase I were bred to Angus bulls during a 4-year period. They were handled similar to phase I females.

Mississippi

Chapman et al 1978

The study was cpmdicted at Mississippi State University from 1971-1974. Angus cows were mated artificially to Limousin or Simmental bulls and Hereford cows were artificially mated to Angus, Limousin or Simmental bulls. Two bulls per breed were used each year with one being replaced after each year. After four years, 396 cow/calf pairs were available. Production traits were analyzed.

Oklahoma

Frahm et al 1980

A study carried out at OSU using 1978 calf crop Limousin- and Charolais-sired calves with the same background as those in Dhuyvetter et al, 1985. There were 134 Lim-X and 138 Char-X calves for pre-weaning, weaning and feedlot. Thirty-five (five from each cow breed group) from each breed sire were evaluated for carcass data.

Dhuyvetter et al 1985

Angus, Hereford, Simmental, Brown Swiss, and Jersey bulls were mated to Angus and Hereford cows to produce eight two-breed cross cow groups. These cow groups were then bred to Limousin and Charolais bulls to produce 541 Limousin-X calves and 640 Charolais-X calves from 1978 to 1982. The calves were born and raised at Lake Carl Blackwell Research Range and weaned to the Southwest Livestock and Forage Research station until slaughter. The study included birth, weaning, feedlot and carcass data.

Tinker et al 1986

The same cow herd as in Dhuyvetter et al, 1985 was used, but mated to Limousin and Gelbvieh bulls to produce 411 Limousin-X calves and 366 Gelbvieh-X calves from 1982 to 1985. The study included birth, weaning, feedlot and carcass data.

Pennsylvania

McAllister et al 1976

A study was conducted at Pennsylvania State University using two sires each of Polled Hereford, Charolais, Limousin and Simmental breeds mated to random groups of Angus-Holstein F1 cows. Eight steers of each breed group were used in the study. Growth, quality indicators and fat, lean and bone distribution were evaluated. Slaughter was determined when Polled Hereford steer was at aprox. 476 kg with the heaviest steer of each of the other breeds being slaughtered at the same time. Steers were implanted with 36 mg of DES.

Texas

Adams et al 1977

A study at Texas A&M that reports information on carcass traits and includes results from taste panel evaluations.

Appendix Summary 2. Abbreviation Code for Breeds Used in Tables and Charts.

Abbreviation	Breed
Lim	Limousin
Ang	Angus
Bra	Brahman
Brg	Brangus
Cha	Charolais
Chi	Chianina
Gel	Gelbvieh
HA	Hereford X Angus
Her	Hereford
Mai	Maine Anjou
Ger	Santa Gertrudis
Sim	Simmental

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APPENDIX TABLE 1. Gestation length (days) for crossbred calves.

		BREED									
AUTHOR		LIM	BRA	BRG	CHA	CHI	GEL	HA	MAI	GER	SIM
Cundiff	N	371	349	119	382	238	213	962	222	109	399
et al 1986	X	289.2	291.7	285.5	287	287.5	286.3	284	285.4	286	287.3

APPENDIX TABLE 2. Calving difficulty (%) for crossbred calves.

		BREED											
AUTHOR		LIM	ANG	BRA	BRG	CHA	CHI	GEL	HA	HER	MAI	GER	SIM
Laster	N	702				419			845				914
et al 1973	X	21.3				34.0			23.0				21.5
Laster	N	65	328			42				359			32
et al 1973	X	73.85	27.04			67.48				38.26			65.61
Laster	N	48	115			139				107			66
et al 1973	X	9.78	2.64			19.04				7.05			22.15
Laster	N	35	33			183				47			67
et al 1973	X	8.71	0.02			6.18				2.05			10.21
Dhuyvetter	N	541				640							
et al 1985	X	3.9				13.8							
Cundiff	N	371		349	119	382	238	213	962		222	109	399
et al 1986	X	9.4		10	3.9	18.4	11.8	8.0	2.9		20.4	4.5	14.9

APPENDIX TABLE 3. Birth weight for crossbred calves.

