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With Sheep, Swine and Beef Cattle

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AGRICULTURAL RESEARCH

OKLAHOMA STATE UNIVERSITY
and USDA

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Summary Reports on Other Projects

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The Experimental Production of Multiple Births in Beef Cows by Hormone Injections

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D. F. Stephens and R. H. Edwards

Story in Brief

The injection of beef cows with a sequence of two subcutaneous doses of PMS (pregnant mare serum), 1500 i.u. on day 4, 5 or 6 and 2000 i.u. on day 16, 17 or 18 resulted in a marked increase in the incidence of multiple births. Of 81 cows so treated, 10 failed to conceive during a 3 months breeding season, while 52 conceived at the first heat following the second PMS injection. These 52 cows produced 29 single and 23 multiple births (12 sets of twins, 8 sets of triplets, 2 sets of quadruplets and 1 set of quintuplets).

Average birth weights were: singles, 83.3 lb.; twins, 63.0 lb.; triplets, 46.2 lb.; quadruplets, 37.5 lb.; and quintuplets, 30.0 lb. Numbers of calves surviving until weaning and adjusted 205 day weaning weights were, respectively: singles, 28 and 462 lb.; twins, 23 and 398 lb.; triplets, 12 and 349 lb.; quadruplets, 3 and 348 lb.; quintuplets, 2 and 316 lb.

Multiple births were not associated with an increased incidence of calving difficulty. Eleven of the 23 cows producing multiples had retained placentas, however, this did not appear to be a factor related to delayed rebreeding. Twenty-five percent of the cows nursing twins were delayed in rebreeding. Five cows nursing twins had failed to settle during the normal 3 months breeding season, but all subsequently settled. Calf crop percentage weaned was 109 percent based on the 81 cows placed in the breeding herd, or 124 percent based on the 71 cows that were wintered.

Introduction

The beef cow is one of the least efficient of all of the meat animals. She is maintained year long to produce only one useful product, her weaner calf, and her production efficiency is measured by the weight and grade of this calf. If she fails to wean a calf, her contribution for that year is nil, and her maintenance costs must be borne by the productive members of the cow herd.

The percent calf crop in the United States is variously estimated to be from 65 to 90 percent annually, with 85 percent suggested as the average for some of the more productive areas of the country. Thus, the average cow herd owner must maintain one hundred cows for every eighty-five calves he weans. However, if he is to maintain this rate of

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production, he normally must add replacement heifers for approximately 20 percent of the cow herd each year. Therefore, he has only sixty-five marketable calves per one hundred cows weaning an 85 percent calf crop.

The primary means available for improving productive efficiency in the beef cow is to wean a greater number of calves each year. This would mean that with no increase in cow numbers, and only a limited rise in production costs, a substantial increase in net income could be achieved. One way in which this could be accomplished would be to increase the rate of twinning in the beef cow.

Unfortunately, the incidence of natural twin births is low. It occurs much more frequently in the dairy breeds, averaging about one set in every 55 births. However, it is a much less frequent occurrence in the beef breed with twins being born in only about 4.4 percent of all births, or one time in every 250 births. Also, most studies have indicated that the heritability of the tendency to produce twins is low. Thus, selection for increased twinning rate should have little or no effect on twinning rate. Therefore, some other means for increasing twinning rate must be developed.

Means for experimentally increasing twinning rate was provided by the basic research that was conducted in the early 1930's on the relationship of the gonadotropic hormones of the anterior pituitary gland to ovulation. It was determined that a specific hormone, follicle stimulating hormone (usually referred to as FSH) was released by the pituitary and carried by the bloodstream to the ovary where it stimulated the growth and development of a structure called the follicle within which the egg matured. When the egg was ready to be fertilized, the follicle ruptured and the egg was expelled (a process called ovulation). Ovulation was brought about by another gonadotropic hormone of the anterior pituitary gland, leuteinizing hormone or LH.

These early research studies also demonstrated that the injection of gonadotropic hormones would result in stimulation of the ovary to develop and ovulate more than the normal number of follicles (superovulation). In the early 1940's, superovulation was reported in a large number of research studies involving cows, sows and ewes as a result of the injection of gonadotropic hormones. The usual source of the gonadotropic hormone used in these early studies was extracts of pituitary glands obtained from slaughterhouses. This was not a reliable source, it was costly and quantities were restricted. In the late 1930's, researchers at the University of California reported the presence of a potent gonadotropic substance in the blood of pregnant mares during part of the gestation period. This substance, called pregnant mare serum or PMS, readily induced superovulation in females when injected. Thus, one of the most

practical methods for the experimental production of superovulation was developed.

Pregnant mare serum, as the name implies, is the blood serum from pregnant mares. It is rich in a gonadotropic substance that is similar in physiological activity to that of FSH. This substance appears in the blood of mares about the 40th day of pregnancy, reaches a high point between the 70th and 120th days, then declines to nearly zero by the 180th day. It is produced by the structures in the uterus that are associated with the placenta or fetal membranes. Thus, it is one of a group of substances referred to as placental gonadotropins.

A second type of placental gonadotropin is produced by the pregnant woman (and other primates). It is produced by the chorion, one of the membranes of the placenta, and is called HCG or human chorionic gonadotropin. It has a physiological activity similar to that of the leuteinizing hormone of the anterior pituitary; thus, when injected, should stimulate ovulation of mature follicles. HCG reaches a peak in the urine of pregnant women by about the 50th day and declines to a low level by the 140th day. It is the basis of several tests for pregnancy in women.

Pharmaceutical supply houses process human pregnancy urine and blood from pregnant mares. Thus, commercial preparations of PMS and HCG are readily available to veterinarians, and have been routinely used by them for many years in treating reproductive problems in farm animals. These hormone preparations are restricted by federal law to be sold only on the order of a licensed veterinarian. Therefore, any livestock producer interested in using them for any purpose will find it necessary to work with his veterinarian.

Many research studies have been reported concerning the effectiveness of PMS in inducing superovulation. However, very few have been directed toward determining whether not only superovulation but also superfetation (increased number of embryos) could be established and multiple births obtained. The few studies that have been reported were not highly successful and pointed up many problems that were involved. In 1963, research workers in Germany reported very promising results from a limited study involving a sequence of two PMS injections on the 5th and the 16th to 18th days after the last heat. This report, and others, stimulated the initiation of a large scale project at the Fort Reno Station to determine whether it was possible to develop a practical means for increasing the occurrence of multiple births by the use of PMS. This paper is a report of the progress of this project to date.

Materials and Methods

The cows used in this study were in a herd at the Fort Reno Research Station and were maintained on native grass range. The PMS treatments were given in June and July of 1967. The cows were lactating, of mixed ages and breeding as shown in Table 1. They were assigned as equally as possible on the basis of age, weight and date of calving to one of three groups to receive their first subcutaneous injection of 1500 i.u. of PMS on either day 4, 5 or 6 of the cycle, counting the day of estrus as day 0. The cows were further sub-divided within each of these three groups to receive a second subcutaneous injection of 2000 i.u. of PMS on either day 16, 17 or 18. The PMS used was "gonadin" prepared by the Cutter Laboratories and obtained through the OSU Veterinary Clinic.

Sterilized bulls were placed with the cows to detect their estrus period prior to the first PMS injection and to determine whether estrus occurred between the first and second PMS injections. Immediately following her second PMS injection, each cow was placed with a fertile bull. On day of first esrus following PMS (first post-PMS estrus) when a cow was observed to have mated, she was immediately removed from the pen, given an intravenous injection of 2500 i.u. of chorionic gonadotropin and hand-mated to a different bull. Following the first post-PMS mating, all cows were pasture exposed to fertile bulls for 2 to 3 months. The pastures were checked twice daily for signs of estrual activity. The cows were examined for pregnancy by rectal palpation in early November. No attempt was made to determine the number of embryos in the uterus because such would require excessive handling that might damage the developing embryos.

The cows were wintered on native grass pastures with a moderate level of protein supplement. At time of calving, the surplus multiple

Table 1. Summary of 1968 Calving Performance of All Cows Treated with PMS in 1967.

Breeding of Cows	Age When Treated (years)	Body Wt. (lbs.)	Total Treated	No. Conceived at 1st Post-PMS Estrus	No. Open	No. of Cows Producing				
						Singles	Twins	Trips	Quads	Quints
Crossbred	2	917	26	16	2	5	6	4	1	0
Hereford	4	1188	43	29	6	19	5	4	11 1	0
Angus	5+	1110	12	7	2	5	1	0	10 0	1
Total for All Cows			81	52	10	29	12	8	2	1
Live Calves						28	24	12	23 3	2

calves from triplet and quadruplet sets were transferred to cows with singles or to cows that had lost their calves so that no cow reared more than twins. The cows rearing twins were maintained in a separate pasture with creep feed provided for the calves. Single calves were not creep fed. The calves were weaned in early November at an average age of 7 months.

Results and Discussion

Table 1 presents the results obtained in the 1968 spring calving season for all cows in the study. The data given under the heading "No. of Cows Producing Singles, Twins, Triplets, Quadruplets and Quintuplets" refers only to the cows that conceived at the first estrus following the second PMS injection. This is the only group of cows that would be expected to be stimulated to produce multiple births as a result of the PMS treatments.

A total of 81 cows were treated, with 52 (or 64.2 percent) conceiving at the first estrus following PMS. Of these 52 conceptions, 23 (or 44.2 percent) resulted in a multiple birth with the type of multiple births distributed as shown in Table 1. The results are not broken down on the basis of time of receiving the PMS injections. It was found that there were no differences in the response of cows, in terms of numbers of multiple births, associated with whether the first PMS injection was given on day 4, 5 or 6. Likewise, there was no difference in the occurrence of multiple births in cows receiving the second PMS injection on either day 16 or 17. However, there was good evidence that day 18 was too late, since fewer cows receiving their second PMS injection on day 18 produced multiples.

The figures given in Table 1 for live calves are for calves surviving at least one month. The survival rate of twins in this study was 100 percent, but fairly heavy death losses were suffered among triplets, quadruplets and the set of quintuplets. However, despite these losses, there were still more live calves than cows in every multiple birth group.

There were three age groups of cows. However, for all practical purposes, the results on the Hereford and Angus groups can be combined. Over ⅔ of the conceptions (68.8 percent) in the Angus-Hereford crossbred heifers resulted in multiples; whereas, 34.5 percent of the conceptions in the Hereford and 28.6 percent of the conceptions in the Angus resulted in multiple births. Just what caused this greater response in the two-year old crossbred heifers cannot be determined from the results obtained in this study. It could be due to the age and body weight difference, or it could be a heterotic effect because she was a crossbred.

The 12.3 percent incidence of open cows is somewhat high when compared to other cow herds maintained at Fort Reno. The open cows

were marketed with no attempt being made to examine the reproductive tracts for possible abnormalities as a result of PMS treatment. However, there was no indication of any abnormalities of the reproductive tracts as a result of the PMS treatments. All cows were observed in estrus following the removal of the bulls, and their ovaries appeared normal when checked by palpation. One factor that may have contributed to the greater number of open cows was the fact that the breeding season for this particular group of cows did not start until mid-June and this meant that most of the matings occurred during hot weather. In contrast, in the other herds at Fort Reno, the breeding season begins May 1, and most of the cows are pregnant prior to the onset of hot weather. There seems to be little doubt that breeding efficiency is reduced during periods of high temperature.

As might be expected, there were differences in the birth weight of single calves as compared to calves from multiple births. The average birth weights were: singles, 83.3 lb.; twins, 63.0 lb.; triplets, 46.2 lb.; quadruplets, 37.5 lb.; and quintuplets, 30.0 lb. It is very likely that this reduced birth weight is one of the important reasons why only two cows producing multiple births required assistance at time of calving.

Multiple births were also associated with a shorter gestation period. The average gestation lengths were: singles, 280.8 days; twins, 277.4 days; triplets, 269.2 days; quadruplets, 262.5 days; and quintuplets, 258.0 days. This reduction in gestation length of nearly three weeks in the case of quadruplets and quintuplets and of nearly two weeks for triplets has very important implications. These calves are physiologically much less mature than are calves born after a gestation of normal length. It is likely that these calves would be much more susceptible to many forms of stress such as exposure to cold weather. Therefore, one might expect higher death losses among these calves unless they receive special attention and protection not required by calves born after a normal gestation.

One problem that was anticipated was that of retained placentas (afterbirth). Eleven of 23 cows producing multiple births suffered retained placentas compared to only one cow of the 29 producing singles. However, the occurrence of retained placentas at time of calving did not appear to be associated with failure of the cows to rebreed.

Table 2 presents the weaning data on the calves (both singles and multiples) droped by the cows that conceived at the first estrus following PMS. With a few exceptions, all calves from multiple births were raised as twins and had access to creep feed. Single born calves were reared as singles and were not creep fed.

In terms of total number of calves, the increased incidence of multiple births had a decided effect on calf crop percentage weaned. The 71 pregnant cows that were wintered weaned a total of 88 calves, or a calf

Table 2. Pre-Weaning Performance of Calves Conceived at the First Post-PMS Estrus.

Item	Type of Birth				
	Singles	Twins	Trips	Quads	Quints.
Total Sets	29	12	8	2	1
Total Calves Born	29	24	24	8	5
Total Calves Weaned	28	23	12	3	2
Avg. Wean. Wt. (lb.)	462	398	349	348	316
Gain-Birth to Wean.	379	335	303	310	286
Lb. Calf/Cow	462	796	698	696	632
Lb. Creep Feed/Calf	0	550	550	550	550

crop percentage of 109 percent. It is evident that this technique has great potential for increasing cow productivity, particularly if additional research will enable reducing the number of open cows and death loss among multiples and increasing the number of cows producing multiples.

It is apparent that the calves reared as twins did not grow as rapidly from birth to weaning as did the singles even with the help of creep feed. There are two possible reasons for this: (1) the beef cows used in this study did not produce enough milk to allow two calves to grow as rapidly as a single calf. Free access to creep feed could not overcome the early retardation that occurred at the time the calf was dependent entirely on milk; (2) calves from multiple births are born after a shorter gestation and at a lighter birth weight. As has been pointed out, they are physiologically less mature than are singles; and, as a result, they are actually younger than their chronological age as counted from birth. It is likely that neither of these fully explains the results, and the real reason for the lighter weaning weights is a combination of these two factors. However, despite the reduced weaning weight per calf, it is apparent that total production per cow is increased. In the case of twins, an additional 334 lbs, of calf was obtained. The very good record in liveability and growth rate of twins suggests the need for additional research to not only increase the incidence of multiple births but to limit it to twins.

This report covers only one year's results, and it must be understood that this project is continuing and additional results will be obtained and reported. Therefore, it should be emphasized that many questions still remain to be answered; and, as a result, there are many limitations associated with the use of PMS to obtain multiple births. A listing and discussion of the more important of these limitations follows.

(1) Retained placentas appear to be a problem associated with multiple births. A total of 11 out of the 23 cows were so affected. This could affect the rebreeding of the cows, although in this study it did not appear to be a factor causing cows to not rebreed.

(2) A greater than normal number of cows dropping multiples may be

delayed in rebreeding. In this study approximately 25 percent of the cows raising twins failed to rebreed during a normal 3 months breeding season while they were nursing calves. This may have been a result of their having produced a multiple birth. However, it is more likely the result of the stress of the additional lactation required to nurse twins, since all of the cows conceived in a subsequent breeding season begun soon after the calves were weaned. This delayed rebreeding is definitely a problem that will have high priority in the additional research that will be conducted.

(3) Under present conditions, these treatments are costly. The hormone cost was approximately $7.00 per cow treated. This meant a total of $567 for the 81 cows to produce the 23 sets of multiples. It is hoped that additional research will show ways to reduce the cost per extra calf by: (a) increasing number of cows producing multiples; (b) saving more of the calves from multiple births; and (c) reducing the cost of the hormone by pointing to new and cheaper sources of gonadotropins reducing levels required, and by the increased demand for these hormones, encouraging pharmaceutical houses to go into quantity production, and thus reduce production costs.

(4) There are large labor requirements under the present system of treatments. Research is now underway to combine these treatments with estrus synchronization. This will permit giving all injections on the same day and reduce the need for heat detection and injections of a few heifers every day.

(5) These procedures are not adapted to extensive systems of production such as are typical of most of our beef cattle herds. Careful and frequent observations are required, not only during the breeding season but during the calving season. It appears best adapted to some type of confinement system.

(6) The restricted milking ability of most beef cows greatly limits the usefulness of this technique in beef herds. It would appear to be most useful if the cows were dairy-beef crossbreds or if the surplus calves were reared artificially.

(7) Approximately 90 percent of the heifers born twin to a bull are "freemartins" and are incurably infertile. Since at least one-half of the twin pairs would be expected to be unlike sexed, increased rate of twinning would not be expected to increase the number of breeding heifers. At best, one would just break even. Since higher death losses would probably result, the number of breeding heifers would probably be reduced somewhat. For this reason, until methods for controlling sex of calf are developed, an increase in occurrence of multiple births would probably appeal most to the commercial breeder who intends to send all calves to market for slaughter.

Summary

The results reported in this paper definitely indicate that the incidence of multiple births in beef cows can be greatly increased by injections of PMS. It should be emphasized, however, that many questions remain to be answered by further research. It, therefore, should be considered to be still in the research stage and not ready for routine use in cattle production.

Evaluation of the K^{40} Counter as A Predictor of Lean in Beef Cattle

C. R. McLellan, Jr., J. V. Whiteman, L. E. Walters and G. V. Odell

Story in Brief

Sixteen Angus heifers and fifteen Angus steers were counted in the potassium-40 (K-40) whole body counter at the OSU live animal evaluation center during the spring of 1968. The 31 head were divided into four groups and each group was counted after shrinking periods of 24 and 72 hours. The animals were slaughtered and the carcasses were counted after chilling about 40 hours. The right side was separated into lean, fat, and bone; and chemical determinations were made to obtain an estimate of the amount of fat-free lean (FFL).

The data was first analyzed to see how well the two counts on the same animal during the same shrink period agreed. The results suggested that shrinking 72 hours improved the extent to which the two counts agreed. The agreement between carcass counts was better than the 24-hour counts, but was not as good as the agreement between 72-hour counts.

Each live and carcass count and the average of the two counts for each counting period was examined to observe the relationship between count and pounds of FFL. Significant positive relationships were observed between all live and carcass counts and pounds of fat-free lean. The 72-hour count did not, however, predict fat-free lean any better than the 24-hour count. Other relationships such as count to percent FFL, count to live weight, and live weight to pounds of FFL were also studied.

In cooperation with USDA Agri. Research Service, Animal Husbandry Research Division.

Statistical procedures were used to study the overall relationship between count, weight, and pounds of FFL, and the ability to predict pounds of FFL when live weight and K-40 count were considered together. The analysis of this data indicated that the K-40 counter may be of some benefit for detecting the meatier animals.

Introduction

In the beef cattle industry, both commercial and purebred producers are becoming increasingly interested in methods to accurately predict the lean content in their cattle. The potassium-40 (K^{40}) whole body counter is one method of live animal evaluation that is presently undergoing evaluation at the OSU evaluation center.

The K^{40} counter is designed to take advantage of the following biological principles:

(1) Potassium in the animal's body is found primarily in the muscle tissue.

(2) K^{40} gamma rays are emitted from potassium ions at a constant rate.

If the K^{40} Counter can accurately detect a constant percentage of the K^{40} gamma rays, then the amount of potassium in the animal's body can be estimated and from this, the amount of lean in the animal. Potassium in the viscera and other non-muscle components (i.e. feet, hide, head, bone, fat, etc.) increases the difficulty of obtaining an accurate count of the potassium in the muscle.

The purpose of this report is to present the results obtained from 31 head of Angus which were counted and slaughtered during the spring of 1968.

Materials and Methods

Animals

Sixteen Angus heifers and sixteen Angus steers were selected at random from the progeny test herd at the Lake Blackwell range. The animals were weaned at an average age of 205 days and taken to the Fort Reno Livestock Research Station for the fattening phase. They were fed at the station until they were weighed off feed and trucked to the evaluation center. One steer died from bloat so the test was conducted with 16 heifers and 15 steers.

Following is a description of the groupings made when the animals were weighed off feed for counting and slaughter.

Group I.

On March 30, the seven heaviest calves were weighed off feed. This group consisted of 5 steers and 2 heifers that weighed off feed at an average of 992 pounds with a range of 950 to 1,050 pounds.

Group II.

This group was weighed off feed on April 13, and was made up of the 8 heaviest calves remaining at the station. There were 6 steers and 2 heifers in this group that ranged from 910 to 965 pounds with an average of 932 pounds.

Group III.

The eight heaviest of the remaining 16 calves were weighed off feed on April 27. There were 6 heifers and 2 steers that weighed between 880 and 955 pounds and averaged 912 pounds.

Group IV.

The last eight animals were weighed off feed May 11, and the six heifers and two steers in this group ranged in weight between 740 and 870 pounds and had an average weight of 812 pounds.

Counting Procedure

Each of the four groups were handled in the following manner when designated for counting and slaughter.

Friday — Animals were weighed off feed at 8:00 a.m. and trucked to Stillwater. On Friday afternoon the animals were tranquilized and washed. Groups I and II were washed with water only and Groups III and IV were washed with soap and water. All groups were then held without feed and water until they were slaughtered on Monday.

Saturday — Each animal was counted twice on Saturday beginning at 8:00 a.m. The animals were coded and were run through in a random order until each had been counted once. They were then recoded and run through a second time in another random order. A ten minute background count before and after each animal count was used to determine the average background. The animal was counted for ten minutes and the average background was subtracted from this count to arrive at a net animal count. The net animal count was the count used in the results discussed in this report.

The distance from the detectors to the shoulders, last rib, and hip bones of each animal was measured so the effects of animal size could be studied. Any unusual circumstances, such as difficulty in loading, filing down in the counter, or other abnormal activity, was recorded in the event these occurrences might have affected the accurate counting of the animal.

The Saturday count is referred to in this report as the 24-hour shrink count. Table 1 shows the amount of weight lost during the 24-hour shrink period from Friday to Saturday, and the additional 48 hour period from Saturday to Monday.

Monday — After 72 hours of shrink (see Table 1), the animals were again counted twice. The counting procedure was the same as that used

Table 1. Average Weights of Each Group for off Feed Weight, Saturday (24-hour shrink) Weight and Monday (72-hour shrink) Weight. Average Weight Lost During Each Shrinking Period in Parentheses.

	Avg. Wt. Off Feed (Friday)	Avg. Wt. Loss-1st 24 Hours	Avg. Wt. Saturday	Avg. Wt. Loss-next 48 Hours	Avg. Wt. Monday	Average Total Loss
Group I	992	(81)	911	(38)	873	(119)
Group II	932	(66)	866	(38)	828	(104)
Group III	912	(67)	845	(29)	816	(96)
Group IV	812	(48)	764	(28)	736	(76)
Average	912	(66)	846	(33)	813	(99)

on Saturday. After the second count, the animals were hauled to the OSU Meat Laboratory and slaughtered. The Monday count is referred to as the 72-hour shrink count.

Slaughter floor data was obtained but has not been analyzed at present; therefore, it is not included in this report. The carcasses were not split and were mounted on racks so they assumed the same position relative to the counter as the live animals.

Wednesday—On Wednesday the carcasses were taken to the evaluation center for counting. Two ten minute counts were again used, but a different procedure was followed. Usually only one carcass count separated the first and second count on the same carcass. Carcasses were positioned in the counter so that the topline of each carcass was the same distance from the detectors.

Thursday — Separation of the right side of the carcass into separable lean, fat and bone started on Thursday and was usually finished on Monday or Tuesday of the following week. The separable lean from each half carcass was first ground through a 1 inch plate. This coarsely ground bulk of lean was ground through a 3/8 inch plate and then through a 1/8 inch hamburger plate. The ground lean was sampled as it emerged from the final plate. Nine random grab samples were taken at estimated uniform intervals so that representation of each portion of the bulk might be obtained. These nine samples were then randomly allotted to three bottles. As much of each sample was used as was needed to fill a 1" x 4" round bottle one-third full. The rest of the sample was then returned to the bulk. The lean from each of the bottles was then emulsified in a high speed omni-mixer until it had a pasty consistency. This paste-like lean was divided evenly into two bottles. There were, therefore, six subsamples for each animal which were frozen and later used for chemical determinations.

In the summer of 1968 each sub-sample was analyzed in the Biochemistry Department at OSU. Moisture, protein, ether extract (fat), and

ash (minerals) content was determined on two four-gram portions taken from each bottle. The content was converted to a percentage figure which was then used to estimate the composition of the separable lean obtained from each carcass.

Since the ether extract procedure is an accurate method of determining fat content, these values were used to obtain an estimate of the amount of fat contained in the separable lean from each half carcass. The amount of fat thus obtained was subtracted from the pounds of separable lean to arrive at fat free lean (FFL). This figure was multiplied times two to put fat free lean on a whole carcass basis. An analysis of the results obtained from these determinations indicated that this method of sampling and chemical analysis was a precise way of estimating the amount of fat in the separable lean. Correlations reported in this study involving lean were calculated on this content of fat free lean.

