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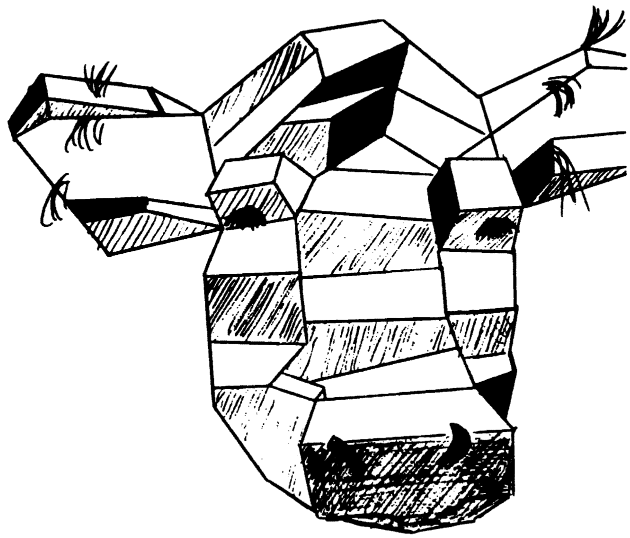

Livestock Research Report

Research Division Report 175
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia 24061
July 1979

1978-1979 LIVESTOCK RESEARCH REPORT

BY

RESEARCH STAFF
ANIMAL SCIENCE DEPARTMENT
VIRGINIA POLYTECHNIC INSTITUTE
& STATE UNIVERSITY

EDITED BY J. A. GAINES

COLLEGE OF AGRICULTURE

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

DEPARTMENT OF ANIMAL SCIENCE (703) 961-6311

July 13, 1979

TO: Livestock Producers
Research Personnel
Consumers of Livestock Products
Other Interested Readers

The mission of the Animal Science Department is to derive and disseminate information which will increase the income of producers of Beef Cattle, Swine, Sheep and Horses.

Our faculty and graduate students are pleased to offer reports based on research conducted during the past year. We feel that these reports will convey information which will be useful to the livestock industry of Virginia.

Research information in this booklet includes nutrition, physiology, genetics and management studies. It is our hope that the information contained herein will contribute to the production of livestock and livestock products in a more efficient and economical manner.

If additional information is desired by the reader on subjects presented in this booklet, this information may be obtained by contacting the authors at the Animal Science Department, V.P.I. & S.U., Blacksburg, Virginia 24061. We would be delighted to hear from you.

Sincerely yours,

Milton B. Wise

Milton B. Wise, Head
Animal Science

MBW:jw

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COOPERATIVE CATTLE BREEDING RESEARCH

Thomas J. Marlowe[1] and Robert C. Oliver[2]

A cooperative cattle breeding research project was initiated between the Animal Science Department of Virginia Polytechnic Institute and State University, Blacksburg, and the Virginia Department of Corrections, Richmond, in 1968 to:

1) evaluate several breeds of cattle as sire breeds;
2) compare the productivity of several kinds of crossbred and straightbred cows produced in the sire breed evaluation phase; and
3) determine the best combination of breeds and mating schemes for maximizing beef production.

Five correctional farm herds were used in this study. These farms are located as follows: Bland is in the mountains of southwest Virginia about 75 miles west of Roanoke. Beaumont and State Farm are located on the James River in the lower piedmont area about 25 to 30 miles west of Richmond. Hanover is located about 30 miles north of Richmond along the border of the Piedmont-Tidewater areas. Southampton is located between Emporia and Suffolk in the tidewater area of the state near the North Carolina border.

The foundation cattle were Hereford at Bland, Beaumont, Hanover and State Farm; whereas, the foundation herd at Southampton was Angus. In addition, Bland had just started a small Angus herd of 20 cows and Southampton had started a herd of Charolais cattle of similar size. These two small herds were carried on as straightbred control herds, along with a straightbred Hereford control herd at four locations and a straightbred Angus control herd at Southampton, during both phase I (sire breed evaluation) and phase II (cow breed evaluation) of this study.

Sire Breed Evaluation Phase

In phase I, eight sire breeds were evaluated in five correctional farm herds during the years of 1970 through 1975. Fertility, calf survival and offspring performance to weaning were reported in the 1976-77 Livestock Research Report. Postweaning performance of these cattle to 12 and 18 months of age were recorded and the data are being analyzed. Carcass data were obtained in two of the five herds and are ready for statistical analyses.

Cow Breed Evaluation Phase

Female offspring from the sire breed evaluation phase were saved as herd replacements to be compared in the cow breed evaluation phase. An attempt was made to put approximately equal numbers of each kind of crossbred and straightbred heifers into the breeding herds at each of the five locations each year, except that for the straightbred control herd at each location the number of

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[2]Superintendent for Agriculture, Department of Corrections, Richmond, Va.

heifers was doubled - one half of which were bred straight and the other half bred the same as all other heifers. This was not entirely possible, however, because in some years there were insufficient numbers of heifers large enough for breeding. The number of heifer replacements by breed and year is shown in table 1 of the individual farm reports that follow. An attempt was made to put replacement heifers into these herds similarly to the way a private cattle producer would replace cows in his herd.

The cow breed evaluation phase was subdivided into three cycles. Cycle 1 involved the breeding of all heifers at all locations (either as yearlings or as two-year-olds) to Angus bulls for their first calf. The only exceptions were the straightbred control herds (Hereford at Beaumont, Hanover and State Farm; Angus and Hereford at Bland; and Angus and Charolais at Southampton) at each location and the Angus x Hereford heifers at State Farm which were bred to Shorthorn bulls. Cycle 2 included all subsequent matings through the 1978 calf crop at each location. The breed of bull used at each location is given in the individual location reports. The breeds were selected to avoid back-crossing and to add to the heterosis within the crosses. Cycle 3 will involve the 1979 and 1980 calf crops. For this cycle all cows, except the straightbred controls and the Shorthorn x Hereford cows at State Farm, are being bred to Limousin x Shorthorn ($L\bar{S}$) and Maine-Anjou x Shorthorn ($M\bar{S}$) bulls. One half of each kind of cow will be bred to $L\bar{S}$ bulls and the other half to $M\bar{S}$ bulls each year at all locations. Cycle 3 data will provide an opportunity to determine if a genetic-environmental interaction exists.

Management of Cattle

Cattle are managed somewhat differently at the several locations; however, the breeding season was limited to 75 days at each location. Heifers were bred to Angus bulls for their first calf at all locations. Thereafter, a different breed of bull was used at each location for cycle 2 and the same kind of crossbred bulls used at all locations for cycle 3.

Cows are identified by ear tattoo and a large rubber ear tag (Ritchey) for easy identification. Calves are identified at birth with a metal ear tag and either at birth or later with an ear tattoo.

In general, all cattle are grazed on grasses native to the area during the summers and wintered on silage (grass or corn) and some hay during the winter. A more detailed explanation of management is given in the individual reports.

The Data and Statistical Analyses

Cow breed evaluation was based on percentage of heifers and cows calving, calf survival or mortality, percent calf crop weaned, weaning weight and grade and pounds of calf weaned per cow exposed. At Bland and Southampton slaughter and carcass data have also been collected. The number of heifers and cows exposed during cycles 1 and 2 by location are shown in table 1.

TABLE 1.
PHASE II HEIFERS AND COWS EXPOSED TO BULLS DURING CYCLES 1 AND 2
BY LOCATION AND AGE OF COW. 1972-1978.

Age of cow	Location					Total
	Beaumont	Bland	Hanover	Southhampton	State Farm	
Heifers	126	403	222	188	427	1366
Cows	541	751	411	596	664	2963
Total	667	1154	633	784	1091	4329

Cycles 1 and 2 were analyzed separately. The sources of variation included in the statistical models were year, age and breed of cow, age and sex of calf, and the breed x year and breed x sex interactions. Calf age was included as a linear regression and cow age as both linear and quadratic regressions. This combination gave the largest R^2 values and the smallest coefficients of variation. The General Linear Models Procedure of the Statistical Analyses System (SAS) by the SAS Institute, Inc., was used for the analyses on a 370 IBM computer.

GENERAL RESULTS AND DISCUSSION

Results discussed here are in general terms. More specific results are included in the reports on the individual herds, which follow this report. There were 1366 heifers exposed and 1005 calves weaned over the years 1972-1978 at the five locations for an average calving percentage of 73.6. Of the 2963 cow exposures, 2217 calves were weaned for a 74.8% calf crop. The range in calving percentage for heifers was from 68.5% at Bland to 79.8% at State Farm and for cows from 68.8% at Hanover to 83.7% at Southampton. Calving percentages were influenced by the number of open cows following the breeding season and the number of calves lost prior to weaning. Percentage of open cows ranged from 11.6% at Southampton to 19.1% at Hanover and calf death losses from 7.9% at Southampton to 14.5% at Bland.

Cows ranked according to the pounds of calf weaned per cow exposed to the bulls are shown in table 2 by location.

TABLE 2.
COW RANK BY LOCATION BASED ON POUNDS OF CALF WEANED PER COW EXPOSED
WHICH COMBINES CALVING PERCENTAGE AND WEANING WEIGHT

Rank of cow breed	Location				
	Beaumont	Bland	Hanover	Southampton	State Farm
1	Hol x Her	Char x Hol	Ang x Her	Hol x Ang	Hol x Her
2	Short x Her	Char x Her	B.Sw x Her	Char x Ang	B.Sw x Her
3	Char x Her	Sim x Her	Hereford (2)	Angus (8)	Short x Her
4	Hereford (2)	Simmental	Char x Her	Charolais	Sim x Her
5	Hereford (8)	Angus	Hereford (8)	Angus (1)	Char x Her
6		Hereford (8)			Ang x Her
7		Hereford (2)			Hereford (8)
8					Hereford (2)

Angus (1), Charolais, Hereford (2) and Simmental were bred to bulls of their own breed; whereas, Angus (8) and Hereford (8) were bred to the same bulls as all of the other cows at a given location to produce crossbred calves.

It can be seen that the Holstein cross cows were superior at every location where they were included. Comparing her to the straightbred Herefords at Beaumont, Bland and State Farm and to the straightbred Angus at Southampton her superiority was 109, 147, 132 and 112 pounds, respectively, per cow exposed. If we multiply this difference per cow times the total number of cows exposed at each location, the differences become 36.3, 84.8, 72.0, and 43.9 tons, respectively, in weaning weights of calves. Expressed another way, we could reduce the cow herds by approximately one third and still produce as many pounds of calf at weaning by using all Holstein cross cows instead of all straightbred Hereford and Angus cows. This superiority is dramatically illustrated in table 3.

TABLE 3. BEST PERFORMING CROSSBRED COWS OVER ALL LOCATIONS AND YEARS COMPARED TO BASE BREED AT START OF RESEARCH PROGRAM

Location	Lbs calf wn per cow exp	No. cows exposed	Total difference Lbs	Tons	% increase
Beaumont	109	667	72,703	36.3	50.0
Bland	147	1154	169,638	84.8	61.3
Hanover	32	633	20,256	10.1	11.7
Southampton	112	784	87,808	43.9	33.6
State Farm	132	1091	144,012	72.0	48.9
Combined	113.9	4329	493,506	246.7	44.1

If we apply these differences and the present cattle prices of $1.00 per pound for steers and $ .90 for heifers to the 1978 calf crop, the increased dollar value at each location would have been (142 x 109 x .95) $15,478.00 at Beaumont, (248 x 147 x .95) $34,633.20 at Bland, (150 x 32 x .95) $4,560.00 at Hanover, (162 x 112 x .95) $17,236.80 at Southampton and (408 x 132 x .95) $51,163.20 at State Farm. The combined increased value of the 1978 calf crop at weaning at all five locations would have been $123,071.20.

All other crossbred cow combinations outproduced the straightbred Hereford and Angus cows, whether the straightbred cows were producing straightbred or crossbred calves, at all locations, except at Hanover where the SB Herefords beat the CH cows and tied the BH cows. This exception can probably be explained by the fact that insufficient straightbred heifers were available at Hanover so that only about half as many heifers were included in the group as in the other groups and they were almost entirely three-year-olds at first calving. Furthermore, the Hereford bull used for two calf crops (1975 and 1976) was the best performing (yearling weight) Hereford bull produced at the Beef Cattle Research Station in 20 years. Weaning grades also favored the crossbred cows.

In general, crossbred cows were superior in fertility, calf liveability and in pounds of calf produced. Unweighted averages over all locations for XB vs SB cows were 12.5 vs 15.4% for open cows, 8.6 vs 12.7% for calves lost, 79.0 vs 73.5% for calves weaned and 377 vs 295 pounds of calf weaned per cow exposed. Calves out of XB cows graded 1/3 USDA grade higher. Cow death losses were less than 2.5% for all groups. Holstein X cows were the top performers at all locations. Corresponding values for Holstein X cows were 10.4%, 7.9%, 83.9% and 410 pounds of calf weaned per cow exposed.

The authors express their appreciation to each of the correctional center superintendents, farm managers, herdsmen and inmates who have supported this research; also, to Dr. T. N. Meacham and Dr. T. L. Bibb for pregnancy checking cows; several graduate students who have assisted with working the cattle and processing the data; and to Mrs. Ellie Stephens for typing the manuscript.

COW BREED EVALUATION AT SOUTHAMPTON: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING

T. J. Marlowe[1], W. E. Burgess[2] and W. H. Gillette[2]

The cow breed evaluation phase was divided into three cycles. Cycle 1 included all heifers calving for the first time at either two or three years of age. Cycle 2 included the same cattle for all subsequent calf crops through the 1978 calf crop. Cycle 3 will include the remaining cows from cycles 1 and 2 which will be bred to Maine-Anjou x Shorthorn and Limousin x Shorthorn bulls for two calf crops, except for the straightbred Angus control herd. This report covers cycle 1 and 2 of the cow breed evaluation phase (II) of the cooperative cattle breeding research at the Southampton Correctional Center between the Animal Science Department of Virginia Polytechnic Institute and State University, Blacksburg, and the Department of Corrections, Richmond.

Source and Management of Cattle

Cows used in this study were produced in phase I (sire breed evaluation) during the years 1970-1975. They were all out of Angus cows, except the straightbred Charolais herd, and sired by 12 bulls each of the Angus, Charolais and Holstein breeds. All calves, except the straightbred Charolais, were weaned in early May and the heifers placed on grass-legume pastures and fed approximately one percent of their body weight of a supplement consisting of three parts corn to one part soybean meal daily. Because of a difference in calving season, the Charolais heifers were weaned in late July, placed on pasture, and treated the same as the other heifers thereafter.

All heifers were reweighed and scored for confirmation and condition at approximately one year of age, usually the last week of October for the Angus and crossbred heifers and in February for the straightbred Charolais heifers. Approximately equal numbers of the four kinds of heifers were selected each year, based on their 365-day weight, to go into the breeding herds for the cow breed evaluation phase, except that twice as many Angus heifers were kept as either of the other groups. The reason for the extra Angus heifers was to have one herd bred as straight Angus and the other herd bred the same as the crossbred heifers.

The composition of the phase II (cow breed evaluation) cow herds was Angus (AA, Ax), Charolais (CC), Charolais x Angus (CA), and Holstein x Angus (FA). Table 1 below gives the number of heifers by breed composition and year that were put into the breeding groups.

TABLE 1. BREED COMPOSITION OF PHASE II COWS

Year	AA	CC	Ax	CA	FA	Total
1971	6	7	6	5	5	29
1972	5	6	6	11	10	38
1973	4	10	5	12	10	41
1974	10	9	11	10	12	52
1975	5	7	5	6	5	28
Total	30	39	33	44	42	188

Ax = Angus cows bred to Simmental x Hereford bulls after the first calf.