		BREED											
AUTHOR		LIM	ANG	BRA	BRG	CHA	CHI	GEL	HA	HER	MAI	GER	SIM
Laster	N	552				277			651				718
et al 1973	X	77.0				81.4			71.28				83.16
Laster	N	150				142			194				196
et al 1973	X	82.5				88.4			70.4				85.14
Laster	N	65	328			42				359			32
et al 1973	X	73.02	63.38			75.31				66.62			76.27
Laster	N	48	115			139				107			66
et al 1973	X	79.4	68.38			79.82				71.35			83.05
Laster	N	35	33			183				47			67
et al 1973	X	83.6	73.06			85.25				74.4			84.46
Laster	N	161				132			132				157
et al 1976	X	76.34				81.62			71.28				80.52
McAllister	N	8				8				8			8
et al 1976	X	95.04				88.66				84.7			91.74
Chapman	N	159	93										144
et al 1978	X	80.7	74.4										80.96
Crocket	N	123		106	95						123		101
et al 1979	X	72.38		75.24	64.24						74.58		71.94
Fredeen	N	762					763						
et al 1982	X	89.98					100.1						

TABLE 3 continued

Knox	N	44	33						108	26		22
et al 1982	X	75.4	76.5						65.9	78.7		77.9
Patterson	N	62							158			
et al 1984	X	82.9							76.3			
Dhuyvetter	N	541			640							
et al 1985	X	78.8			84.7							
Cundiff	N	371	349	119	382	238	213	962		222	109	399
et al 1986	X	85.58	89.98	80.74	90.42	89.1	85.8	78.54		90.42	85.58	88.66
Tinker	N	411					366					
et al 1986	X	84.9					87.2					
Comerford	N	172	176						172			179
et al 1987	X	74.73	80.28						72.67			78.03

APPENDIX TABLE 4. Total mortality (%).

AUTHOR		BREED LIM	CHA	CHI	SIM
Fredeen	N	144			144
et al 1982	X	5.2			7.4
Fredeen	N	144	144		
et al 1982	X	5.1	9.7		
Fredeen	N	216	216	216	
et al 1982	X	5.1	9.7	8.0	
Fredeen	N	216		216	216
et al 1982	X	5.2		6.5	7.4
Fredeen	N	288		288	
et al 1982	X	5.6		7.1	
Fredeen	N	96	96	96	96
et al 1982	X	2.0	9.2	8.3	4.9

APPENDIX TABLE 5. Weaning weight (lb) for crossbred calves.

AUTHOR		BREED											
		LIM	ANG	BRA	BRG	CHA	CHI	GEL	HA	HER	MAI	GER	SIM
Laster	N	161				132			132				157
et al 1976	X	435.6				468.6			446.6				464.2
McAllister	N	8				8				8			8
et al 1976	X	534.6				519.2				484.6			521.4
Chapman	N	159	93										144
et al 1978	X	471	462										466.4
Crocket	N	123		106	95						123		101
et al 1979	X	444.7		476.7	444.8						479.8		473.2
Fredeen	N	762					763						
et al 1982	X	541.7					477.4						
Knox	N	44		33						108	26		22
et al 1982	X	451		470.4						411.5	484.8		473.1
Patterson	N	62								158			
et al 1984	X	568.4								556.2			
Dhuyvetter	N	541				640							
et al 1985	X	489				509							
Cundiff	N	371		349	119	382	238	213	962		222	109	399
et al 1986	X	435.6		455.4	435.6	457.6	455.4	459.8	429.0		453.2	440.0	451.0
Cundiff	N	161		103	63	132	92	81	322		89	41	157
et al 1986	X	422.4		448.8	424.6	446.6	442.2	435.6	418.0		440.0	433.4	440. 0
Tinker	N	411						366					
et al 1986	X	531						557.5					
Comerford	N	153		150						156			158
et al 1987	X	489.5		505.78						487.08			512.38

APPENDIX TABLE 6. Yearling weight (lb) of crossbred calves.

		BREED						
AUTHOR		LIM	BRA	CHA	GEL	HER	MAI	SIM
Knox	N	44	33			108	26	22
et al 1982	X	532	593.1			497.9	542.9	552.5
Dhuyvetter	N	541		640				
et al 1985	X	899		942				
Tinker	N	217			192			
et al 1986	X	960			985			
Comerford	N	151	146			156		155
et al 1987	X	895.2	826.1			869.4		857.6

APPENDIX TABLE 7. Average daily gain on test (lb/day) of crossbred calves.