Results and Discussion

Repeatability

In the process of evaluating a new piece of equipment designed to estimate hard to measure traits, it is desirable to know if two independent estimates on the same animal agree. Since the trait being measured (FFL, in this case) remained relatively constant over the time of measurement, then it was expected that the two measurements (counts) taken on the same animal during the same day would be close together. Repeatability is the term used to express the extent of agreement. If the two counts taken on the same day were very close for each animal, the repeatability would be close to 1.0. The farther apart the two counts on the same day were, the lower the repeatability would be. Many factors determine what would be a desirable repeatability estimate, but, in general, the more sophisticated and expensive a measurement is the higher the repeatability must be to justify the cost.

Repeatability estimates for this data were calculated for each shrink period since variation in GI tract content from count to count was expected to be less after 72 hours than after 24 hours. Table 2 shows the repeatability estimates for each group after 24 and 72 hours of shrink. On Saturday the estimates of repeatability for the individual groups ranged from 0.75 to 0.89. The pooled within group value, which is a kind of average, was 0.79. The pooled values are the most meaningful since they were obtained from the counts on all 31 animals and not just 7 or 8 as were the individual group estimates. On Monday the individual group's repeatability estimates ranged from 0.81 to 0.93 with a pooled value of 0.90. Those values indicate that, as was expected, the repeatability was, on the average, higher on Monday than on Saturday. This increase in

agreement between counts may have been a result of the weight lost which averaged 33 pounds from Saturday to Monday.

A second method of obtaining repeatability estimates was used to examine how well the K^{40} counter would repeat itself with weight held constant. In other words, if two animals weighed the same and one had considerably more FFL than the other, the counter should count this meatier animal higher on every count. To study this aspect of the counter, each count on Saturday was adjusted to 844 pounds which was the mean weight of all animals on Saturday. Each count on Monday was adjusted to the mean weight on Monday of 811 pounds. As can be seen from Table 2, the pooled repeatability of the adjusted counts was similar to that of the unadjusted counts. In this instance the counter repeated itself about as well on cattle of the same weight as it did on cattle of different weights.

Since the carcasses were stationary and a fixed distance from the detectors, and since no fill or offal was involved, the carcasses should have changed less from one count to the next. Therefore, it was expected that estimates of repeatability would be higher for carcass counts than for live animal counts. Table 2 illustrates the fact that carcass count repeatabilities were generally lower than the repeatabilities of the Monday counts. This indicates that there may be some different factors affecting the live and carcass counts. More evaluation of data is planned to discover explanations for these differences.

Correlations

Once it has been established that a measurement does or does not repeat itself at an acceptable level, the next step in evaluation can take place. If the machine does not repeat itself in line with its expense and expectation, it is usually rejected as a satisfactory tool. If, on the other hand, the measurement is rather highly repeatable the next step is to calculate correlations. Correlations, which are measurements of the degree

Table 2. Repeatability Estimates by Groups for Each Shrink Period, Carcass Counts, and Live Counts Adjusted to a Constant Weight.

	Repeatability (Correlation Between Counts 1 & 2)				
	Saturday (24 hr.)	Monday (72 hr.)	Saturday (Adj. to 844#)	Monday (Adj. to 811#)	Carcass Counts
Group I	0.84	0.81	0.88	0.88	0.86
Group II	0.84	0.93	0.76	0.88	0.96
Group III	0.89	0.92	0.90	0.91	0.82
Group IV	0.75	0.93	0.61	0.89	0.94
Pooled	0.79	0.90	0.77	0.89	0.87

of association between two variables, are determined to see if the measurement is actually estimating the trait it is designed to measure. In this study the association between count and pounds of fat free lean was the relationship examined.

Correlation coefficients range from —1.0 to +1.0. A negative correlation, in this case, would mean as count went up pounds of FFL went down. Conversely, a positive correlation would indicate that as count went up, pounds of FFL went up. A coefficient of zero would indicate that there was no apparent association between the two traits being studied.

Each count on Saturday and on Monday was correlated to pounds of fat free lean. The average of the two counts for each day was also correlated to pounds of FFL since if one count was a good estimate of FFL, then it was expected that the average of two independent counts would be a better estimate than either of the two counts

Table 3 shows the correlation coefficients by groups when count 1, count 2, and the average of the two counts for each day and for the carcass was correlated to pounds of fat free lean. Table 4 gives the pooled within group coefficients for each of these counts. From Table 3 it is obvious that accurate estimation of correlation coefficients from groups of only seven or eight is almost impossible. Each of these coefficients from 0.36 to 0.95 were estimating the association between count and pounds of fat free lean. The pooled values in Table 4 are more reliable figures since they were obtained from calculations involving all 31 animals. All of the values in this table were significantly different from zero ($P < .01$) indicating that there is a positive association between count and FFL. It was interesting to note (Table 3) that groups II and IV had high correlation coefficients for all counts considered and groups I and III were consistently low.

Carcass counts correlated to pounds FFL exhibited the same pattern as the live counts with a range from 0.37 to 0.97 and a pooled value around 0.80 as can be observed from Table 3.

Table 3. Correlations Between Count and Pounds of Fat Free Lean for Each Group for Each Count and the Average of the Two Counts on Saturday, Monday & Carcass Counts.

	Saturday Count 1	Saturday Count 2	Average Saturday Counts	Monday Count 1	Monday Count 2	Average Monday Counts	Carcass Count 1	Carcass Count 2	Average Carcass Counts
Group I	0.70	0.69	0 72	0.66	0.74	0.74	0.37	0.77	0.60
Group II	0.86	0.95	0.91	0.89	0.92	0 93	0.97	0.95	0.97
Group III	0.65	0.36	0.53	0.49	0.63	0.57	0.71	0.69	0.73
Group IV	0.94	0.88	0.92	0.92	0.87	0.90	0.83	0.86	0.86
Pooled	0.80	0.75	0.81	0.75	0.80	0.79	0.77	0.81	0.82

Table 4. Pooled Correlation Coefficients Between Counts (Saturday, Monday and Carcass) and Fat Free Lean (FFL).

	Saturday	Monday	Carcass
Count 1	0.80	0.75	0.77
Count 2	0.75	0.80	0.81
Average of Counts	0.81	0.79	0.82

Correlatons between count and percent of fat free lean were determined for the live counts. The pooled estimates tended to be close to 0.70 which, although significant ($P < .01$), was 0.10 lower than those obtained for pounds of FFL.

Correlations between count and live weight were calculated to examine the extent to which weight influenced count. Individual group values ranged from —0.18 to 0.81 and the pooled within estimates were all around 0.32. These extreme individual group values were easily explained. In the group with a coefficient of —0.18 the heaviest animal had the lowest count while one of the lighter animals had a high count. At the other extreme, 0.81, the lighter animals in this group counted low and the heavier animals counted high. Groups II and IV had the high significant count to weight correlations while groups I and III both had coefficients that were not significantly different from zero. Since this was in line with the high and low count to pounds FFL correlations, further evaluations of this similarity is suggested.

Since it is logical that heavier animals will, on the average, have more pounds of fat free lean; correlations between weight and pounds FFL were determined for comparison with count of pounds FFL correlations. The individual group coefficients ranged from 0.48 to 0.69 and the pooled estimates were around 0.54 ($P < .01$) when the average weight on Saturday and the average weight on Monday was correlated to pounds of FFL. This pooled estimate was lower than most reported figures due to the fact that the heaviest animal of the 31 was third from the bottom in terms of percent fat free lean.

Multiple Correlations

Since it has been established that both count and weight are correlated to pounds of fat free lean, it would be desirable to observe the association when all three variables are considered together. Multiple correlation coefficients were calculated on the data to study this association. The multiple correlation on a pooled basis between count, weight, and pounds FFL was 0.85. This illustrates that considering both count and weight is better than considering either one alone when trying to estimate pounds of FFL.

Another way to show this is to use the "average miss" concept. The basis for this concept is that each time information about an animal is added to what is known, then the estimate (or guess) of the pounds of FFL in that animal should miss by a fewer number of pounds. The group of cattle in this study had an average of 228 pounds of FFL. Since the standard deviation (average deviation) was 18 pounds, each animal could have been estimated as having 228 pounds and the average miss would have been 18 pounds. If the weight of the animal was known, one could estimate on the basis of the relationship between weight and FFL. The average miss would have been 15 pounds. Knowing both weight and count permits one to use both in predicting. When this was done the average miss was reduced to 9 pounds. This indicates that the K^{40} count increased the ability to estimate pounds of fat free lean in the live animal. How this would compare to prediction based upon body weight and the estimate of a good judge is not known.

Sire-Sex Interactions and Sex Differences in Growth and Carcass Traits of Cattle and Carcass Traits of Lambs

James E. Tanner, Richard R. Frahm, Joe V. Whiteman and Lowell E. Walters

Story in Brief

This study was designed to investigate the consistency of differences in performance of progeny of different sexes by different sires. A differential sex performance of the progeny of different sires is measured as a sire-sex interaction. The bull, steer and heifer progeny of 24 Angus sires over a 3 year period were analyzed for various growth and carcass traits. Preweaning gain and weaning weight analyses involved 487 individuals and postweaning performance and carcass data were analyzed on 394 individuals. Sire-sex interactions were investigated for various carcass traits of 120 lambs involving equal numbers of ram, wether, and ewe progeny of 18 sires studied over a 2 year period. Estimates of differences between bulls (rams) and steers (wethers) and between steers (wethers) and heifers (ewes) are presented.

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There were no significant sire-sex interactions for beef growth or carcass traits and the only one of thirteen lamb carcass traits analyzed in which there was an indication ($P < .10$) of an interaction was percent carcass lean. These results suggest that differences between the sexes for the various traits are similar for different sires and sires evaluated on the basis of progeny tests involving one sex would be ranked in a similar manner if evaluation were based on the performance of a different sex. This study indicates that reliable progeny tests of bulls and rams can be based on performance of different sexes or unequal proportions of a particular sex if adequate adjustment factors are available.

Introduction

Sire evaluation based on the performance of offspring (progeny test) is an effective means of measuring genetic worth. Although the time and expense involved in progeny testing sires has limited its practical use in many breeding programs, progeny testing may be advisable in situations where selected sires can be used extensively as in artificial insemination or where selection is for those traits that are not directly measurable on the animal being evaluated.

Sex differences have been demonstrated to exist in many important growth and performance traits of cattle and sheep. A possible problem may arise in progeny testing if sex differences are not similar among the progeny of different sires. This differential sex response could be in the form of large sex differences in performance among the progeny of some sires and relatively small differences among the progeny of other sires. A more extreme example would be a case in which the performance of male progeny exceeded that of female progeny of certain sires while the performance of female progeny of other sires was superior to that of the male progeny. A differential sex performance is measured statistically as a sire-sex interaction.

If sire-sex interactions are important, the estimated breeding value of a sire would depend on the sex of the progeny involved in the evaluation. This would indicate the necessity of evaluating sires on the performance of a given sex or equal proportions of different sexes. If sire-sex interactions are not important, sire evaluation could be based on the records involving different sexes providing sex adjustments were available.

The purpose of this study was to investigate the importance of sire-sex interactions in growth and carcass traits of bulls, steers and heifers and carcass traits of ram, wether and ewe lambs. Estimates of sex differences were also obtained.

Materials and Methods

The cattle used in this study were Angus calves raised during a 3 year period in the Experiment Station herd at Lake Blackwell Range, Stillwater. Calves were the progeny of 24 different sires, 8 used each year. There were 139 bulls, 121 steers and 227 heifers involved in the analysis of preweaning average daily gain and weaning weight. The analyses of feedlot gain, yearling weight and carcass traits included 126 bulls, 113 steers and 155 heifers.

About one-half of the male calves from each sire group were randomly selected for castration at an average age of 3 months. Calves were weaned at an average age of 205 days and shipped to the Fort Reno Livestock Research Station where they were fed for a 168 day period. After completing the feeding period, all animals were shipped to a commercial packing plant where they were slaughtered and carcass data obtained.

One-hundred twenty lambs from the Fort Reno Station, consisting of equal numbers of ram, wether and ewe progeny for each of 18 sires involved in the analyses of lamb carcass traits. All lambs were out of grade Rambouillet or Dorset x Rambouillet ewes and Dorset, Hampshire or Suffolk rams. All lambs were raised as twins on wheat pasture with access to creep feed. Lambs were weaned at approximately 70 days of age and weighed every two weeks until reaching a minimum full weight of 100 lb., at which time they were transported to Stillwater for slaughter and carcass evaluation.

Statistical analyses for testing sire-sex interactions were conducted separately for each year and the results pooled or combined over all years. Previous Feeders' Day reports contain sex means for the first two years of the cattle data (Okla. Agr. Exp. Sta. MP-79, page 31) and for the lamb data (Okla. Agr. Exp. Sta. MP-80, page 16), consequently sex means have been omitted from this report.

Results and Discussion

The existence of a possible sire-sex interaction for each trait was tested statistically by the analysis of variance. The results of the tests for sire-sex interactions in beef growth and carcass traits are presented in Table 1. The ratio (F value) obtained from the comparison of mean squares is expected to be one (1.0) if the interaction truly does not exist, with an equal likelihood of deviating slightly above or below the expected F value due to chance. None of the traits analyzed exhibited significant evidence of sire-sex interactions. This would indicate that sex differences were similar for the progeny of different sires. These results do not support the belief that some bulls tend to sire better progeny of one sex than they do of the other.

Table 1. F Values Obtained in Tests of Significance for Sire-Sex Interactions in Beef Growth and Carcass Traits

	Interaction F Value[1]
ADG[2] (birth to weaning), lb.	0.86
Adjusted weaning weight, lb.	0.80
ADG[2] (feed lot), lb.	0.73
Adjusted yearling weight, lb.	0.96
Trimmed round percent[3]	0.88
Carcass wt./day of age	0.89
Rib eye area, in.[2]	0.94
Rib eye area/100 lb. carcass	0.92
Average fat thickness at 12th rib, in.	0.87
Single fat thickness/100 lb. carcass	0.76
Estimated percent kidney fat	0.98
Carcass conformation	1.05
Marbling score	0.75
Carcass grade	0.96
Cutability percent[4]	0.84

[1] All F values were nonsignificant; if the interaction truly does not exist, the F value should be near 1.0.
[2] Average daily gain
[3] Percent of hot carcass weight
[4] Estimated percentage boneless retail cuts from round, loin, rib and chuck

Estimates of sex differences between bulls and steers and between steers and heifers are presented in Table 2. Bulls had a small but nonsignificant advantage over steers in gain from birth to weaning and weaning weight, while steers were superior to heifers in these traits. The 7.7 lb. advantage of bulls over steers in weaning weight is less than that generally reported, but should be a realistic difference since calves to be castrated were randomly selected from each sire group. Bulls gained more rapidly in the feedlot than steers and had a significant advantage in carcass weight per day of age. Bulls had leaner carcasses than steers, less marbling and a lower carcass grade. Heifer carcasses had more kidney fat than steer carcasses, while there was little difference in carcass grade or marbling score. Bulls were significantly higher than steers in estimated carcass cutability, while there was no difference between steers and heifers. The values contained in Table 2 can be used to adjust for sex differences.

Table 3 contains the F values for statistically testing for the existence of sire-sex interactions for each of the lamb carcass traits. Six of the F values were less than 1.0 and seven were greater than 1.0 which is the expected result due to chance variation about the expected F value of 1.0 when there are no sire-sex interactions. The only trait which gave any indication of a sire-sex interaction was percent carcass lean, which was significant at the 10 percent level of probability. This provides some evidence, although not strong, of an interaction. However, considering the number of traits analyzed, it would not be unusual to obtain at least

Table 2. Differences Between Bulls and Steers and Between Steers and Heifers in Growth and Carcass Traits.

	Bulls-Steers	Steers-Heifers
ADG (birth to weaning), lb.	0.038	0.107**
Adjusted weaning weight[1], lb.	7.7	25.7**
ADG (feed lot), lb.	0.376**	0.466**
Adjusted yearling weight, lb.	68.10**	100.11**
Trimmed round percent	0.59**	0.38**
Carcass wt./day of age	0.108**	0.165**
Rib eye area, in.[2]	1.67**	0.44**
Rib eye area/100 lb. carcass	0.133**	—.149**
Av. fat at 12th rib., in.	—.19**	—.05**
Single fat/100 lb. carcass	—.037**	—.001
Estimated percent kidney fat	—.86**	—.38**
Carcass conformation[3]	0.04	0.67
Marbling score[3]	—1.59**	—.12
Carcass grade[2]	—2.08**	0.23
Cutability percent	2.49**	0.00

** Differences were significant ($P < .01$)

[1] Adjusted to 205 days and for age of dam.

[2] Converted to the following numerical designations: low prime-13, high choice-12, average choice-11, low choice-10, high good-9, average good-8.

[3] Marbling score equivalents: moderate-7, modest-6, small-5, slight-4.

Table 3. F Values Obtained in Tests of Significance for Sire-Sex Interactions in Lamb Carcass Traits.

	Interaction F Value[1]
Percent carcass bone	1.04
Percent carcass fat	1.18
Percent carcass lean	1.60*
Carcass wt./day of age	0.75
Percent trimmed wholesale cuts	1.32
Percent trimmed leg	0.64
Loin eye area, in.[2]	1.09
Carcass conformation grade	0.74
Carcass quality grade	0.85
Carcass grade	0.54
Fat thickness at 5th rib, in.	1.18
Fat thickness at 12th rib, in.	1.12
Specific gravity of carcass	0.80

*Significant ($P < .10$)

[1] If the interaction truly does not exist, the F value should be near 1.0.

one significant interaction due to chance. Consequently, the slight indication of a sire-sex interaction for percent carcass lean probably should not be taken too seriously. It seems more likely from considering all data analyzed that sire-sex interactions are not a significant factor. Furthermore, the Hampshire, Suffolk and Dorset sires used in this study probably represented larger gentic differences among sires than those normally found within a breed, and consequently should have enhanced the likelihood of detecting sire-sex interactions if they exist.

Estimates of sex differences in lamb carcass traits are given in Table 4. The only significant differences between wether and ewe carcasses were in fat thickness, with wethers having slightly less fat cover at the 5th and 12th ribs. When making sex comparisons it should be kept in mind that lambs were killed on a weight constant basis rather than following a constant feeding period. Definite differences were obtained between rams and wethers in body composition based on chemical analysis of bone free tissue. Ram carcasses were significantly lower in percent fat and higher in percent bone and lean than wether carcasses. Ram carcasses had less fat cover than wether carcasses. Ram carcasses tended to grade lower than wether carcasses and wether carcasses lower than ewe carcasses, although the differences were nonsignificant. The sex differences in Table 4 can be used as adjustment factors in situations similar to those in this study.

In view of the number of traits analyzed for sire-sex interactions in beef cattle and lamb data and the similarity of the results, it does not seem probable that sire-sex interactions are of major concern in sire evaluation. These results suggest that differences between the sexes are similar for different sires and that observed discrepancies can be attributed to random variation. This means that sires evaluated on the basis of progeny tests involving one sex would be ranked in a similar manner if evaluation had been based on the performance of a different sex. This study indicates that reliable progeny tests of bulls and rams could be conducted in which sires were represented by different sexes, or unequal numbers of a particular sex providing adequate adjustment factors were available.

Table 4. Differences Between Rams and Wethers and Between Wethers and Ewes in Carcass Traits.

	Rams-Wethers	Wethers-Ewes
Percent carcass bone	0.85*	— .23
Percent carcass fat[1]	—6.42**	—1.82
Percent carcass lean[2]	4.43**	0.86
Carcass wt./day of age	0.029**	0.011
Percent trimmed wholesale cuts	— .28	— .04
Percent trimmed leg	0.77**	0.17
Loin eye area, sq. in.	0.09	0.03
Carcass conformation grade[3]	0.35	0.20
Carcass quality grade[3]	0.22	0.13
Carcass grade[3]	0.19	0.59
Fat thickness at 5th rib, in.	— .16**	— .09**
Fat thickness at 12th rib, in.	— .08**	— .04**
Specify gravity of carcass	0.0023	0.0012

*Differences were significant ($P < .05$)
**Differences were significant ($P < .01$)
[1] Determined from chemical analysis of bone free tissue
[2] Calculated by difference using percent bone and fat
[3] Converted to the following numerical designations: high prime-0, average prime-1, low prime-2, high choice-3, average choice-4

Observations on Certain Aspects of Preconditioning Calves

Robert Totusek and Dwight Stephens

Story in Brief

Three trials to compare various weaning management practices and rations for weaned calves were conducted. Total lb. gain per calf for the 28-day experimental period by treatment in each trial were as follows: Trial I: Unweaned on pasture, 26; weaned on pasture, 14; weaned in a pen, 25. Trial II: High concentrate ration, 7; high concentrate plus roughage, 41; all roughage, 40. Trial III: Unweaned on pasture with creep, 34; weaned in trap, 32; weaned in drylot, 34.

In this experiment, (1) a high roughage ration was much superior to a high concentrate ration for newly weaned calves, (2) calves weaned in a pen performed better than calves weaned on pasture, but there was little difference between pen weaned and trap weaned calves, and (3) unweaned calves in the pasture, with or without creep, returned more above feed cost than weaned calves.

Introduction

Because of poor performance, excessive sickness, and high death loss of many newly arrived cattle in the feedlot, there has been much interest in preconditioning cattle previous to their transfer to the feedlot.

Preconditioning is not a clearly defined term. Some of the practices implied by preconditioning include, (1) weaning calves previous to shipment, (2) teaching calves to eat a grain ration, (3) conditioning calves to a confined environment with water and feed facilities similar to a feedlot, (4) treating for grubs, (5) treating for internal parasites, (6) immunizing against various diseases such as blackleg, IBR, BVD, parainfluenza and pasteurella, (7) castrating, and (8) dehorning.

Some of these jobs, such as castrating and dehorning, are done routinely by good operators. Certain of the jobs, such as treating for grubs, treating for internal parasites, and immunizing against certain diseases, can undoubtedly be done most economically and efficiently by the feedlot operator, who is well equipped to perform many of the operations, and buys supplies in large quantities at a lower price than most ranchers.

The most important preconditioning jobs which can be performed on the ranch are weaning calves and teaching them to eat. This involves labor, feed, capital and risk. These added costs must either result in a

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premium selling price for the calves, or in a profitable weight gain of the calves, or both, of sufficient magnitude to justify the practices. Otherwise, the rancher will have little interest in preconditioning.

Whether a bonus will be commonly paid for preconditioned calves remains to be seen. The possibility is good in the case of large groups of calves accompanied by good assurance that certain preconditioning practices have occurred. The possibility is poor for small groups of calves, particularly if their identity is lost in marketing channels.

The rancher considering the practices of weaning calves and teaching them to eat must consider weight changes which will occur with certain management and feeding regimes. Three trials to obtain such information were conducted.

Trial I

This trial was conducted at the Ft. Reno Experiment Station, El Reno, Oklahoma.

Procedure

One-hundred-twenty steers and heifer calves, most of which were grade Hereford, were divided into three groups at a normal weaning age of 7 months in early October. Three practices were compared, as follows:

(1) In Group 1, calves were not weaned. They were allowed to remain on their dams in the pasture, without creep feed.

(2) In Group 2, calves were weaned and placed in a 40-acre native grass (bluestem) pasture which had not been grazed during the summer. A supplement (equal parts milo and cottonseed meal) was fed at the rate of 2 lb. per head daily. A small amount of alfalfa hay was fed initially to encourage the calves to start eating out of feed bunks in the pasture.

(3) In Group 3, calves were weaned and placed in a bermuda grass pen approximately one acre in size without shelter. Prairie hay was offered free-choice, and supplement (equal parts milo and cottonseed meal) was fed at the rate of 2 lb. per head daily.

The trial was conducted for 28 days. Initial, 14-day, and 28-day unshunk weights were obtained. Following the 28-day weighing, the calves were shrunk for 20 hr. without feed and water and weighed again.

Results

Results are summarized in Table 1. Calves on all treatments gained more during the first 14 days than during the second 14 days, possibly because of cool weather at the time of the 28-day weighing which probably reduced the water fill at that time. No sickness occurred in any of the groups.

Table 1. Results of Trial I.

	Weaning Treatment		
	Unweaned-Pasture	Weaned-Pasture	Weaned-Pen
1st 14-day gain, lb.	27	13	22
2nd 14-day gain, lb.	—1	1	3
28-day gain, lb.	26	14	25
Shrink, %	4.5	4.9	5.3
Daily feed, lb.			
Supplement	--	2.0	2.0
Prairie hay	--	--	9.3
Total feed, lb.			
Supplement	--	56	56
Prairie hay	--	--	260
Cost and returns, per head			
Value of gain, $[1]	7.28	3.92	7.00
Feed costs, $[2]			
Supplemental feed	0	1.85	4.45
pasture	1.50	1.50	0
Total	1.50	3.35	4.45
Difference, gain less cost, $	5.78	.57	2.55

[1] At 28¢/lb.
[2] At 3.3¢/lb. for supplement, 1.0¢/lb. for prairie hay, and $1.50/head for pasture.