[1]Professor of Animal Science at VPI&SU and project leader.
[2]Herdsman and Farm Manager, respectively, Southampton Correctional Center.

All Heifers were exposed to Angus bulls (except that the straightbred Charolais heifers were exposed to Charolais bulls) as yearlings in order to calve at two years of age. Thereafter, one half of the Angus cows and all of the Charolais x Angus and Holstein x Angus cows were exposed each year to Simmental x Hereford (SH) crossbred bulls. The other half of the Angus cows were bred to Angus bulls to provide a straightbred Angus control herd. The Charolais heifers were bred to Charolais bulls to provide a straightbred Charolais control herd. The ratio of bulls to heifers and/or cows was approximately 1 to 25. The breeding season was limited to 75 days annually starting on or about December 20.

All heifers being bred for the first time, except for the Charolais control herd, were run together as a group and fed silage and/or hay during the winter and grazed on summer pasture. After their first calf crop, they went into the cow herd. Cows of each breed type were run together on summer pasture and fed together during the winter, except that the straightbred Angus and straightbred Charolais herds were fed in separate groups and ran on separate pastures. The nutritional level of this herd was about optimal for the coastal area environment and better than the average commercial herd in that area of the state.

Cows were culled only if they failed to wean two calves, would not claim their calves, prolapsed, or developed some other physical disabilities that would obviously prevent them from further production.

Data and Statistical Analyses

Cow breed evaluation was based on percentage of cows calving, calf survival, percent calf crop weaned, weaning weights and grades, and pounds of calf weaned per cow exposed. There was a total of 188 heifers exposed and 137 calves weaned in cycle 1 and 596 cows exposed and 499 calves weaned in cycle 2. The breakdown by year, cow age and breed is shown in tables 2, 3 and 4. Cycles 1 and 2 data were analyzed separately to obtain the values shown in the tables and then all ages were analyzed together to obtain the combined values presented in table 4. The sources of variation included in the models were year, age and breed of heifer or cow, age and sex of calf, and breed x year and breed x sex interactions. The General Linear Models Procedure of the Statistical Analyses System (SAS) by the SAS Institute, Inc., was used for the analyses on a 370 IBM computer.

Results and Discussion

Four kinds of cows were compared during the years 1972-1978. These comparisons are shown in tables 2, 3 and 4 by age and breed composition of cow and year. The effect of breed of heifer calving for the first time was significant for preweaning average daily gain, weaning weight and grade, but not for weaning condition. Among the cows, breed effect was significant for all four traits. The average weaning age was 207 $\pm$ 23 days. Differences in weaning age by kind of cow were not significant.

Crossbred cows weaned 7.5 (85.3 vs 77.8) more calves per 100 cows exposed which averaged 31 pounds heavier than those from straightbred cows. Among the crossbred cows, Holstein x Angus were superior to the Charolais x Angus, weaning 1.4 more calves per cow exposed that averaged 33 pounds heavier.

By combining calving percentage and adjusted weaning weight, we obtain the pounds of calf weaned per cow exposed to the bulls which provides a more realistic base for comparison. Using this comparison, the cow rank (H to L) was Holstein x Angus, Charolais x Angus, straightbred Angus cows producing crossbred calves, straightbred Charolais (tied with the Ax cows for third place) and the straightbred Angus in last place. When the best of the crossbred cows (FA) was compared to the straightbred Angus cows producing straightbred calves, the difference was 112 pounds per cow exposed. Where compared to Angus cows producing crossbred calves,the difference was 99 pounds per cow exposed.

If all cows had been Holstein x Angus cross cows and they were compared to the straightbred Angus cows (which was the cow herd before this cooperative research was started) for all 784 exposures, the difference would have amounted to 112 pounds x 784 cow exposures = 87,808 pounds or 43.9 tons of extra calf weight at weaning. The average weaning grade of calves out of crossbred cows was .8 of a grade point higher than that for calves out of straightbred Angus cows. There was no difference between the grade of the straight Charolais calves and calves out of crossbred cows. Differences in condition of the calves at weaning was nonsignificant, however, the straight Charolais calves were slightly lower than the others.

The percentage of open cows was drastically different among the five groups, ranging from 5.1% for the FA cows to 22.9% for the CC cows. Over all breeds and years, 11.6% of the cows were open. Calf losses averaged 7.9%, ranging from 4.0% for the CA cows to 13.0% for the Angus cows producing crossbred calves. Cow death losses were 4.2% or 8 deaths out of 188 cows with 784 exposures.

The authors express their sincere appreciation to Mr. Purvis and Mr. Grizzard for their full support of this research, to the numerous inmates who helped handle the cattle, to Wayne Wyatt for assistance in analyzing the data, and to Mrs. Ellie Stephens for typing the manuscript.

TABLE 2.

HEIFER BREED EVALUATION AT SOUTHAMPTON: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING, CALVING AS EITHER 2- OR 3-YEAR-OLDS, 1972-1976

Breed of bull	Breed of heifer	Year	Number of heifers			Calf survival and performance to weaning								Lbs calf wean per cow exp.
			exp	open	died	born	lost	wean	%	ADG	W.wt.	grade	cond	
Ang	AA	1972	12	1	0	11	2	9	75.0	1.32	338	9.2	8.2	254
		1973	11	3	0	8	2	6	54.5	1.61	390	11.0	8.0	212
		1974	9	4	0	5	0	5	55.5	1.56	394	11.1	6.8	219
		1975	21	1	1	20	1	19	90.5	1.43	365	11.7	7.4	330
		1976	10	2	0	8	1	7	70.0	1.47	374	11.9	6.7	262
		Combined	63	11	1	52	6	46	73.0	1.48	372	11.0	7.4	271
Char	CC	1972	7	1	0	6	1	5	71.4	1.90	479	12.3	7.7	342
		1973	6	2	1	4	1	3	50.0	2.04	522	13.4	7.6	261
		1974	10	3	0	7	1	6	60.0	1.48	399	11.6	6.5	240
		1975	9	2	0	7	1	6	66.7	1.86	467	11.9	6.6	311
		1976	7	3	0	4	1	3	42.9	2.22	540	13.3	6.9	232
		Combined	39	11	1	28	5	23	59.0	1.90	481	12.5	7.1	284
Ang	CA	1972	5	2	0	3	0	3	60.0	1.38	379	12.0	7.3	228
		1973	11	3	0	8	2	6	54.5	1.85	462	12.0	8.3	252
		1974	12	3	1	8	1	7	58.3	1.56	402	11.7	6.5	234
		1975	10	0	0	10	0	10	100.0	1.62	413	12.8	7.3	413
		1976	6	1	0	5	0	5	83.3	1.51	392	11.5	6.6	326
		Combined	44	9	1	34	3	31	70.4	1.58	410	12.0	7.2	289
Ang	FA	1972	5	0	0	5	0	5	100.0	1.59	403	11.2	8.3	403
		1973	10	1	0	9	1	8	80.0	1.88	467	11.0	7.9	374
		1974	10	2	0	8	1	7	70.0	1.79	450	12.8	6.4	315
		1975	12	0	0	12	0	12	100.0	1.84	464	12.7	8.0	464
		1976	5	0	0	5	0	5	100.0	1.66	433	11.6	7.0	434
		Combined	42	3	0	39	2	37	88.1	1.75	443	11.9	7.5	390
All Breeds		1972	29	4	0	25	3	22	75.9	1.55	400	11.2	7.9	307
		1973	38	9	1	29	6	23	60.5	1.85	460	11.9	8.0	279
		1974	41	13	1	28	3	25	61.0	1.60	411	11.8	6.6	251
		1975	52	3	1	49	2	47	90.4	1.69	427	12.3	7.3	386
		1976	28	6	0	22	2	20	71.4	1.71	435	12.1	6.8	310
		Combined	188	35	3	153	16	137	72.9	1.64	417	11.8	7.4	304

TABLE 3.
COW BREED EVALUATION AT SOUTHAMPTON: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING
BY BREED OF COWS AND YEAR FOR COWS CALVING AT 3-8 YEARS OF AGE. 1973-1978

Breed of bull	Breed of cow	Year	Number of cows			Calf survival and weaning performance								Lbs calf wean per cow exp.
			exp	open	died	born	lost	wean	%	ADG	W.wt.	grade	cond	
Ang	AA	1973	7	0	0	7	0	7	100.0	1.79	445	11.9	8.7	445
		1974	17	5	0	12	0	12	66.7	1.81	442	12.3	7.6	295
		1975	14	0	0	14	2	12	85.7	1.61	404	13.1	7.7	346
		1976	25	7	0	18	1	17	68.0	1.82	442	12.3	7.9	300
		1977	26	2	0	24	0	24	92.3	1.44	359	11.8	7.2	331
		1978	28	1	0	27	0	27	96.4	1.55	383	12.5	6.9	369
		Combined	117	15	0	102	3	99	84.6	1.66	412	12.3	7.7	348
Char	CC	1973	7	0	0	7	0	7	100.0	2.14	552	13.1	7.3	552
		1974	12	1	2	9	1	8	66.7	2.01	496	13.0	7.5	331
		1975	17	2	0	16	2	14	82.3	2.38	575	13.0	7.2	473
		1976	20	9	0	11	0	11	55.0	2.31	548	13.6	7.4	301
		1977	16	4	0	12	0	12	75.0	2.05	503	13.0	7.5	377
		1978	20	3	0	17	0	17	85.0	1.85	450	13.6	6.9	382
		Combined	92	19	2	72	3	69	75.0	2.12	521	13.2	7.3	391
SmH	AA	1973	7	0	0	7	2	5	71.4	1.89	458	12.1	8.2	327
		1974	17	4	0	13	3	10	58.8	1.72	419	11.9	8.3	246
		1975	18	0	0	18	3	15	83.3	1.76	434	11.9	8.0	361
		1976	28	1	1	27	3	24	96.0	2.02	493	13.0	7.6	473
		1977	30	1	1	29	3	26	89.6	1.95	476	12.8	7.4	426
		1978	26	1	1	25	2	23	79.3	1.49	387	13.0	7.1	307
		Combined	126	7	3	119	16	103	82.4	1.80	444	12.4	7.8	366
SmH	CA	1973	7	4	0	3	0	3	42.8	2.40	603	13.3	8.4	258
		1974	17	3	0	14	0	14	82.3	1.98	487	13.0	7.1	401
		1975	18	2	0	16	0	16	88.9	1.89	467	12.7	7.7	415
		1976	25	1	0	24	0	24	60.0	1.82	458	12.9	7.1	275
		1977	29	0	0	29	3	26	89.7	1.91	474	12.9	7.1	425
		1978	29	0	0	29	0	29	100.0	1.46	385	13.2	6.8	385
		Combined	125	10	0	115	3	112	89.6	1.91	479	13.0	7.4	429

CONTINUED

TABLE 3.
COW BREED EVALUATION AT SOUTHAMPTON: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING BY BREED OF COWS AND YEAR FOR COWS CALVING AT 3-8 YEARS OF AGE. 1973-1978 (Continued)

Breed of bull	Breed of cow	Year	Number of cows exp	open	died	Calf survival and weaning performance born	lost	wean	%	ADG	W.wt.	grade	cond	Lbs calf wean per cow exp.
SmH	FA	1973	7	0	0	7	2	5	71.4	2.17	540	12.5	8.4	385
		1974	16	1	0	15	3	12	75.0	2.11	522	13.0	7.2	391
		1975	20	0	0	20	0	20	100.0	2.08	509	13.3	8.2	509
		1976	30	4	0	26	2	24	80.0	2.12	523	13.6	7.5	418
		1977	32	0	0	32	4	28	87.5	2.17	532	13.3	7.5	465
		1978	31	1	0	30	3	27	87.1	1.81	456	13.3	7.2	397
		Combined	136	6	0	130	14	116	92.1	2.07	514	13.2	7.7	473
All Breeds		1973	35	4	0	31	4	27	77.1	2.08	519	12.6	8.2	400
		1974	79	14	2	63	7	56	70.9	1.92	473	12.7	7.5	335
		1975	87	4	0	84	7	77	88.5	1.94	478	12.8	7.8	423
		1976	128	22	1	106	6	100	78.1	2.02	493	13.1	7.5	385
		1977	133	7	1	126	10	116	87.2	1.90	469	12.8	7.3	409
		1978	134	6	1	128	5	123	91.8	1.62	412	13.1	7.0	378
		Combined	596	56	5	538	39	499	83.7	1.86	461	12.9	7.4	386

TABLE 4.
COW BREED EVALUATION AT SOUTHAMPTON: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING COMBINED FOR HEIFERS AND COWS. 1972-1978

Breed of bull	Breed of cow	Age group	Number of cows			Calf survival and performance to weaning									Lbs calf wean per cow exp.
			exp	no.	%	born	lost	%	wean	%	ADG	W.wt.	grade	cond	
Ang	AA	Heifers	30	5	16.7	25	3	12.0	22	73.3	1.48	372	11.0	7.4	273
Ang	AA	Cows	117	15	0	102	3	2.9	99	84.6	1.66	412	12.3	7.7	348
		Combined	147	20	13.6	127	6	4.7	121	82.3	1.63	405	12.1	7.6	333
Char	CC	Heifers	39	11	28.2	28	5	17.8	23	59.0	1.90	481	12.5	7.1	284
Char	CC	Cows	92	19	20.6	72	3	4.2	69	75.0	2.12	521	13.2	7.3	391
		Combined	131	30	22.9	100	8	8.0	92	67.6	2.06	511	13.0	7.2	345
Ang	AA	Heifers	33	6	18.2	27	3	11.1	24	72.7	1.48	372	11.0	7.4	270
SmH	AA	Cows	126	7	5.5	119	16	13.4	103	82.4	1.80	444	12.4	7.7	366
		Combined	159	13	8.2	146	19	13.0	127	80.4	1.74	430	12.1	7.6	346
Ang	CA	Heifers	44	9	20.4	34	3	8.8	31	70.4	1.58	410	12.0	7.2	289
SmH	CA	Cows	125	10	8.0	115	3	2.4	112	89.6	1.91	479	13.1	7.4	429
		Combined	169	19	11.2	149	6	4.0	143	84.6	1.84	464	12.9	7.4	392
Ang	FA	Heifers	42	3	7.1	39	2	5.1	37	88.1	1.75	443	11.9	7.5	390
SmH	FA	Cows	136	6	4.4	130	14	10.8	116	92.1	2.07	514	13.2	7.7	473
		Combined	178	9	5.1	169	16	9.5	153	89.5	1.99	497	12.9	7.7	445
All Breeds		Heifers	188	34	18.1	153	16	10.4	137	72.9	1.65	418	11.8	7.3	305
		Cows	596	57	9.6	538	39	7.2	499	83.7	1.86	461	12.9	7.4	386
		Combined	784	91	11.6	691	55	7.9	636	81.1	1.85	452	12.7	7.4	366

COW BREED EVALUATION AT STATE FARM: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING

T. J. Marlowe[1], G. V. Hogue[1], C. Sims[2] and E. S. Strawderman[2]

This report covers phase II, cycles 1 and 2, of the cooperative cattle breeding research at the James River-Powhatan Correctional Center between the Animal Science Department of VPI&SU, Blacksburg, and the Department of Corrections, Richmond.