		BREED											
AUTHOR		LIM	ANG	BRA	BRG	CHA	CHI	GEL	HA	HER	MAI	GER	SIM
Adams	N	10	10			10				10	10		10
et al 1973	X	2.75	2.77			2.64				2.68	3.23		3.15
Loyacana	N	13		18						24	6		11
et al 1974	X	1.66		1.48						1.48	1.83	1.56	
Dikeman and	N	9								9			9
Crouse 1975	X	2.62								2.55			2.79
Rahnefeld	N	215				196							265
et al 1977	X	2.49				2.62							2.62
Blakely	N	5				18	9				9		
et al 1978	X	.176				.374	.154				.220		
Crocket	N	34		106	36						32		36
et al 1979	X	2.79		2.84	2.53						2.99		2.75
Frahm	N	64				79							
et al 1980	X	2.46				2.46							
Frahm	N	70				59							
et al 1980	X	2.1				2.28							
Fredeen	N	762					763						
et al 1982	X	1.88					1.93						
Dhuyvetter	N	541				640							
et al 1985	X	2.33				2.46							
Vanderwert	N	29	29										
et al 1985	X	2.71	3.01										

TABLE 7 continued

Cundiff et al 1986	N X	173 2.32	153 2.4	52 2.34	176 2.67	119 2.49	111 2.56	508 2.4		109 2.65	62 2.51	176 2.69
Tinker et al 1986	N X	217 2.84					192 2.83					
Comerford et al 1987	N X	149 2.22	145 2.13						156 2.33			154 2.35

APPENDIX TABLE 8. Feed efficiency (pounds of feed/pound of gain).

		BREED								
AUTHOR		LIM	ANG	BRA	BRG	CHA	GEL	HER	MAI	SIM
Adams et al 1973	N X	10 6.97	10 6.76			10 7.02		10 7.43	10 6.01	10 6.91
Crocket et al 1979	N X	34 6.55		106 6.95	36 6.99				32 6.44	36 7.01
Frahm et al 1980	N X	70 7.68				59 7.95				
Frahm et al 1980	N X	64 7.03				79 7.55				
Dhuyvetter et al 1985	N X	541 7.83				640 7.88				
Vanderwert et al 1985	N X	29 6.94	29 6.40							
Tinker et al 1986	N X	217 7.08					192 6.9			

APPENDIX TABLE 9. Hot carcass weight as a % of live weight for crossbred calves.

		BREED									
AUTHOR		LIM	ANG	BRA	CHA	CHI	GEL	HER	HA	MAI	SIM
Adams	N	10	10		10			10		10	10
et al 1973	$\bar{X}$	62.1	61.1		61.2			62.3		60.7	60.9
Loyacana	N	13		18				24		6	11
et al 1974	$\bar{X}$	65.1		64.5				63.5		63.7	62.5
Koch	N	58	28		56			23	70		57
et al 1976	$\bar{X}$	63.7	63.0		63.3			62.2	62.6		62.4
Koch	N	58	28		61			24	71		61
et al 1976	$\bar{X}$	64.6	64.1		63.6			63.0	63.7		63.1
Koch	N	58	29		60			22	69		59
et al 1976	$\bar{X}$	64.2	64.3		64.0			62.8	64.3		63.2
Rahnefeld	N	215			196						265
et al 1977	$\bar{X}$	60.2			60.6						59.5
Fredeen	N	305			300	317					215
et al 1979	$\bar{X}$	61.75			60.68	61.61					60.36
Fredeen	N	217			215	223					215
et al 1979	$\bar{X}$	60.68			59.90	60.74					59.0
Frahm	N	64			79						
et al 1980	$\bar{X}$	64.8			63.9						
Frahm	N	70			59						
et al 1980	$\bar{X}$	64.9			64.5						
Rahnefeld	N	1617			941	869					801
et al 1983	$\bar{X}$	60.80			59.64	60.62					59.17

TABLE 9 continued

Dhuyvetter et al 1985	N 541 X 64.6			640 63.9			
Vanderwert et al 1985	N 29 X 64.6	29 60.2					
Tinker et al 1986	N 217 X 62.9				192 62.1		
Comerford et al 1987	N 149 X 63.1		141 61.8			156 61.6	152 61.3

APPENDIX TABLE 10. Ribeye area (in^2) in carcasses from crossbred calves.