There was little difference in performance between the unweaned calves and those weaned in a pen. Both groups outgained the calves weaned in the pasture. Differences in shrinkage were not large.

Value of the 28-day gain, feed costs, and returns above feed costs are shown in Table 1. On the basis of assumed prices, the calves weaned in a pen were more profitable than those weaned on pasture. However, those calves which remained unweaned in the pasture were considerably more profitable than either weaned group. This advantage would be a valid one if the calves were weighed for delivery on the ranch. If the calves were delivered to a market, the weaned calves would probably regain some of their disadvantage because they would probably eat and drink more at the market.

The results of this trial indicate that, considering the advantage for unweaned calves of less feed cost, less labor cost, and less risk from potential sickness following weaning, a premium would be required to justify the preweaning of calves before selling.

Trial II

The trial was conducted at the Lake Carl Blackwell Range near Stillwater, Oklahoma.

Procedure

One-hundred-twenty calves, mostly Angus and Hereford, both steers and heifers, were weaned in early October at an average age of 6 months.

They were divided into three similar groups and each group was placed in a trap approximately 1 acre in size, with no shelter. Water was available in automatic tank type waterers. Three types of rations were fed:

(1) High concentrate. The ration was 90 percent concentrate (high in rolled milo), 10 percent roughage, and was offered free-choice. Prairie hay was offered free-choice the first day, and was gradually withdrawn within 3 days.

(2) Concentrates plus roughage. Prairie and alfalfa hays were offered free-choice, and the 90 percent concentrate mix was fed at a level of approximately 1 lb./100 lb. weight of the calves.

(3) All roughage. Prairie and alfalfa hays were offered free-choice.

The trial was conducted for 28 days, and weights were taken in the same manner as in Trial I.

Results

Results are summarized in Table 1. The gain performance of the calves fed the high concentrate ration was obviously poor. These calves went on feed rapidly and appeared to be doing well. However, a cold rain occurred during the night near the end of the first week, and within the second week many calves became sick. The disease was diagnosed as "shipping fever complex." A total of 7 calves quit eating completely, and an additional 10 calves were treated. Two calves died. Acidosis caused by the high concentrate ration was probably a factor contributing to the difficulty. A small amount of prairie hay was fed until the calves were again consuming the high concentrate ration.

In contrast, groups of calves receiving roughage free-choice performed well. Of the calves fed concentrates plus roughage, none went "off-feed" and only two were treated for shipping fever. Of the calves fed roughage only, none went off feed and none required treatment.

Gains of calves fed roughage only and those fed concentrates in addition to roughage were almost identical. As in Trial I, gain was better the first 14 days than the second 14 days, probably for the same reason. Shrinkage increased as the level of roughage in the ration increased, probably because of greater fill in the digestive tract.

With the prices which were assumed in Table 2, the calves fed roughage only showed the greatest return above feed cost for added gain during the post-weaning period, followed by the calves which were fed concentrates in addition to roughage. Calves fed the high concentrate ration showed a considerable loss, especially considering the death loss which occurred. This substantiates the commonly recommended practice of feeding considerable roughage when starting weaned calves on feed.

The return above feed cost by the calves fed roughage is sufficient to pay labor and interest costs and still show some profit, and might en-

Table 2. Results of Trial II.

	Ration		
	High Concentrate	Concentrate + Roughage	All Roughage
1st 14-day gain, lb.	5	30	33
2nd 14-day gain, lb.	2	11	7
28-day gain, lb.	7	41	40
Shrink, %	3.2	5.0	6.4
Daily feed, lb.			
Concentrates	6.0	3.2	0
Prairie hay	1.4	2.5	3.5
Alfalfa hay		9.5	10.9
Total feed, lb.			
Concentrates	168	107	0
Prairie hay	39	70	98
Alfalfa hay	0	266	305
Costs and returns, per head			
Value of gain, $[1]	1.96	11.48	11.20
Feed costs, $[2]			
Concentrates	4.20	2.67	0
Prairie hay	.39	.70	.98
Alfalfa hay	0	3.99	4.57
Total	4.59	7.36	5.55
Difference, gain less cost, $	—2.63	4.12	5.65
Death loss	—6.50		
Total	—9.13		

[1] At 28¢/lb.
[2] At 2.5¢/lb. for concentrates, 1.0¢/lb. for prairie hay and 1.5¢/lb. for alfalfa hay.

courage consideration of such a practice by the rancher. The weaned calves might even do better, relatively, if shipped to market because of better eating and drinking, and consequently higher selling weight, than unweaned calves. On the other hand, there is always the risk of sickness and death loss of weaned calves, especially due to cool nights and cold rain often encountered in the fall.

Trial III

This trial was conducted at the Lake Carl Blackwell Range near Stillwater, Oklahoma.

Procedure

Fifty-four Angus and Hereford calves, both steers and heifers, were divided into three groups in early October at a normal weaning age of 7 months. Three practices were compared.

(1) Calves in Group 1 were not weaned. They were allowed to remain with their dams on pasture, with access to a mixed ration in a creep feeder.

(2) Calves in Group 2 were weaned, placed in a small drylot pen for 3 days, then turned into a 5-acre trap which contained a pond and some

trees for shelter. They were allowed free access to prairie hay when weaned; the prairie hay was gradually withdrawn during the first week following weaning as the calves increased consumption of the mixed ration. The mixed ration was offered free choice after 24 hr. following weaning.

(3) Calves in Group 3 were weaned and placed in a small drylot pen without shelter with access to an automatic tank type water. These calves were shifted from prairie hay to the mixed ration in the same manner as the calves in Group 2.

Calves in all three groups received the same mixed ration which contained 38 percent roughage (28 percent cottonseed hulls, 10 percent dehydrated alfalfa pellets) and 62 percent concentrates (mostly rolled milo and cottonseed meal). Unshrunk weights were obtained initially, at 14 days, and at 28 days when the trial was terminated.

Results

Results are summarized in Table 3. During the first 14-day period the unweaned calves with access to creep feed gained considerably more than the weaned calves. During the 2nd 14-day period the weaned calves outgained the unweaned calves, in spite of the fact that about 80 percent of the creep consumed by the unweaned calves was consumed during this period. For the total 28-day period, there was little difference in gain among the three treatments.

Table 3. Results of Trial III.

	Treatment		
	Weaned in Pasture, Creep	Weaned in Trap	Weaned in Drylot
1st 14-day gain, lb.	21	6	1
2nd 14-day gain, lb.	13	26	33
28-day gain, lb.	34	32	34
Daily feed, lb.			
Concentrate mix	4.4	5.9	7.1
Prairie hay	0	1.5	1.4
Total feed, lb.			
Concentrate mix	123	165	199
Prairie hay	0	42	40
Costs and returns, per head			
Feed costs, $[2]			
Value of gain, $[1]	9.52	8.96	9.52
Concentrate mix	2.83	3.74	4.58
Prairie hay	0	.42	.40
Pasture	1.50	0	0
Total	4.33	4.16	4.98
Difference, gain less cost, $	5.19	4.80	4.54

[1] At 28¢/lb.
[2] At 2.5¢/lb. for concentrate mix, 1.0/lb. for prairie hay and $1.50/head for pasture.

Calculation of value of the gain and return above feed cost showed a similar potential profit for the three groups of calves, with the unweaned calves the highest.

There was no sickness among the unweaned calves during the trial, while several calves in the weaned groups suffered from mild respiratory infections; 3 calves in the drylot group and 1 calf in the trap group required treatment with antibiotics.

If the calves in this experiment had been sold on the basis of ranch weights, there would have been no advantage in preweaning. The weaned calves actually returned less above feed costs than the unweaned calves, and presented more risk from sickness. Had the calves been hauled to market, the weaned calves should have had some advantage in regaining hauling shrink due to better eating and drinking at the market.

There was no advantage in these trials for preweaning calves in terms of increasing returns above feed costs. Had the calves been marketed at a central or auction market, the results might have been somewhat different. Furthermore, if calves were being sold direct, the possible superior performance of weaned calves might result in repeat sales, or possibly a premium, in subsequent years.

Methods of Harvesting and Processing the Sorghum and Corn Plants for Finishing Cattle

Jerry Martin, Raymond Peck, Milton England, Jack Alexander and Robert Totusek

Story in Brief

Yearling steers were used to compare four rations: (1) dry-harvested milo plus corn silage, (2) dry-harvested milo plus sorghum stover (silage or dry), (3) high-moisture-harvested milo plus corn silage, and (4) high-moisture-harvested corn plus corn silage. A supplement was added to all rations. The replacement of corn silage with sorghum stover resulted in little change in daily gain (0.1 lb. less), but a 9.3 percent improvement in feed efficiency. Steers on high-moisture-harvested milo or corn gained 10 percent faster and 19.0 and 23.9 percent more efficiently, respectively, than steers on dry milo. Net energy values followed the same trends as feed effiicency. Carcass traits were not significantly affected by rations.

In cooperation with USDA Agri. Research Service, Animal Husbandry Research Division.

Introduction

Sorghum grain (milo) is the principle feed grain produced in the Panhandle areas of Oklahoma and Texas at the present time. However, with the increasing use of irrigation, corn production is increasing and the future outlook is for a continued increase in production of this feed grain. The predicted competition between the sorghum and corn grains raises questions that need to be answered regarding their production capacities and relative feeding values.

Research studies in Oklahoma and elsewhere have pointed to the relatively inefficient utilization of milo by beef cattle. This has stimulated a search to find methods of preparation that will increase the efficiency of utilization of the feed grains, particularly the sorghums. Results obtained with high-moisture grains for beef cattle in research and in the feedlot have been encouraging. Expensive structures have not been required for the satisfactory preservation of these high-moisture-harvested grains when stored in the ground form. Both ground milo and ground corn harvested at about 30 percent moisture have been preserved in large conventional concrete floored trench silos with very little loss from spoilage.

When the grain is harvested at a moisture content of about 30 percent, the forage portion of the plant is relatively green and at a moisture content of about 65 percent. This level of moisture in the forage is adequate for satisfactory preservation as ensilage and the nutritive value of the potential feed source for feedlot cattle needs to be determined.

The agronomic phase of the present study was designed to study and measure the comparative yield of dry matter from the conventional and high moisture (30 percent) harvested milo the efficiency of harvesting of high moisture corn and milo grains, and the storage of these grains from harvesting to feeding.

The feedlot phase of the study was designed to measure the relative feeding value of the following ration treatments:

1. Dry harvested milo plus corn silage
2. Dry harvested milo plus sorghum stover silage
3. High-moisture-harvested (HMH) milo plus corn silage
4. High-moisture-harvested (HMH) corn plus corn silage.

Materials and Methods

This experiment was conducted at Panhandle State College at Goodwell, Oklahoma. Sixty head of 690 lb. yearling Hereford steers were used in a 142-day feeding trial. Four representative steers were selected from the initial group of 60 steers for initial body composition measurements. The remaining 56 head were divided into eight groups of seven steers

each according to body weight and conformation. These weight groups were randomly assigned to the four ration treatments listed above, two replicates per treatment. The steers on Treatment 2 received sorghum stover silage the first 46 days, then dry sorghum stover the remaining 96 days.

The HMH corn and milo contained 25 to 30 percent moisture when harvested. These grains were ground through a conventional type hammer mill using a three-eighths in. screen and blown into two small above ground horizontal concrete trench silos. The silos were 50 ft. x 4 ft. x 4 feet. The ground grains were packed by tramping as they were blown into the silos. Grain in the filled silos was covered with polyethelene sheeting and green chopped sorghum and corn forage. A sheet of the polyethelene was placed next to the grain, then six to eight in. of the green chop was added, and then another sheet of polyethelene was placed over the green chop. Used tires were placed on top to protect against wind.

The ration of all steers consisted of ground grain, silage or stover, and supplement, plus plain block stock salt free choice. The steers were to receive 80 percent of their daily dry matter intake from the concentrate portion of the ration and 20 percent from the forage portion. The protein supplement shown in Table 1 was fed at a constant level of 1.6 lb. per steer per day throughout the feeding period. Initially, the steers were started on a concentrate: roughage ratio of 50:50 on a dry matter basis; this ratio was gradually changed during a 28-day period to an 80:20 concentrate: roughage ratio.

The four steers selected for the initial body composition measurements were slaughtered after a 16-hr. shrink without feed and water. Initial body composition was estimated from carcass specifc gravity using the procedure outlined by Lofgreen *et al.* at the California Station.

Initial and final weights in the feeding trial were taken after a 16-hr. shrink. All steers were slaughtered at the end of the feeding period and

Table 1. Ingredient Makeup of the Supplement.

Ingredient	Amount (Percent)	
Dehydrated alfalfa meal (17%)	37.0	
Soybean meal (50%)	40.0	
Urea (45% nitrogen)	10.0	
Stock salt	5.0	
Dicalcium phosphate	2.0	
Calcium carbonate	6.0	
	100.0	
Aureomycin	87	gms/ton
Stilbestrol	12	gms/ton

final body composition estimated by the specific gravity method. Other pertinent carcass data were also collected. The net energy value of the rations was calculated from feed consumption and body composition data.

Results and Discussion

The HMH milo and corn grains were harvested four and three weeks, respectively, prior to the initiation of the feeding trial. When the silos were first opened, only a very small amount of spoilage was observed in the first four to six in. layer at the entrance. Very little additional spoilage was encountered. The appearance of the corn was similar to that at the time of ensiling while the milo was somewhat darker in color. Both grains had a pleasant yeasty aroma and were moist and crumbly. There was a slight but distinct odor difference between the corn and milo with the sorghum having more of an alcohol aroma than the corn.

Periodic dry matter determinations of the ensiled grains and other ration ingredients were made and are shown in Table 2. There was very little change in the moisture content of the HMH grains as they were fed from the silo; the corn was particularly consistent in dry matter content.

No difficulty was encountered in bringing the steers to a full feed, with no difference due to ration treatment noted. No digestive disturbances were noted at any time during the feeding trial and visual signs of bloat and urinary calculi were absent.

The feedlot performance of the steers is shown in Table 3. The steers on the dry milo-corn silage ration gained on excellent 2.9 lb. per

Table 2. Dry Matter of Feeds in Percent.

Date	Corn Silage	Sorghum Stover Silage	Sorghum Stover	HMH Corn	HMH Milo	Dry Harvested Milo	Supplement
11-14-67	23.03			68.17	70.90		
12-12-67	30.06	33.04		71.65	75.18	87.73	93.05
12-19-67	39.17	32 97		70.91	75.64	88.76	92.63
1- 4-68	26.83	33.23		70.78	74.65	87.29	93.05
1-11-68	25.23		79.11	71.11	74.71	83.23	92.28
1-19-68	25.67		73.22	71.25	76.42	88.13	93.69
1-26-68	27.16		83.18	70.92	71.56	88.39	93.73
2- 1-68	27.39		82.81	70.71	70.80	87.97	93.63
2- 8-68	25.58		87.21	71.57	70.20	88.34	93.59
2-15-68	25.48		79.07	70.11	73.26	87.60	93.29
2-22-68	24.25		81.97	70.49	73.79	88.27	93.92
2-29-68	24.96		82.71	71.11	73.58	88.16	93.16
3- 7-68	28.70		85.92	71.10	74.25	88.12	93.36
3-15-68	26.93		86.18	71.11	74.90	87.96	93.84
Average	27.17	33.08	82.14	70.79	73.56	87.69	93.32

Table 3. Feedlot Performance and Net Energy Data.

	Treatment			
	Dry Milo Corn Silage	Dry Milo Sorghum Stover	HMH Milo Corn Silage	HMH Milo Corn Silage
No. steers	14	14	14	14
Initial wt., lb.	701	682	671	706
Final ft., lb.	1116	1081	1125	1156
Daily gain, lb.	2.9	2.8	3.2	3.2
Daily feed, lb.[1]				
Grain	18.6	17.2	16.4	15.2
Silage	5.6	4.0	5.3	5.0
Supplement	1.6	1.6	1.6	1.6
Total	25.8	22.8	23.3	21.8
Feed/lb. gain, lb.[1]				
Grain	6.52	6.20	5.16	4.80
Total	9.05	8.21	7.33	6.89
	Net Energy Data (megcal. per 100 lb.)			
NEm+p of total ration	55.4	59.4	64.4	71.1
NEm+p of grain	58.0		70.6	80.1
NEm of grain	62.4		78.6	89.6
NEp of grain	41.6		52.4	59.7

[1] All feed values are expressed on a 90% dry matter basis.

day on 9.05 lb. feed per lb. of gain, a rather normal feed conversion for the type of ration and size of steers involved. The steers on the dry milo-sorghum stover ration gained only slightly less, but consumed 3.0 lb. less feed per day, consequently their feed efficiency was 9.3 percent better. This result was unexpected. It should be noted that the concentrate: roughage ratio was higher for the dry milo-sorghum stover ration than for the dry milo-corn silage ration, because less of the dry sorghum stover was consumed. It is also possible that a slower passage of the dry stover ration in the digestive tract resulted in a higher digestibility of the dry milo-sorghum stover ration.

The steers on both HMH grains gained about 10 percent faster than those on dry milo. This advantage in gain for high moisture grain has been observed in some but not all other trials.

The advantage in feed efficiency for the HMH grains over dry milo was even more striking since rate of gain was up and feed intake was down. The HMH milo and corn rations were utilized 19.0 and 23.9 percent more efficiently than dry milo. A dry corn treatment was not used in this trial, but a current trial at Goodwell includes a comparison of dry vs. HMH shelled corn as well as dry vs. HMH ground ear corn.

The net energy values of the rations determined from feed consumption and body energy gain is shown in Table 3. The net energy values are very consistent with the feed conversion figures which were observed. The HMH milo-corn silage ration contained 64.4 megcal. of NEm+p

per 100 lb. milo — which was 16.2 percent greater than the value of 55.4 obtained for the dry milo-corn silage ration. The HMH corn-corn silage ration had a value of 71.1 megcal. of NEm+p per 100 lb., 28.3 percent greater than the value for the dry milo-corn silage ration and 10.4 percent greater than the value for the HMH milo-corn silage ration. Calculation of NEm+p, NEm, and NEp of the grain portion of the ration resulted in even greater advantages for the HMH grains. It is not known whether the greater net energy value of the HMH grains was due to an improvement in digestibility, an improvement in utilization of digested nutrients, or both. Previous work at the Oklahoma and Texas Stations has shown that high moisture milo is digested to a greater degree than dry milo.

There was an increase of 7.2 percent in the NEm+p value of the dry milo-sorghum stover ration compared to the dry milo-corn silage ration.

The carcass characteristics of the steers on the ration treatments are shown in Table 4. There was no significant treatment effect on any of the carcass traits measured.

Table 4. Carcass Data.[1]

	Treatment			
	Dry Milo Corn Silage	Dry Milo Sorghum Stover	HMH Milo Corn Silage	HMH Milo Corn Silage
Dressing %[2]	60.9	61.1	60.7	60.7
Carcass Grade[3]	9.7	10.4	10.6	9.9
Ribeye Area, sq. in.	11.4	11.8	11.4	11.9
Fat Thickness, in.	.66	.68	.72	.71
Marbling[4]	14.8	16.4	17.0	14.9
Cutability,[5] %	48.4	49.0	48.1	48.3

[1] Treatment did not significantly affect any of the carcass traits ($P < .05$).
[2] Calculated on the basis of final shrunk weight (Goodwell) and chilled carcass weight (Okla. City).
[3] Carcass grade: low choice=10, average choice=11, high choice=12.
[4] Marbling: 11=slight, 14=small, 17=modest.
[5] Estimated from ribeye area, fat thickness, kidney fat and carcass weight.

Grinding Milo Before vs After Reconstitution

Dennis White, James Newsom, Vincent Neuhaus
and Robert Totusek

Story in Brief

Milo reconstituted and stored in the whole form, then ground before feeding (reconstituted-ground), was compared to milo which was ground before being reconstituted and stored (ground-reconstituted) and both were contrasted to dry finely ground milo. Compared to dry milo, the reconstituted-ground milo produced 11.6 percent greater gain and 9.0 percent better feed efficiency, whereas the ground-reconstituted milo produced 1.8 and 3.5 percent decrease in gain and efficiency, respectively. Apparently, at the moisture level used in this trial, milo must be in the whole form to benefit from reconstitution.

Introduction

Milo is the best source of feed grain for fattening cattle in the Southwest; as the number of cattle fed in the Southwest increases, milo will increase in importance as an energy source.

High moisture processing (both high moisture harvesting and reconstituting) of milo has received considerable attention as a method of improving utilization over the dry product. Reconstituting milo (adding water to air-dry milo to raise the moisture to about 30 percent, followed by storage under oxygen-free conditions) has increased feed efficiency an average of 8 percent in previous research. In some comparisons the improvement has been greater. There are still many unanswered questions concerning the optimum conditions of harvesting storing, processing and feeding high moisture milo.

Reconstituted milo is usually stored in either an upright air-tight structure or packed in a trench silo to exclude air. The upright structure is versatile in that the wet grain can be stored in either whole or ground form. However, due to packing problems, the wet whole grain cannot be satisfactorily stored in a trench silo without considerable spoilage.

This experiment was designed to determine the effect of storage form (ground vs. whole) on the subsequent utilization of milo in a fattening ration. The following three milo processing methods were compared: (1) fine ground, grinding of dry milo, (2) reconstituting of whole milo, followed by storage for 21 days, followed by grinding before feeding (reconstituted-ground), and (3) grinding of dry milo, followed

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by reconstitution and storage for 21 days before feeding (ground-reconstituted).

Materials and Methods

Thirty-six Hereford, Angus, and crossbred (Hereford x Angus) steers and heifers with an average weight of 415 lb. and an average age of 8 months were started on trial November 16, 1967. The calves were from the Oklahoma State University experimental herds. The calves were started on feed one week before the trial began on a starter ration consistng of 50.0 percent dry ground milo, 24.0 percent cottonseed hulls, 20.0 percent dehydrated alfalfa pellets, 5.0 percent cottonseed meal, 0.5 percent bonemeal and 0.5 percent salt.

The calves were divided into three blocks on the basis of sex, breed, weight and age of dam and randomly alloted to the three treatments within each block. Three pens of four calves each were assigned to each treatment. The three types of processed milo were fed in a high concentrate ration, shown in Table 1. All ingredients other than milo were combinded into a premix which was mixed with the processed milo in the ratio of 83 percent milo to 17 percent premix. Proximate analyses of the processed milo grains and premix are shown in Table 2.

Grain Processing Methods

The reconstituted milo was produced by adding water to dry milo and mixing in a cement mixer to bring the moisture level to approximately 30 percent. The reconstituted-ground milo was prepared by adding water to the whole grain. The ground-reconstituted milo was ground through a 1/8 inch screen before the addition of water. Both treatments were then stored for 21 days in airtight plastic bags containing 90 lb. per bag. The dry ground milo and reconstituted-ground milo were ground through a 1/8 inch screen just prior to feeding.

Table 1. Ration Composition.

Ingredient	Amount (Percent)
Milo	83.0
Dehydrated alfalfa pellets (17% C.P.)	6.4
Cottonseed hulls	4.2
Cottonseed meal (41% C.P.)	4.2
Urea (45% Nitrogen)	1.0
Salt	0.6
Steamed bonemeal	0.6
	100.00
Added, per lb. of ration	
Vitamin A	2040 I.U.
Aureomycin	5 mg.

Table 2. Proximate Analyses in Percent.

Feed	Dry[1] Matter	Ash[2]	Crude[2] Protein	Ether[2] Extract	Crude[2] Fiber	NFE[3]
Milo						
Dry-finely ground	87.4	1.43	9.92	3.55	2.80	82.30
Recon.-ground	71.8	.89	8.53	2.70	1.85	86.03
Ground-recon.	67.6	.95	8.68	3.25	2.00	85.12
Premix	90.5	11.55	29.73	6.35	22.80	29.57

[1]Average of 24 determinations.
[2]Average of 2 determinations.
[3]100 - (sum of figures reported for ash, crude protein, ether extract, and crude fiber).

Feeding

The three rations were fed daily in quantities to assure availability of feed until the next feeding. Unconsumed feed was weighted back frequently to assure that fresh feed was available at all times. The reconstituted-ground milo was ground daily except that enough was processed on Friday to supply the amount needed over the weekend. The calves had access to open-sided sheds and outside lots, with water (warmed in winter) available at all times.

Data Obtained

Feed samples were taken at regular intervals during each 28-day period for proximate analysis and dry matter determination. Dry matter percentages were used to adjust all rations to a 90 percent dry matter basis. The grains were sieved and test weights were taken to determine particle size and density, respectively as shown in Table 3.

Initial and final weights were taken after a 16-hr. shrink off feed and water. Intermediate weights were taken at 28-day intervals, after a 16-hour shrink with no water (feed was available). The calves were fed 189 days, then slaughtered the following day; carcass data was collected after a 36-hr. cooler chill.

Table 3. Particle Size[1] and Density[2] of Processed Milo.