Source and Management of Cattle

Cows used in this study were produced in phase I (sire breed evaluation) during the years 1972-1975. They were out of Hereford cows and sired by 6 Angus, 6 Brown Swiss, 9 Charolais, 11 Herefords, 8 Shorthorn and 11 Simmental bulls. Breeding seasons were limited to 75 days annually starting on or about February 15. All calves were identified by metal ear tags at birth and later tattooed.

Calves from all breeding groups were treated alike. They were weaned in late July or early August of each year, grazed until November and fed corn silage, protein supplement and a small amount of hay through the first winter, and grazed again the following summer.

All heifers were weighed, graded and scored for condition at weaning, 12 and 18 months of age. Heifers were selected on the basis of 18 months weight and flesh condition. Heifers under 650 pounds, as well as extremely thin heifers, were culled. Heifers with serious physical defects were also culled. Prior to going into the breeding herds, a rubber (Ritchey) ear tag was placed in the right ear for easy identification.

The composition of the phase II (cow breed evaluation) cow herds were Angus x Hereford (AH), Brown Swiss x Hereford (BH), Charolais x Hereford (CH), Holstein x Hereford (FH), Shorthorn x Hereford ($\bar{S}$H), Simmental x Hereford (SH), Hereford (Hx) and Hereford (HH). The table below gives the numbers of heifers by breed composition and year that went into the breeding groups.

TABLE 1. BREED COMPOSITION OF PHASE II COWS

Year	AxH	BSxH	CxH	FxH	$\bar{S}$xH	SxH	Hx	HH	Total
1974	17	6	16	16	11	14	16	16	112
1975	17	16	17	17	8	18	16	15	124
1976	17	12	15	16	14	9	16	15	114
1977	8	12	6	11	10	10	7	13	77
Total	59	46	54	60	43	51	55	59	427

Hx = Hereford cows bred to produce crossbred calves.

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All heifers were bred to Angus bulls as two-year-olds to calve as three-year-olds and to Shorthorn bulls thereafter except that the AH heifers and cows were bred to Shorthorn bulls and the HH heifers and cows were bred to Hereford bulls for a straightbred Hereford control group.

The breeding season was limited to 75 days, starting on or about January 15 for the heifers and February 15 for the cows, except for the 1977 breeding season when bulls were turned with the heifers on April 15 and with the cows on May 15. The ratio of bulls to heifers or cows was approximately 1 to 25.

Heifers produced in the same calf crop ran together as a group during all years through the 1978 calf crop, except for the straightbred Hereford controls and the AH or $\bar{S}$H cows during the breeding season when they were cut out for breeding to bulls of another breed.

The Data and Statistical Analyses

Cow breed evaluation was based on percentage of cows calving, calf mortality, percent calf crop weaned, age at weaning, weaning weights and grades, and pounds of calf weaned per cow exposed. Cycle 1 included all heifers bred for the first time and cycle 2 included those same cattle for all subsequent calf crops. Cows were culled only if they failed to wean two calves, would not claim their calves, prolapsed or developed some other physical disability that would obviously prevent them from further production. There was a total of 427 heifers exposed and 341 calves weaned in cycle 1 and 664 cows exposed and 504 calves weaned in cycle 2. The breakdown by year, cow age and breed is shown in tables 2, 3 and 4.

Cycle 1 and 2 data were analyzed separately. The sources of variation included in the models were year, age and breed of cow, sex of calf, and breed x year and breed x sex interactions. The general linear models procedure of the Statistical Analysis System (SAS) by the SAS Institute, Inc., was used for the analysis on a 370 IBM computer.

Results and Discussion

Seven kinds of cows were compared on fertility, calf survival, preweaning growth, weaning weights and grades of offspring and pounds of calf weaned per cow exposed over four calf crops. These comparisons are shown in tables 2, 3 and 4 by year, age and breed composition of the cow.

The effect of breed of cow was highly significant for preweaning ADG, weaning weight, grade and condition at weaning but not for weaning age for both heifers and cows. The average age at weaning was 244 days for first calf heifers and 220 days for cows.

Crossbred cows weaned seven (7) more calves that averaged 75 pounds heavier than straightbred calves and 46 pounds heavier than crossbred calves out of straightbred cows. Holstein x Hereford (FH) cows were superior to all others, weaning 39 pounds more calf per cow exposed than her closest competitor (Brown Swiss x Hereford), 79 pounds more than Hereford (Hx) cows with crossbred calves and 132 pounds more than Hereford cows with Hereford calves. The Holstein x Hereford cows had the fewest (9.2%) cows open, next to lowest in calf losses (8.3%), fastest growing calves (1.76 lb ADG), heaviest weaning weights (475 lb), highest weaning grade (13.1), as well as the most pounds of calf weaned per cow exposed (397 lb). The rank from high to low on pounds of calf weaned per cow exposed (for all calves) was Holstein x Hereford (FH), Brown Swiss x Hereford (BH), Shorthorn x Hereford ($\bar{S}$H), Simmental x Hereford (SH), Charolais x Hereford (CH), Angus x Hereford (AH), Hereford (Hx) cows producing crossbred calves and, last, Hereford (HH) cows producing Hereford calves. Calf weaning grades also favored the crossbred cows.

The FH cows were even more impressive as young cows. They weaned 89.3 calves for each 100 heifers exposed (surpassed only by the $\bar{S}$H heifers with 90.7%) that average 468 pounds that graded middle choice and 418 pounds of calf per cow exposed. This was 97 pounds over the Angus x Hereford cows or 9,700 pounds more in a herd of 100 cows. The Brown Swiss x Hereford and Shorthorn x Hereford heifers performed well with their first calves also, 382 and 379 pounds, respectively, per cow exposed; however, their calves graded about one grade point lower. As the cows got older the differences between FH and BH or $\bar{S}$H cows increased but decreased when compared to AH cows. Young CA and SH cows were intermediate in performance.

To dramatize these differences, let's assume that, in one case, all exposures were FH *vs* HH cows, (397 - 265) x 1091 = 144,012 pounds or 72.0 tons; and, in the second case, that all exposures were FH *vs* AH cows, a more reasonable comparison, (397 - 324) x 1091 = 79,643 pounds or 39.8 tons of additional weaning weight.

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TABLE 2.
COW BREED EVALUATION AT STATE FARM: FERTILITY, CALF SURVIVAL AND PERFORMANCE
OF HEIFERS CALVING AS THREE-YEAR-OLDS, 1975-1978

Breed of bull	Breed of heifer	Year	Number of heifers exp	open	died	Calf survival and performance to weaning born	lost	wean	%	ADG	W.wt.	grade	cond	Lbs calf wean per cow exp.
Sh	AxH	1975	17	1	0	16	2	14	82.4	1.31	371	10.9	6.6	306
		1976	17	2	0	15	0	15	88.2	1.20	358	11.4	6.0	316
		1977	17	2	1	15	3	12	70.6	1.40	393	12.8	6.6	277
		1978	8	1	0	7	1	6	75.0	1.77	490	12.7	9.5	367
		Combined	59	6	1	53	6	47	79.7	1.42	403	11.9	7.2	321
Ang	BxH	1975	6	0	0	6	2	4	66.7	1.52	468	11.4	5.7	312
		1976	16	2	0	14	1	13	81.2	1.33	378	11.7	5.7	307
		1977	12	1	0	11	1	10	83.3	1.49	408	12.5	6.6	340
		1978	12	0	0	13	1	12	100.0	2.00	552	11.9	8.3	552
		Combined	46	3	0	44	5	39	84.8	1.60	451	11.9	6.6	382
Ang	CxH	1975	16	2	0	14	5	9	52.2	1.42	434	12.5	7.3	226
		1976	17	2	0	15	0	15	88.2	1.40	406	12.8	6.7	358
		1977	15	1	0	14	1	13	86.7	1.40	375	12.6	6.2	325
		1978	6	1	0	5	1	4	66.7	1.76	503	13.0	8.2	335
		Combined	54	6	0	48	7	41	75.9	1.50	429	12.7	7.1	326
Ang	FxH	1975	16	0	0	16	1	15	93.8	1.52	470	12.9	6.9	441
		1976	17	2	0	15	3	12	70.6	1.52	434	13.2	6.5	306
		1977	16	0	0	16	0	16	100.0	1.61	432	13.3	6.4	432
		1978	11	0	0	11	1	10	90.9	1.97	536	12.6	8.7	487
		Combined	60	2	0	58	5	53	89.3	1.67	468	13.0	7.1	418
Ang	S̄xH	1975	11	0	0	11	0	11	100.0	1.32	402	12.6	7.2	402
		1976	8	0	0	8	0	8	100.0	1.43	384	11.9	6.2	384
		1977	14	1	0	13	1	12	85.7	1.50	404	11.5	6.5	346
		1978	10	2	0	8	0	8	80.0	1.66	482	12.5	8.1	385
		Combined	43	3	0	40	1	39	90.7	1.47	418	12.1	7.0	379

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TABLE 2.
COW BREED EVALUATION AT STATE FARM: FERTILITY, CALF SURVIVAL AND PERFORMANCE
OF HEIFERS CALVING AS THREE-YEAR-OLDS, 1975-1978 (Continued)

Breed of bull	Breed of heifer	Year	Number of heifers			Calf survival and performance to weaning								Lbs calf wean per cow exp.
			exp	open	died	born	lost	wean	%	ADG	W.wt.	grade	cond	
Ang	SxH	1975	14	2	0	12	2	10	71.4	1.29	401	12.3	6.7	286
		1976	18	1	0	17	0	17	94.4	1.34	387	12.6	6.6	365
		1977	9	1	0	8	1	7	77.8	1.67	447	13.5	6.7	348
		1978	10	1	0	9	2	7	70.0	1.51	451	12.0	8.0	316
		Combined	51	5	0	46	5	41	80.4	1.48	422	12.6	7.0	339
Ang	HxH	1975	16	0	0	16	5	11	68.8	1.22	372	12.0	6.6	256
		1976	16	2	0	14	1	13	81.2	1.22	361	12.2	6.2	293
		1977	16	1	1	14	1	13	81.2	1.20	333	10.5	5.6	270
		1978	7	1	0	6	1	5	71.4	1.51	447	12.8	8.0	319
		Combined	55	4	1	50	8	42	76.4	1.31	378	11.9	6.6	289
Her	HxH	1975	16	4	0	11	1	10	62.5	1.19	361	11.6	7.4	226
		1976	15	3	0	12	2	10	66.7	1.23	359	10.8	6.0	239
		1977	15	0	0	15	5	10	66.7	1.23	363	12.2	6.3	242
		1978	13	2	1	10	1	9	69.2	1.57	437	12.1	9.1	302
		Combined	59	9	1	48	9	39	66.1	1.31	380	11.7	7.2	251
All Breeds		1975	112	9	0	102	18	84	75.0	1.41	410	12.0	6.8	307
		1976	124	14	0	110	7	103	83.1	1.31	383	12.1	6.2	318
		1977	114	7	2	106	13	93	81.6	1.39	394	12.4	6.4	321
		1978	77	8	1	69	8	61	79.2	1.77	487	12.4	8.5	386
		Combined	427	38	3	387	46	341	79.8	1.44	411	12.2	6.8	328

TABLE 3.
COW BREED EVALUATION AT STATE FARM: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING OF 4-, 5-, AND 6-YEAR-OLD COWS, 1976-1978

Breed of bull	Breed of cow	Year	Number of cows			Calf survival and performance to weaning								Lbs calf wean per
			exp	open	died	born	lost	wean	%	ADG	W.wt.	grade	cond	cow exp.
Sh	AxH	1976	16	1	0	15	0	15	93.7	1.44	402	12.7	7.3	377
		1977	32	7	2	24	5	19	63.3	1.65	420	12.2	7.0	266
		1978	44	6	0	39	4	35	79.5	1.87	487	13.0	8.9	387
		Combined	92	14	2	78	9	69	75.0	1.65	436	12.6	7.7	327
Sh	BxH	1976	6	1	0	5	1	4	66.7	1.53	436	12.8	6.2	291
		1977	21	7	0	14	0	14	66.7	1.82	460	12.9	7.2	307
		1978	32	6	0	26	1	25	78.1	1.94	505	13.1	7.8	394
		Combined	59	14	0	45	2	43	72.9	1.77	467	12.9	7.1	340
Sh	CxH	1976	16	1	0	15	3	12	75.0	1.62	449	13.6	7.0	337
		1977	29	10	0	19	3	16	55.2	1.76	444	13.0	7.2	245
		1978	44	7	0	37	2	35	79.5	1.90	500	13.4	7.8	397
		Combined	89	18	0	71	8	63	70.8	1.76	464	13.4	7.4	328
Sh	FxH	1976	16	0	0	16	1	15	93.3	1.69	458	13.4	7.2	427
		1977	32	6	0	26	2	24	75.0	1.87	470	13.0	7.0	352
		1978	44	6	0	33	3	35	79.5	1.93	509	13.0	8.2	405
		Combined	92	12	0	75	6	74	80.4	1.83	479	13.1	7.5	385
Sh	S̄xH	1976	12	2	0	10	0	10	83.3	1.50	414	11.9	6.4	345
		1977	20	9	0	11	2	9	45.0	1.74	436	12.8	7.0	197
		1978	34	2	0	32	2	30	88.3	1.73	480	12.9	8.2	424
		Combined	66	13	0	53	4	49	74.2	1.66	459	12.6	7.2	340
Sh	SxH	1976	14	2	0	12	0	12	85.7	1.53	422	13.3	7.2	367
		1977	31	7	0	24	4	20	64.5	1.76	436	13.1	7.0	281
		1978	40	7	0	34	3	31	76.9	1.94	481	13.3	8.0	370
		Combined	85	16	0	70	7	63	74.1	1.74	446	13.2	7.4	330
Sh	HxH	1976	16	1	0	15	1	14	87.5	1.37	394	12.6	6.7	345
		1977	38	4	0	34	6	28	73.7	1.53	389	11.9	6.9	287
		1978	53	6	0	47	2	45	84.9	1.74	449	12.9	8.0	381
		Combined	107	11	0	96	9	87	81.3	1.55	411	12.5	7.2	334

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TABLE 3.
COW BREED EVALUATION AT STATE FARM: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING OF 4-, 5-, AND 6-YEAR-OLD COWS, 1976-1978

Breed of bull	Breed of cow	Year	Number of cows			Calf survival and performance to weaning								Lbs calf wean per cow exp.
			exp	open	died	born	lost	wean	%	ADG	W.wt	grade	cond	
Her	HxH	1976	11	4	0	7	1	6	54.5	1.34	356	10.5	6.2	194
		1977	23	2	0	21	4	17	73.9	1.27	337	12.0	6.6	249
		1978	40	3	0	37	4	33	82.5	1.51	398	11.9	7.9	328
		Combined	74	9	0	65	9	56	75.7	1.37	364	11.5	6.9	275
All Breeds		1976	107	12	0	95	7	88	82.2	1.50	416	12.6	6.8	342
		1977	226	52	2	173	26	147	65.0	1.68	424	12.6	7.0	276
		1978	331	43	0	285	21	269	81.3	1.82	476	12.9	8.1	387
		Combined	664	107	2	553	54	504	75.9	1.72	449	12.8	7.6	341

TABLE 4.