AUTHOR		LIM	ANG	BRA	BRG	CHA	CHI	GEL	HER	MAI	SIM
Adams	N	10	10			10			10	10	10
et al 1973	$\bar{X}$	12.8	11.1			11.7			11.01	12.0	12.87
Loyacana	N	13		18					24	6	11
et al 1974	$\bar{X}$	12.4		11.2					10.5	13.0	11.6
May 1976	N	12							12		12
	$\bar{X}$	13.2							11.3		11.51
McAllister	N	8				8			8		8
et al 1976	$\bar{X}$	13.66				14.2			11.22		12.59
Rahnefeld	N	215				196					265
et al 1977	$\bar{X}$	10.9				10.9					10.9
Crocket	N	34		106	36					32	36
et al 1979	$\bar{X}$	12.71		11.63	10.54					12.87	12.09
Fredeen	N	305				300	317				300
et al 1979	$\bar{X}$	12.25				12.28	12.6				11.97
Fredeen	N	217				215	223				215
et al 1979	$\bar{X}$	12.04				11.93	12.12				11.63
Frahm	N	64				79					
et al 1980	$\bar{X}$	13.7				13.2					
Frahm	N	70				59					
et al 1980	$\bar{X}$	12.7				13.3					
Rahnefeld	N	1617				941	869				801
et al 1983	$\bar{X}$	12.1				11.9	12.3				11.6

TABLE 10 continued

Dhuyvetter	N	541			640			
et al 1985	X	13.1			13.1			
Vanderwert	N	29	29					
et al 1985	X	16.69	11.63					
Tinker	N	217				192		
et al 1986	X	14.0				13.9		
Comerford	N	149		141			156	152
et al 1987	X	13.04		11.25			11.55	12.9

APPENDIX TABLE 11. Fat thickness (in) in carcasses from crossbred calves.

		BREED											
AUTHOR		LIM	ANG	BRA	BRG	CHA	CHI	GEL	HA	HER	MAI	GER	SIM
Adams	N	10	10			10				10	10		10
et al 1973	X	.31	.55			.30				.579	.339		.402
Loyacana	N	13		18						24	6		11
et al 1974	X	.330		.490						.510	.470		.340
McAllister	N	8				8				8			8
et al 1976	X	.280				.276				.413			.228
Koch	N	58	28			56			70	23			57
et al 1976	X	.33	.570			.340			.530	.417			.346
Koch	N	58	28			61			71	24			61
et al 1976	X	.410	.650			.390			.660	.559			.398
Koch	N	58	29			60			69	22			59
et al 1976	X	.480	.740			.460			.750	.575			.472
Rahnefeld	N	215				196							265
et al 1977	X	.559				.579							.579
Fredeen	N	305				300	317						300
et al 1979	X	.610				.583	.567						.618
Fredeen	N	217				215	223						215
et al 1979	X	.437				.406	.402						.417
Frahm	N	64				79							
et al 1980	X	.36				.38							
Frahm	N	70				59							
et al 1980	X	.43				.39							

TABLE 11 continued

Rahnefeld	N	1617				941	869						801
et al 1983	X	.549				.536	.504						.528
Patterson	N	29								53			
et al 1984	X	.45								.57			
Dhuyvetter	N	541				640							
et al 1985	X	.660				.620							
Vanderwert	N	29	29										
et al 1985	X	.264	.343										
Cundiff	N	177		128	52	177	112	108	472		109	62	175
et al 1986	X	.409		.559	.567	.382	.319	.370	.642		.370	.598	.390
Tinker	N	217						192					
et al 1986	X	.500						.450					
Comerford	N	149		141						156			152
et al 1987	X	.307		.398						.465			.287

APPENDIX TABLE 12. Taste panel tenderness* in meat from crossbred calves.

AUTHOR		LIM	ANG	CHA	HER	MAI	SIM
		BREED					
Adams	N	10	10	10	10	10	10
et al 1973	X	6.3	6.4	5.9	6.8	6.5	6.7
Dikeman and	N	9			9		9
Crouse 1975	X	6.88			7.56		7.31
May 1976	N	12			12		12
	X	7.0			7.48		7.16
McAllister	N	8		8	8		8
et al 1976	X	5.3		5.9	6.0		5.7

*NOTE: 1 = highly unacceptable and 9 = highly acceptable.