Process	Screen Size, in. 8/64	1/12	1/18	1/25	40 Mesh	40 Mesh	Wt.[2] Per Bu.
	% Retained on Screen					Through	lb.
Finely ground	0	0.2	8.4	37.2	32.4	21.8	42.7
Recon.-ground	7.1	27.1	28.3	14.6	17.6	5.3	26.4
Ground-recon.	1.5	2.2	17.8	37.9	34.4	6.2	34.9

[1] Particle size: Four 100 gm. samples of each grain were sieved.
[2] Test weight's reported are the average of four determinations and are on a 90% dry matter basis.

Results and Discussion

The moisture percentage of the dry ground, reconstituted-ground and ground-reconstituted milos averaged 12.6, 28.2 and 32.4 percent, respectively. The reconstituted-ground and ground-reconstituted milos were 38 and 18 percent less dense, respectively, than dry ground milo. The amount of fine material was reduced considerably in the reconstituted grains.

Feedlot performance, including daily gain, feed intake, and feed efficiency, is summarized in Table 4. The cattle fed reconstituted-ground milo gained considerably faster than those fed dry ground or ground-reconstituted milo, and required 9 and 12 percent less feed per pound of gain, respectively, than the cattle on dry ground and reconstituted-ground milo. Feed intake, adjusted to a 90 percent dry matter basis, was almost identical for all three treatments.

Carcass information is shown in Table 5. Differences in carcass merit were small and apparently not affected by grain processing method.

These results indicate that, at a moisture level of approximately 30 percent, milo grain must be reconstituted and stored in the whole form in order to obtain an improvement in feed efficiency. The reconstitution of whole grain apparently results in partial germination which converts the starch into simpler carbohydrates more available to the rumen microorganisms. The milo carbohydrates, after partial germination, may be in a form similar to that of high moisture harvested milo. This would explain the similarities in feeding value of the two forms of milo. In ground-reconstituted milo the enzyme system necessary for the germination process has apparently been disrupted. This would explain the lack of improvement in feed efficiency with this process.

Extensive laboratory analysis of several reconstituted and high moisture harvested milo samples is currently underway to determine changes in the various chemical constituents of the grain.

Table 4. Feedlot Performance (189 days).

	Milo Processing Method		
	Dry Ground	Recon.-Ground	Ground-Recon.
No. steers	12	12	10
Av. initial wt. lb.	410	416	419
Av. final wt. lb.	812	900	851
Av. daily gain, lb.[1]	2.25[a,b]	2.51[b]	2.20[a]
% change[2]		11.6	—1.8
Av. daily feed, lb.	14.6	14.6	14.8
Feed/lb. grain, lb.	6.34	5.77	6.56
% change[2]		9.0	—3.5

[1] Any 2 averages without a common letter differ significantly ($P < .05$).
[2] Compared to dry finely ground.

The specific gravity of each carcass was determined to allow calculation of the net energy value of the grains. These will be reported later.

Table 5. Slaughter and Carcass Information.

	Method of Processing Milo		
	Finely Ground	Recon.-Ground	Ground-Recon.
Dressing %[1]	61.29	61.72	61.89
Carcass grade[2]	10.54	10.05	9.87
Ribeye area, sq. in.[3]	11.14	10.38	10.30
Fat thickness, in.[4]	0.83	0.83	0.73
Marbling[5]	13.28	15.54	12.73
Cutability, %[6]	48.02	48.25	48.91

[1] Calculated on basis of Stillwater live shrunk weight and chilled carcass weight.
[2] U.S.D.A. carcass grade converted to following numerical designations: high prime—15, average prime—14, low prime—13, high choice—12, av. choice—11, low choice—10 good—9, av. good—8, low good—7.
[3] Determined from tracings at the 12th rib.
[4] Average of three measurements determined on tracing at th 12th rib.
[5] Marbling scores: 1 to 30, 11=slight, 12=slight plus, 13=small minus, 14=small, 15=small plus.
[6] Percent of boneless trimmed retail cuts on carcass basis=51.34 −5.78 (fat thickness) −.462 (% kidney fat) + .740 (ribeye areas) −.0093 (chilled carcass wt.).

The Effect of Moisture Level on the Feeding Value of Reconstituted Milo

Dennis White and Robert Totusek

Story in Brief

Five methods of processing milo were compared in a high concentrate ration for finishing heifers: (1) dry rolled, (2) reconstituted to 22 percent moisture — stored 21 days, (3) reconstituted to 30 percent moisture — stored 21 days, (4) reconstituted to 38 percent moisture — stored 21 days, and (5) reconstituted to 38 percent moisture — stored 1 day. Differences in rate of gain were not significant. Heifers on 30 and 38 percent reconstituted milo stored 21 days utilized their feed 11.8 and 12.1 percent more efficiently, respectively, than heifers fed dry rolled milo. Utilization

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of milo reconstituted to 22 percent and stored 21 days, or 38 percent and stored 1 day was not improved significantly over dry milo. These results suggest (1) a definite advantage in raising the moisture level of reconstituted milo from 22 to 30 percent, but no advantage in an additional moisture increase to 38 percent, and (2) storage of reconstituted milo for one day is not sufficient to improve utilization appreciably.

Introduction

Previous work at the Oklahoma and Texas Stations has shown that reconstituting of milo markedly improved feed efficiency. In most studies, milo has been reconstituted to a moisture level of approximately 30 percent, but the optimum moisture level for reconstituted milo has not been identified. Some preliminary *in vitro* digestibility work with the "artificial rumen" at this station indicated (1) that as the moisture level of high moisture milo increased, to a level of 38 percent, digestibility also increased, and (2) a large part of the improvement in digestibility occurred the first day following reconstitution. The objective of this experiment was to determine the optimum moisture level for reconstituted milo in order to realize the greatest benefit from the reconstituting process. The five milo treatments were as follows: dry rolled, 22 percent moisture — stored 21 days, 30 percent moisture — stored 21 days, 38 percent moisture — stored 21 days, and 38 percent moisture — stored 1 day.

Methods and Materials

Fifty Hereford, Angus and crossbred (Hereford x Angus) heifers with an average weight of 377 lb. were started on trial July 2, 1968. The heifers were purchased at the Oklahoma City stockyards. The calves were divided into two blocks on the basis of weight, breed and condition score and randomly allotted to the five treatments within each block. Two pens of five calves each were assigned to each treatment.

The calves were placed on a starter ration consisting of 40 percent dehydrated alfalfa pellets, 10 percent cottonseed meal, 48 percent cottonseed hulls, 1 percent salt and 1 percent bonemeal for 20 days prior to the start of the trial. At this point, the processed milo was introduced into the ration at the rate of 10 percent. The milo was increased 5 percent per day until the calves were on full feed. The five types of processed milo were fed in a high concentrate ration as shown in Table 1. All ingredients other than milo were combined into a premix, which was mixed with the processed milo in the ration of 84 percent milo to 16 percent premix.

Table 1. Ration Composition

Ingredient	Amount Percent
Milo	84.0
Dehydrated alfalfa pellet crumbles (17% C.P.)	4.93
Cottonseed hulls	4.93
Soybean meal crumbles (44% C.P.)	4.30
Urea (45% nitrogen)	0.64
Salt	0.60
Bonemeal	0.60
	100.00
Added, per lb. of ration	
Vitamin A	1600 I.U.
Aureomycin	5.0 mg.

Grain Processing Methods

The 22 and 30 percent reconstituted milo was produced by adding water to dry milo and mixing in a cement mixer to bring the moisture to the desired level. The 38 percent reconstituted milo was produced by soaking the dry milo in an open container for approximately 10 hours. The excess water was then drained off. The reconstituted milo that was stored for 21 days was placed in airtight plastic bags containing 90 lb. per bag. The 38 percent-1-day milo was allowed to stand 24 hr. in an open container prior to feeding. The dry and reconstituted milo was rolled with a roller tolerance of approximately .003 in. just prior to feeding.

Feeding

The five rations were fed daily in quantities to assure availability of feed until the next feeding. Unconsumed feed was weighed back daily to assure that fresh feed was available at all times. All rations were processed daily. The calves had access to open-sided sheds and outside lots with water available at all times.

Data Obtained

Feed samples were taken at regular intervals during each 28-day period for proximate analysis and dry matter determination. Dry matter percentages were used to adjust all rations to a 90 percent dry matter basis. The grains were sieved and test weights were taken at 28-day intervals, after a 16-hr. shrink with no water (feed was available). Performance data was summarized after an average of 112 days on feed. The heifers were then taken to the Live Animal Evaluation Center where they were subjected to measurement by the K^{40} counter and ultrasonic equipment.

They were then slaughtered and carcass data was collected after a 24-hr. cooler chill. Specific gravity determinations were made on each carcass to allow calculation of net energy values, which will be reported later.

Results and Discussion

The moisture level of the dry rolled, 22, 30, 38, and 38 percent-1-day averaged 86.9, 77.3, 68.6, 62.0 and 64.7 percent, respectively, for the five treatments.

The density of the milo was reduced 33 to 45 percent by reconstituting and rolling, compared to the dry rolling. The particle size (Table 2) was very similar for the 22, 30 and 38 percent reconstituted milo.

A complete sumary of feedlot performance is shown in Table 3. The differences in average daily gain were not statistically significant. The heifers on 22 percent milo gained 8 percent faster, while the heifers on 30, 38 and 38 percent-1-day milo gained 2.4, 7.6 and 2.4 percent slower,

Table 2. Particle Size[1] and Density[2] of Processed Milo.

Process	Screen Size, in.								Wt.[2] Per Bu.
	.315	.157	.079	.039	.020	.010	.005	.005	
	% Retained on Screen							% Thru	lb.
Dry rolled	0	0.3	30.9	61.8	3.0	3.0	0.5	0.5	40.7
Recon.—22%	0	42.8	43.8	6.1	2.8	3.1	1.4	0	27.2
Recon.—30%	0	41.4	35.5	8.6	9.3	4.9	0.3	0	24.5
Recon.—38%	0	50.2	38.7	5.9	4.2	1.0	0	0	22.3
Recon.—38%-1-day	0	0.3	43.3	41.6	8.2	4.5	2.1	0	23.1

[1] Particle size: Four 100 gm. samples of each grain were sieved.
[2] Test weights reported are the average of six determinations, and are on a 90% dry matter basis.

Table 3. Feedlot Performance (112 days)

	Method of Processing Milo				
	Dry rolled	Recon. 22%	Recon. 30%	Recon. 38%	Recon. 38%-1-day
No. heifers	10	10	10	10	10
Initial wt., lb.	380	376	381	366	381
Final wt., lb.	660	680	656	638	654
Daily gain, lb.	2.51	2.71	2.45	2.32	2.45
% change[1]		8.0	—2.4	—7.6	—2.4
Daily feed, lb.	16.8	17.4	14.3	13.6	16.1
Feed/lb. gain, lb.[2]	6.78[a]	6.51[a]	5.98[b]	5.96[b]	6.62[a]
% change[1]		4.0	11.8	12.1	2.4

[1] Compared to dry rolled.
[2] Any 2 averages without a common letter differ significantly ($P < .05$).

respectively, than the heifers on dry rolled milo. It is interesting to note that the heifers on 30 and 38 percent milo consumed 15.0 and 19.1 percent less feed, but because of similar gain, were 11.8 and 12.5 percent more efficient in utilizing feed, respectively, than the heifers on dry rolled milo. This advantage in feed efficiency was statistically significant. Feed intake and feed efficiency for the heifers on dry rolled, 22 and 38 percent-1-day milo were similar.

Apparently, the energy in the 30 and 38 percent reconstituted grain stored for 21 days was utilized more efficiently that that in the other milo treatments. The results suggest that there is a real advantage in reconstituting to a moisture level of 30 percent, but no additional advantage in raising the moisture level to 38 percent. Carcass merit was apparently unrelated to treatment for any of the criteria shown in Table 4.

The results of this trial further indicate that the storage of 38 percent moisture milo for one day is not sufficient to benefit from the reconstituting process.

Additional screening work is now under way using the *in vitro* system to determine the feasibility of reconstituting both whole and ground grains at even higher moisture levels.

Table 4. Slaughter and Carcass Information

	Method of Processing Milo				
	Dry rolled	Recon. 22%	Recon. 30%	Recon. 38%	Recon. 38%-1-day
Dressing %[1]	59.30	59.39	59.42	58.80	59.21
Carcass grade[2]	9.8	9.9	9.3	10.2	9.8
Ribeye area, sq. in.[3]	9.08	9.46	9.59	8.57	9.08
Fat thickness, in.[4]	0.60	0.63	0.56	0.61	0.61
Marbling[5]	13.7	14.3	13.8	15.1	13.6
Cutability[6]	50.00	50.22	50.41	49.64	50.24

[1] Calculated on basis of Stillwater live shrunk weight and chilled carcass weight.
[2] U.S.D.A. carcass grade converted to following numerical designations: high prime-15, average prime-14, low prime-13, high choice-12, av. choice-11, low choice-10, high good-9, av. good-8, low good-7.
[3] Determined from tracing at the 12th rib.
[4] Average of three measurements on tracing at the 12th rib.
[5] Marbling scores: 1 to 50, 11=slight, 12=slight plus, 13=small minus, 14=small, 15=small plus.
[6] Percent of boneless trimmed retail cuts on carcass base=51.34–578 (fat thickness) – .462 (% kidney fat) + .740 (ribeye areas) – .0093 (chilled carcass wt.).

A Comparison of Dry and High Moisture Methods of Processing Milo

Dennis White, Robert Renbarger, James Newsom, Vincent Neuhaus and Robert Totusek

Story in Brief

Seven kinds of processed milo — coarsely rolled, finely ground, very finely ground, high moisture harvested (HMH)-ground, high moisture harvested (HMH)-rolled, reconstituted-ground and reconstituted-rolled — were compared in a high concentrate ration for finishing cattle.

Calves fed HMH-rolled and reconstituted-rolled milo gained considerably faster than the other treatment groups. Differences in gain among the other treatments were small. Of the dry processing methods, very fine grinding resulted in the best feed efficiency, 6.7 percent better than fine grinding; the finely ground milo in turn was utilized 6.7 percent more efficiently than the coarsely ground grain. Grinding of HMH and reconstituted milo improved efficiency of utilization about the same as very fine grinding of the dry product, 9.1 and 7.3 percent better than fine grinding. The largest improvements in efficiency resulted when the wet grains were rolled. The HMH-rolled and reconstituted-rolled grains were utilized 18.8 and 16.9 percent more efficiently, respectively, than finely ground milo.

Introduction

Several trials have shown very little difference between dry rolled and finely ground milo. However, work at this station has indicated that if milo is ground, it should be ground rather finely for most efficient utilization (1/8 in. screen). A 1/8 in. hammermill screen has been the smallest used in previous research.

Milo which is dry rolled is often rolled very coarsely, with many kernels passing through the roller unbroken. Whole milo is not well utilized by cattle.

Previous research has shown that both reconstituted milo and high-moisture-harvested milo are more efficiently utilized than dry milo. Reports of a 10 percent or greater increase in feed efficiency due to high moisture processing are not uncommon.

Results of another trial at this station indicate that at a moisture level of 30 percent, reconstituted milo must be stored in the whole form to benefit from the reconstituting process.

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The objective of this experiment was to compare three dry and four high moisture types of processed milo — coarsely rolled, finely ground, very finely ground, high moisture harvested-ground (HMH-ground), high moisture harvested-rolled (HMH-rolled), reconstituted-ground and reconstituted-rolled.

Methods and Procedures

Eighty-four Hereford and crossbred (Angus x Hereford) steers with an average weight of 511 lb. and an average age of 9 months were used in a feeding trial. The calves were divided into two blocks on the basis of shrunk weight, condition score and breed, and then were randomly assigned to the seven treatments within each block. Four pens of three steers each were assigned to each treatment.

The calves were started on feed 6 days before the trial began. The initial ration consisted of 8 lb. of test ration and 4 lb. of cottonseed hulls per head per day. The test ration was gradually increased until the steers were receiving 13 lb. of the test ration on the sixth day following initial feeding, at which time the feeding trial started.

The composition of the ration is shown in Table 1. All ingredients other than milo were combined into a premix, which was mixed with the processed milo in the ratio of 83.4 percent milo and 16.6 percent premix. Stilbestrol was not used in this trial. Proximate analyses of the processed milo grains and premix are shown in Table 2.

Processing Method

Coarsely rolled milo was produced by setting the rollers to allow approximately 25 percent of the milo grains to be unbroken. Finely and very finely ground milo were produced with a hammer mill, using ⅛ in. and 1/16 in. screens, respectively. The HMH milo was combined when it had matured to a moisture level of 30-31 percent, then stored in the

Table 1. Ration Composition.

Ingredient	Amount Percent
Milo	83.4
Alfalfa hay, chopped	6.0
Cottonseed hulls	4.0
Cottonseed meal	4.0
Urea (42% nitrogen)	1.0
Salt	1.0
Bonemeal	.6
	100.0
Added per lb. of ration	
Vitamin A	1500 I.U.
Aureomycin	5 mg.

Table 2. Proximate Analyses.

Feed	Dry[1] Matter	Ash[2]	Crude[2] Protein	Ether[2] Extract	Crude[2] Fiber	NFE[3]
	Percent					
Milo						
Coarsely rolled	85.3	1.37	8.86	3.85	1.95	83.97
Finely ground	85.5	1.16	9.35	3.0	2.1	84.39
Very finely ground	85.5	1.31	10.28	3.65	1.95	82.81
HMH-ground	70.1	.94	8.36	2.3	1.1	87.3
HMH-rolled	68.9	.91	8.06	1.8	.85	88.38
Recon.-ground	74.3	1.27	8.77	3.4	1.45	85.11
Recon.-rolled	73.4	1.03	9.05	2.9	1.40	85.62
Premix	90.9	10.82	36.7	6.05	25.29	21.14

[1] Average of determinations of 24 samples.
[2] Average of 2 determinations.
[3] 100 — (Sum of figures reported for ash, crude protein, ether extract, and crude fiber).

whole form in a 14 x 27 ft. Harvestore structure. Reconstituted milo was produced in a 14 x 27 ft. Harvestore structure by adding water to the air-dry grain as it was augered into the structure, raising the moisture level to approximately 26 percent. Both reconstituted and HMH milos were either ground (1/8 in. screen) or rolled (.003 in. tolerance between rollers) just prior to feeding.

All milo used in this trial was of the variety Northrup King 222 and was produced in the same field on the Fort Reno Station. In order to minimize variation in the milo due to location in the field, the milo was strip combined so that all areas of the field were represented in all treatments. All rolling was done with a heavy duty Ross 18 x 24 in. roller mill.

Feeding

The coarsely rolled, finely ground, and very-finely ground grains were processed, combined with the premix, and stored in one-ton quantities. The four "wet" grains (HMH-ground, HMH-rolled, reconstituted-ground and reconstituted-rolled) were processed daily, wth the exception that enough was processed on Friday to feed over the weekend.

The steers were fed once daily in sufficient quantities to assure availability of feed until the next feeding. Unconsumed feed was removed and weighed back as necessary to assure that only fresh feed was available at all times. The steers had access to open-sided sheds and outside lots, with water (warmed in winter) available at all times.

Data Obtained

Feed samples were taken at regular intervals during each 28-day period for proximate analysis and dry matter determination. Dry matter percentages were used to adjust all rations to a 90 percent dry matter basis. The grains were sieved and test weights were taken to determine particle size and density, respectively, as shown in Table 3.

Initial and final weights were taken after a 16-hr. shrink off feed and water. Intermediate weights were taken at 28-day intervals, after a 16-hr. shrink with no water (feed was available). The steers were slaughtered on two different days after an average of 174 days on trial. Carcass data was obtained after a 36-hr. cooler chill. Bladders were collected at slaughter, and the amount of calculi in each bladder was determined.

Results and Discussion

HMH-rolled and reconstituted-rolled milo was 37.8 and 32.7 percent bulkier, respectively, than finely ground milo (see Table 3). The very-finely ground and the HMH-ground milos were very similar in particle size; however, the fluffy nature of the high moisture grain was very evident as shown by the test weight per bushel (density) of the two processed grains (40.8 and 31.3 lb. per bushel, respectively, for very finely ground milo and HMH-ground milo).

Performance information is summarized in Table 4. Statistically, rate of gain was not siginificantly affected by method of milo processing; how-

Table 3. Particle Size[1] and Density[2] of Processed Milo.

Process	Screen Size, in. 12/64	8/64	1/12	1/18	1/25	40 Mesh	40 Mesh	Wt.[2] Per Bu.
	% Retained on Screen						% Thru	lb.
Coarsely rolled	0	33.4	59.8	5.8	.62	.17	.18	53.3
Finely ground	0	.14	.90	9.64	18.1	32.6	38.6	44.7
Very finely ground	0	.12	.12	.39	4.17	28.6	66.6	40.8
HMH-ground	0	.56	1.9	5.9	9.0	18.3	64.3	31.3
HMH-rolled	6.2	26.6	19.8	7.8	3.3	9.0	27.2	27.8
Recon.-ground	0	.19	1.0	11.6	14.7	22.8	49.7	37.6
Recon.-rolled	4.6	27.2	24.3	10.9	3.8	7.2	22.0	30.1

[1] Particle size: Four 100 gm. samples of each grain were sieved.
[2] Test weights reported are an average of four determinations, and are on a 90% dry matter basis.

Table 4. Feedlot Performance (174 days).

	Coarsely Rolled	Finely Ground	Very Finely Ground	HMH Ground	HMH Rolled	Recon. Ground	Recon. Rolled
No. steers	12	12	11	11	12	12	11
Initial wt., lb.	513	514	518	495	513	506	516
Final wt., lb.	902	930	908	886	972	908	981
Daily gain, lb.	2.23	2.34	2.18	2.18	2.58	2.25	2.62
% change[1]	—4.7		—6.8	—6.8	10.3	3.8	12.0
Daily feed, lb.[2]	16.9[c]	16.8[c]	14.7[a]	13.4[e]	15.2[b]	15.0[c,b]	15.7[d]
Feed/lb. gain, lb.[2]	7.60[a]	7.12[a]	6.64[b]	6.47[b,c]	5.78[d]	6.60[b]	5.92[c,d]
% change[1]	—6.7		6.7	9.1	18.8	7.3	16.9

[1] Compared to finely ground milo.
[2] Any 2 averages without a common letter differ significantly ($P < .05$).

ever, it is interesting to note that the calves fed HMH-rolled and reconstituted-rolled milo gained faster than those fed dry milo or the ground "wet" milos.

The feed intake of the calves fed very finely ground milo, HMH-ground milo, HMH-rolled milo, reconstituted-ground milo and reconstituted-rolled milo was significantly lower than that of calves fed coarsely rolled milo and finely ground milo. This is simply a reflection of improved feed utilization; note that the feed efficiency figures for these treatments followed the same pattern, and these differences were also significant.

Rolling of HMH milo and reconstituted milo markedly improved feed efficiency over the other processing methods in this trial. Apparently the rolling process imparts a beneficial effect to "wet" grains, similar to that which has been observed with both dry and streamed milo.

The results of this trial indicate that if milo is dry rolled, no grain should pass through the roller unbroken. It was also apparent that very finely ground milo was utilized more efficiently (6.7 percent) than was the finely ground milo, and a marked decrease in feed intake and gain due to a very floury texture did not occur.

Carcass merit and dressing percentage were not significantly affected by processing method, as shown in Table 5. Quantities of calculi in the bladder were very small and unrelated to the processing method.

Table 5. Slaughter and Carcass Information.

	Method of Processing Milo						
	Coarsely Rolled	Finely Ground	Very Finely Ground	HMH Ground	HMH Rolled	Recon. Ground	Recon. Rolled
Dressing %[1]	59.6	60.6	59.4	61.4	60.2	59.2	60.0
Carcass grade[2]	9.2	9.7	9.0	9.5	9.8	9.3	9.9
Ribeye area, sq. in.[3]	10.8	10.7	11.0	10.6	11.5	10.5	11.0
Fat thickness, in.[4]	0.66	0.75	0.68	0.65	0.71	0.68	0.76
Marbling score[5]	11.9	12.9	11.7	12.4	13.3	12	14.3
Cutability, %[6]	49.5	48.7	49.6	49.5	49.3	49.3	49.9

[1] Calculated on basis of Ft. Reno live shrunk weight and chilled carcass weight.
[2] U.S.D.A. carcass grade converted to following numerical designations: av. choice-11, low choice-10, high good-9, av. good-8, low good-7.
[3] Determined from tracing at the 12th rib.
[4] Average of three measurements determined on tracing at the 12th rib.
[5] Marbling scores. 1 to 30, 11=slight, 12=slight plus, 13=small minus 14=small, 15=small plus.
[6] Percent of boneless trimmed retail cuts on carcass basis=51.34 − 5.78 (fat thickness) − .462 (% kidney fat) + .740 (ribeye area) − .0093 (chilled carcass wt.).