COW BREED EVALUATION AT STATE FARM: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING BY AGE AND BREED OF COW, 1975-1978

Breed of bull	Breed of cow	Age group	Number of cows: No. exp	Open: no.	Open: %	Calf survival and performance to weaning: No. born	Lost: no.	Lost: %	Weaned: no.	Weaned: %	ADG	W.wt.	grade	cond	Lbs calf wean per cow exp.
Sh	AxH	3 yr	59	6	10.2	52	6	11.5	47	79.7	1.42	403	11.9	7.2	321
Sh	AxH	4-6 yr	92	14	15.2	78	9	11.5	69	75.0	1.65	436	12.6	7.7	324
		Combined	151	20	13.2	130	15	11.5	116	76.8	1.56	423	12.3	7.5	324
Ang	BxH	3 yr	46	3	6.5	44	5	11.6	39	84.8	1.60	451	11.9	6.6	382
Sh	BxH	4-6 yr	59	14	23.7	45	2	4.4	43	72.9	1.77	467	12.9	7.1	340
		Combined	105	17	16.2	89	7	7.9	82	78.1	1.68	459	12.4	6.9	358
Ang	CxH	3 yr	54	6	11.1	48	7	14.6	41	75.9	1.50	429	12.7	7.1	326
Sh	CxH	4-6 yr	89	18	20.2	71	8	11.3	63	70.8	1.76	464	13.4	7.4	328
		Combined	143	24	16.8	119	15	12.6	104	72.7	1.66	450	13.1	7.3	327
Ang	FxH	3 yr	60	2	3.3	58	5	8.6	53	89.3	1.67	468	13.0	7.1	418
Sh	FxH	4-6 yr	92	12	13.0	75	6	8.0	74	80.4	1.83	479	13.1	7.5	383
		Combined	152	14	9.2	133	11	8.3	127	83.5	1.76	475	13.1	7.3	397
Ang	S̄xH	3 yr	43	3	7.0	40	1	2.5	39	90.7	1.47	418	12.1	7.0	379
Ang	SxH	4-6 yr	66	13	19.7	53	4	7.5	49	74.2	1.66	444	12.6	7.2	329
		Combined	109	16	14.7	93	5	5.4	88	80.7	1.57	432	12.4	7.1	349
Ang	SxH	3 yr	51	5	9.8	46	5	10.9	41	80.4	1.48	422	12.6	7.0	339
Sh	SxH	4-6 yr	85	16	18.8	70	7	10.0	63	74.1	1.74	446	13.2	7.4	330
		Combined	136	21	15.4	116	12	10.3	104	76.5	1.63	436	13.0	7.2	333
Ang	HxH	3 yr	55	4	7.3	50	8	16.0	42	76.4	1.31	378	11.9	6.6	289
Sh	HxH	4-6 yr	107	11	10.3	96	9	9.4	87	81.3	1.55	411	12.5	7.2	334
		Combined	162	15	9.2	146	17	11.6	129	79.6	1.47	400	12.3	7.0	318
Her	HxH	3 yr	59	9	15.2	48	9	18.7	39	66.1	1.31	380	11.7	7.2	251
Her	HxH	4-6 yr	74	9	12.2	65	9	13.8	56	75.7	1.37	364	11.5	6.9	275
		Combined	133	18	13.5	113	18	15.6	95	71.4	1.35	371	11.6	7.0	265
All Breeds		3 yr	427	38	8.9	385	46	11.9	341	79.8	1.47	420	12.3	7.0	336
		4-6 yr	664	107	16.1	553	54	9.8	504	75.9	1.66	438	12.7	7.3	332
		Combined	1091	145	13.3	938	100	10.7	845	77.4	1.58	431	12.5	7.2	333

COW BREED EVALUATION AT BLAND
FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING

T. J. Marlowe[1], R. L. Saunders[2] and A. J. Smith[2]

This report covers phase II, cycles 1 and 2, of the cooperative cattle breeding research at the Bland Correctional Center between the Animal Science Department of Virginia Polytechnic Institute and State University, Blacksburg, and the Department of Corrections, Richmond, Virginia.

Source and Management of Cattle

Cows used in this study were produced in phase I (sire breed evaluation) during the years 1970-1975, and thereafter from the remaining phase I cows. They were out of Angus and Hereford cows sired by 8 Angus, 14 Charolais, 16 Hereford and 13 Simmental bulls. The Charolais x Holstein cows were produced in other correctional farm herds and moved to Bland for these comparisons. These heifers were produced in a split breeding season of approximately 75 days each with the sires turned in on or about December 20 and May 1. All calves were identified at birth by metal ear tags and later tattooed. They were weaned at an average age of 220 days. Prior to going into the breeding groups, a rubber (Ritchey) ear tag was placed in the right ear for easy identification.

All heifers were fed together each year and treated alike. They were fed corn silage plus a protein supplement and some hay to gain from 0.75 to 1.25 pounds per day through the winter and grazed during the summer on blue grass pasture.

All heifers were weighed, graded and scored for condition at weaning, 12 and 18 months of age. Heifers that were 650 pounds or heavier at the beginning of the breeding season were exposed to bulls as yearlings. The lighter heifers were held over and bred as two-year-olds.

The composition of the phase II (cow breed evaluation) cow herds were Angus (AA), Charolais x Hereford (CH), Charolais x Holstein (CF), Simmental x Hereford (SH), Hereford (HH or Hx) and percentage Simmentals (Sm%). Table 1 gives the number of heifers by breed composition and year that went into the breeding herds.

TABLE 1. BREED COMPOSITION OF PHASE II COWS

Year	AA	CF	CH	SH	Hx	HH	Sm%	Total
1971	5	6	13	16	15	23	3	81
1972	4	4	8	10	11	11	5	53
1973	4	4	19	8	18	11	2	66
1974	5	7	5	11	9	0	5	42
1975	4	1	5	4	8	7	7	36
1976	12	0	12	17	12	14	4	71
1977	12	0	5	7	5	4	21	54
Totals	46	22	67	73	78	70	47	403

Hx = Hereford cows that were bred to produce crossbred calves.

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All heifers were bred to Angus bulls to calve at either two or three years of age except for the straightbred Hereford (HH) control group and the percentage Simmental (Sm%) heifers which were bred to bulls of their own breed. The breeding season was limited to 75 days, starting either on or about December 20 or May 1 of each year. The ratio of bulls to heifers was about 1 to 25 or 30.

Heifers and cows of each breed type were run together on summer pasture and fed together during the winter, except that the straightbred controls were separated out during the breeding seasons. All cattle were grazed on mountain bluegrass pastures during the summers and fed corn silage and/or orchardgrass-clover hay and pasture clippings during the winter. Severe winters and feed shortages during the 1976-77 and 1977-78 winters were especially detramental to calving percentages due largely to exceptionally large numbers of open cows.

The Data and Statistical Analyses

Cow breed evaluation was based on percentage of cows calving, calf survival, percent calf crop weaned, weaning weights and grades, and pounds of calf weaned per cow exposed. Cycle 1 included all heifers calving for the first time at either 2 or 3 years of age and cycle 2 included those same cattle for all subsequent calf crops through the 1978 calf crop. Cows were culled only if they failed to wean two calves (except in 1975 when all heifers and cows open or losing calves were culled), would not claim their calves, prolapsed or developed some other physical disability that would obviously prevent them from further production. There was a total of 403 heifers exposed and 276 calves weaned in cycle 1 and 751 cows exposed and 529 calves weaned in cycle 2. The breakdown by year, cow age and breed is shown in tables 2, 3 and 4.

Cycles 1 and 2 data were analyzed separately. The sources of variation included in the models were year, age and breed of heifer or cow, age and sex of calf and breed x year and breed x sex interactions. The General Linear Models Procedure of the Statistical Analyses System (SAS) by the SAS Institute, Inc., was used for the analyses on a 370 IBM computer.

Results and Discussion

Six kinds of cows were compared during the years 1972-1978. These comparisons are shown in tables 2, 3 and 4 by age and breed composition of cow and year. The effect of breed of cow was significant for preweaning ADG, weaning weight, and grade and condition at weaning for both heifers and cows. The average weaning age was 207 days.

The crossbred (XB) cows weaned 3.4 more calves per 100 cows exposed which averaged 57 pounds heavier than did the straightbred (SB) matings. Straightbred Hereford cows (Hx) bred to produce crossbred calves weaned 9 pounds more calf per cow exposed than did Hereford cows producing Hereford calves. The straightbred Angus cows did surprisingly well, exceeding the straight Herefords by 96 pounds per cow exposed and were only a few pounds under the CH and SH crossbred cows but 51 pounds under the best kind of XB cows (Charolais x Holstein). The best XB cow group (CF) out-produced the straightbred HH cows by 147 pounds of calf weaned per cow exposed. If all cow exposures had been Charolais x Holstein vs all straight Herefords the increased weaning weight over the seven years would have been 1154 x 147 = 169,638 pounds or 84.8 tons. Of course, these extra pounds would have come at a higher feed cost due to the extra nutrients required to maintain the heavier cow weights and to produce the extra milk from the CF cows.

Based on pounds of calf weaned per cow exposed, which takes into account both the calving percentage and calf weaning weight, the cows ranked as follows (from high to low): Charolais x Holstein, Charolais x Hereford and Simmental Hereford, Simmental percentage cattle, Angus, Hereford cows producing XB calves and Hereford cows producing Hereford calves.

Weaning grades favored the crossbred cows, also.

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TABLE 2.

COW BREED EVALUATION AT BLAND: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING OF TWO- AND THREE-YEAR-OLD HEIFERS

Breed of bull	Breed of cow	Year	Number of heifers exp	open	died	Calf survival and performance to weaning born	lost	wean	%	ADG	Wnwt	grade	cond	Lbs calf wean per cow exp
Ang	AA	1972	5	0	0	5	0	5	100.0	1.90	502	12.4	7.9	502
		1973	4	0	0	4	1	3	75.0	1.73	454	12.3	7.9	341
		1974	4	0	0	4	2	2	50.0	1.49	402	11.7	6.4	201
		1975	5	0	0	5	0	5	100.0	1.70	443	12.4	7.4	443
		1976	4	0	0	4	1	3	75.0	1.32	353	9.7	4.2	265
		1977	12	0	1	11	0	11	91.7	1.66	430	12.0	7.6	394
		1978	12	3	0	9	1	8	66.7	1.57	409	11.4	6.9	273
		Combined	46	3	1	42	5	37	80.4	1.62	427	11.7	6.9	343
Ang	CH	1972	13	3	0	10	0	10	76.9	1.48	425	11.9	7.9	327
		1973	8	1	0	7	1	6	71.4	1.66	458	12.6	7.0	327
		1974	19	2	0	17	3	14	73.7	1.67	461	13.1	7.3	340
		1975	5	2	0	3	0	3	60.0	1.64	449	12.4	7.2	269
		1976	5	1	0	4	1	3	77.8	1.47	416	11.6	5.6	324
		1977	12	3	0	9	0	9	75.0	1.62	442	12.7	6.6	332
		1978	5	3	0	2	0	2	40.0	1.63	444	12.8	7.0	178
		Combined	67	15	0	52	5	47	70.1	1.60	442	12.5	6.9	310
Ang	CF	1972	6	1	0	5	0	5	83.3	1.66	459	12.2	7.5	382
		1973	4	0	0	4	0	4	100.0	1.90	506	12.3	7.2	506
		1974	4	0	0	4	0	4	100.0	1.78	481	12.7	7.1	481
		1975	7	0	0	7	1	6	85.7	1.87	515	13.0	8.3	441
		1976	1	0	0	1	0	1	100.0	1.59	453	8.1	6.7	453
		1977	0	0	0	0	0	0	00.0	-	-	-	-	-
		1978	0	0	0	0	0	0	00.0	-	-	-	-	-
		Combined	22	1	0	21	1	20	90.5	1.79	489	12.3	7.2	443
Ang	SH	1972	16	7	0	9	0	9	56.2	1.55	434	12.7	8.0	244
		1973	10	1	0	9	3	6	60.0	1.59	444	12.6	7.3	266
		1974	8	0	0	8	0	8	100.0	1.73	472	13.7	7.0	472
		1975	11	1	1	10	2	8	72.7	1.66	468	13.1	7.1	340
		1976	4	0	0	4	0	4	100.0	1.46	409	12.2	6.6	409
		1977	17	4	1	13	2	11	64.7	1.50	412	12.5	6.2	267
		1978	7	0	0	7	2	5	71.4	1.67	466	12.1	6.7	333
		Combined	73	13	2	60	9	51	69.9	1.59	444	12.7	7.0	310

Continued

TABLE 2.

COW BREED EVALUATION AT BLAND: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING OF TWO- AND THREE-YEAR-OLD HEIFERS (Continued)

Breed of bull	Breed of cow	Year	Number of heifers exp	open	died	Calf survival and performance to weaning born	lost	wean	%	ADG	Wnwt	grade	cond	Lbs calf wean per cow exp
Ang	HH	1972	15	2	0	13	4	9	60.0	1.50	419	10.9	7.2	251
		1973	11	2	0	9	6	3	35.7	1.11	340	10.0	5.9	121
		1974	18	0	0	18	11	7	38.9	1.41	401	12.9	7.0	156
		1975	9	1	0	8	1	7	77.8	1.53	422	11.7	7.1	328
		1976	8	0	0	8	1	7	87.5	1.34	372	12.0	6.0	326
		1977	12	1	0	11	3	8	66.7	1.15	323	11.1	6.0	215
		1978	5	1	1	4	1	3	60.0	1.41	375	11.3	6.5	225
		Combined	78	7	1	71	27	44	56.4	1.35	379	11.4	6.5	214
Her	HH	1972	23	1	0	22	6	16	69.6	1.15	338	11.7	7.6	235
		1973	11	1	0	10	2	8	72.7	1.15	334	10.0	5.9	243
		1974	11	0	0	11	5	6	54.5	1.20	345	10.6	5.7	188
		1975	0	0	0	0	0	0	00.0	-	-	-	-	-
		1976	7	0	0	7	1	6	50.0	1.30	361	10.6	6.7	181
		1977	14	5	1	9	4	5	33.3	1.01	299	10.2	5.3	100
		1978	4	1	0	3	2	1	25.0	1.33	366	9.9	6.1	92
		Combined	70	8	1	62	20	42	60.0	1.17	338	10.8	6.6	203
Sim	Sim%	1972	3	0	0	3	1	2	66.7	1.59	457	14.7	7.1	305
		1973	5	1	0	4	1	3	80.0	1.62	456	12.9	7.3	365
		1974	2	0	0	2	0	2	100.0	1.83	512	14.2	7.8	512
		1975	5	0	0	5	1	4	80.0	1.59	456	13.7	6.8	365
		1976	7	1	0	6	3	3	42.8	1.52	431	12.5	6.8	184
		1977	4	0	0	4	0	4	100.0	1.06	548	14.0	7.2	548
		1978	21	4	0	17	0	17	80.9	1.71	471	12.8	7.0	381
		Combined	47	6	0	41	6	35	74.5	1.70	476	13.6	7.1	355
All Breeds		1972	81	14	0	67	11	56	69.1	1.55	434	12.4	7.6	300
		1973	53	6	0	47	12	35	66.0	1.54	427	11.8	6.9	282
		1974	66	2	0	64	23	41	62.1	1.59	439	12.7	6.9	273
		1975	42	4	1	38	5	33	78.6	1.67	460	12.7	7.3	362
		1976	36	2	0	34	7	27	75.0	1.43	399	11.0	6.1	299
		1977	71	13	3	57	9	48	67.6	1.41	406	12.1	6.5	274
		1978	54	12	1	42	6	36	66.7	1.63	444	12.2	6.9	296
		Combined	403	53	5	349	73	276	68.5	1.53	422	12.1	7.0	289

TABLE 3.