APPENDIX TABLE 13. Taste panel juiciness* in meat from crossbred calves.

AUTHOR		LIM	ANG	CHA	HER	MAI	SIM
		BREED					
Adams	N	10	10	10	10	10	10
et al 1973	X	5.2	5.7	4.9	6.1	5.8	6.4
Dikeman and	N	9			9		9
Crouse 1975	X	6.79			7.24		7.49
May 1976	N	12			12		12
	X	6.83			7.2		7.4
McAllister	N	8		8	8		8
et al 1976	X	5.4		6.0	6.2		6.1

*NOTE: 1 = highly unacceptable and 9 = highly acceptable.

APPENDIX TABLE 14. Taste panel flavor* in meat from crossbred calves.

		BREED					
AUTHOR		LIM	ANG	CHA	HER	MAI	SIM
Adams	N	10	10	10	10	10	10
et al 1973	X	6.3	6.1	5.9	6.2	6.4	6.4
Dikeman and	N	9			9		9
Crouse 1975	X	7.59			7.46		7.59
May 1976	N	12			12		12
	X	7.62			7.41		7.58
McAllister	N	8		8	8		8
et al 1976	X	6.0		6.2	6.5		6.1

*NOTE: 1 = highly unacceptable and 9 = highly acceptable.

APPENDIX TABLE 15. Total retail product as a percentage of carcass weight* in carcasses of crossbred calves.

AUTHOR		LIM	ANG	BRA	BRG	CHA	CHI	GEL	HA	HER	MAI	GER	SIM
		BREED											
Dikeman and	N	9								9			9
Crouse 1975	X	72.2								65.07			67.32
Koch	N	58	28			56			70	23			57
et al 1976	X	73.8	67.9			71.7			67.3	69.2			71.2
Koch	N	58	28			61			71	24			61
et al 1976	X	72.1	65.4			71.5			65.6	68.1			70.1
Koch	N	58	29			60			69	22			59
et al 1976	X	70.4	64.4			69.8			64.2	65.5			68.9
Cundiff	N	177		128	52	177	112	108	472		109	62	175
et al 1986	X	72.4		69.4	66.0	71.8	73.0	69.8	66.3		70.2	66.5	71.0

*NOTE: Total retail product = total of roasts, steaks and adjusted lean trim.

APPENDIX TABLE 16. Warner-Bratzler shear strength*in meat from crossbred calves.

AUTHOR		BREED: LIM	ANG	CHA	HER	MAI	SIM
Dikeman and Crouse 1975	N	9			9		9
	X	8.71			6.71		7.986
May 1976	N	12			12		12
	X	8.36			6.732		7.92
McAllister et al 1976	N	8		8	8		8
	X	18.92		19.36	17.82		21.12
Adams et al 1977	N	10	10	10	10	10	10
	X	9.68	7.92	8.14	7.48	8.14	9.02
Frahm et al 1980	N	64		79			
	X	13.2		13.9			

*NOTE: Adams, Dikeman and May used 1/2" cores whereas Frahm and McAllister used 1" cores to determine the values listed.

APPENDIX TABLE 17. USDA yield grade for carcasses from crossbred calves.

		BREED							
AUTHOR		LIM	ANG	BRA	BRG	CHA	HER	MAI	SIM
Adams	N	10	10			10	10	10	10
et al 1973	X	2.1	3.12			2.59	3.22	2.52	2.61
Loyacana	N	13		18			24	6	11
et al 1974	X	2.6		3.3			3.2	3.0	2.7
Crocket	N	34		106	36			32	36
et al 1979	X	2.4		3.6	3.4			2.5	2.7
Patterson	N	29					53		
et al 1984	X	2.7					3.1		
Vanderwert	N	29	29						
et al 1985	X	1.18	2.33						
Comerford	N	149		141			156		152
et al 1987	X	2.06		2.68			2.93		2.1

APPENDIX TABLE 18. Age at puberty (days) in crossbred heifers.