Winter Supplementation of Spring Calving Cows Grazing Midland Bermudagrass Year-Long

J. E. McCroskey, Stephen Armbruster, Robert Renbarger, Darrell McNutt and Jack Eason

Story in Brief

This report is a summary of a three-year study to determine the effects of feeding three levels of cottonseed meal (1, 2 and 3 pounds per head daily) to mature, spring-calving Hereford cows. All cows grazed a common pasture of Midland bermudagrass year-long and were fed their respective winter supplements in individual stalls.

Winter weight loss of the cows was slightly less with each increase in level of supplement. There was also a slight increase in milk production of the cows and in calf weaning weights with each increase in winter supplement. Although increasing the level of supplement reduced weight losses of cows during the winter, all losses were within the safe range for cattle of this age. Results of the study indicte that one pound of cottonseed meal daily was adequate for wintering cows under these conditions. However, under less than optimum grazing conditions it would be advisable to feed a higher level.

Introduction

The use of bermudagrass as pasture for beef cattle has increased considerably in the past 10 years. Because of the nature of the grass it appears to be better adapted to cow-calf operations than to stocker programs. The need for information regarding supplemental feeding of cows grazing bermudagrass during the fall and winter months prompted this study. This report summarizes a three-year study of the effects of different levels of protein supplment upon cow and calf performance.

Methods and Materials

The study was initiated in the fall of 1965 with 48 grade Hereford cows ranging in age from three to four years, bred to calve in February, March and April. The cows were divided into three groups of 16 based on age, weight and previous treatment. Lots 1, 2 and 3 received one, two and three pounds of cottonseed meal (41 percent C.P.) per head daily, respectively. All three treatment groups grazed a common pasture year-

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long and were fed their respective winter supplements in individual stalls. Cows were fed a two-day allowance of feed every-other-day to reduce labor.

The pasture contained approximately 140 acres of non-irrigated Midland bermudagrass which was cross-fenced to permit rotational grazing. In 1965 two hundred pounds of nitrogen was applied per acre in three equal applications during the growing season. In 1966, 1967 and 1968 fertilization consisted of the application of 50 pounds each of nitrogen, phosphorus and potassium per acre in the spring followed by two applications of 50 pounds per acre of nitrogen in mid and late summer. Cattle were rotated from one pasture to the next about every 7 to 10 days depending on rainfall and amount of grass. Pastures were mowed and dragged as needed.

Data were collected on cow weight change, milk production, blood minerals, calf birth weight and weaning weight. Milk production was determined by weighing the calf before and after nursing. Blood samples were taken from one-half of the cows in each treatment group at the start (December) and at the end of the wintering period (April).

Results and Discussion

Table 1 shows the effects of three levels of winter supplementation upon cow and calf performance. Cow weight loss through calving decreased with each increase in amount of supplement. However, weight losses of all groups were within the range found to be allowable for mature cows in previous studies.

Average daily milk production and calf weaning weights increased slightly as level of winter supplement increased. Calf birth weights were slightly lower when cows were fed one pound of cottonseed meal daily. An economic comparison of returns from cattle on the three treatments is also shown in Table 1. Although the gross returns were slightly higher with each increase in level of winter supplement of the cows, net returns

Table 1. Effects of Level of Winter Supplement on Performance of Spring-Calving Cows Grazing Midland Bermudagrass

Level of C.S.M. (lb./head/day)	1	2	3
Cow wt. loss including calving loss (% of fall wt.)	13.5	11.5	10.4
Ave. daily milk production (lb.)	12.7	13.0	13.6
Calf birth wt. (lb.)	74	78	78
Calf weaning wt. (lb.)	470	477	481
Ave. Gross Return/calf (@ 28¢/lb.)	$131.60	$133.56	$134.68
Ave. Winter Feed/cow (145 days)[1]	6.53	13.06	19.59
Ave. Net Return/cow (calf value minus feed cost)	$125.07	$120.50	$115.09

[1] Cost based on $89.50 per ton for cottonseed meal.

were greatest for the lowest level due to the increase in cost of winter feed on the other treatments. Conception rate and calving percentages are not shown but were essentially the same for the three groups.

Figure 1 shows the average monthly weights of the cows during the three-year period. Cows fed one pound of cottonseed meal daily lost more weight and were lighter from January to May than the other two lots. However, it is important to note that by July the Lot 1 cows were equal in weight with the other treatment groups. There was very little difference in cow weights at any time during the year between the groups receiving two and three pounds of supplement daily.

Figures 2 and 3 show the levels of certain minerals in blood serum of cows in December and April, respectively. Level of winter supplement apparently had no effect upon the level of any of the minerals measured at either sampling time.

The data from the three trials indicate that there was little or no advantage in feeding more than one pound of cottonseed meal per head daily to spring calving cows under these conditions. However, it is important to point out that the quality and quantity of winter forage were excellent during all three years.

In situations where forage is poor in quality and somewhat limited in amount it would probably be advisable to feed two pounds of protein

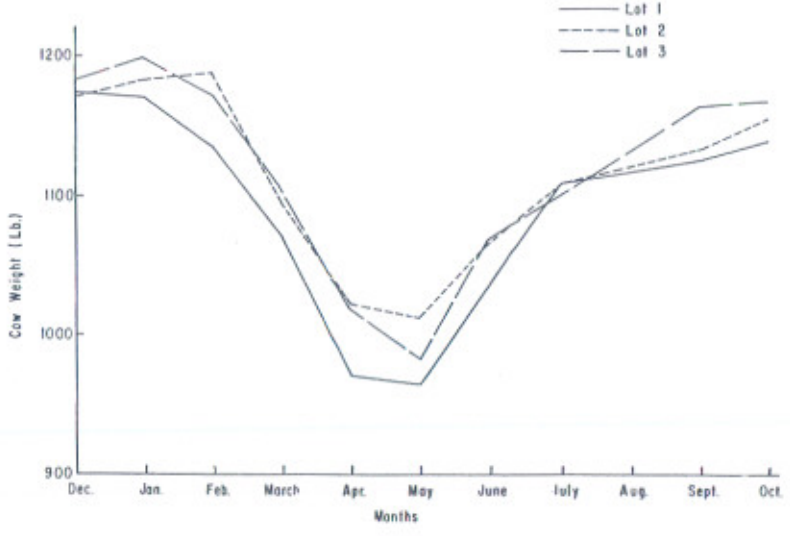

Figure 1. Monthly Cow Weights (Ave. of 3 Years)

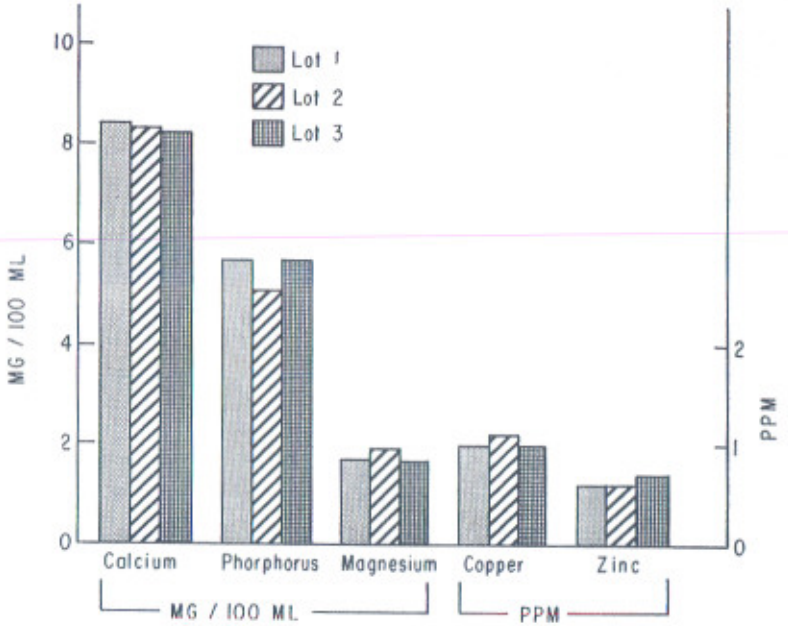

Figure 2. Mineral Content of Blood Serum Taken in December (Ave. of 3 Years)

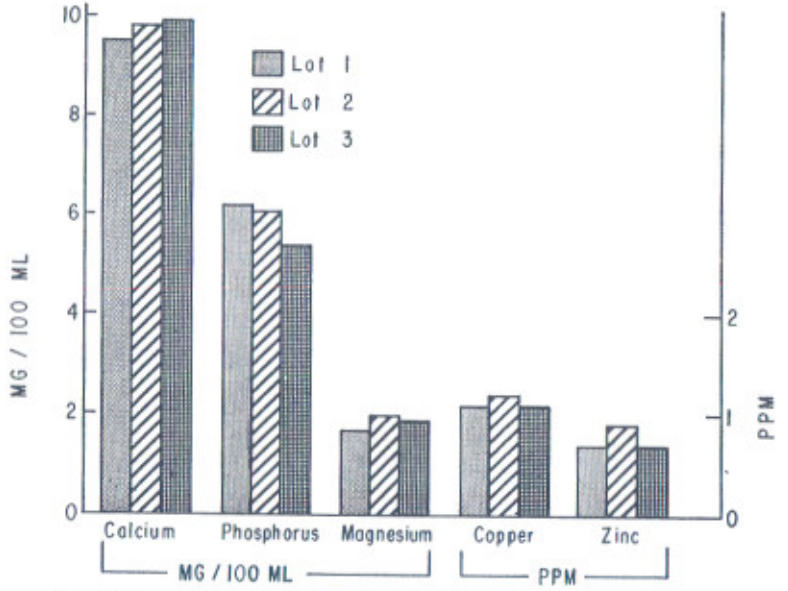

Figure 3. Mineral Content of Blood Serum Taken in April (Ave. of 2 Years)

supplement per head daily. It is important to consider the condition of the cattle, and feed enough supplement to keep the winter weight loss to about 15 percent of the previous fall weight. This may require feeding some grain as well as protein supplement during the winter if forage is quite deficient.

A Comparison of Hormones for Heifers Grazing Wheat Pasture

J. E. McCroskey, Robert Renbarger and Jack Eason

Story in Brief

This study consisted of two trials comparing different hormones with heifer calves grazing wheat pasture. In Trial I Melengestrol Acetate (MGA) and Synovex-H were compared using 72 heifers averaging 431 pounds in weight. In Trial II, 20 heifer calves weighing approximately 260 pounds were used to compare Diethylstilbestrol and Synovex-H.

In Trial I Synovex-H increased gains 16.9 percent while MGA decreased gains 17.9 percent, when compared with controls. Cattle receiving both MGA and Synovex-H gained 7.5 percent less than controls. In Trial II gains were almost identical for calves receiving Diethylstilbestrol and Synovex-H.

Introduction

In recent years various hormones have been shown to improve performance of cattle in the feedlot. Most data indicate increases in gains of grazing cattle implanted with Diethylstilbestrol. There is only limited data available on the effects of other hormones upon grazing cattle.

This study was conducted to determine the influence of Diethylstilbestrol, Melengestrol Acetate (MGA) and Synovex-H upon gains of heifers grazing wheat pasture.

In cooperation with USDA Agri. Research Service, Animal Husbandry Research Division.

Methods and Materials

Trial I.

Seventy-two spring-born Hereford and Angus heifers calves were selected from the experiment station herd and divided into four equal lots of 18 based on weight and previous treatment. Lot 1 served as controls and received no hormones; lot 2 was fed 0.4 mg. MGA per head daily in a small amount of grain; lot 3 was implanted with Synovex-H (200 mg. testosterone and 20 mg. estradiol); and lot 4 received both MGA and Synovex-H. MGA was mixed with ground milo so that each pound of grain contained approximately 0.4 mg. of MGA. This mixture was fed at the rate of one pound per head daily. The two lots which received no MGA were fed one pound of grain per head daily to equalize the effect of grain feeding among all lots.

Heifers were put on pasture November 11, 1968, and weighed off March 18, 1969, for a total of 126 days on pasture. Initial and final weights were taken following an 18-hour shrink (without feed and water). All lots had free access to wanter and a mineral mixture composed of two parts salt and one part steamed bonemeal. The stocking rate was about 1.5 acres per heifer. The pasture was divided into four equal lots and cattle were rotated between lots once each month.

Trial II.

Twenty lightweight Hereford and Angus heifer calves averaging 266 pounds were used to compare Diethylstilbestrol and Synovex-H. The calves were divided into two groups of 10 on the basis of weight. Lot 1 was implanted with 12 mg. of Diethylstilbestrol while Lot 2 received an implant of 20 mg. of estradiol and 200 mg. testosterone (Synovex-H).

Both groups grazed the same pasture and had no supplemental feed. Water and the mineral mix described in Trial I were available free-choice. The stocking rate in this trial was approximately two acres per head. Cattle were implanted and started on trial November 15, 1968 and final weights were taken on March 18, 1969 — a period of 122 days. Initial and final weights were taken following an 18-hour shrink.

Results and Discussion

Trial I.

Table 1 shows the gains of the four groups of heifers. The lot implanted with Synovex-H gained 16.9 percent more while those fed MGA gained 17.9 percent less than the control lot during the 126-day grazing period. The lot receiving both MGA and Synovex-H gained 7.5 percent less than controls.

The percentage increase in gain due to Synovex-H is similar to the improvement frequently observed in the feedlot. Feedlot studies with heifers of this weight have normally shown about an 11 percent improvement in gain when MGA was fed. The reason for the decreased performance of MGA-fed cattle in this study is not apparent.

Trial II.

Table 2 presents the results of the study comparing the effects of Diethylstilbestrol and Synovex-H on gains of lightweight heifers grazing wheat pasture. There was essentially no difference in the gains of the two groups of heifers. It is interesting to compare the gains of both lots of heifers in this study with those in Trial I. One factor which may account for greater gains in this trial is the lighter stocking rate and considerably more available forage. Another point to consider is the difference in weight since the heifers used in this study were about 165 pounds lighter than those in Trial I.

Table 1. Effect of MGA and Synovex-H Upon Weight Gains of Heifers Grazing Wheat Pasture[1]

Lot No.	1	2	3	4
Treatment	Control	MGA	Synovex-H	MGA + Synovex-H
No. of heifers	18	18	18	18
Initial wt. (lb.)	432	427	433	431
Final wt. (lb.)	565	537	589	555
Total gain (lb.)	133	110	156	124
Gain/day (lb.)	1.06	0.87	1.24	0.98
Gain index (%)	100.0	82.1	116.9	92.5

[1] MGA was fed at the rate of 0.4 mg./head/day mixed with ground milo; Synovex-H (20 mg. estradiol, 200 mg. testosterone) was implanted at the base of the ear.

Table 2. Effect of Diethylstilbestrol and Synovex-H Upon Weight Gains of Lightweight Heifers Grazing Wheat Pasture

Lot No.	1	2
Treatment	Diethylstilbestrol[1]	Synovex-H[2]
No. of heifers	10	10
Initial wt. (lb.)	262	270
Final wt. (lb.)	456	462
Total gain (lb.)	194	192
Gain/day (lb.)	1.59	1.57

[1] 12 mg. diethylstilbestrol implanted at the base of the ear.
[2] 20 mg. estradiol and 200 mg. testosterone implanted at the base of the ear.

MGA furnished by TUCO Products Company, Division of The Upjohn Company, Kalamazoo, Michigan.

Urea in Ruminant Nutrition

Allen D. Tillman

Story in Brief

Protein is one of the most important nutrients in the nutrition of man and his domestic and wild animals. Thus, it behooves him to use protein judiciously and to utilize substitutes whenever possible.

Urea can be made from the products of air and many workers have shown that urea plus grain may be used to replace vegetable protein supplements in beef, dairy and sheep rations providing the level of grain is high. Tillman (1) [1] has discussed in some detail how ruminants utilize urea and the reader is referred to this article for this background information. The purpose of this paper is to discuss the using of urea in the rations of beef cattle.

Introduction

Most beef fattening rations contain urea. The compound is mixed with other feeds to formulate a premix, which contains a high level of urea, minerals, vitamins, and other items considered important by the feeder such as antibiotics and stilbestrol. The premix is then mixed with other feeds in a mobile mixer while the feed is enroute from the weighing area to the feed bunk. Examples of such mixtures are shown in Table 1 (2,3). Urea consumption under these conditions will be from 0.15 to 0.20 lb./day, representing a protein potential of 0.4 to 0.5 lb.

Table 1. Percentage Composition of Premixes[1] for Beef Cattle Feeding.

Rations	Purdue 64	Iowa 80
Dried molasses	----	33.0
Cane molasses	14.0	----
Alfalfa meal	51.0	----
Bone meal	10.4	----
Iodized salt	3.5	----
$CaHPO_4$	----	20.0
$CaCo_3$	----	12.0
Trace minerals	----	1.0
Stilbestrol premix	----	2.0
Vitamin A mix	----	2.0
Urea	21.1	30.0
Total	100.0	100.0

[1] Beeson *et al.* (2)
[2] Burroughs *et al.* (3)

[1] Numbers in parentheses are references which appear at the end of the article.

In cooperation with USDA Agri. Research Service, Animal Husbandry Research Division.

Urea has been used in "all concentrate" diets and an example is shown in Table 2. It will produce results comparable to the vegetable protein supplements as was shown in North Carolina studies (4). Oklahoma studies (5) are shown in Tables 3 and 4 in which milo was the grain. One-hundred and ten steers were used in these trials and treatments did not affect ($P<.05$) animal performance; however it will be noted that rations containing urea produced greater financial returns than those containing the vegetable protein supplement. An interesting aspect of this study concerns the improvement obtained by adding alfalfa meal to the urea-containing ration even though the mineral content of that ration met requirements as set forth by the National Research Council. Other workers have also found that alfalfa hay improved similar rations.

Results and Discussion

In general, it may be considered that 7 lb of milo plus 1 lb. of urea (45 percent N) will be isonitrogenous with 8 lb. of a vegetable protein supplement. If urea sells for 4 cents, milo 2 cents and cottonseed meal 4 cents/lb. the following calculations are relevant to the economics of urea utilization in fattening rations:

Table 2. Percentage Composition of an All-Concentrate Diet for Beef Cattle.[1]

Ingredient	Percent
Ground shelled corn	95.1
Urea	1.0
Cottonseed oil	2.0
NaCl	0.5
$CaCO_3$	0.7
Defluorinated phosphate	0.2
Trace minerals	0.4
Vitamin A & D	0.1
Total	100.0

[1] Wise *et al.* (4)

Table 3. Percentage Composition or the Diets[1]

	Diets				
Ingredients	1	2	3	4	5
Ground milo	87.50	84.75	96.25	91.50	87.70
Dehydrated alfalfa	-- --	5.00	-- --	5.00	5.00
Cottonseed meal	8.10	7.00	-- --	-- --	3.20
Urea[1]	-- --	-- --	0.96	0.84	0.46
Premix	4.40	3.25	2.77	2.66	3.59
Total	100.00	100.00	100.00	100.00	100.00

[1] McCartor and Tillman (5)

Table 4. Feedlot Performance of Steers (143 Day-Test)[1]

Item	CSM[2]	CSM+D[3]	Urea (u)[3]	U+D	CSM+U+D
Animal, Nos.	23	21	23	22	18
Final weight, lb.	1070	1050	1055	1066	1056
Initial weight, lb.	716	714	714	722	721
Daily gain, lb.	2.48	2.35	2.38	2.40	2.34
Daily feed, lb.	19.99	19.72	19.77	19.83	19.53
Feed/lb. gain, lb.	8.06	8.39	8.31	8.23	8.35
Final value-dollars[4]	273.00	268.00	269.00	272.00	269.00
Initial value-dollars	200.00	199.50	199.50	202.00	202.00
Increase-dollars	73.00	68.50	69.50	70.00	67.00
Feed cost-dollars[5]	66.92	60.06	55.99	55.02	55.50
Return over feed-dollars	6.08	8.44	13.51	14.98	11.60

[1] McCartor and Tillman (5)
[2] CSM=Cottonseed meal
[3] D=Dehydrated alfalfa meal
[4] Appraisals used for initial and final values.
[5] Actual feed cost only.

Cost of protein from cottonseed meal will be 8 X 4 = 32 cents.
Cost of protein from urea + grain:

Urea	1 X 4 =	4 cts.
Grain	7 X 2 =	14 cts.
Total		18 cts.

The costs of 18 vs. 32 cents for 8 lb. of feed, is significant, and is of course, reflected in the financial statement of the Oklahoma results.

The major problem in beef cattle nutrition concerns the poor utilization of urea by mature cows allowed to graze low-protein forages during the winter season. Such forages are, of course low in protein, phosphorus, certain trace minerals, and available energy. Vegetable protein supplements, such as cottonseed meal and soybean meal, have always found wide usage as supplements when cattle are allowed to graze these forages during the winter season. As there is great demand for the vegetable protein supplements for feeding of poultry and swine, and even in human nutrition, the price per unit of nitrogen is higher for these products as compared to urea-grain mixtures; therefore, economics dictate the usage of urea in range supplements.

Early Oklahoma research (6) indicated that urea could be used in range supplements if the level of urea in the mixture was low. However, in later Oklahoma studies involving 16 tests using 879 cattle in which urea supplied one-third of nitrogen in the supplements which were isonitrogenous with cottonseed meal, it was found (7) that animal performance was always lower on the urea supplements even though the urea containing supplements were always improved by addition of trace minerals or alfalfa meal. Many feedmen and applied nutritionists often forget that

urea is a pure compound and that it replaces a vegetable protein supplement, which contains phosphorous, trace minerals, and energy. Urea must be fed in balanced rations for good results.

Another factor to consider in urea utilization on the range concerns the amount of energy in the supplement. Oklahoma results (8) indicate that the supplement should contain a N.F.E.:N ratio of at least 30:1 and that urea-containing rations, in which grain is the carrier should not contain over 2 percent urea. Higher levels of urea produce poorer results than when vegetable protein sources are the control rations.

Berry *et al.* (9) fed range cattle a liquid mixture compound of cane molasses, urea, phosphoric acid, trace minerals and vitamin A. The supplement contained about 10 percent urea and the phosphoric acid content was varied so as to regulate intake when the mixture was fed free choice. It is believed that the slow rate of intake improved urea utilization but definitive experiments have not been conducted. Because of their labor saving potential, liquid supplements are finding increasing interest and use in Oklahoma. In most of these supplements, intake is also limited by mechanical means. If labor is not a factor, the liquid supplements, during most years, cannot compare economically with vegetable protein supplements or with supplements containing grain plus urea. Molasses are lower in energy and are a more expensive source of energy as compared to milo. The liquid supplements must be protected from rain or toxicity will result; water will dissolve the urea and the animal will drink this in the absence of a carbohydrate source.

A major difficulty of feeding urea supplements concerns possibility of urea toxicity. Oklahoma workers (10) have studied in detail urea toxicity symptoms and these are as follows:

1. From 30 to 60 minutes after ingesting urea, steers showed uneasiness, staggering and kicking at the flanks.
2. These symptoms were followed by more serious incoordination, tetany and finally prostration.
3. These animals went down within 30 to 60 minutes after dosing. While prostrate, the most pronounced symptoms of distress were severe convulsions, slobbering at the mouth and bloating.
4. Ammonia levels of rumen contents were high. This was quickly followed by high ammonia levels in peripheral blood.
5. Blood urea levels were high but cannot be taken as an indicator of severity of toxicity. When tetany begins, blood urea levels begin to drop.
6. Bloating was always present and the rumen contents had pH readings consistently above 8.0.

7. The amount of urea necessary to produce toxicity was about 14 grams per 100 lb. body weight.
8. All animals were dead within one to three hours after dosing.

Florida workers (11) repeated and extended the Oklahoma experiment and found that acetic acid, if administered prior to the onset of tetany, would alleviate toxicity symptoms. It required 2 moles of acetic acid for each mole of urea consumed. For example, a 1000 lb. cow required about 140 gm. of urea to cause toxicity. It would require 280 gm. of pure acetic acid to neutralize the amomnia liberated by catalysis of the urea. Since concentrated acetic acid would cause phosiological harm to the animal, it is diluted to a 5 percent v/v solution and pumped directly into the rumen. If the 280 gm. of acetic acid needed is converted to volume of 5 percent solution, it is found that 4600 ml. are needed. As vinegar contains about 5 percent acetic acid, about one and one-half to two gallons of vinegar would be just as effective.

Later Oklahoma work indicated (12) that a second dose of acetic acid or vinegar given about 160-170 min. after the first prevents reappearance of urea toxicity symptoms. The second dose should be one-half as much as the first dose, about one gallon of vinegar.

Oklahoma workers (13) conducted further research on feeding conditions which might cause urea toxicity and their results indicate that there are predisposing factors which increase the susceptibility of cattle and sheep to urea toxicity. These are as follows:

1. Animals which have never consumed urea appear to be the most susceptible.
2. Animals which have previously been consuming only low-nitrogen roughages and are in a semi-starved condition will consume urea-containing feed rapidly.
3. Individual animals within the herd which are aggressive and consume their feed rapidly are more susceptible. In many cases where urea toxicity in the field has occurred, the rancher reports that his best animals were the victims.
4. Animals which have had previous access to urea-containing feeds will consume the diet slowly and will not consume enough urea to cause toxicity. In Oklahoma studies, sheep weighing 75 lb. have consumed over 80 grams of urea per day but consumption was slow; the animals simply nibble the feed and spend much more time at the feed trough. Also cattle weighing 500 lb. consumed in a similar manner over 400 grams of urea with no toxicity symptoms becoming apparent.