COW BREED EVALUATION AT BLAND: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING OF 3-8-YEAR-OLD COWS, 1973-1978

Breed		Number of cows			Calf survival and weaning performance								# Calf/
of cow	Year	exp	open	died	born	lost	wean	%	ADG	Wnwt	grade	cond	cow exp
Angus	1973	5	0	0	5	1	4	80.0	1.61	423	11.3	7.4	338
	1974	7	0	0	7	0	7	100.0	1.78	460	12.1	7.5	460
	1975	8	0	0	8	2	6	75.0	1.59	406	12.3	6.9	305
	1976	10	2	0	8	1	7	70.0	1.76	449	12.0	7.8	314
	1977	13	2	0	11	0	11	84.6	1.57	398	12.3	7.7	337
	1978	22	5	1	16	1	15	68.2	1.75	441	11.8	7.9	301
	Combined	65	9	1	55	5	50	76.9	1.68	430	12.0	7.4	331
C x H	1973	15	4	0	11	2	9	60.0	1.85	495	13.3	7.6	297
	1974	17	0	0	17	0	17	100.0	1.92	505	13.6	7.7	506
	1975	28	6	2	22	2	20	71.4	1.80	485	13.3	7.2	346
	1976	29	5	1	23	1	22	75.9	1.88	496	12.8	7.4	376
	1977	28	5	2	23	2	21	75.0	1.82	467	12.9	6.9	350
	1978	37	11	2	24	2	22	59.5	2.03	512	13.5	7.9	305
	Combined	154	31	7	120	9	111	72.1	1.88	493	13.2	7.4	356
C x F	1973	5	0	0	5	1	4	80.0	2.05	520	12.6	6.6	416
	1974	9	1	0	8	0	8	88.9	2.24	575	14.1	7.7	511
	1975	12	4	0	8	0	8	66.7	1.92	507	13.6	7.3	338
	1976	19	1	0	18	1	17	89.5	2.04	543	13.2	7.2	486
	1977	18	4	3	11	2	9	50.0	1.75	457	12.3	5.7	229
	1978	12	4	0	7	0	7	58.3	2.17	539	13.1	8.6	314
	Combined	75	14	3	57	3	53	70.7	2.03	523	13.1	7.2	370
Hereford	1973	16	2	0	14	3	11	68.8	1.84	485	13.0	7.7	334
	1974	12	0	0	12	0	12	100.0	1.69	454	14.2	7.5	454
	1975	18	5	1	13	2	11	61.1	1.39	388	13.2	6.9	237
	1976	14	4	0	10	2	8	57.1	1.71	441	12.8	6.5	251
	1977	22	8	0	14	0	14	63.6	1.48	375	12.3	6.1	303
	1978	29	10	0	19	2	17	58.6	1.57	403	12.7	7.0	236
	Combined	111	29	1	84	9	73	64.6	1.61	424	13.0	7.0	274

Continued

TABLE 3.
COW BREED EVALUATION AT BLAND: FERTILITY, CALF SURVIVAL AND PERFORMANCE
TO WEANING OF 3-8-YEAR-OLD COWS, 1973-1978 (Continued)

Breed		Number of cows			Calf survival and weaning performance								# Calf/
of cow	Year	exp	open	died	born	lost	wean	%	ADG	Wnwt	grade	cond	cow exp
S x H	1973	18	1	0	17	3	14	77.8	1.97	505	13.7	8.3	393
	1974	25	1	0	25	4	21	84.0	1.89	498	13.6	7.9	418
	1975	24	3	1	23	5	18	75.0	1.78	476	13.7	7.3	358
	1976	27	3	0	24	3	21	77.8	1.82	477	12.8	7.0	371
	1977	27	3	0	24	1	23	85.2	1.69	434	12.6	6.6	370
	1978	35	13	0	22	3	19	54.3	1.88	478	13.2	7.4	260
	Combined	156	24	1	135	19	116	74.4	1.84	478	13.3	7.4	356
Her Cont	1973	7	0	0	7	1	6	85.7	1.25	367	11.1	6.6	315
	1974	18	0	0	18	1	17	94.4	1.56	418	12.0	7.8	395
	1975	20	8	1	12	2	10	50.0	1.48	390	12.2	7.6	195
	1976	20	6	0	14	1	13	65.0	1.46	386	11.8	6.8	251
	1977	24	3	2	19	3	16	66.7	1.21	331	11.3	6.4	221
	1978	31	11	1	19	3	16	51.6	1.45	391	12.0	6.5	202
	Combined	120	28	4	89	11	78	65.0	1.40	381	11.8	7.0	248
Simmental	1973	1	0	0	1	0	1	100.0	1.88	491	15.4	8.3	492
	1974	6	0	0	6	1	5	83.3	1.78	486	14.5	7.4	405
	1975	7	0	0	8	1	7	100.0	1.82	484	13.5	7.3	484
	1976	9	0	0	9	1	8	88.9	1.92	495	13.7	6.4	441
	1977	19	2	1	17	3	14	73.7	1.55	419	13.4	6.1	309
	1978	28	9	0	20	7	13	46.4	1.90	501	13.9	6.5	232
	Combined	70	11	1	61	13	48	68.6	1.81	479	14.0	7.0	329
All Breeds	1973	67	7	0	60	11	49	73.1	1.78	469	12.9	7.5	343
	1974	94	2	0	93	6	87	92.5	1.84	485	13.4	7.6	449
	1975	117	26	5	94	14	80	68.4	1.68	448	13.1	7.2	358
	1976	128	21	1	109	10	96	75.0	1.80	470	12.7	7.0	352
	1977	151	27	8	118	10	108	71.5	1.58	412	12.4	6.3	294
	1978	194	63	4	127	18	109	56.2	1.82	466	12.9	7.4	262
	Combined	751	146	18	601	69	529	70.4	1.71	448	12.8	7.1	315

Angus, Hereford and Simmental controls were bred straight. Other cows were bred to Charolais, Hereford and Simmental bulls for 1973 through 1975 calf crops, and to Angus bulls for the 1976 and 1978 calf crops.

TABLE 4.
COW BREED EVALUATION AT BLAND: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING BY AGE AND BREED OF COW, 1972-1978

Breed of bull	Breed of cow	Age of cow (year)	Number of cows			Calf survival and performance to weaning									Lbs. calf wn per cow exp.
				Open			Lost		Weaned						
			exp	no.	%	born	no.	%	no.	%	ADG	Wnwt	grade	cond	
Ang	AA	2-3	46	3	6.5	42	5	11.9	37	80.4	1.62	427	11.7	6.9	343
		3-8	65	9	13.8	55	5	9.1	50	76.9	1.68	430	12.0	7.4	330
		Combined	111	12	10.8	97	10	10.3	87	78.4	1.65	429	11.9	7.2	336
Ang	CH	2-3	67	15	22.4	52	5	9.6	47	70.1	1.60	442	12.5	6.9	310
		3-8	154	31	20.1	120	9	7.5	111	72.1	1.88	493	13.2	7.4	356
		Combined	221	46	20.8	172	14	8.1	158	71.5	1.80	478	13.0	7.2	342
Ang	CF	2-3	22	1	4.5	21	1	4.8	20	90.5	1.79	489	12.3	7.2	443
		3-8	75	14	18.7	57	3	5.3	53	70.6	2.03	523	13.1	7.2	369
		Combined	97	15	15.5	78	4	5.1	73	75.3	1.96	514	12.9	7.2	387
Ang	SH	2-3	73	13	17.8	60	9	15.0	51	69.9	1.59	444	12.7	7.0	310
		3-8	156	24	15.4	135	19	14.1	116	74.3	1.84	478	13.3	7.4	356
		Combined	229	37	16.2	195	28	14.3	167	72.9	1.76	468	13.1	7.3	341
Ang	HH	2-3	78	7	9.0	71	27	38.0	44	56.4	1.35	379	11.4	6.5	214
		3-8	111	29	25.7	84	9	10.7	73	64.6	1.61	424	13.0	7.0	274
		Combined	189	36	18.8	155	36	23.2	117	61.2	1.51	407	12.4	6.8	249
Her	HH	2-3	70	8	11.4	62	20	32.2	42	60.0	1.35	379	11.4	6.5	203
		3-8	120	28	23.3	89	11	12.3	78	65.0	1.40	381	11.7	7.0	248
		Combined	190	36	18.9	151	31	20.5	120	63.1	1.38	380	11.6	6.8	240
Sim	Sm%	2-3	47	6	12.8	41	6	14.6	35	74.5	1.70	476	13.5	7.1	355
		3-8	70	11	15.7	61	13	21.3	48	68.6	1.81	479	14.0	7.0	328
		Combined	117	17	14.5	102	19	18.6	83	70.9	1.76	478	13.8	7.0	339
All Breeds		2-3	403	53	13.1	349	73	20.9	276	68.5	1.53	422	12.1	7.0	289
		3-8	751	146	19.4	601	69	11.5	529	70.4	1.71	448	12.8	7.1	315
		Combined	1154	199	17.2	950	142	14.5	805	69.7	1.65	439	12.6	7.1	306

COW BREED EVALUATION AT BEAUMONT
FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING

T. J. Marlowe[1], G. V. Hogue[1], C. G. Sims[2] and E. S. Strawderman[2]

The cow breed evaluation phase was divided into three cycles. Cycle 1 included all heifers calving for the first time at three years of age. Cycle 2 included those same cattle for all subsequent calf crops through the 1978 calf crop. In cycle 3 all cows except for the straightbred Hereford controls will be bred to Maine-Anjou x Shorthorn and Limousin x Shorthorn bulls for two calf crops. This report covers cycles 1 and 2 of the cow breed evaluation phase (II) of the cooperative cattle breeding research in the Beaumont unit between the Animal Science Department of Virginia Polytechnic Institute and State University and the Department of Corrections, Richmond.

Source and Management of Cattle

The Beaumont farm is located in the lower Piedmont area of Virginia, about 30 miles west of Richmond, adjoining the James River near Goochland. At the beginning of phase I (sire breed evaluation) there were 75 commercial Hereford cows in the herd. They were divided into three breed groups at random by age of cow. Two bulls each of the Charolais, Holstein and Shorthorn breeds were allotted at random to the three groups of cows. This procedure was followed for each of the three years with the exception that a few more cows were allotted to the Shorthorn and Charolais bulls than to the Holsteins one year by mistake. During the three breeding seasons of 1969-1971, 83 cows were exposed to 6 Charolais bulls, 79 cows to 6 Holstein bulls, and 85 cows to 6 Shorthorn bulls.

Cows were limited to a 75-day breeding season starting on about April 1 so that calves were dropped mainly in January and February. Calves were weaned during September. No creep feeding was used. During the summer, cattle were grazed mostly on unimproved river bottom pastures consisting largely of fescue and Johnson grass with some upland pasture of local native grasses. Cows were wintered on low quality Johnson grass and fescue hay without supplementation. Feeding and management practices at Beaumont farm were suboptimal during the entire period of phase I. Consequently, it was decided after the third calf crop to discontinue the herd at Beaumont farm and to move all of the heifers for the cow breed evaluation phase and the best of the remaining phase I cows to the James River-Powhatan Correctional Center at State Farm, about five miles down the James River toward Richmond.

All heifers were weighed, graded and scored for condition at weaning, 12 months and 18 months of age. All heifers that were large enough at two years of age (650 pounds or heavier) were put into the breeding groups and designated as phase II cows (cow breed evaluation phase).

The breed composition of these heifers were Charolais x Hereford (CH), Holstein x Hereford (FH), Shorthorn x Hereford ($\bar{S}$H) and Hereford (HH, Hx). Table 1 gives the number of heifers by breed composition and year that went into the breeding groups.

[1]Animal Science Department, VPI&SU, Blacksburg and State Farm.
[2]James River-Powhatan Correctional Center, State Farm.

TABLE 1. BREED COMPOSITION OF PHASE II COWS

Year	CH	FH	S̄H	Hx	HH	Total
1972	12	14	13	11	18	68
1973	6	10	9	10	9	44
1974	15	11	11	12	9	58
Total	33	35	33	33	36	170

The phase II heifers were handled as a separate unit at State Farm through the 1978 calf crop. Prior to going into the breeding herd, a rubber (Ritchey) ear tag was placed in the right ear for easy identification. All heifers and cows except the straightbred Hereford controls were bred to Angus bulls through the 1975 calf crop. Thereafter they were bred to Simmental x Angus bulls. Unfortunately, due to illness of the herdsman, the 1974 calf crop was not identified with their dams at birth and the data for that year was lost.

The breeding season was limited to 75 days starting on about January 15 for the heifers and February 15 for the cows, except for the 1977 breeding season when bulls were turned with the cows on April 15. The ratio of bulls to heifers or cows was approximately 1 to 25. All cows except the straightbred Hereford controls ran together as a group during all years following their first calving.

Data and Statistical Analyses

Cow breed evaluation was based on the percentage of cows calving, calf mortality, percent calf crop weaned, age at weaning, weaning weight and grades, and pounds of calf weaned per cow exposed. Cows were culled only if they failed to wean two calves, did not claim their calves, prolapsed or developed some other physical disability that would obviously prevent them from further production. There were a total of 126 heifers exposed and 95 calves weaned in cycle 1 and 541 cows exposed and 400 calves weaned in cycle 2. This does not include the year 1974 in which calves were not identified and the information lost.

Cycles 1 and 2 data were analyzed separately. The source of variation included in the models were year, age and breed of heifer or cow, sex of calf, breed x year, and breed x sex interactions. The General Linear Models Procedure of the Statistical Analysis System (SAS) by the SAS Institute, Inc., was used for the analyses on a 370 IBM computer.

Results and Discussion

Four kinds of cows were compared on fertility, calf survival, preweaning growth, weaning weights and grades of offspring, pounds of calf weaned per cow exposed and age of calf at weaning over five calf crops. These comparisons are shown in tables 2, 3 and 4 by year, age and breed composition of cow.

The effect of breed of cow was highly significant for preweaning average daily gain, weaning weight, grade and condition at weaning, but not for age of calf at weaning for both heifers and cows. The average at weaning was 252 days from heifers' first calves and 224 days for the cows.

Crossbred cows weaned 7.4 more calves that averaged 93 pounds heavier at weaning than straightbred cows. Holstein x Hereford (FH) cows were superior to all others, weaning 17 pounds more calf per cow exposed than their closest competitor (Shorthorn x Hereford), 62 pounds more than the Charolais x Hereford, and 109 pounds more than Herefords producing straightbred Hereford calves.

The percentage of open cows ranged from a low of 9.8% for the Shorthorn x Hereford to 18.5% for the Charolais x Hereford cows, with an average of 16.2% for all groups. Calf death losses ranged from a low of 5.7% for the Holstein x Hereford cows to a high of 16.1% for the Hereford cows producing crossbred calves. The average for all groups was 11.3%. Cow death losses amounted to 4.1% or 7 cows out of 170 over the seven-year period.

To dramatize the differences between the best crossbred group (FH) and the straight Hereford matings (which was the breeding program prior to the beginning of this research), we multiply 107 pounds x 667 cow exposures = 72,703 pounds or 36.3 tons of extra calf at weaning.

The authors express their sincere appreciation to Mr. Walter Riddle for his full support of this research, also to Dr. T. N. Meacham and Dr. T. L. Bibb for pregnancy checking the cows, and the several inmates who helped handle the cattle, and to Mrs. Ellie Stephens for typing the manuscript.

TABLE 2.