		BREED									
AUTHOR		LIM	BRA	BRG	CHA	CHI	GEL	HA	MAI	GER	SIM
Laster	N	161			132			132			157
et al 1976	X	398			398			371			372
Cundiff	N	161	103	63	132	92	81	322	89	41	157
et al 1986	X	384	429	377	384	384	326	357	357	383	358

APPENDIX TABLE 19. Crossbred cow weights.

AUTHOR		LIM	BRA	BRG	CHA	CHI	GEL	HA	MAI	GER	SIM
		BREED									
Lawson et al 1980											
		18 months									
	N	325			291			148			360
	X	793.1			866.9			777			860.2
		24 months (calving)									
	N	218			202			113			266
	X	824.8			900.2			785.4			883.7
		30 months (weaning)									
	N	218			202			113			266
	X	885.1			965.9			850.7			918.9
		mature cows									
Cundiff et al 1986	N	851	519	161	693	475	429	1685	468	111	872
	X	1232	1280	1219	1353	1366	1280	1221	1361	1292	1278

APPENDIX TABLE 20. Pregnancy rate (%) in crossbred cows.

		BREED									
AUTHOR		LIM	BRA	BRG	CHA	CHI	GEL	HA	MAI	GER	SIM
Laster	N	161			132			132			157
et al 1976	X	82.0			80.6			93.0			86.2
Cundiff	N	161	103	63	132	92	81	322	89	41	157
et al 1986	X	76.2	98.2	84.8	74.8	85.6	93.2	87.2	94.2	92.0	80.4

APPENDIX TABLE 21. Gestation length (days) in crossbred cows.

		BREED			
AUTHOR		LIM	CHA	HA	SIM
Notter	N	97	89	97	110
et al 1978	X	285	284	284	284
Notter	N	96	80	86	91
et al 1978	X	286	286	284	286
Lawson	N	252	228		318
et al 1980	X	280.5	281.3		281.6

APPENDIX TABLE 22. Birth weight (lb) for calves from crossbred cows.

AUTHOR		LIM	BRA	BRG	CHA	CHI	GEL	HA	HER	MAI	GER	SIM
		BREED										
Fredeen	N	126			88							160
et al 1974	X	77.8			82.1							81.3
Fredeen	N	84			98							123
et al 1974	X	72.2			76.8							78.3
Notter	N	129			103			97				128
et al 1978	X	68.86			74.58			66.88				72.6
Notter	N	120			105			86				122
et al 1978	X	82.28			86.02			79.42				83.82
Notter	N	105			89			80				116
et al 1978	X	69.3			75.02			66.88				72.38
Notter	N	106			95			77				113
et al 1978	X	82.94			86.02			80.52				83.82
Lawson	N	218			202							266
et al 1980	X	73.33			78.47							78.03
Fredeen	N	710										710
et al 1982	X	91.3										99.22
Fredeen	N	667			667							
et al 1982	X	90.2			97.68							
Knox	N	53	114						106	25		27
et al 1982	X	69.3	71.6						69.3	68.6		73.1
Cundiff	N	851	519	161	693	475	429	1685		468	111	872
et al 1986	X	87.78	82.72	87.78	92.84	94.82	89.76	85.8		95.7	87.78	90.86
Comerford	N	188	184						163			164
et al 1987	X	81.27	65.74						77.7			80.87

APPENDIX TABLE 23. Calving difficulty (%) in crossbred cows.

		BREED									
AUTHOR		LIM	BRA	BRG	CHA	CHI	GEL	HA	MAI	GER	SIM
Notter	N	129			103			97			128
et al 1978	X	37.0			44.0			40.0			46.0
Notter	N	120			105			86			122
et al 1978	X	18.0			29.0			31.0			27.0
Cundiff	N	851	519	161	693	475	429	1685	468	111	872
et al 1986	X	12.0	1.0	12.0	15.0	8.0	11.0	13.0	11.0	6.0	17.0

APPENDIX TABLE 24. Total mortality (%) in calves from crossbred cows.

		BREED										
AUTHOR		LIM	BRA	BRG	CHA	CHI	GEL	HA	HER	MAI	GER	SIM
Notter	N	129			103			97				128
et al 1978	X	20			13			13				8
Notter	N	120			105			86				122
et al 1978	X	11			8			10				8
Fredeen	N	144										144
et al 1982	X	11.2										8.9
Fredeen	N	144			144							
et al 1982	X	6.9			7.1							
Knox	N	56	117						118	25		29
et al 1982	X	7.9	8.0						7.8	2.7		0.3
Cundiff	N	851	519	161	693	475	429	1685		468	111	872
et al 1986	X	7.0	8.0	4.0	8.0	7.0	8.0	7.0		8.0	12.0	6.0

APPENDIX TABLE 25. Milk production (lbs) in crossbred cows.