Oklahoma workers (12) produced urea toxicity symptoms in pregnant cows by drenching at two stages in the gestation cycle, 90 days and 4½ months after breeding. When toxicity symptoms became apparent

(15 min. after urea administration), 5 percent acetic acid was pumped via stomach pump directly into the rumen; the urea: acetic molar ratio was 2:1. After an elapse of 165 min., acetic acid at a urea: acetic ratio of 1:1, was administered as before.

Rumen fluid and blood ammonia levels were high in all treated cows at the time of acetic acid administration and urea toxicity symptoms were apparent. In fact, several animals died in spite of all precautions. When acetic acid was administered rumen fluid blood ammonia levels dropped quickly and the cows showed no signs of distress. All cows, which recovered, completed the normal term of pregnancy and produced normal calves. Subsequent breeding performance was as good as that obtained in the controls. Thus it appears that if pregnant cows recover from urea toxicity symptoms that reproductive performance is not affected.

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Reproductive Performance of Ewes Involved in A Twice-Yearly Lambing Program

W. A. Zollinger, M. B. Gould, S. V. Tennery, and J. V. Whiteman

Story in Brief

Over a four year period, 182 ewes produced 1,049 lambs or an average of 1.86 lambs per ewe annually. Seven hundred and ninety five or 75.8 percent, of these lambs were produced in the spring lambing season. Of 537 ewes having an opportunity to conceive in the spring, only 188, or 35 percent, actually lambed the following season; whereas, of the 591 ewes, 495, or 85 percent, conceived in the fall and lambed in the spring. These results are associated with the fact that 71 percent of the ewes lambing in the fall rebred and conceived, but only 23 percent of the spring lambing ewes rebred and conceived. Also, spring lambing ewes required 27 more days to rebreed post-partum and had a 22 day longer interval from lambing to conception than did the fall lambing ewes.

A comparison of breed differences indicated post-partum performance was low for all three breeds studied. Of these breed groups, a lower percentage (16 percent) of the Rambouillet group lambed, rebred and conceived in the spring; however, in the fall a larger percentage (81 percent) of the Rambouillet ewes conceived post-partum than either of the other breed groups. Just the reverse trend was observed in Dorset ewes. The interval from lambing to conception was slightly shorter for Ram bouillets and longest for crossbred ewes in both seasons. With respect to lamb production, crossbred ewes produced more lambs per ewe per year (2.07) than either the Dorset or Rambouillet ewes, 1.77 and 1.73, respectively. Also, crossbred ewes produced more lambs per ewe lambing in both the spring and fall seasons; however, Rambouillet ewes raised a larger percent of lambs born.

Introduction

Presently sheepmen with limited capital and resources are searching for management practices whereby they can intensify their production programs. In general, two methods may be employed: (1) increase the number of lambs born per ewe at each lambing, or (2) increase the number lambings per year. Since a ewe has difficulty producing and raising three or more lambs at a time, the latter production method would appear more feasible.

Ewes have been known to produce more than one lamb crop within a one year period. Possible programs include lambing every six months,

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thus producing two lamb crops within a one year period, or lambing every eight months which results in three lamb crops within a two year period. In 1963, Oklahoma State University initiated a program of twice-yearly lambing at the Fort Reno Livestock Research Station to evaluate the problems associated with such a program. This paper presents results relative to the ewe reproductive performance under this program.

Materials and Methods

The breeding flock consisted of 182 ewes, of which 60 were of Dorset breeding, 60 of Rambouillet breeding, and 62 of the cross between these two breeds. Ten crossbred ewes were obtained from the existing ewe flock at Fort Reno. The other 52 crossbred ewes and 60 Dorset ewes were purchased from various flocks within Oklahoma. The 60 Rambouillet ewes were obtained from several sources in Texas. In 1963, sixty spring-born ewes (20 of each breed group) were purchased. Sixty fall-born ewes of similar origin were obtained about six months later. In 1964, another purchase of 60 spring-born ewes completed the breeding flock.

The ewes were purchased from flocks that normally were lambed both in the fall and late winter or early spring. As the ewes were obtained, they were added to the flock and each group was first bred when they were approximately one year of age. Thus, part of each breed group were bred first in the fall and the remainder during the spring seasons.

The following breeding, lambing and management procedures were followed:

1. Figure 1 illustrates the breeding and subsequent lambing periods used in this twice-yearly lambing program. Spring breeding extended for a 60 day interval beginning on April 20 and continuing through June 19; thus, fall lambing began about September 15 and ended about November 15.
2. Similarly, fall breeding extended for 60 days from October 20 through December 19, and spring lambing extended from March 15 through May 15.
3. Ewes lambing more than ten days prior to the next breeding season were exposed to a vasectomized teaser ram daily to detect estrous

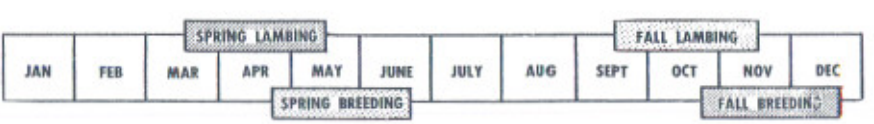

Figure 1. Breeding and Subsequent Lambing Periods Associated with a Twice-Yearly Lambing Program.

until the breeding season began, after which they were exposed to fertile rams. Later lambing ewes were exposed to a fertile ram approximately ten days after lambing. Both marking harness and visual observations were used to detect ewes in heat.

4. For approximately three days post-partum, the ewe and her lamb (s) were confined to a small pen. Afterwards, they were transferred to a large pen with about ten other ewes and their lambs. Here the lambs were docked, and after approximately one week, the animals were released into the main lots.
5. All lambs were weighed biweekly and were weaned when they reached a minimum age of 66 days and a minimum weight of 50 pounds. Upon weaning, the lambs were moved to a finishing feedlot.
6. In an effort to make a record of ewe's condition relative to fatness, all ewes were weighed and scored (for fat covering) prior to each lambing season and at the end of each breeding season.
7. All ewes were shorn about one week before spring lambing began and tagged about one week before fall lambing began.
8. Fall lambing ewes were supplemented with one pound of milo daily plus alfalfa hay during the last month of gestation and during the lactation period. In addition, the ewes and their lambs were allowed to graze on wheat pasture. After weaning the ewes were returned to a separate pasture with the other dry ewes.
9. Spring lambing ewes were similarly supplemented and were allowed to graze on small grain or a bermuda grass-alfalfa pasture. However, in an effort to reduce internal parasite infestation in the spring-born lambs, they were not allowed to graze but were retained in the dry lot while the ewes grazed.

Results and Discussion

Table 1 presents a summary of the reproductive performance of ewes under this program. Records were available for the lamb crops produced

Table 1. Summary of Reproductive Performance of Ewes on a Twice-Yearly Lambing Program.

Item Year	Fall 1964,65,66,67	Spring 1965,66,67,68	Total 1964-68
No. Ewe seasons[1]	537	591	1,128
No. Ewes lambing	188	495	683
% Ewes lambing	35	84	60
No. lambs born	254	795	1,049
Lambing rate[2]	1.35	1.60	1.53
No. lambs reared	202	726	928
% lambs reared	79.5	91.3	88.5

[1] Number of records available
[2] Based on ewes that lambed

from the fall of 1964 to the spring of 1968, inclusive. In that time period the equivalent of 1,128 ewes had an opportunity to lamb, but only 683 or 60 percent actually lambed. These 683 ewes produced 1,049 lambs, or an average of 1.53 lambs per ewe lambing. The survival rate on these lambs was 88.5 percent or, of the 1,049 lambs, 928 were reared.

When one figures that one ewe in the total constitutes two ewe seasons, then 564 ewes had an opportunity to lamb twice each year. Using these data, each ewe in the flock produced an average of 1.86 lambs per year. An estimate of average herd production in Oklahoma would be approximately 1.15 lambs per ewe. Although the figure 1.86 represents a marked increase in production, the lambing rate potential should be approximately double that of a normal production program. Since this figure is not double, where does the program fall short of its potential?

Spring vs. Fall Performance

Table 1 indicates a marked difference in the two seasons' performances. Of the 537 ewes having an oppotrunity to lamb in the fall, 188 or 35 percent lambed; whereas, in the spring 84 percent or 495 of 591 ewes lambed. These results are in response to the breeding performance in the alternate season, i.e., ewes lambing in the fall season must breed and conceive in the spring and vice versa. The number of ewes lambing in the fall indicates lower conception performance in the spring.

The primary emphasis should be placed on getting a ewe to lamb and then rebreed in time to produce another lamb the next season. Table 2 presents data collected on ewe post-partum performance. Of the 188 ewes lambing in the fall, 159 or 85 percent remated; whereas, only 50 percent (248 of 495 ewes) remated in the spring. From these data, more ewes are likely to become pregnant in the fall than in the spring. Of the 188 ewes lambing in the fall, 134 or 71 percent rebred and conceived, while only 113 of the 495 (23 percent) ewes lambing in the spring con-

Table 2. Post-Partum Breeding Performance of Ewes Involved in a Twice-Yearly Lambing Program.

	Fall	Spring
No. ewes lambing	188	495
Av. lambing date	Oct 12	Apr 4
No. ewes mating	159	248
% ewes mating	85	50
Av. int. lambing to first mating	32	59
No. lamb., rebred, conc.[1]	134	113
% lamb., rebred, conc.[1]	71	23
Av. int. lamb. to conc.	44	66
Av. conc. date[1]	Nov 29	June 1

[1] Indicates those ewes that lambed, rebred and conceived

ceived. Relative to lamb production, 795 or 75.8 percent of the 1,049 lambs produced under this program were born in the spring season. These differences indicate that the ewes were more sexually active and fertile in the fall. Since the ewe's natural breeding period is in the fall, one could expect these observations. More information is obtained when studies are made of the intervals from lambing to first mating and conception.

Intervals Associated with the Program

In order to sustain a continuous program of twice-yearly lambing, a ewe must lamb, rebreed and conceive within 35 days. A ewe on such a program will carry lambs for 294 days out of the year (147 day gestation period); thus, within the remaining 71 days, she must lamb, rebreed and conceive twice. Table 2 presents averages relative to these post-partum intervals. Ewes lambing and remating in the fall had an average interval of 32 days to first mating. This length would allow slightly more than half of the ewes to remate within the required limits outlined; however, the spring interval is an average of 27 days longer or 59 days. This interval length lowers the efficiency or potential of the program.

An examination of the interval from lambing to conception indicates that a large percentage of the ewes in both the spring and the fall did not conceive soon enough to maintain a successful program over a period of years. Ewes that conceived required an average of 44 days post-partum in the fall but required 22 additional days or 66 days to conceive in the spring.

The evaluation of this program indicates where further studies need to be done. Before a program of twice-yearly lambing can be successfully installed into production, these intervals, especially the intervals within the spring season, need to be shortened. Ways need to be discovered to increase the sexual activity and fertility of ewes in the spring season.

Breed Comparisons

One of the primary objectives of the program was the evaluation of the performance of the three breed groups. Table 3 summarizes the performance of the three breeds within each season. A smaller percentage of the Rambouillet ewes lambed in the fall than either Dorset or crossbred ewes, indicating that less Rambouillet ewes conceived in the spring. Although approximately the same percentage of the three breeds lambed and remated in the fall, fewer Dorset ewes (56 percent) conceived to these matings than either crossbred (77 percent) or Rambouillet ewes (81 percent). The average intervals from lambing to first mating and conception were approximately the same length for the three breed groups.

Table 3. Reproductive Performance of Dorset, Rambouillet and Dorset x Rambouillet Ewes Involved in a Twice-Yearly Lambing Program.

Breed group[1]	Season: Fall D	Fall D x R	Fall R	Spring D	Spring D x R	Spring R
No. ewe seasons[2]	163	189	185	178	207	206
No. ewes lambing	60	74	54	132	178	185
% ewes lambing	37	39	29	74	85	89
No. ewes remated[3]	48	65	46	82	96	70
% ewes remated	80	87	85	62	53	37
No. ewes lamb. rebred. conc.	34	56	44	36	46	31
% ewes lamb. rebred. conc.	56	77	81	26	25	16
Av. conc. date[4]	Nov 21	Dec 7	Nov 25	May 31	June 2	May 23
Av. intv. lamb-1st matg.	32	32	33	52	63	65
Av. intv. lamb-conc.	44	46	41	63	68	66
No.. lambs born	81	105	68	220	305	270
Lambing rate[3]	1.35	1.41	1.25	1.66	1.71	1.45
No. lambs reared	56	86	60	194	280	252
% lambs reared	69	81	88	88	91	93

[1] D=Dorset, D x R=Dorset x Rambouillet, R=Rambouillet
[2] Number of records available for each season
[3] Based on the ewes that lambed
[4] Based on those ewes that lambed, rebred, and conceived

With respect to lamb production, the crossbred ewes produced more lambs per ewe lambing, 1.41, than the Dorset or Rambouillet ewes, 1.35 and 1.25 respectively. Rambouillet ewes raised a larger percentage (88 percent) of their lambs than did the crossbred (81 percent) and Dorset (69 percent) ewes; however, a larger number of lambs from crossbred ewes were actually born and reared.

The spring performance indicated that although a higher percentage of the Rambouillet ewes lambed, only 37 percent remated as compared to 62 percent of the Dorsets remating and 53 percent of the crossbred ewes remating. Of the ewes lambing, only 16 percent of the Rambouillets conceived post-partum; whereas, 26 percent of the Dorset ewes and 25 percent of the crossbred ewes conceived. Although these percentages are low for all three breeds, the latter two have an advantage over the Rambouillets. An examination of the intervals indicated that although Dorset ewes mated an average of 10 days earlier (52 vs. 63 days) than the other two breeds, the three breeds conceived at approximately the same time after lambing.

An examination of lamb production indicated the same trend as was seen in the fall. Crossbred ewes produced more lambs per ewe lambing, 1.71, than either Dorset ewes, 1.66, or Rambouillet ewes, 1.45, but were intermediate in the percentage of lambs raised. The crossbred ewes also raised more lambs (280) than either Rambouillet (252) or Dorset

ewes (194). Table 4 presents combined lamb production over the two seasons. The 198 crossbred ewes produced 410 lambs or an average of 2.07 lambs per ewe; whereas, the Dorset ewes produced 1.77 lambs per ewe and the Rambouillet ewes produced 1.73 lambs per head. Although crossbred ewes tended to have an advantage in number of lambs produced, it is believed that none of the three breeds performed up to the potential of this management program.

Table 4. Lambing Rate Under a Twice-Yearly Lambing Program.

Breed group[1]	Spring and Fall		Combined
	D	D x R	R
No. of ewes	170	198	195
No. of lambs born	301	410	338
Flock lambing rate[2]	1.77	2.07	1.73

[1] D=Dorset, D x R=Dorset x Rambouillet, R=Rambouillet
[2] Lambs born per ewe in the flock per year within breed

The Association Between Potassium^{40} Measurement and Measures of Leanness in Swine

B. D. Moser, L. E. Walters, J. V. Whiteman, J. C. Hillier, & G. V. O'Dell

Story in Brief

Potassium^{40} gamma radiation measurements were made in 1968 on fifty-three Yorkshire barrows representing five weight groups: 100, 150, 200, 250 and 300 pounds. Each pig was taken off feed and "counted" at each weight interval, irrespective of final slaughter weight, and was placed back on feed until it reached the predetermined slaughter weight. The pigs were slaughtered at their pre-determined slaughter weight immediately following live counting. The carcasses were counted and then cut into standard wholesale cuts; the right side was separated into lean, fat, and bone.

Correlation coefficients between first and second K^{40} counts were determined on the live animals and the carcasses to determine how well counts taken at different times agreed. Correlations between first and second carcass K^{40} counts were in closer agreement than those obtained

In cooperation with USDA Agri. Research Service, Animal Husbandry Research Division.

for the live animal. From studies designed to find out how important length of counting time may be, there was essentially no difference between 10, 20, and 30 minute counting times for the live animals.

Correlations between K^{40} counts on live hogs, and pounds of fat-free lean and percent fat-free lean increased as live weight increased. This is interpreted to mean that the counts predicted the fat-free lean in the heavier weight hogs better than in the lighter weight hogs. The higher correlations for the heavier weights suggested that the procedure was more reliable than in the lighter weights. Similar trends held true for correlations among K^{40} counts on live hogs and lean cuts through the 250 pound weight group. Correlations between carcass K^{40} counts and lean cuts or fat-free lean followed basically the same trend as for the live animal—being higher in the heavier weights and lower in the lighter weights.

Introduction

The increased emphasis placed on muscling in meat animals in recent years has brought about a greater need for more accurate means of evaluating live animals with respect to fat and muscle development. Through their buying practices, consumers have expressed a strong preference for meatier, heavier muscled retail cuts of meat with a minimum of trimmable fat. Animals of similar ages and market weights have been shown to differ greatly in the lean-to-fat ratio in their carcasses. These differences are observed not only within breeds but also within family lines as well as within sire progency. Since most carcass traits are moderately to highly heritable, more effective tools than are now available for meat animal appraisal are needed to estimate more accurately the body composition of animals for breeding purposes, as well as for slaughter.

These studies involved the use of a new concept in live animal appraisal, the whole-body K^{40} counter.

Principle of the K^{40} Counter

This method makes use of two basic principles:

(1) Most of the potassium in the body of a live animal is found in the muscle.

(2) Potassium contains a fixed proportion of naturally occurring radioactive atoms (called K^{40}, hence the name) which give off very small amounts of gamma radation which may be measured.

In view of these principles, if K^{40} can be measured accurately, it follows that the amount of K^{40} present in a substance should become useful

as a predictor of total potassium. Total body potassium then, may, in turn become useful as a predictor of total lean (muscle) in the animal since much of the potassium in an animal is found in the muscle. The instrument is designed to measure the K^{40} gamma-ray emission from the live animal. The gamma-rays emitted by K^{40} enter a "detector" and upon entry produce very minute bursts of light (scintillations). These scintillations are fed into a light sensing mechanism, the photo-multipler tube, which converts the light energy into amplified electrical signals that can be counted electronically.

Methods and Materials

Fifty-three Yorkshire barrows averaging 62 pounds were randomly alloted by slaughter weight groups — 100, 150, 200, 250, or 300 pounds. Each pig was taken off feed and "counted" at each weight interval, irrespective of final slaughter weight and was placed back on feed until it reached the pre-determined slaughter weight. The pigs were self-fed a milo-soybean meal ration containing 16 percent protein.

In preparation for counting, feed and water were removed from the pigs 36 hours prior to counting and they were thoroughly washed to remove possible potassium containing foreign materials. They were then placed in the counter in a suitable restraining crate allowing for comparable positioning of the animal in the counter among readings. The net K^{40} count for each animal was obtained in the following manner: two 10-minute background counts (to determine environmental radiation) were obtained for each animal by measuring the background K^{40} activity of the empty counter, one prior to, and one immediately following the 10-minute counting period for the animal. The average of the two background measurements was subtracted from total count (animal count + environmental gamma radiation) to obtain net K^{40} count for each animal at each counting period. This total count was converted to counts per minute, which was used in the analysis of the data. This counting procedure was repeated for each animal with an interval between the first and second counting of not less than one hour nor more than four hours.

Ten, 20, and 30 minute counting periods were used to determine the possible influence of length of counting time on repeatability of K^{40} measurement on the same pig the same day. As animals reached the predetermined slaughter weight, they were counted and slaughtered on the same day.

At the time of slaughter, the unsplit carcasses were mounted on a carcass rack in such a way as to simulate the standing position of the live pig. This was done in order to study possible effects and interrelation-

ships of "dress-off" items on net K^{40} count. The counting procedure used for the carcasses was the same as that for the live animal—obtaining a 10-minute net count. The right side of each carcass was then separated into standard trimmed wholesale cuts following the procedure described by the American Meat Science Association. Weights of all cuts as well as total separable lean, fat and bone were obtained.

The total separable lean mass from the right side of each carcass was ground once through a 3/8" meat grinding plate and thoroughly mixed. The lean mass was then ground and mixed in a combination meat mixer-grinder through a 1/8" plate. As the mass came from the mixer-grinder, two sets of four grab samples each were randomly taken and placed in airtight sample jars for storage and subsequent proximate chemical analysis. These analyses included moisture, ether extract (fat), protein, and ash determinations. Percent fat-free lean in the carcass (and live animal) was determined by subtracting the ether extract from total separable lean.

The data were analyzed to determine (1) the degree to which the K^{40} counter repeated itself and (2) the association between net counts per minute and pounds of lean cuts (trimmed ham, loin and shoulder) and fat-free lean; and percent lean cuts and fat-free lean, both live and in the carcass.

Results and Discussion

Correlation

In order for any method or tool to be of value in a research effort, it must first of all be repeatable. The term *repeatable* means that two independent counts taken on the same animal on the same day are in close agreement. Studies were made to determine the degree to which this instrument would repeat itself. To accomplish this, it became necessary to calculate the degree of association between variables under investigation. For example, coefficients were calculated to express the association between two K^{40} counts on the same animal at different times on the same day and which became important criteria for measuring the dependability of a procedure.

Correlation coefficients range from —1.0 to +1.0. A high positive correlation would mean strong agreement between two readings. A correlation near zero would mean little agreement and unreliability in the procedure.

Live Animal Studies

The correlation coefficients between first and second live K^{40} counts for three different lengths of counting time (10, 20, and 30 minutes) and

for five different weight groups are presented in Table 1. The correlation coefficients between the two 10 minute counting periods ranged from +.61 to +.94. These correlations were all significant ($P < .01$). These positive coefficients indicate that there was fair to good agreement between the two readings and thus the instrument was found to be repeating itself fairly well.

There was a trend for correlations to be lowest in the lighter weights and highest in the heavier weights. The correlations for the 20 and 30 minute counting periods followed the same general trend with a range of +.44 to +.90 for the 20 minute period and +.53 to +.90 for the 30 minute period. These data indicate that increasing the counting periods to 20 and 30 minutes did not increase the agreement between first and second live counts. Therefore, the 10 minutes counting period was used in the analysis of the data when correlations were obtained between count and measures of leanness.

Table 2 presents the correlation coefficients between first and second live K^{40} counts and the average of the two live counts for each weight group taken on the same day with pounds of lean cuts and fat-free lean and the percent of lean cuts and fat-free lean. The correlations obtained for the 100 pound weight group between count and pounds of lean cuts ranged from —.37 to +.07 and between count and percent lean cuts ranged from —.08 to +.41. When count and pounds of fat-free lean and count and percent fat-free lean were considered, the range was —.05 to 0 and +.24 to +.26 respectively. These correlations proved to be low and non-significant, meaning that there was little agreement between count and lean cuts expressed as pounds or as percent.

The 150 pound weight group showed basically the same trend. The range of correlations between count and lean cuts and count and fat-free lean was +.18 to +.47 and —.18 to +.07, respectively. The negative correlations obtained in the 100 and 150 pound weight groups show a

Table 1. Correlation Coefficients Between First and Second Live K^{40} Counts Per Minute

[Length of Counting Time (Minutes)]

Group	Ave. Live Wt.	10 N	10 r	20 N	20 r	30 N	30 r
1	103	(49)	.72**	(23)	.57**	(24)	.66**
2	151	(40)	.61**	(18)	.44*	(18)	.53*
3	199	(32)	.77**	(15)	.85**	(15)	.86**
4	250	(22)	.76**	(10)	.90**	(10)	.90**
5	296	(9)	.94**				

N = number of animals
r = correlation coefficient
* ($P < .05$)
** ($P < .01$)

Table 2. Correlation Coefficients Between K^{40} Live Counts Per Minute and Measures of Leanness

[Weight Group at Slaughter (Pounds[1])]

Measures of Leanness	K^{40} Counts	100		150		200		250		300	
		Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	%
Lean Cuts	First	—.37	—.08	.47	.43	.38	.96**	.91**	.83**	.48	.52
	Second	.07	.41	.25	.18	.52	.49	.78**	.81**	.72*	.71*
	Average	—.20	.16	.39	.33	.48	.45	.88**	.86**	.61	.63
Fat-Free Lean	First	—.04	.24	.07	.05	.62**	.58	.92**	.84**	.82**	.71**
	Second	0	.26	—.14	—.18	.56	.52	.72*	.74**	.83**	.79*
	Average	—.05	.24	—.04	—.07	.62*	.58	.85**	.83**	.84**	.82**

[1] Eleven animals in all weight groups except 300 pound, (with 9).
* ($P < .01$)
** ($P < .05$)

reverse order agreement; as count went up, lean cuts and fat-free lean went down; and thus in this case, the method proved to be unreliable.