COW BREED EVALUATION IN BEAUMONT HERD: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING BY BREED AND YEAR FOR HEIFERS CALVING FIRST TIME AT THREE YEARS OF AGE, 1973-1975

Breed of bull	Breed of heifer	Year	Number of heifers exp	open	died	Calf survival and performance to weaning born	lost	wean	%	ADG	W.wt.	grade	cond	Lbs calf wean per cow exp.
Ang	CxH	1973	12	2	0	10	2	8	66.7	1.64	438	12.8	8.5	292
		1975	15	2	0	13	3	10	66.7	1.34	421	12.8	7.3	281
		Combined	27	4	0	23	5	18	66.7	1.47	430	12.8	7.8	287
Ang	FxH	1973	14	3	0	11	1	10	71.4	1.72	440	12.6	8.2	314
		1975	11	0	0	11	0	11	100.0	1.52	499	13.4	8.0	499
		Combined	25	3	0	22	1	21	84.0	1.62	471	13.0	8.1	395
Ang	S̄xH	1973	13	4	0	9	0	9	69.2	1.56	414	13.3	8.4	286
		1975	11	0	0	11	1	10	90.9	1.22	407	12.6	7.3	370
		Combined	24	4	0	20	1	19	79.2	1.38	410	13.0	7.8	325
Ang	HxH	1973	11	2	0	9	0	9	81.8	1.29	377	12.1	8.1	308
		1975	12	1	0	11	4	7	58.3	1.04	344	10.1	6.4	201
		Combined	23	3	0	20	4	16	69.6	1.18	363	11.2	7.4	244
Her	HxH	1973	18	2	0	16	1	15	80.0	0.98	318	10.4	6.8	254
		1975	9	2	0	7	1	6	66.7	1.31	365	11.5	7.4	243
		Combined	27	4	0	23	2	21	77.8	1.07	331	10.7	7.0	257
All Breeds		1973	68	13	0	56	5	51	75.0	1.39	388	12.0	7.9	291
		1975	58	5	0	53	9	44	75.9	1.31	417	12.3	7.4	316
		Combined	126	18	0	109	14	95	75.4	1.35	402	12.2	7.6	303

Due to illness of the cattle manager, calves were not identified in the 1974 calf crop. All heifers were bred to calve first at three years of age.

TABLE 3.
COW BREED EVALUATION AT BEAUMONT: FERTILITY, CALF SURVIVAL AND CALF PERFORMANCE TO WEANING
BY BREED AND YEAR FOR 4-8-YEAR-OLD COWS, 1975-1978

Breed of bull	Breed of cow	Year	Number of cows			Calf survival and performance to weaning								Lbs calf wean per cow exp
			exp	open	died	born	lost	wean	%	ADG	W.wt.	grade	cond	
SmA	CxH	1975	18	2	0	16	3	13	72.2	1.42	407	13.1	7.3	294
		1976	29	4	1	25	2	23	79.3	1.65	448	13.0	6.6	355
		1977	29	7	1	22	2	20	69.0	1.83	439	13.1	7.2	303
		1978	27	7	0	20	3	17	63.0	2.07	572	13.7	8.5	360
		Combined	103	20	2	83	10	73	70.9	1.74	466	13.2	7.4	330
SmA	FxH	1975	17	1	0	16	1	15	88.2	1.48	447	13.2	7.2	394
		1976	29	3	0	26	1	25	82.2	1.81	477	13.1	6.5	392
		1977	28	11	0	17	1	16	57.1	2.00	465	13.2	6.9	266
		1978	27	3	0	24	2	22	81.5	2.06	576	13.8	8.6	469
		Combined	101	18	0	83	5	78	77.2	1.84	491	13.3	7.3	379
SmA	S̄xH	1975	19	1	0	18	3	15	78.9	1.40	404	12.9	7.4	319
		1976	29	3	0	26	1	25	86.2	1.61	437	12.6	6.5	377
		1977	31	4	0	27	3	24	77.4	1.78	433	12.9	7.0	335
		1978	29	1	0	29	2	27	93.1	1.46	512	13.0	8.0	477
		Combined	108	9	0	100	9	91	84.2	1.63	446	12.8	7.2	375
SmA	HxH	1975	21	4	1	17	2	15	71.4	1.10	322	10.9	6.0	230
		1976	31	11	2	19	4	15	48.4	1.30	360	12.1	5.7	174
		1977	22	5	0	17	1	16	72.7	1.52	363	12.1	6.6	264
		1978	26	6	0	20	4	16	61.5	1.61	460	12.9	8.1	283
		Combined	100	26	3	73	11	62	62.0	1.38	376	12.0	6.6	229
Her	HxH	1975	25	3	0	22	4	18	72.0	1.35	382	12.3	7.2	275
		1976	40	5	1	34	5	29	72.5	1.35	363	11.7	6.6	263
		1977	31	4	0	27	3	24	77.4	1.31	355	12.7	6.8	275
		1978	33	5	1	28	3	25	72.7	1.46	395	12.0	8.3	287
		Combined	129	17	2	111	15	96	74.4	1.37	374	12.2	7.2	278

TABLE 4.
COW BREED EVALUATION IN BEAUMONT HERD: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING BY BREED OF COW AND AGE AT CALVING

Breed of bull	Breed of cow	Cow age (yr)	Number of cows: No. exp	Open no.	Open %	Died no.	Died %	Calf survival and weaning performance: No. born	Lost no.	Lost %	Weaned no.	Weaned %	Weaning weight	Weaning grade	Weaning cond	Lbs calf wean per cow exp.
Ang	CxH	3	27	4	14.8	0	0.0	23	5	21.7	18	66.7	430	12.8	7.9	287
A,SA	CxH	4-8	103	20	19.4	2	1.9	83	10	12.0	73	70.9	466	13.2	7.4	330
	Combined		130	24	18.5	2	1.5	106	15	14.1	91	70.0	459	13.1	7.7	321
Ang	FxH	3	25	3	13.0	0	0.0	22	1	10.0	21	84.0	471	13.0	8.1	396
A,SA	FxH	4-8	101	18	17.8	0	0.0	83	5	6.0	78	77.2	491	13.3	7.3	379
	Combined		126	21	16.7	0	0.0	105	6	5.7	99	78.6	487	13.2	7.4	383
Ang	S̄xH	3	24	4	16.7	0	0.0	20	1	5.0	19	79.2	410	13.0	7.8	325
A,SA	S̄xH	4-8	108	9	8.3	0	0.0	100	9	9.0	91	84.2	446	12.8	7.2	375
	Combined		132	13	9.8	0	0.0	120	10	8.3	110	83.3	440	12.8	7.3	366
Ang	HxH	3	23	3	17.4	0	0.0	20	4	20.0	16	69.6	363	11.2	7.4	253
A,SA	HxH	4-8	100	26	26.0	3	3.1	73	11	15.7	62	62.0	376	12.0	6.6	229
	Combined		123	29	25.6	3	2.5	93	15	16.1	78	63.4	373	11.8	6.7	236
Her	HxH	3	27	4	14.8	0	0.0	23	2	8.7	21	77.8	331	10.7	7.0	257
Her	HxH	4-8	129	17	13.2	2	1.5	111	15	13.5	96	74.4	374	12.2	7.2	278
	Combined		156	21	13.5	2	1.3	132	17	12.9	117	75.0	366	12.0	7.2	274
All Breeds		3	126	18	14.3	0	0.0	108	13	12.0	95	75.4	401	12.2	7.6	302
		4-8	541	90	16.6	7	1.3	450	50	11.1	400	73.9	430	12.7	7.2	318
			667	108	16.2	7	1.0	558	63	11.3	495	74.2	424	12.6	7.3	315

COW BREED EVALUATION AT HANOVER: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING

Thomas J. Marlowe[1] and Raymond E. Myers[2]

The cow breed evaluation phase was divided into three cycles. Cycle 1 included all heifers calving for the first time at either two or three years of age. Cycle 2 included those same cattle for all subsequent calf crops through the 1978 calf crop. In cycle 3 all cows, except for the straightbred Hereford controls, will be bred to Maine-Anjou x Shorthorn and Limousin x Shorthorn bulls for two calf crops. This report covers cycles 1 and 2 of the cow breed evaluation phase (II) of the cooperative cattle breeding research at Correctional Field Unit #14 between the Animal Science Department of Virginia Polytechnic Institute and State University, Blacksburg, and the Department of Corrections, Richmond.

Source and Management of Cattle

Cows used in this study were produced in phase I (sire breed evaluation) during the years 1973-1975. They were out of Hereford cows and sired by 7 Angus, 5 Brown Swiss, 7 Charolais and 8 Hereford bulls. Breeding seasons were limited to 75 days annually, starting on or about February 15. All calves were identified by metal ear tags at birth and later tattooed. Calves of all breeding groups were treated alike. They were weaned in late August or early September, grazed until November and fed corn silage and/or hay with a protein supplement through the first winter and grazed again the following summer.

All heifers were weighed, graded and scored for condition at weaning, 12 months and 18 months of age. Heifers were selected on the basis of their 12 months weight if bred as yearlings or on their 18 months weight if bred as two-year-olds. Heifers that were 650 pounds or heavier at the beginning of the breeding season were exposed to bulls as yearlings. The lighter heifers were held over and bred as two-year-olds.

Composition of the phase II (cow breed evaluation) cow herds were Angus x Hereford (AH), Brown Swiss x Hereford (BH), Charolais x Hereford (CH), and Hereford (HH or Hx). Table 1 gives the number of heifers by breed composition and year that went into the breeding groups.

TABLE 1. BREED COMPOSITION OF PHASE II COWS

Year	AH	BH	CH	Hx	HH	Total
1972	10	0	9	9	3	31
1973	12	16	13	12	0	53
1974	2	9	10	11	0	32
1975	5	8	8	9	13	43
1976	5	12	8	7	5	37
1977	8	9	2	4	3	26
Totals	42	54	50	52	24	222

Hx = Hereford cows that were bred to produce crossbred calves.

[1]Project Leader, VPI&SU, Blacksburg.
[2]Farm Manager, Correctional Field Unit #14, Hanover.

All heifers were bred to Angus bulls to calve at either two or three years of age, except for the straightbred Hereford (HH) control group which was bred to Hereford bulls. The breeding season was limited to 75 days starting on or about January 15 for the heifers and February 15 for the cows. The ratio of bulls to heifers was approximately 1 to 25.

All heifers being bred for the first time were run together as a group and fed hay and/or silage during the winter and grazed on summer pastures, except that the straightbred control heifers were run with the straightbred control cows during the breeding season and bred to the same bull. After their first calf crop they went into the cow herd. Cows of each breed type were run together on summer pasture and fed together during the winter, except that the straightbred controls were separated out during the breeding season. All cattle were grazed on grass pastures common to the upper coastal area of the state and fed hay and/or corn silage during the winter. The nutritional level among these cows was quite poor and cows lost considerable weight (up to 15% or more) during the winter.

Cows were culled only if they failed to wean two calves, would not claim their calves, prolapsed, or developed some other physical disability that would obviously prevent them from further production.

Data and Statistical Analyses

Cow breed evaluation was based on percentage of cows calving, calf survival, percent calf crop weaned, weaning weights and grades, and pounds of calf weaned per cow exposed. There was a total of 222 heifers exposed and 156 calves weaned in cycle 1 and 411 cows exposed and 283 calves weaned in cycle 2. The breakdown by year, cow age, and breed is shown in tables 2, 3, and 4.

Cycles 1 and 2 data were analyzed separately. The sources of variation included in the models were year, age and breed of heifer or cow, age and sex of calf, and breed by year and breed by sex interactions. The General Linear Models Procedure of the Statistical Analysis System (SAS) by the SAS Institute, Inc., was used for the analyses on a 370 IBM computer.

Results and Discussion

Four kinds of cows were compared during the years of 1973-1978. These comparisons are shown in tables 2, 3 and 4 by age and breed composition of cow and year. The effect of breed of heifers calving for the first time was significant for preweaning average daily gain and weaning weight, but not for grade and condition at weaning. Among the cows, breed effect was significant for preweaning ADG, weaning weight and condition but not for grade. There was no significant difference in calving percentage when all crossbreds were compared to all straightbreds, however, there were differences between the three kinds of crossbreds and also between the straight Hereford cows that were producing crossbred or straightbred calves.

Crossbred cows weaned calves that were 25 pounds heavier than those by the straightbred cows. The top performing cows, based on pounds of calf weaned per cow exposed, were the Angus x Hereford cows. The rank of the remaining cow groups was Brown Swiss x Hereford, Hereford controls, Charolais x Hereford and Hereford cows producing crossbred calves. The good performance of the straight Hereford cows appeared to be due largely to three factors: 1) the fact that only about half as many Hereford heifers calved for the first time as heifers of the other groups; 2) nearly all of those calved first as three-year-olds rather than as two-year-olds; and 3) the use of an exceptional Hereford bull for two calf crops.

If all cows had been Angus x Hereford cross cows and they were compared to the performance of straight Hereford cows (which was the program before this cooperative research was started) for all 633 exposures, the difference would amount to 32 pounds x 633 cow exposures = 20,256 pounds more calf weaned. There were no significant differences in weaning grades or flesh condition of the calves.

Percentage of open cows was unusually high in this herd, ranging from a low of 15.2% for the AH cows to 22.1% for the Hx cows, with an average of 19.1% for all cows. Calf death losses were also unusually high ranging from a low of 9.4% for the AH cows to a high of 19.2% for the CH cows. This was due largely to the fact that almost no assistance was given to cows during the calving season. In fact, they were usually not seen between 4:00 PM and 8:00 AM. Even so, cow death losses were quite low, amounting to only 8 deaths from 633 cow exposures.

The authors express their appreciation to Mr. R. C. Oliver and the men on the farm who helped with this project; to Dr. T. N. Meacham for pregnancy checking the cows; to Wayne Wyatt for assistance in analyzing the data; and to Mrs. Ellie Stephens for typing the manuscript.

TABLE 2.

COW BREED EVALUATION AT HANOVER: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING OF TWO- AND THREE-YEAR-OLD HEIFERS. 1973-1978

Breed of bull	Breed of heifer	Year	Number of heifers			Calf survival and performance to weaning								Lbs calf wean per cow exp.
			exp	open	died	born	lost	wean	%	ADG	W.wt.	grade	cond	
Ang	AH	1973	10	0	0	10	3	7	70.0	1.13	341	10.9	6.8	239
		1974	12	3	0	9	1	8	66.7	1.04	319	10.6	6.4	213
		1975	2	1	0	1	1	0	00.0	-	-	-	-	-
		1976	5	0	0	5	1	4	80.0	1.25	385	11.3	6.4	308
		1977	5	0	0	5	2	3	60.0	1.61	443	13.5	7.5	266
		1978	8	0	0	8	0	8	100.0	1.08	308	9.1	4.9	308
		Combined	42	4	0	38	8	30	71.4	1.16	342	10.7	6.2	244
Ang	BH	1973	0	0	0	0	0	0	00.0	-	-	-	-	-
		1974	16	3	0	13	5	8	50.0	1.11	329	11.1	6.1	164
		1975	9	2	0	7	3	4	44.4	1.40	428	11.3	6.2	190
		1976	8	2	0	6	0	6	75.0	1.53	451	12.9	6.8	338
		1977	12	3	0	9	1	8	66.7	1.55	440	13.0	6.2	293
		1978	9	0	0	9	1	8	88.9	1.11	328	9.4	5.3	291
		Combined	54	10	0	44	10	34	63.0	1.32	388	11.5	6.1	244
Ang	CH	1973	9	3	0	6	1	5	55.5	1.27	383	10.6	7.0	212
		1974	13	2	0	11	5	6	46.1	1.10	340	12.6	6.6	157
		1975	10	4	0	6	2	4	40.0	1.21	383	12.6	6.5	153
		1976	8	1	0	7	0	7	87.5	1.40	429	12.0	6.7	312
		1977	8	1	0	7	2	5	62.5	1.53	437	13.2	6.8	273
		1978	2	0	0	2	0	2	100.0	1.09	345	11.4	5.1	345
		Combined	50	11	0	39	10	29	58.0	1.27	386	12.1	6.5	224
Ang	HH	1973	9	0	0	9	2	7	77.8	0.96	299	10.3	6.4	232
		1974	12	2	0	10	2	8	66.7	0.95	301	11.0	6.0	201
		1975	11	1	0	11	0	11	100.0	1.24	374	11.0	6.2	374
		1976	9	0	0	9	0	9	100.0	1.45	424	11.9	6.5	424
		1977	7	1	0	6	1	5	71.4	1.39	400	11.7	6.4	286
		1978	4	0	0	4	0	4	100.0	1.00	288	10.4	5.4	288
		Combined	52	4	0	49	5	44	84.6	1.16	348	11.1	6.1	294

CONTINUED

TABLE 2.