AUTHOR		BREED: LIM	BRA	CHA	CHI	GEL	HA	MAI	SIM
					12 hours				
Cundiff	N	851	519	693	475	429	1685	468	872
et al 1986	X	5.5	9.02	5.5	6.16	8.36	6.16	6.38	8.36
					24 hours				
Notter	N	10		9			10		10
et al 1978	X	8.36		9.02			9.68		10.34
Notter	N	18		18			18		18
et al 1978	X	5.94		5.94			5.72		8.8

APPENDIX TABLE 26. Weaning weight (lb) in calves from crossbred cows.

AUTHOR		BREED: LIM	BRA	BRG	CHA	CHI	GEL	HA	HER	MAI	SIM
Fredeen	N	126			88						160
et al 1974	X	412.0			413.0						434.0
Fredeen	N	84			98						123
et al 1974	X	384.0			395.0						416.0
Notter	N	105			89			80			116
et al 1978	X	371.8			385.0			360.8			398.2
Notter	N	106			95			77			113
et al 1978	X	305.8			312.4			303.6			332.2
Notter	N	106			95			77			113
et al 1978	X	418.0			424.6			413.6			453.2
Lawson	N	218			202						266
et al 1980	X	401.6			408.1						430.3
Fredeen	N	710									710
et al 1982	X	449.2									489.3
Fredeen	N	667			667						
et al 1982	X	450.8			464.4						
Cundiff	N	851	519	161	693	475	429	1685		468	872
et al 1986	X	484.0	536.8	495.0	501.6	521.4	532.4	473.0		521.4	519.2
Comerford	N	175	161						143		138
et al 1987	X	496.7	524.9						454.3		519.9

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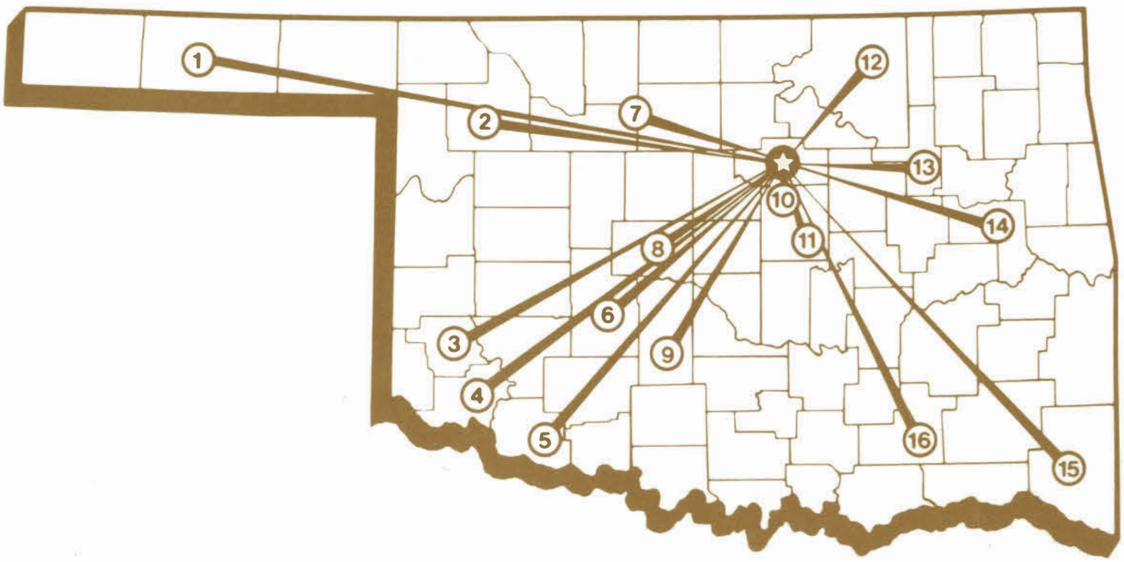

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