The correlations obtained between count and measures of leanness for the 200 pound weight group were higher than in the case of the lighter weight groups discussed above. The correlation between count and lean cuts and count and fat-free lean ranged from +.38 to +.96 and +.52 to +.62, respectively. Although there were some significant correlations in this group, there still was a low agreement between count and lean cuts or count and fat-free lean for this weight group.

The correlations for the 250 pound weight group were substantially higher than those previously discussed for the lighter weights. These correlations were all significant ($P < .05$) and most were highly significant ($P < .01$). The range in correlations for this group was +.78 to +.91 between count and lean cuts and +.72 to +.92 between count and fat-free lean. These relationships indicate that the live K^{40} counts per minute were highly associated with pounds and percent lean cuts as well as pounds and percent fat-free lean. In this case the counter proved to be rather precise as a predictor of leanness. Similarly, live K^{40} counts per minute were found to be significantly associated with pounds and percent fat-free lean in the 300 pound weight group with a range of +.71 to +.84 which were all statistically significant ($P < .05$), also indicating close agreement between counts and measures of leanness. Correlations obtained between count and lean cuts were not as high, for this group, as those for count and fat-free lean, with only two (+.72 and +.71) being significant ($P < .05$).

There was a trend toward higher correlations between K^{40} count and both pounds and percent of fat-free lean with increase in live weight. When K^{40} count and pounds or percent lean cuts were correlated, a similar trend was noticed through the 250 pound weight group. Correlations

between count and lean cuts for the 300 pound weight group, however, were lower than in the 250 pound group. There is no explanation for the apparent decrease in accuracy considering these variables in this weight group.

Carcass Studies

Table 3 presents the correlation coefficients for the first and second carcass counts for the respective weight groups. As with the live animal, the counting period was for 10 minutes. Correlations between counting times in all weight groups were found to be significant ($P < .01$ and ranged from +.88 to +.96. This is interpreted to mean that the readings from the instrument from one count to another on the same day were in good agreement. Between-count correlations are expected to be higher for carcasses than for the live animals because the carcasses were held firmly in place and at a fixed distance from the detectors, and the counts were not influenced by inedible offal such as hair, gastro-intestinal tract and contents.

The data presented in Table 4 indicates the same general trend as was found for the live animals; namley, lower correlations in the lighter weights and higher correlations in the heavier weights. The correlations

Table 3. Correlation Coefficients Between First and Second Carcass K^{40} Counts Per Minute[1]

Group	Carcass Weight (lb.)	Number of Carcasses	Correlation Coefficients
1	71	11	.91**
2	108	11	.88**
3	146	11	.92**
4	187	11	.89**
5	224	9	.96**

** ($P < .01$)
[1] 10 minute counting period

Table 4. Correlation Coefficients Between K^{40} Carcass Counts per Minute and Measures of Leanness (Pounds)
[Weight Groups at Slaughter (Pounds)]

K^{40} Counts Per Minute	100		150		200		250		300	
	Lean Cuts	Fat-Free Lean	Lean Cuts	Fat-Free Lean	Lean Cuts	Fat-Free Lean	Lean Cuts	Fat-Free Lean	Lean Cuts	Fat-Free Lean
First	.25	.14	.74*	.40	.26	.69*	.60	.60	.73*	.80**
Second	.19	.17	.50	.24	.31	.74*	.70*	.72*	.81**	.85**
Average	.22	.16	.60	.33	.29	.73*	.66*	.67*	.78*	.83**

* ($P < .01$)
** ($P < .05$)

for the 100 pound weight group ranged from +.14 to +.25 between carcass K^{40} count and pounds of lean cuts and fat-free lean. These correlations were low and non-significant. The correlations between carcass K^{40} count and pounds of lean cuts or fat-free lean for the 150 pound weight group were also non-significant with the exception of the one +.74 between first count and pounds of lean cuts. In the 200 pound weight group, correlations between carcass K^{40} count and pounds of fat-free lean were all statistically significant ($P < .05$) with a range of +.69 to +.73. When count was correlated with pounds of lean cuts none of the three was significant.

In the 250 pound weight group, all correlations were significant ($P < .05$) with the exception of the correlation between first count and pounds of lean cuts or fat-free lean. The range for this group was from +.60 to +.72. There was a substantial increase in the correlations for the 300 pound group over those previously discussed for the lighter weight groups. The correlation between count and lean cuts and count and fat-free lean was from +.73 to +.85, which were all significant ($P < .05$) and most were highly significant ($P < .01$). This suggests that there was good agreement with both K^{40} count and pounds of lean cuts as well as K^{40} count and pounds of fat-free lean.

Heritability Estimates and Phenotypic Correlations for Various Measures of Carcass Meatiness in Swine[1]

V. G. Arganosa and I. T. Omtvedt

Story in Brief

Swine carcass data were analyzed to estimate heritabilities and phenotypic correlations among various measures of carcass meatiness. The results revealed that the various measures of meatiness, such as percent lean and ham-loin index, tended to be highly heritable ($h^2 \geqslant .40$). Ham-loin index was more closely correlated with total lean-cut weight and percent lean cuts than was loin eye area but showed no advantage over percent ham of slaughter weight. Ham-loin index accounted for 71 percent of the variation in percent lean of live weight, while percent ham of slaughter weight accounted for 69 percent of the variation in percent lean of live weight.

Introduction

Ham-loin index is commonly used in pork carcass evaluation as a measure of muscling. However, the heritability of this measurement or its relationship to other measures of carcass merit are not known. This study was initiated to estimate the heritabilities of various measurements of carcass meatiness and to determine the phenotypic correlations among them.

Methods and Materials

The data used in this report was collected from 1964 fall through 1966 fall involving 650 pigs out of 280 dams, 89 sires and seven lines of breeding. All pigs were self-fed in confinement in groups of six pigs per pen from approximately eight weeks of age to 200 pounds live weight. Carcasses were evaluated 48 hours after slaughter.

Closely trimmed hams, loins, and shoulders were used to evaluate meatiness. These three lean cuts were expressed as total lean-cut weight, as percent of slaughter weight, and as percent of chilled carcass weight. Percent ham, percent loin, percent ham and loin, and ham-loin index

[1] Department of Animal Sciences and Industry in cooperation with USDA, ARS, AHRD and the Regional Swine Breeding Laboratory. Data from Project 808.
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were also calculated. The ham-loin index was computed using the following method:

H-L Index = 10 (% ham of sl. wt. — 10) + 10 (loin eye area).

Loin eye area was measured between the 10th and 11th ribs, carcass backfat was measured at the first rib, last rib and last lumbar vertebra at the midline.

All data were adjusted to a barrow equivalent basis. The analysis of variance for a nested classification with unequal number of sub-classes was used to account for the season and line of breeding effects. Heritability estimates of the different traits were calculated using the paternal half-sib correlation analysis. Phenotypic correlations among the traits were also calculated on a within year-season-line of breeding basis.

Results and Discussion

The means and standard deviations of the different traits studied are presented in Table 1, the heritability estimates in Table 2, and the phenotypic correlations in Table 3.

Heritability Estimates:

The heritability estimates obtained for the different measures of meatiness tended to be high; ranging from 0.47 (loin eye area) to 0.82 (percent ham + loin of carcass weight).

Expressing lean-cut weight either as percent of slaughter weight or as percent of chilled carcass weight did not affect the magnitude of the heritability estimates. This was attributed to the small amount of varia-

Table 1. Means and Standard Deviations for Traits Studied.

Trait	Mean	Standard Deviation
Percent of slaughter weight:		
Ham	14.1	.60
Loin	12.0	.56
Ham + loin	26.1	.99
Ham + loin + shoulder	37.0	1.30
Percent of carcass weight:		
Ham	20.1	.78
Loin	17.0	.75
Ham + loin	37.1	1.26
Ham + loin + shoulder	52.5	1.69
Ham-loin index	81.6	8.48
Lean cut weight, lb.	76.0	2.89
Loin eye area, sq. in.	4.02	.39
Carcass backfat, in.	1.37	.12

Table 2. Heritability Estimates and Standard Errors for Traits Studied.

	$h^2 \pm$ S.E.
Percent of slaughter weight:	
Ham	0.58 ± .17
Loin	0.64 ± .18
Ham + loin	0.75 ± .19
Ham + loin + shoulder	0.62 ± .18
Percent of carcass weight:	
Ham	0.57 ± .17
Loin	0.65 ± .18
Ham + loin	0.82 ± .20
Ham + loin + shoulder	0.64 ± .18
Ham-loin index	0.69 ± .18
Lean cut weight	0.68 ± .18
Loin eye area	0.47 ± .15
Carcass backfat	0.53 ± .16

Table 3. Correlations Among Various Measures of Meatiness.[1]

	Total lean cut weight	Percent lean cuts of: slaughter wt.	carcass wt.	Ham-loin index
Percent of slaughter weight:				
Ham	0.70	0.83	0.67	0.91
Loin	0.68	0.78	0.65	0.56
Ham + loin	0.81	0.94	0.77	0.87
Ham + loin + shoulder	0.85	- --	0.83	0.84
Percent of carcass weight:				
Ham	0.58	0.67	0.78	0.78
Loin	0.54	0.60	0.73	0.38
Ham + loin	0.68	0.78	0.93	0.72
Ham + loin + shoulder	0.72	0.83	- --	0.68
Ham-loin index	0.74	0.84	0.68	- --
Loin eye area	0.54	0.56	0.47	0.78
Carcass backfat	— .27	— .36	— .49	— .23

[1] All correlations significant at $P \leq .01$

tion present in slaughter and/or carcass weights of the animals used in the study.

The heritability of 0.69 for ham-loin index was similar to those obtained for the other measures of carcass meatiness. The heritabilities for loin eye area (0.47) and carcass backfat (0.53) found in this study were in close agreement with those previously reported in the literature.

Phenotypic Correlations:

Table 3 shows the phenotypic correlations among the different measures of meatiness. Percent loin had lower phenotypic correlations with total lean-cut weight and percent lean-cuts than did percent ham or per-

cent ham + loin. Ham + loin percentage was more closely correlated with the other traits than was percent ham alone. Loin eye area was less closely associated with total lean-cut weight and percent lean cuts than was the other measures of meatiness. Carcass backfat thickness accounted for only a small percentage of the variation in total lean weight or percent lean cuts.

Ham-loin index accounted for 71 percent of the variation in percent lean cuts of slaughter weight, while percent ham of slaughter weight accounted for 69 percent of the variation in the percent lean cuts of slaughter weight. However, loin eye area accounted for only 31 percent of the variation in percent lean cuts of slaughter weight. Ham-loin index was also more closely correlated with total lean cut weight than was either percent ham or loin eye area.

Some Genetic Aspects of Pork Quality[1]

I. T. Omtvedt, V. G. Arganosa and L. E. Walters

Story in Brief

Data from 650 pigs sired by 89 sires from seven lines of breeding were used to estimate heritabilities and to calculate genetic and phenotypic correlations among various measurements of carcass quality. Backfat thickness, carcass length, loin eye area, lean cut yield, ether extract, and total moisture were highly heritable ($h^2 \geqslant .40$) while marbling score, firmness determinations, and shear value were moderately heritable ($.20 \leqslant h^2 \leqslant .45$). In these data color score was lowly heritable ($h^2 = .20$).

Based on genetic relationships obtained, it was concluded that backfat thickness can be decreased and muscling increased and still have an acceptable degree of marbling and firmness through proper selection procedures. The results indicated that selection for less backfat thickness would increase percent lean cuts without significant effects on loin eye area, color, firmness or moisture content. Selection for larger loin area would tend to increase lean cut yields, but would decrease color score

[1]This study was supported by a grant-in-aid from the American Meat Institute Foundation Chicago, Illinois.

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and increase softness. Most of the genetic relationships among quality traits were moderately high and compatible. For example, selection for marbling would increase ether extract, firmness and color.

The results obtained in this study provide justification from a genetic standpoint for including pork quality as a trait to consider in the selection of breeding stock.

Introduction

The swine industry has made tremendous strides in increasing the lean-to-fat ratio of their product in recent years. But now the industry is concerned about the possibility that the increased incidence of pale, soft, watery pork may be a result of intense selection against fat and for greater muscling. For all practical purposes, meat quality has been completely ignored by swine breeders in selection. But before we can justify placing emphasis on quality characters in our breeding programs, we need to know how heritable these traits are and how they are related to other traits being considered.

Quality has been described in many ways, but perhaps it may most appropriately be defined as the combination of characteristics that provide for an edible product that looses a minimum of constituent, free of spoilage during processing, attractive, appetizing, nutritious and palatable. Marbling, firmness, color and tenderness are some of the most important predictive guides presently used in appraising pork quality.

This study was initiated in 1964 to estimate the heritabilities of various carcass quality measurements and to determine the genetic and phenotypic associations between quality factors and other carcass measurements.

Methods and Materials

Carcass data from 650 pigs sired by 89 boars from seven lines of breeding in the Oklahoma swine breeding project were used in this study.

All pigs were self-fed in confinement in groups of six pigs per pen from approximately 8 weeks of age to 200 lb. live weight. Carcasses were evaluated 48 hours after slaughter. Quality was evaluated in terms of fat content, water content, marbling, color, firmness and tenderness of the loin eye muscle (*l. dorsi*) at the 10th rib. A committee of at least two persons scored each loin for marbling, color and firmness using a scoring system ranging from one (extremely low quality) to seven (high quality). Ether extract and total moisture determinations were obtained on samples taken at the 10th rib. In addition to using the firmness score, penetrometer determinations were also used to evaluate firmness. Tenderness was measured in terms of the shear force required to cut a one-inch

core of deep-fried meat cooked to an internal temperature of 160° F.

Backfat measurements were taken at the first rib, last rib and last lumbar vertebra approximately 1½ inches from the midline on the live pig and at the midline on the carcasses. Loin eye area was measured between the 10th and 11th ribs. Lean cuts represented the weights of closely trimmed hams, loins and shoulders.

Since no large differences in variances were noted for sex or lines of breeding, the data were adjusted for sex and analyzed on a within line of breeding basis and pooled over breeding groups. Heritability estimates were based on the paternal half-sib correlations obtained.

Results and Discussion

The means and standard deviations for the traits evaluated are presented in Table 1. It should be noted that the pigs used in this study were considered to be of average quality and meatiness with very few individuals exhibiting extremely low quality carcasses.

Heritability Estimates. Table 2 shows the heritability estimates for the various traits studied. With the exception of color scores, most of the measurements of pork quality were considered moderately heritable .20 $\leqslant h^2 \leqslant .45$) indicating that selection could be effective in changing quality. Variations in color score were lowly heritable ($h^2 = .10$). It should be noted that quality attributes had lower heritabilities than did lean cut yield, loin eye area, backfat thickness or carcass length, which all tended to be highly heritable ($h^2 \geqslant .45$).

Table 1. Means and Standard Deviations for Traits Studied.

Trait	Mean	Standard Deviation
Marbling score[1]	3.78	1.05
Ether extract, %	5.12	1.66
Firmness score[1]	4.41	1.07
Penetrometer, mm.	4.08	0.89
Color score[2]	3.90	0.81
Total moisture, %	70.7	1.49
Shear value, lb.	11.9	1.97
Probe backfat, in.	1.40	0.12
Carcass backfat, in.	1.37	0.12
Loin eye area, sq. in.	4.02	0.39
Carcass length, in.	29.6	0.56
Total lean cut wt., lbs.	76.0	2.89
% lean of full wt.	37.0	1.30
% lean of carcass wt.	52.5	1.69
Ham-loin index[3]	81.6	8.48

[1] A score of one indicates extremely low quality and a score of seven represents exceptionally high quality with a score of four considered average.
[2] Color scored from one to seven with one being extremely pale, four being moderately pink and seven being dark.
[3] Ham-loin index = 10 (% ham of full wt. − 10) + 10 (loin eye area).

Table 2. Heritability Estimates and Standard Errors for Various Carcass Traits Studied.

Trait	$h^2 \pm$ S. E.
Marbling score	0.28 ± .12
Ether extract	0.42 ± .16
Firmness score	0.30 ± .13
Penetrometer value	0.30 ± .14
Color score	0.10 ± .10
Total moisture	0.52 ± .18
Shear value	0.33 ± .18
Probe backfat thickness	0.62 ± .19
Carcass backfat thickness	0.53 ± .16
Loin eye area	0.47 ± .15
Carcass length	0.96 ± .23
Total lean cut wt.	0.68 ± .18
% lean of slaughter wt.	0.62 ± .18
% lean of carcass wt.	0.64 ± .18
Ham-loin index	0.69 ± .18

Genetic and Phenotypic Correlations. The correlations between various traits are presented in Table 3. Phenotypic correlations represent the observed associations between various traits while genetic correlations measure the extent to which two traits are affected by the same genes. Both are important considerations in a breeding program in that both influence the amount of selection progress possible.

In most cases the genetic relationships between traits were similar to the phenotypic relationships obtained. However, there was a tendency for the genetic correlations to be slightly higher than the phenotypic correlations.

The correlations obtained reveal that reduced backfat thickness was associated with increased carcass length and higher yield of lean cuts but that backfat thickness was not closely related to the various measurements of pork quality. Loin eye area was favorably correlated with lean yield, but the phenotypic correlations indicated that increased lion eye area was associated with decreased quality. An increase in lean cut yield was associated with decreased firmness, increased toughness and lower color scores. The genetic and phenotypic relationships among most of the quality measurements were moderately high and compatible. These data show that selection for marbling should result in an increase in ether extract and firmness and a decrease in total moisture.

Conclusions

Additional studies are needed before drawing final conclusions on the inheritance of pork quality factors, but based on the data available

Table 3. Genetic and Phenotypic Correlations Among Various Traits Evaluated.

Traits Correlated	Genetic Correlations	Phenotypic Correations
Carcass Backfat and:		
carcass length	— .62 ± .12	— .33**
loin eye area	— .22 ± .21	— .05
lean cut yield	— .58 ± .14	— .49**
marbling score	— .56 ± .18	— .04
ether extract	— .18 ± .26	— .02
firmness score	— .16 ± .25	0.06
color score	— .05 ± .39	0.04
shear value	— .17 ± .31	— .17**
Loin Eye Area and:		
carcass length	— .51 ± .14	— .19**
lean cut yield	0.77 ± .09	0.47**
Marbling score	— .01 ± .27	— .18**
ether extract	0.37 ± .23	— .23**
firmness score	— .39 ± .22	— .25**
color score	— .73 ± .19	— .18
shear value	0.41 ± .28	0.16**
Lean Cut Yield and:		
marbling score	0.48 ± .19	— .08
ether extract	0.36 ± .21	— .08
firmness score	— .11 ± .24	— .22**
color score	— .54 ± .26	— .14**
shear value	0.41 ± .28	0.19**
Marbling Score and:		
ether extract	0.94 ± .05	0.66**
firmness score	0.75 ± .14	0.48**
color score	0.53 ± .34	0.29**
shear value	0.36 ± .33	— .12*
moisture content	— .71 ± .18	— .48**
Firmness Score and:		
penetrometer reading	—1.00 ± .06	— .65**
ether extract	— .58 ± .20	0.36**
color score	0.35 ± .40	0.35**
shear value	0.13 ± .33	0.00
moisture content	— .60 ± .18	— .27**
Shear value and:		
color score	0.00 ± .63	0.06
moisture content	0.18 ± .31	0.05

* Differences were significant ($P < .05$)

** Differences were significant ($P < .01$)

at the present time, it appears that most measures of quality are moderately to highly heritable. Although these heritability estimates for quality traits tend to be lower than most estimates for length, backfat thickness and loin eye area, they are high enough to justify exerting selection pressure on them in a breeding program if their economic importance justifies considering them.

The concern that selection for less backfat thickness increases the probability of lower quality is not fully justified. Most of the genetic relationships between backfat thickness and quality factors obtained were

in an unfavorable direction, but fortunately these correlations were of a quite low magnitude. The data indicates that superior meat-type hogs with acceptable quality can be produced, but attention must be given to quality as well as meatiness in order to accomplish the goal. The relationships between backfat thickness and quality factors are similar to those believed to exist between backfat thickness and growth rate, but unfortunately quality can not be appraised in the live animal.

Although it would be desirable to analyze additional data involving breeding groups with greater variation in the expression of quality aspects, the current results provide justification for placing some emphasis on these traits in swine breeding programs at the present time.

Wheat vs. Milo for Growing-Finishing Swine

W. G. Luce, I. T. Omtvedt, D. R. Rule, D. F. Stephens and S. D. Welty

Story in Brief

Three hundred twenty crossbred pigs were fed at the Fort Reno Livestock Research Station to compare the value of wheat vs. milo for growing-finishing swine. The pigs were fed in confinement from eight weeks of age to an average weight of 204.1 pounds.

Wheat tended to support similar gains as milo especially when equal amounts of supplemental protein were used. However, significantly more feed was required per pound of gain when wheat replaced all the milo. When only 50 percent of the milo was replaced with wheat, feed utilization was not appreciably affected. The type of grain used had little apparent effect on average daily feed intake or backfat thickness.

Introduction

Wheat is an important economic crop in Oklahoma. In 1968, 5,374,000 acres were harvested with a yield of 123,602,000 bushels. This is a yield of approximately three times the rest of the cereal grains combined.

Appreciation is expressed to T. E. Nelson for assistance in conducting laboratory analysis. This project was conducted by the Department of Animal Sciences and Industry in cooperation with the Regional Swine Breeding Laboratory, U. S. D. A., ARS, AH.

In cooperation with USDA Agri. Research Service, Animal Husbandry Research Division.

Recently wheat has been competitively priced with other cereal grains to suggest its use as a feed for swine. However, current information concerning the feeding value of wheat for swine is limited.

Since milo is the standard cereal grain used for swine production in Oklahoma, a study was conducted with the objective of comparing the feeding value of wheat vs. milo for growing-finishing swine.

Procedure

Three hundred twenty Duroc-Beltsville crossbred pigs were self-fed in confinement at the Fort Reno Livestock Experiment Station. The pigs were fed from eight weeks of age to an average weight of 204.1 pounds. Pigs were randomly allotted within sex and litters to five experimental treatments. Each experimental treatment consisted of four pens containing sixteen pigs (eight barrows and eight gilts). Upon completion of the experiment, all pigs were probed for backfat thickness adjusted to 200 pounds.

Results of the chemical analysis of the two cereal grains are shown in Table 1. Composition of the experimental rations fed are shown in Table 2. Soybean meal was added at levels in rations 1, 2 and 3 to bring the total crude protein of each of these rations to 15.0 percent. Rations 4 and 5 contained the same amount of soybean meal as ration 1. Thus, rations 2 and 3 were identical in total crude protein to ration 1 while rations 4 and 5 contained the same amount of supplemental protein as ration 1.

Table 1. Chemical Composition of Experimental Wheat and Milo.

Chemical Analysis, Percent	Wheat	Milo
Dry Matter	89.73	87.90
Calcium	0.06	0.02
Phosphorus	0.48	0.29
Crude Protein	12.50	8.07
Essential Amino Acids[1]		
Lysine	0.28	0.15
Tryptophan	0.21	0.13
Methionine	0.16	0.09
Histidine	0.23	0.12
Arginine	0.56	0.26
Threonine	0.30	0.22
Valine	0.47	0.28
Isoleucine	0.34	0.24
Leucine	0.71	0.75
Phenylalanine	0.50	0.31

[1] Amino acid analysis were conducted using a Beckman Model 120 amino acid analyzer.

Table 2. Composition of Experimental Rations.

Ingredients, Percent	Ration Number				
	1	2	3	4	5
Ground Milo	75.00	40.05	----	37.60	----
Ground Wheat	----	40.05	85.90	37.60	75.40
Soybean Meal (44%)	20.10	15.15	9.50	20.10	20.10
Molasses	1.50	1.50	1.50	1.50	1.50
Dicalcium Phosphate	1.40	1.10	0.70	1.05	0.65
Ground Limestone	0.90	1.05	1.30	1.05	1.25
Trace Mineralized Salt	0.50	0.50	0.50	0.50	0.50
Vitamin-Antibiotic Mix[1]	0.60	0.60	0.60	0.60	0.60
Total	100.00	100.00	100.00	100.00	100.00
Percent Composition					
Protein, Calculated	15.00	15.00	15.00	16.67	18.35
Protein, Chemical	15.42	15.42	14.95	16.87	18.00
Calcium, Calculated	0.70	0.70	0.70	0.70	0.70
Calcium, Chemical	0.67	0.68	0.72	0.67	0.73
Phosphorus, Calculated	0.60	0.60	0.60	0.60	0.60
Phosphorus, Chemical	0.60	0.56	0.55	0.60	0.57

[1] Vitamin-antibiotic mix furnished 1500 IU, Vitamin A; 500 IU, Vitamin D; 1.1 mg., riboflavin; 6.8 mg., niacin; 2.1 mg., pantothenic acid; 114 mg., choline; 8.2 mcg., Vitamin B_{12} and 20 mg., tylosin per pound of complete feed.