COW BREED EVALUATION AT HANOVER: FERTILITY, CALF SURVIVAL AND PERFORMANCE TO WEANING OF TWO- AND THREE-YEAR-OLD HEIFERS. 1973-1978 (Continued)

Breed of bull	Breed of heifer	Year	Number of heifers			Calf survival and performance to weaning								Lbs calf wean per cow exp.
			exp	open	died	born	lost	wean	%	ADG	W.wt.	grade	cond	
Her	HH	1973	3	0	0	3	0	3	100.0	1.17	371	11.5	7.5	371
		1974	0	0	0	0	0	0	00.0	-	-	-	-	-
		1975	0	0	0	0	0	0	00.0	-	-	-	-	-
		1976	13	0	0	13	2	11	84.6	1.49	423	12.3	7.0	133
		1977	5	2	0	3	0	3	60.0	1.49	424	13.0	5.6	254
		1978	3	0	0	3	1	2	66.7	0.76	264	8.3	4.6	176
		Combined	24	2	0	22	3	19	79.2	1.36	398	11.9	6.6	315
All Breeds		1973	31	3	0	28	6	22	68.7	1.11	341	10.7	6.8	234
		1974	53	10	0	43	13	30	56.6	1.05	321	11.2	6.4	182
		1975	32	8	0	25	6	19	59.4	1.27	387	11.4	6.3	230
		1976	43	3	0	40	3	37	86.0	1.42	423	12.1	6.7	364
		1977	35	7	0	30	6	24	68.6	1.51	429	12.9	6.5	294
		1978	26	0	0	26	2	24	92.3	1.01	307	9.7	5.1	283
		Combined	222	31	0	192	36	156	70.3	1.25	371	11.4	6.3	261

TABLE 3.
COW BREED EVALUATION AT HANOVER: FERTILITY, CALF SURVIVAL AND PERFORMANCE
TO WEANING OF 3-7-YEAR-OLD COWS. 1974-1978

Breed of bull	Breed of cow	Year	Number of cows			Calf survival and performance to weaning								Lbs calf wean per cow exp.
			exp	open	died	born	lost	wean	%	ADG	W.wt.	grade	cond	
SmH	AH	1974	7	3	0	4	1	3	42.8	1.00	299	11.5	6.6	129
		1975	19	1	1	18	2	16	84.2	1.46	422	12.5	6.8	356
		1976	20	2	0	18	0	18	90.0	1.55	437	12.8	6.7	394
		1977	26	6	1	20	0	20	76.9	1.52	411	12.9	6.1	316
		1978	24	5	0	19	0	19	79.2	1.33	367	11.8	6.3	290
		Combined	96	17	2	79	3	76	79.2	1.37	387	12.3	6.5	306
SmH	BH	1974	0	0	0	0	0	0	00.0	-	-	-	-	-
		1975	10	3	0	7	2	5	50.0	1.35	397	12.5	6.2	199
		1976	18	2	0	16	3	13	72.2	1.76	493	13.2	6.8	357
		1977	19	8	0	11	0	11	57.9	1.56	421	13.3	5.8	244
		1978	32	6	2	25	0	25	78.1	1.16	352	11.5	6.0	275
		Combined	79	19	2	59	5	54	68.3	1.40	404	12.4	6.2	276
SmH	CH	1974	5	0	0	5	3	2	40.0	0.87	254	9.9	6.1	102
		1975	13	2	1	11	1	10	76.9	1.52	450	13.2	6.6	347
		1976	19	4	1	14	2	12	63.1	1.46	431	12.7	6.6	272
		1977	20	6	0	14	1	13	65.0	1.48	407	13.2	5.8	266
		1978	24	3	0	21	3	18	75.0	1.30	384	12.4	6.2	288
		Combined	81	15	2	65	10	55	67.9	1.33	385	12.3	6.3	261
SmH	HH	1974	6	2	0	4	1	3	50.0	0.79	248	9.5	5.7	125
		1975	10	5	0	5	2	3	30.0	1.28	386	12.1	5.9	116
		1976	17	4	0	13	0	13	76.5	1.26	378	11.6	5.8	291
		1977	22	9	0	13	1	12	54.5	1.22	348	12.8	5.5	190
		1978	24	5	0	19	4	15	62.5	1.15	333	11.7	5.8	207
		Combined	79	25	0	54	8	46	58.2	1.14	339	11.5	5.7	197

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TABLE 3.
COW BREED EVALUATION AT HANOVER: FERTILITY, CALF SURVIVAL AND PERFORMANCE
TO WEANING OF 3-7-YEAR-OLD COWS. 1974-1978 (Continued)

Breed of bull	Breed of cow	Year	Number of cows exp	open	died	Calf survival and performance to weaning born	lost	wean		ADG	W.wt.	grade	cond	Lbs calf wean per cow exp.
Her	HH	1974	13	1	0	12	3	9	69.2	0.87	270	10.2	6.3	187
		1975	9	0	0	9	4	5	55.5	1.45	409	12.1	7.2	226
		1976	12	0	0	12	0	12	100.0	1.70	462	12.9	7.2	461
		1977	22	8	0	14	1	13	59.1	1.65	435	13.0	6.2	257
		1978	20	5	2	13	0	13	65.0	1.15	331	11.6	6.1	216
		Combined	76	14	2	60	8	52	68.4	1.36	381	12.0	6.6	261
All Breeds		1974	31	6	0	25	8	17	54.8	0.88	269	10.3	6.2	147
		1975	61	11	2	50	11	39	63.9	1.41	413	12.5	6.5	264
		1976	86	12	1	73	5	68	71.1	1.55	440	12.6	6.6	313
		1977	109	37	1	72	3	69	63.3	1.49	404	13.0	5.9	256
		1978	124	24	4	97	7	90	72.6	1.22	354	11.8	6.1	256
		Combined	411	90	8	317	34	283	68.8	1.37	391	12.3	6.3	269

TABLE 4.
COW BREED EVALUATION AT HANOVER: FERTILITY, CALF SURVIVAL AND PERFORMANCE
TO WEANING BY AGE AND BREED OF COW. 1973-1978

Breed of bull	Breed of cow	Age of cow (yr)	Number of cows			Calf survival and performance to weaning									Lbs calf wean per cow exp.
				open			lost		weaned						
			exp	no.	%	born	no.	%	no.	%	ADG	W.wt.	grade	cond	
Ang	AH	2-3	42	4	9.5	38	8	21.0	30	71.4	1.16	342	10.7	6.2	244
SmH	AH	3-7	96	17	17.7	79	3	3.8	76	79.2	1.37	387	12.3	6.5	306
		Combined	138	21	15.2	117	11	9.4	106	76.8	1.31	378	11.8	6.4	290
AH	BH	2-3	54	10	18.5	44	10	22.7	34	63.0	1.32	388	11.5	6.1	244
SmH	BH	3-7	79	19	24.0	59	5	8.5	54	68.3	1.40	404	12.4	6.2	276
		Combined	133	29	21.8	103	15	14.6	88	66.2	1.37	398	11.8	6.2	263
Ang	CH	2-3	50	11	22.0	39	10	25.6	29	58.0	1.27	386	12.1	6.5	224
SmH	CH	3-7	81	15	18.5	65	10	15.4	55	67.9	1.33	385	12.3	6.3	261
		Combined	131	26	19.8	104	20	19.2	84	64.1	1.31	385	12.3	6.4	247
Ang	HH	2-3	52	4	7.7	49	5	10.2	44	84.6	1.16	348	11.1	6.1	294
SmH	HH	3-7	79	25	31.6	54	8	14.8	46	58.2	1.14	339	11.5	5.7	197
		Combined	131	29	22.1	103	13	12.6	90	68.7	1.15	343	11.3	6.0	236
Her	HH	2-3	24	2	8.3	22	3	13.6	19	79.2	1.36	398	11.9	6.6	315
Her	HH	3-7	76	14	18.4	60	8	13.3	52	68.4	1.36	381	12.0	6.6	261
		Combined	100	16	16.0	82	11	13.4	71	71.0	1.36	386	12.0	6.6	274
All Breeds		2-3	222	31	14.0	192	36	18.7	156	70.3	1.24	369	11.4	6.3	256
		3-7	411	90	21.9	317	34	10.7	283	68.8	1.37	391	12.1	6.3	269
		Combined	633	121	19.1	609	70	11.5	439	69.3	1.32	381	11.8	6.3	264

GUIDELINES ON CROSSBREEDING FOR BEEF PRODUCTION

T. J. Marlowe, A. L. Eller, Jr., J. A. Gaines and D. R. Notter

Rationale

Research has documented that hybrids (crossbreds) resulting from the crossing of pure lines (straightbreds) are generally superior to the average of the parental lines in one or more traits. This result comes about because the pure lines differ in their genetic constitution and the bringing together of the lines allows complementarity (combining the desirable characteristics of two or more breeds) and heterosis to operate. Traits low in heritability, such as fertility, respond most to crossbreeding, but since none of the traits of economic importance to beef production are completely heritable, all traits respond in varying degrees. Traits with heritability estimates (h^2) under .3 (30%) are considered lowly heritable and usually respond well to crossbreeding. Traits with h^2 of .3 to .5 (30 to 50%), such as weaning weight and grade, are moderately heritable but still respond reasonably well to crossbreeding. Traits with h^2 above .5 (50%), such as feedlot gains, ribeye area or tenderness, are considered highly heritable and show little response from crossbreeding. On the other hand, these highly heritable traits respond well to selection, whereas the lowly heritable traits respond poorly to selection but well to crossbreeding. Therefore, a knowledge of the heritability of each trait of economic importance is important so that a balanced combination of selection and crossbreeding can be applied to maximize production.

A word of caution is in order. Crossbreeding is not a cure-all for increasing pounds of marketable beef. Although most lines, strains and breeds of cattle will respond to crossing, one should be careful in choosing the lines or breeds used in order to maximize the heterotic response and to provide for the desired complementarity in the crossbred offspring. For example, if size is of primary interest, one should realize that pairing a small breed with a large breed will result in offspring that are likely to be intermediate in size, i.e., considerably larger than the smaller breed but still smaller than the larger breed. On the other hand, if the objective is to increase the size of the smaller breed, then the fastest way to achieve that objective is to breed the cows of that breed to sires of a larger breed.

Expected Gains from Crossbreeding

Most research has shown that the amount of heterosis that can be expected from crossbreeding of cattle will fall within the ranges shown for the following traits.

Preweaning Performance

	% Heterosis	Unit of measure
1. Straightbred cows		
a) % calves born	2-4	-
b) % calf crop weaned	3-5	-
c) weaning weight	3-5	15-20 lb
d) weaning wt/cow exposed	6-10	40-50 lb
e) efficiency of calf produced	3-5	-

	% Heterosis	Unit of measure
2. Crossbred cows		
a) % calves born	2-5	-
b) % calf crop weaned	3-5	-
c) weaning weight	3-6	15-20 lb
d) weaning wt/cow exposed	6-10	35-50 lb
e) efficiency of calf produced	10-15	-
Postweaning Performance		
Feedlot gains	2-3	.05-.07 ADG
Pasture gains	3-7	.04-.12 ADG
Yearling weights	4-5	40-50 lb
Mature weights	2-3	25-40 lb

The crossbreeding advantages of calf crop and growth to weaning are additive. Therefore, the total gain expected from crossbreeding systems utilizing crossbred cows as compared to averages of straightbred matings is 20 to 25% in pounds of calf weaned per cow exposed in the breeding herd. Even greater gains (up to 35 or 50%) may be expected from crossbreeding in the Gulf Coast area when Brahman cattle are included in the crosses.

Systems of Crossbreeding

1. Two-Breed Cross

This system utilizes straightbred cows and a bull of another breed. If stopped at this point, it would be a terminal cross. Advantages: maximizes heterosis (for two breed crosses) in the calf and is simple to manage, especially in small herds. Disadvantages: replacements must be purchased or a part of the cow herd must be straightbreds to produce replacements, thereby losing the advantages of heterosis for nearly half the herd. This system can be extended into a crisscross system, discussed next.

2. Crisscross System

This form of crossbreeding utilizes two breeds. It can be started from the two breed cross described above by keeping the crossbred heifers or by purchasing crossbred heifers for this purpose. These second generation (G2) heifers may be mated to bulls of either of the two breeds to produce G3 (backcross) offspring. Thereafter, the G3 and later generation heifers and cows are always mated to the opposite breed of their sire. Advantages: it is simple and self sustaining, takes advantage of heterosis in the crossbred cow and retains about 2/3 of the maximum heterosis in the calf. It also permits selection among the replacements. Disadvantages: must have more than one breeding group and once in operation it utilizes only about 2/3 of the available heterosis.

3. Three-Way Cross

Terminal - Crossbred cows are bred to bulls of a third breed and all offspring are marketed. Advantages: maximizes heterosis both in the cow and in the calf, requires maintaining only one kind of cow and minimizes the number of pastures required. Disadvantages: requires purchasing replacement females or maintaining a separate straightbred herd for that purpose, with no opportunity for selection within the herd, and the loss of heterosis in cows kept to produce replacement heifers.

Rotational - Utilizes three breeds in a continuous rotation in which replacement heifers and crossbred cows are always mated to the breed of sire to which they are least related. Advantages: comes close to maximizing heterosis both in the calf and in the cow (87.5%), avoids having to purchase replacement females and permits selection. Disadvantages: the overlap of generations makes at least three breeding groups necessary. Accurate records must be kept if matings are to be made to maximize heterosis.

4. Combination Systems

Many combinations of the above systems could be devised. One workable system for a larger herd would be to keep a fraction of the cows (40-50%) in a seedstock herd and the other fraction (50-60%) for a three breed terminal cross. In the seedstock herd, two breeds of bulls (such as Angus and Hereford) would be used in a crisscross program as described above to provide replacement females for the market herd. Cows in the seedstock herd, after producing their second or third calf would be moved to the terminal cross (market) herd to be bred for the remainder of their productive life to bulls (of larger breeds) selected as terminal crossing sires. All of the offspring from the market herd would be sold along with the steers and undesirable females from the seedstock herd. Advantages: nearly maximizes heterosis and allows for production of all replacement females. Disadvantages: somewhat complicated and depends heavily on good breeding records.

5. Four-Way Cross

F_1 x F_1 - Two-way cross (F_1) cows are bred to two-way cross (F_1) bulls of different breeding from the cows. Advantages: maximizes heterosis in the cow, bull and calf and thereby in fertility, liveability, growth and longevity. Disadvantages: requires purchasing replacement females or maintaining a straightbred herd for that purpose, offspring will be multicolored.