Results and Discussion

The results of this experiment are shown in Table 3. Pigs on ration 3 (100 percent wheat - 15.0 percent crude protein) had the lowest average daily gains of 1.61 pounds per day. However, this study does show that it is possible to obtain similar gains with an all wheat as compared to a milo ration if equal amounts of supplmental protein are used. Pigs on ration 5 gained 1.69 pounds per day vs. 1.68 pounds for the pigs on ration 1.

Pigs on ration 4, a 50 percent wheat-50 percent milo ration containing the same amount of soybean meal as ration 1, had the highest average daily gain of all treatments (1.76 pounds per day). These gains were significantly higher than the gains obtained by the pigs on ration 3.

Significant differences were noted in average daily feed intake with the pigs on rations 4 and 5 having significantly higher daily feed intakes than pigs on ration 3. Significantly more feed was required per pound of gain for the pigs on either of the wheat rations (3 and 5) than for the pigs on the milo or wheat-milo combination rations (1, 2 and 4).

Adjusted backfat probes to 200 pounds were similar for pigs on all treatments as shown in Table 3.

The results of this investigation indicate that wheat will support similar gains to milo for growing-finishing swine when equal amounts of supplemental protein are used. Although wheat is normally higher in

Table 3. Comparative Values of Wheat Vs. Milo for Growing-Finishing Swine[1]

	Ration Designation				
	1	2	3	4	5
Treatment	100% milo (basal)	50% milo 50% wheat equal crude protein	100% wheat equal crude protein	50% milo 50% wheat equal supp. protein	100% wheat equal supp. protein
Pens per treatment, no.	4	4	4	4	4
Pigs per pen, no.	16	16	16	16	16
Av. initial wt., lbs.	49.30	49.00	49.20	49.70	49.80
Av. final wt., lbs.	203.30	204.90	201.80	205.30	205.40
Av. daily gain, lbs.	1.68	1.68	1.61	1.76[1]	1.69
Av. daily feed intake, lbs.	5.28	5.28	5.22	5.51[2]	5.48[2]
Feed per lb. gain, lbs.	3.15[3]	3.17[3]	3.28	3.16[3]	3.28
Av. adjusted backfat, in.	1.36	1.39	1.43	1.37	1.40

[1] Treatment 4 is significantly higher ($P < .05$) than treatment 3.
[2] Treatments 4 and 5 are significantly higher ($P < .05$) than treatment 3.
[3] Treatments 1, 2 and 4 are significantly lower ($P < .05$) than treatments 3 and 5.

crude protein and essential amino acids than milo, a certain amount of supplemental protein is needed to meet the pig's requirement of essential amino acids. Based on analyzed lysine content of the wheat and calculated content of the soybean meal, the lysine content of ration 3 was 0.51 percent. The requirement for a 44 to 77 pound pig as reported in "Nutrient Requirements of Swine", Sixth Revised Edition, 1968, published by the National Academy of Sciences is 0.70 percent. A deficiency of lysine in the earlier growth stages of the pigs on ration 3 may be the reason for the decreased average daily gains.

Although significant differences were noted in average daily feed intake, it should be pointed out that no appreciable problem was observed in this trial in getting pigs to consume the two all wheat rations (3 and 5). Pigs on ration 3 did not eat an appreciably smaller amount of feed daily than did pigs on rations 1 and 2. Pigs on ration 5 ate more feed per day than the pigs on the other rations with the exception of ration 4.

Results from this study does not show wheat to be equal to milo for growing-finishing swine when feed utilization was considered. It took 0.13 more pounds of feed per pound of gain using the 100 percent wheat rations (3 and 5) as compared to the 100 percent milo ration (ration 1). However, when wheat replaced only 50 percent of the milo, feed utilization was not appreciably affected. More research is being planned to further explore methods of feeding wheat that may improve feed utilization.

Summary Reports on Other Projects

The Eating Quality of Beef as Influenced by Age and Muscle Difference

R. L. Hendrickson

Procedures and Results

Three bovine muscles, biceps femoris, sartorius and vastus intermedius were studied. Each of the three muscles vary in size, shape, structure, action, and tenderness. The sartorius muscles showed the least number of nuclei per 100 micron of fiber length. They ranged from 1.5 to 6.9 micron per 100 micron of fiber length with a mean of 4.1. Fibers of greater diameter generally showed more nuclei. The biceps femoris averaged 11.2 micron in length and 5.0 micron in diameter. Vastus intermedius muscle is small but the fibers are large and possessed 14.6 nuclei per 100 micron of length. These fiber nuclei averaged 10.2 micron long and 5.7 micron in diameter for shear fiber. The significance of nuclei number, size, and function in muscle development and quality remains obscure.

Shear force was measured using a newly developed microsensitive shear. A direct relationship was evident between fiber diameter and shear strength. As the diameter increased, the shear force increased. Fifty micron diameter fibers required a shear force of 7.08×10^8g, while those 70 micron in diameter required 9.41×10^8. Fibers from the biceps femoris consistantly required the greater shear force followed by the vastus intermedius and sartorius.

The Influence of Preweaning Plane of Nutrition on Subsequent Performance of Beef Females

Robert Totusek

Procedures and Results

Low, medium and high levels of preweaning nutrition of Angus and Hereford heifers have been accomplished by (1) weaning at 140 days, (2) weaning at 240 days, and (3) creep feeding to weaning at 240 days, respectively. Large treatment differences in condition and weight (an average of 120 lb. from low to high level heifers) at 240 days of age have largely disappeared by 18 months, although low level heifers have re-

mained 30-40 lb. lighter to 5 years of age. Higher preweaning planes of nutrition have also resulted in larger skeletal size at 240 days, but differences have largely disappeared by 18 months.

Preweaning plane of nutrition has had little affect on conception date and birth weight, but an increasing level of preweaning nutrition has tended to result in a slightly higher percentage calf crop, both calved and weaned. Those females which were weaned at 140 days have produced calves 20 lb. heavier at weaning than those heifers weaned at 240 days or creep fed.

The experiment is being continued through the production of three calf crops. Milk production estimates are also being made.

Selection Procedures for Beef Cattle Improvement

Richard R. Frahm and Joe V. Whiteman

Procedures and Results

The beef cattle selection experiment being conducted at Ft. Reno was designed to measure direct and correlated genetic response to selection for increased body weight at 205 and 365 days of age and to compare responses from selection based on individual performance with selection based on a combination of individual and progeny test performance.

The process of establishing this project is now complete. The two Hereford lines were closed in 1965, two Angus lines were closed in 1967 and the two progeny test Angus lines were closed in 1968. Seventy head of Angus-Holstein crossbred cows were added to the progeny test herd maintained at Stillwater for the purpose of determining if cows with greater potential for producing heavy weaning calves will be more effective for providing progeny test information.

The Influence of Supplemental Winter Feeding on Lifetime Performance of Beef Cows

D. F. Stephens and Robert Totusek

A study designed to determine the influence of supplemental winter feeding on the productivity and longevity of beef cows is nearing completion. One group of 10-year-old cows was removed from the study in 1968. A subsequent final group will wean calves in the fall of 1969.

This study has indicated that a moderate winter feed level is optimum for spring calving beef females maintained yearlong on good quality native range, considering both productivity and economics. This moderate level feeding regime permits the weaner heifer to gain approximately 100 lb. her first winter and to loose approximately 10 percent of her fall weight during subsequent winters as a pregnant-lactating female, until she reaches maturity. After maturity is reached, a winter weight loss of 15-20 percent is not detrimental provided adequate summer forage is available. Higher feeding levels have maintained heavier body weights of the female and resulted in earlier calving, higher percent calf crops, and heavier weaning weights, but have resulted in less profit at current feed costs. Lower feeding levels have maintained lighter body weights of the females and resulted in poorer reproductive performance, lower weaning weights, and less profit.

Detailed reports covering twenty years of research will be prepared for publication when the current study is terminated.

Non-Protein Nitrogen Studies With Ruminants

Allen D. Tillman, J. E. McCroskey, R. J. Panciera and E. I. Williams

Procedures and Results

Sodium bentonite was found to absorb the ammonium ion when the concentration of NH_4^+ in the medium was high and release it when the concentration drooped. Growth and metabolism results indicate ration improvement when 2% bentonite was included in high-roughage diets containing high levels of urea. Calcium retention was decreased and that of phosphorus increased by bentonite. A high concentration of ruminal fluid and blood ammonia levels for a short period of time was not detrimental to reproduction in cattle. Acetic acid was found to alleviate urea toxicity symptoms in cattle for about 150 min. and a second does had to be administered within 165 min. in order to prevent toxicity. A urea supplement was not as efficacious as one containing cottonseed meal when these were fed to pregnant and lactating cows kept on the winter range in Oklahoma. A hemicellulose, in the liquid form, when mixed with cane molasses, was found to furnish carbon fragments for amino acid synthesis by ruminants fed urea as the dietary nitrogen source. The subcutaneous injection of purified jackbean urease into sheep produced antiurease in the blood and fluids. Associated with the accumulation of antiurease was improved growth of sheep, improved feed/gain and lower NH_3-N levels in blood and gastrointestinal fluid.

Publications

The following articles have been published from this project during the past year:

Sidhu, K. S., E. W. Jones and A. D. Tillman. 1968. Effect of urease immunity on growth, digestion and nitrogen metabolism in ruminants animals. J. Animal Sci. 27:1703.

Clifford, A. J., J. R. Bourdette, and A. D. Tillman. 1968. Effect of urease inhibitors on sheep fed diets containing urea. J. Animal Sci. 27:1073.

Clifford, A. J., J. R. Bourdette and A. D. Tillman. 1968. Amino acid supplementation of urea-rich diets for lambs. J. Animal Sci. 27:1081.

Goodrich, R. D., B. P. Bradley and A. D. Tillman. 1968. The importance of initial blood and plasma values. J. Animal Sci. 27:247.

Tillman, A. D. 1969. Urea utilization by ruminants. Oklahoma Veterinarian, 21:1.

Role of Vitamin E and Selenium in Sheep Reproduction

Allen D. Tillman, E. C. Nelson, B. I. Osburn and J. E. Smith

Procedures and Results

Forty-eight ewe and 12 ram lambs were fed a purified diet containing urea as the sole nitrogen source in a 2 by 2 factorial arrangement of treatments. Subcutaneous injections of vit. E (700 I.U. as alpha tocopheryl acetate) and selenium (5 mg. as sodium selanate) were given separately and in combination once weekly. After 140 days, 24 of the ewes were bred, with treatments being continued until lambing, and then for several additional months. The remaining ewes were bred and sacrificed at various stages of pregnancy to obtain tissues for examinations. Sheep fed the basal purified ration died between the 80th and 230th days of the trials and all had muscular dystrophy. Vitamin E prevented death, while selenium only delayed it. Selenium stimulated growth. Satisfactory reproduction was obtained only in those animals receiving both vitamin E and selenium. Abortions occurred in several ewes on the selenium-deficient diet; however, no pathological changes were found in the reproductive tracts of the ewes, or the rams. None of the fetuses taken from sacrified ewes had pathological changes. Fertility of rams was not affected by treatment. Vit. E and selenium increased tocopherol level of blood initially but later selenium was ineffective. Vitamin A level in blood was increased by selenium or vitamin E. Blood and tissue enzyme values were determined.

Publications

The following articles have been published from this project during the past year:

Buchanan-Smith, J. G., B. I. Osburn, J. E. Smith, E. C. Nelson and A. D. Tillman. 1968. Vitamin E and selenium in ewe reproduction. J. Animal Sci. 27:1176.

Buchanan-Smith, J. G., E. C. Nelson and A. D. Tillman. 1969. Tocopherol levels in sheep tissues. J. Animal Sci. 28:127.

Buchanan-Smith, J. G. 1969. Effects of Vitamin E and Selenium Deficiencies in Sheep Fed Purified Diet During Growth and Reproduction. Ph.D. Thesis. Oklahoma State University, Stillwater, Oklahoma.

Mineral Interrelationship Studies With Ruminants

Allen D. Tillman, T. E. Nelson and L. J. Bush

Procedures and Results

A purpose of this project is to study the importance of the parathyroid glands to calcium homeostasis in ruminants and two trials were conducted to study the effect of age and a calcium-free diet on thyroparathyroidectomized (TPX) sheep. Rate of decline in serum calcium, following TPX in young lambs, was rapid and followed by fatal tetany, even when the animals were fed a normal diet. Positive calcium balances were found in TPX lambs. Adult sheep were more tolerant to TPX, being capable of correcting hypocalcemia and maintaining serum calcium levels above those associated with tetany, even after an extended time on a calcium-free diet. Neither TPX nor feeding a calcium-free diet affected serum magnesium. Two treatments, thyroparathyroidectomy (TPX) and thyroidectomy (TX) were compared to control sheep, which were sham-operated. The TX operation did not influence any of the components measured by the TPX sheep exhibited elevated serum inorganic phosphorus, glutamic-oxalacetic transaminase, creative phosphokinase and isocitric dehydrogenase just prior to death. In other work, lambs were fed the Oklahoma purified diet containing the following calcium: phosphorus ratios: 1:1, 4:1, 7:1, and 10:1. Growth, blood cation levels, blood inorganic phosphorus and balance of dietary cations were response criteria. The data are being analyzed.

Publications

The following articles have been published from this project during the past year:

Nelson, T. E. and A. D. Tillman. 1967. Calcium status studies in adult sheep. J. Nutr. 93:475.

Nelson, T. E., W. D. Tavernor, E. W. Jones and A. D. Tillman. 1969. Influence of age and calcium-free diet on thyroparathyroidectomized sheep. J. Nutr. 97:351.

Tillman, A. D. 1969. Trace mineral nutrition in cattle. Proceedings Kansas Formula Feed Conference. Kansas State University, Manhattan, Kansas.

Tillman, A. D. 1969. Mineral nutrition for ruminants. Proceedings Cattle Feeders' Seminar. Oklahoma State University, Stillwater, Oklahoma.

Mouse Selection Studies

Richard R. Frahm and Irvin T. Omtvedt

Procedures and Results

Currently under construction in the basement of Poultry Industries Building is a mouse genetics laboratory to be utilized in conducting basic research studies in the area of population genetics. Many of the genetic problems facing livestock producers can be at least partially answered more efficiently by utilizing laboratory organisms. In addition to testing population gentics theory, laboratory organisms can be used to conduct pilot studies for obtaining a provisional indication of the possible outcome of similar experiments in other species. Mice are particularly well-suited to use in this capacity since they are mammals with a generation interval of only three months, and large numbers can be economically reared under carefully controlled environmental conditions. Rigid environmental control will be maintained in this laboratory with respect to temperature, humidity and light.

A series of selection lines will be initiated for the purpose of (1) measuring direct and correlated responses to selection for preweaning and postweaning rate of gain in mice, and (2) determining the genetic correlation between preweaning and postweaning rate of gain. This study will consist of 170 litters of mice produced each generation. Three selection lines consisting of 20 litters per line will be selected on the basis of individual rate of gain between three and six weeks of age. An additional 50 litters will be maintained in a random mating control line in order to measure genetic changes that occur in the selection lines. All mice in this study will be individually weighed at three weeks and again at six weeks of age.

The economic importance of growth rate is well recognized by all segments of the livestock industry. Selection of animals at the earliest age possible is a desirable aspect of all breeding programs, but this requires a basic understanding of the genetic relationships between early and late

growth periods. Although the genetic relationship between preweaning and postweaning growth rate is of fundamental importance in livestock improvement programs, it has not been previously established with cattle, sheep or swine because of the necessity of large numbers of experimental animals that must be reared under controlled environmental conditions. The results obtained from this study should reveal the basic genetic relationships that exist and provide a basis of application to other species.

Factors Affecting the Energy Value of Feeds and Energetic Efficiency of Ruminants

J. E. McCroskey

Six sets of identical twin heifers fed a finishing ration are being used in an energy balance study to determine the effects of Melengestrol Acetate (MGA) upon basal heat production and efficiency of energy utilization. Cattle are brought in from the feedlot at intervals and put in open-circuit respiration chambers to determine total energy balance.

Development of Methods for Relating Forage Properties to Intake and Digstibility

J. E. McCroskey

Studies are in progress to compare different levels of polyethylene glycol as an indicator for use in measuring voluntary intake of grazed forage. Data collected during the past year with steers grazing bermudagrass and given indicators to determine forage intake are being analyzed in an attempt to correlate changes in chemical composition of the forage with voluntary intake.

The Effects of Season and Exogenous Hormones on the Reproductive Performance of Swine

C. V. Maxwell, E. J. Turman and J. C. Hillier

Procedures and Results

This project has involved several separate studies with gilts and boars. One study comparing lot-mating and handmating of gilts has been completed and published. The present research with gilts involves the testing of various experimental compounds for possible use in synchronizing estrus. No results are ready for release at this time.

A study has just been completed on the effects of season and three types of shelters, and two methods of cooling on semen quality of boars. This data is now being analyzed and will be published at a later date.

Publications

The following articles have been published from this project during the past year:

Rich, T. D., E. J. Turman and J. C. Hillier. 1968 A comparison of the ovulation rate, fertilization rate and embryo survival of hand-mated and lot-mated gilts. J. Animal Sci. 27:443.

The Desirability of Pork Products Processed Prior to Chilling

R. L. Hendrickson, A. F. Parr, E. D. Cagle, F. C. Arganosa, and Roger Johnson

Procedures and Results

The effect of pre- and post-chill curing on the development and stability of nitroso-pigments in individual pork muscles was investigated. The rate of cure diffusion varied directly with the muscle structure and composition. However, the cure diffused most rapid through the warm muscle. The pre-chilled cured muscles contained significantly ($P < .01$) higher initial concentration of nitroso-pigments than the post-chill cured muscle. This cured pigment was more stable when exposed to 100 ft.c of light for periods up to 24 hours than the post-chill cured muscle.

Tenderness as reflected by the shear force of pre-chill muscle decreased at a rate that closely paralleled the pH decline. This was particularly true beyond four hours after death. Fiber diameter and percent fiber kinkiness exhibited a direct relationship. As one decreased so did the other. Shear value decreased with a decrease in fiber diameter and percent kinkiness.

Longissimus dorsi muscle sliced before the removal of body heat had a significantly higher shear force than corresponding muscle sliced after a 24 hour chill. This difference was due to muscle contraction caused by muscle excision and slicing. Fiber diameter and percent kinkiness were also significantly affected by the slicing temperature. Large fiber diameter and greater kinkiness were found for the cold sliced muscle.

Study of the Calcium and Phosphorous

James A. Coalson, J. C. Hillier, E. C. Nelson, and Charles Maxwell

Procedures and Results

Forty-five pigs were used to study the calcium and phosphorus requirements of baby pigs reared on purified diets from three to nine weeks of age. The pigs were collected in sterile plastic bags and transported to the laboratory under sterile conditions. The fortified and pasteurized cows' milk diet, fed during the first two weeks, contained 1.32 percent calcium and 0.98 percent phosphorus.

During the third week of life, the pigs were gradually changed from the liquid diet to a dry, purified, test diet, on which they remained until they were nine weeks of age. During the test period (three to nine weeks of age) four levels of calcium and phosphorus were fed. Rations A through D contained 0.27, 0.57, 0.95 and 1.25 percent calcium and 0.14, 0.44, 0.73 and 1.05 percent phosphorus, respectively. Body weight and feed intake for each pig were recorded weekly. Blood samples were drawn at the end of the third, sixth and ninth weeks. Four pigs from each treatment group were slaughtered at the conclusion of the trial and various bones and organs were removed for observation and chemical analysis.

Ration A appeared to support normal feed efficiency but the total gain was not comparable to the other rations. Ration A produced normal values for serum calcium, serum inorganic phosphorus, hemoglobin concentrations and hematocrit. The data suggested that pigs on Ration A had the greatest bone resorption rate and pigs on Ration C had the least amount of resorption. Ration C produced the heaviest pigs at nine weeks, the best efficiency, heaviest absolute bone weight, diameter and length, highest percent bone ash and the highest concentrations of calcium and phosphorus in bone ash.

The nasal turbinates were grossly examined for symptoms of atrophic rhinitis but none were positively diagnosed.

On the basis of this study, a level of 0.95 percent calcium and 0.73 percent phosphorus is recommended in complete rations from three to

nine weeks of age when soundest skeletal development is desired. This level of calcium and phosphorus would probably result in increased daily gains and improved feed efficiency, but the added phosphate would increase the cost of the ration.

The data indicated that the higher levels of calcium and phosphorus resulted in greater mineral deposition in the skeleton and presumably a sounder structure. Phosphorus is a rather expensive nutrient, thus, the economics of feeding the higher mineral levels would be of concern to commercial producers interested particularly in feed costs per unit gain to market weights. It would appear that the producer of breeding animals could produce a sounder skeleton by using the higher mineral levels.

Publications

The following articles have been published from this project during the past year.

Coalson, J. A., R. D. Washam, J. C. Hillier, and E. C. Nelson. 1968. A study of the calcium and phosphorus requirements of artificially reared pigs. J. Animal Sci. 27:1150, (Abstr.).

Washam, R. D., J. C. Hillier, E. C. Nelson, and J. A. Coalson, 1968. A study of the Ca and P requirements of young pigs. J. Animal Sci. 27:1157, (Abstr.).

Washam, R. D., 1968. A study of the calcium and phosphorus requirements of artificially reared young pigs. Thesis for Ph.D. Degree. Oklahoma State University, Stillwater.

Selection for Specific Combining Ability in Swine

I. T. Omtvedt

Procedures and Results

The basic objective of this project is to study the feasibility of selecting purebreds on the basis of their ability to cross. Sow productivity traits generally exhibit considerable hybrid vigor in crossbreeding studies, but unfortunately these traits are lowly heritable and show very little response to direct selection. The hybrid vigor obtained in crossbreeding is "one-shot improvement" and breeders can not expect to obtain increased performance due to additional heterotic response each generation. In this project an effort is made to make continued improvement in two-breed crossbred gilts by selecting the two parent lines on the basis of their crossing ability. The basic procedure is to select the Duroc and Beltsville No. 1 boars and gilts for breeding on the basis of their Duroc-Beltsville crossbred half sisters' productivity (litter size and 21-day weight).

Although the project is only in the fifth generation and it is too early to draw conclusions as to the effectiveness of this mating scheme at the present time, the data collected have been used to answer many questions on other problems confronting the swine industry.

Publications

The following articles have been published from this project during the past year:

Apple, Kenneth L. 1968. Influence of age of dam and season on productivity and the relationship between productivity of first and second litters in swine. MS Thesis.

Arganosa, Valentino G. 1968. The influence of genetic factors on pork quality. PhD Thesis.

Arganosa, V. G., I. T. Omtvedt and L. E. Walters. 1968. Phenotypic and genetic parameters of some carcass traits in swine. J. Animal Sci. 27: 283. (abstract)

Cunningham, P. J. 1969. An investigation of selection indexes in swine populations. PhD Thesis.

Jesse, Earl F. 1968. Influence of sex and sire-sex interactions on post-weaning performance and carcass traits in swine. MS Thesis.

Morrissette, M. C. and I. T. Omtvedt. 1969. Influence of an orally active progesterone and diethylstilbestrol on litter size and weights of pigs. J. Vet. Res. 29:271.

Omtvedt, I. T. 1968. Inheritance of some pork quality measurements and their importance in a selection program. *Pork Industry:Problems and Progress.* Iowa State University Press, Ames, Iowa, page 128.

Omtvedt, I. T., E. L. Jesse and V. G. Arganosa. 1968. Sex and sire-sex interactions in swine. J. Animal Sci. 27:285. (abstract)

Influence of High Ambient Temperatures On Reproductive Performance in Swine

I. T. Omtvedt, E. J. Turman, D. F. Stephens and G. W. A. Mahoney

Procedures and Results

In swine operations where producers attempt to farrow a uniform number of pigs during all seasons of the year, seasonal variations become a critical factor. Since reduced reproductive efficiency is most prevalent during summer months, this project was initiated to determine the influence of exposing sows to high ambient temperatures at the time of breeding and at various stages of gestation on their reproductive performance.

Heat stress prior to breeding had no marked influence on performance, but exposing sows to high temperatures the first 15 days after breeding compared to subjecting sows to heat stress 15-30 days post breeding resulted in fewer viable embryos and lower survival rates to 30 days post-breeding. At the present time, emphasis is being placed on possible influences of heat stress during mid and late pregnancy.

Publications

The following articles were published during the past year based on results obtained from this project:

Edwards, Ronnie, I. T. Omtvedt, E. J. Turman, D. R. Rule, D. F. Stephens and G. W. A. Mahoney. 1968. Influence of high ambient temperatures on sow productivity. Okla. Agr. Exp. Sta. MP-80:97.

Edwards, R. L., I. T. Omtvedt, E. J. Turman, D. F. Stephens and G. W. A. Mahoney. 1968. Heat stress prior to breeding and in early gestation in gilts. J. Animal Sci. 27:300. (abstract)

Edwards, Ronnie L., I. T. Omtvedt, E. J. Turman, D. F. Stephens and G. W. A. Mahoney. 1968. Reproductive performance of gilts following exposure to heat stress prior to breeding and in early gestation. J. Animal Sci. 27:1634.