Rotational - Four different breeds are used in a continuous rotation, similar to the three-breed rotational cross, in which the replacement heifers and crossbred cows are always bred to a breed of bull to which they are least related. The advantages and disadvantages are similar to those for three-way rotational crossing.

4-Way Cross or "Synthetic Breed" - Females would be produced from the F_1 x F_1 matings discussed above. They would then be bred to 4-way cross bulls of the same breeding. Advantages: heterosis would be maximized in the cow, bull and calf and complementarity could be utilized more effectively through selection of the replacements. Once established, in practice it would be as simple as straightbreeding. Disadvantages: more time is required to establish the 4-way cross animal, however, heterosis would be fully utilized at each stage of development. When established, and all replacements are coming from *inter se* matings, the heterotic effect would be expected to decrease some with each generation but should stabilize at a higher level of production than present established breeds. Warwick and Legates (1979) suggest that it should stabilize at about 3/4 of maximum potential heterozygosity and should compare favorably in productivity with rotational crossing systems.

General Recommendations

1. Read the suggested references to gain a clearer understanding of expected gains and disadvantages before starting a crossbreeding program.

2. Plan your program carefully. Start with the cows that you have. Select a sire breed for complementarity in the offspring such as size, milking ability of the females, color pattern, growth rate, etc. This will be influenced greatly by the kind of crossbreeding program you intend to develop. Be aware of calving difficulties when bulls of larger breeds are mated to heifers or cows of smaller breeds. If you have no cows at present, you may want to consider the purchase of F_1 or 3-way cross females. This will put you at least one generation ahead and have the greatest heterotic advantage available immediately.

3. Don't use crossbreeding as a coverup for poor management. Maximum benefits can be gained from crossbreeding only when management practices are above average.

4. Use a systematic approach such as one of those described above; otherwise, you will not gain full advantage from crossbreeding. Attempt to maximize heterosis and desired complementarity at each stage in your program.

5. Combine an effective selection program (through performance and progeny testing) with your systematic crossbreeding program for optimum economic gains. Most progress will be made through sire selection because there is little opportunity for selection among the female replacements.

6. If you take the 4-way cross or "synthetic breed" route, develop a formal or informal partnership with other breeders so that each one can provide the other(s) with a source of 4-way cross bulls to avoid inbreeding depression.

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COMPARISON OF CHAROLAIS, LIMOUSIN, MAINE-ANJOU AND SHORTHORN BULLS ON SHORTHORN COWS

T. J. Marlowe, E. T. Barnes and J. S. Copenhaver

In the fall of 1974 it was decided to make some Limousin x Shorthorn and Maine-Anjou x Shorthorn crossbred bulls for use in the cow breed evaluation phase of a cooperative cattle breeding research project (200212) between the Animal Science Department of Virginia Polytechnic Institute and State University, Blacksburg, and the Department of Corrections, Richmond. Since no Limousin or Maine-Anjou bulls were available, it was necessary to use artificial insemination.

A supplement was written to project 200212 with the following objectives:

1. to compare reproductive performance and growth traits of two new continental breeds of beef cattle, Limousin and Maine-Anjou; and

2. to produce Limousin and Maine-Anjou crossbred bulls for use in phase II and III of project 200212.

Source of Cattle and Management

Shorthorn cows remaining from the topcrossing project were used for this purpose. Cows were bred artificially from about May 1 until June 10 in the spring of 1975 with semen from two Limousin and three Maine-Anjou bulls. Then, a Charolais bull was turned in as a cleanup bull. Of the 51 cows in the AI breeding group, 22 were bred to the Limousin bulls Crusader and Eclair, and 29 cows to the Maine-Anjou bulls Capone, Cosic and Covino II. Six of the cows were rebred to Limousin bulls and two to Maine-Anjou bulls for a total of 59 inseminations. Records were kept of all breeding dates, service sires, and calving dates. Fifteen cows had been set aside for breeding to a Shorthorn bull at the same time the other cows were being bred AI.

There were 71 remaining cows for the 1976 breeding season. Again, the cows were bred artificially during the period May 10 through June 30 and a Shorthorn bull was turned in as a cleanup bull. Of the 71 cows in the herd, 34 were bred artificially to two Maine-Anjou bulls (Cosic and Covino II) and 29 cows were bred artificially to two Limousin bulls (Crusader and Eclair). Twenty-one calves were weaned from the Limousin bulls, 20 calves from the Maine-Anjou bulls and 8 calves from the Shorthorn bulls.

The cows were run on the Hoge Farm about five miles west of Blacksburg. The pastures consisted mainly of bluegrass and white Dutch clover. However, there was some orchardgrass and fescue present. The cows were wintered on mixed grass hay and corn silage. Calves were dropped from about mid-February through April each year.

Calves were identified with a metal ear tag at birth and later tattooed. No creep feeding was done. They were weaned in October each year.

Data and Statistical Analyses

The data were adjusted for the effects of year; age of dam; and age, sex and month of birth of calf by using the partial regression coefficients published by Marlowe, Mast and Schalles (1965), except for birth weight and condition score which were unadjusted. The General Linear Models Procedure of SAS was then used for the Least Squares Analyses of Variance. The model for birth weight included year, breed of sire and age of dam (both linear and quadratic). The analysis of variance for each of the other measurements included only year and breed of sire. The type III sums of squares was used to determine the F values.

Results and Discussion

The effect of breed of sire was highly significant for birth weight, adjusted preweaning average daily gain, adjusted 205-day weight, adjusted grade, but not for condition score. The year effect was significant only for condition score.

The least squares adjusted means are shown in the table below.

COMPARISON OF CHAROLAIS, LIMOUSIN, MAINE-ANJOU AND SHORTHORN SIRED CALVES OUT OF SHORTHORN COWS, 1976-1977

Breed of	Birth	Calf survival and performance to weaning						
sire	wt.	born	lost	wean	ADG	205d wt	grade	cond
Charolais	91.9	21	0	21	2.13	529	13.0	8.3
Limousin	79.1	37	3	34	1.97	484	13.0	8.8
Maine-Anjou	84.6	44	6	38	2.02	499	13.1	8.7
Shorthorn	78.0	24	2	22	1.82	453	12.2	8.0
Combined	82.8	126	11	115	1.99	491	12.8	8.5

One standard deviation was 0.26 for ADG, 57 for weaning weight, 1.0 for grade and 1.3 for condition.

Birth weights were lowest for Shorthorn sired calves and highest for the Charolais sired calves. The birth weights of Limousin and Shorthorn sired calves were not significantly different from each other but were different from Charolais and Maine-Anjou sired calves. Birth weights of the Maine-Anjou calves were intermediate, averaging about 6 pounds heavier than Limousin and Shorthorn sired calves, but about 7 pounds lighter than the Charolais sired calves.

Adjusted average daily gain and adjusted 205-day weights followed the same pattern as birth weights; with Shorthorns being the lowest, Charolais the highest, and the Limousin and Maine-Anjou sired calves intermediate. Maine-Anjou sired calves averaged 15 pounds heavier than the Limousin sired calves, but 30 pounds lighter than the Charolais sired calves at weaning. There was no difference in grade among the Charolais, Limousin and Maine-Anjou sired calves, all of which were about 1 grade point higher than the Shorthorn sired calves. When all crossbred calves were compared to the straightbred

Shorthorn calves, the average differences were 7.2 pounds heavier in birth weight, .22 pounds faster preweaning gains, 51 pounds heavier 205-day weight, .8 grade point higher, and .6 condition score higher than the straightbred calves.

No attempt was made to determine calving percentages since two breeds were used AI and the Charolais bull and one of the Shorthorn bulls were used as cleanup bulls. However, a comparison between the Limousin and Maine-Anjou bulls was possible since all matings were by AI. There were 59 Limousin matings with 37 calves weaned for 62.7% and 65 Maine-Anjou matings with 44 calves weaned for 67.7% or a difference of 5 percentage points in favor of the Maine-Anjou bulls.

PREDICTION EQUATIONS BASED ON RELATIONSHIPS BETWEEN A DAM'S PERFORMANCE TRAITS AND THE WEANING WEIGHT OF HER PROGENY

William H. Whittle, Jr., and Thomas J. Marlowe

One of the important decisions that a cow-calf producer is faced with is how to select replacement heifers to make his operation most efficient and profitable. It is important that this decision be made early in the life of the animal, if possible, in order to save valuable time and to keep production costs at a minimum. The logical time to make this decision, from a management standpoint, is at weaning. Research has shown that heritability of weaning weight is moderately high (.30 to .35). In the past, the emphasis on increased weaning weight has been through the selection of bulls; however, with the advent of "produce of dam" and "most probable producing ability" reports, selection through the female side has been greatly enhanced. However, before selection by these procedures are possible, the cow must have weaned at least one calf. Consequently, the procedure is time consuming and increases the generation interval, thereby slowing progress. If by measuring the dam's performance one can increase the effectiveness of selection at weaning, he can reduce the number of undesirable heifers that are placed in the breeding herd by more accurately identifying the superior breeding stock at an early age. At the same time he could turn the non-replacement heifers into operating capital at an earlier date and improve heifer management through proper feeding for her intended use.

The purpose of this study was to derive prediction equations and growth patterns for replacement heifers based on the relationship between the cow's performance traits of weight, grade and condition scores taken at weaning, 12 months and 18 months of age, and the weaning weight of her offspring.

Materials and Methods

Data for this study were collected at the Bland Correctional Center as part of a cooperative cattle breeding project between the Animal Science Department of Virginia Polytechnic Institute and State University, Blacksburg, and the Department of Corrections, Richmond. The cows were the female off-spring of the phase I cow herds (sire breed evaluation) and were designated as phase II cows (cow breed evaluation). They were produced in the six calf crops of 1970 through 1975 and were weaned at approximately 205 days of age. Calving season was split into fall and spring so that weaning occurred in the summer (June, July, August, September) and fall (October, November). They were sired by Charolais, Hereford and Simmental bulls and out of Hereford cows, except for the Angus cows (about 20) which were by Angus bulls out of straightbred Angus cows.

Following weaning, all heifers were fed hay and/or silage, supplemented with 1.0 to 1.5 pounds of protein, until spring when they went on bluegrass pasture. Following summer grazing, they were fed hay and/or silage during the second winter. All heifers that were large enough (over 600 lbs) were exposed to Angus bulls (except the straightbred Hereford control group) as yearlings to calve as two-year-olds. Lighter heifers were held over and exposed at two years of age to calve at three years of age. Therefore, all dams calved first between 1.8 and 3.5 years of age with most of them calving between 2.0 and 2.5 years of age. Each cow had her second calf by the time she was 4.5 years old. When all available calves were included (up to 6 calves per cow) the oldest dams were eight years old.

Once a heifer entered the breeding herd, she was not removed unless she failed to wean two calves, would not claim her calf, prolapsed or developed some other physiological abnormality which would obviously interfere with future production or died.

The offspring (calves) were produced in the six years of 1972-1977. Management of these cattle was basically the same as the management of the cattle in years when the dams were produced. All first calves (except the straightbred Hereford controls) were sired by Angus bulls. During the years 1973 through 1975 all cows except heifers calving for the first time and the straightbred Angus and half of the straightbred Herefords were bred to Charolais, Hereford and Simmental bulls so that half of the offspring would be backcrosses and the other half three-way crosses. For the 1976 and 1977 calf crops all cows except straightbred Hereford controls were sired by Angus bulls.

Data collected on both the dams and their offspring included weights, grades and condition scores taken at weaning, 12 months and 18 months of age. Grades and condition scores were subjective evaluations based on a scoring system ranging from 3 through 17 in common use in the southern regional beef cattle breeding research program. The dam's performance traits (weight, grade and condition) at weaning, 12 months and 18 months of age were correlated with the weaning weights of their offspring after they had been standardized by use of a statistical model which included the effects of year, season of birth, sire breed, dam breed, sex of calf, age of dam (linear and quadratic) and age of calf (linear) for both the dam's traits and the weaning weight of the offspring, except that sex of calf was not included in the model standardizing the dam's traits.

Four categories of progeny weaning weights from 176 different dams with the number of offspring records varying from 176 to 532 (referred to hereafter as Sets I, II, III and IV) were analyzed. Set I consisted of the performance traits of the 176 dams and the adjusted weaning weights of their first offspring. Set II was the same except it consisted of both the first and second offspring records. Set III consisted of all progeny records of all 176 dams. Set IV was the same as set III, except that the weaning weights of the offspring were adjusted by using the Virginia BCIA's adjustment factors. Each of the other sets of weaning weights were standardized statistically within the data set. In data sets II, III and IV the weaning weights were converted to most probable producing ability (MPPA) values as described by J. L. Lush in 1945 and reprinted in the 1977 Beef Improvement Federation Guidelines. The data were standardized by use of the General Linear Models Procedure of the Statistical Analyses System (SAS) by the SAS Institute, Inc., on a 370 IBM computer.

All main effects were maintained in the model even though some effects were not significant for every trait. This was done to maintain consistency.

Residual values resulting from the standardized dam performance traits and the standardized progeny weaning weight (MPPA) were used in deriving Pearson's product moment correlations (simple correlations) between dam performance traits and progeny weaning weights (MPPA). Prediction equations for progeny weaning weight (the dependent variable) were calculated by using residuals of the dam performance traits (the independent variables). The prediction equations were derived through a set of stepwise regressions called Maximum R^2 Improvement (Barr et al., 1976). Multiple regression equations, utilizing standardized dam performance traits as independent variables, were fitted to predict progeny weaning weight (MPPA). At each step of the maximum R^2 procedure the one variable that would give the maximum increase in R^2 would be added to the equation after all variables and their combinations were considered.

Results and Discussion

Correlation coefficients between dam performance traits and progeny weaning weights (MPPA) are presented in table 1. When only the first offspring record was used (Set I), 18 months condition had the highest correlation (r = .24). When all offspring records were used (Set III), the dam traits with the highest correlation with offspring weaning weight were 12 months weight (r = .15) and 18 months weight (r = .18). In data Set IV, in which the data were adjusted according to the Virginia BCIA factors, the correlation coefficients were generally lower and nonsignificant. The only values approaching significance were 18 months weight and 18 months condition score.

An example of the "best" model prediction equation is shown as table 2 for Set I. These prediction equations appeared to have little practical value except for first calf weaning weights (Set I). All prediction traits combined accounted for only about 10% of the total variation in first calf weaning weight. Dam's growth traits (weight and grade) were not as important in predicting progeny weaning weight in Set I as they were in Set III. On the other hand, condition score of the dam appeared to be generally more important in Set I than in Set III.

In general, these analyses indicate that prediction equations for weaning weight, utilizing dam performance traits, are of limited use as selection tools and probably should be used only as indicators of superior breeding stock.

Replacement heifers selected to produce heavy calves at weaning should be growthy animals with large frames but should not be permitted to get fat prior to breeding. However, this study indicates that a growthy heifer in average or below condition at 18 months of age will produce a first calf which is likely to have an adjusted weaning weight less than her subsequent offspring; whereas, a similar heifer, but in better condition, would likely produce a first calf that is closer to the average of her subsequent calves.

The authors express their appreciation to R. L. Saunders and the inmates at the Bland Correctional Center for their assistance in handling the cattle and collecting the data and to Mrs. Ellie Stephens for typing the manuscript.

TABLE 1. CORRELATION COEFFICIENTS BETWEEN DAM PERFORMANCE TRAITS AND PROGENY WEANING WEIGHT (MPPA)

Dam Traits	Set I 1st Calf	Set II 1st & 2nd Calf	Set III All Calves W/in Herd Adjusted	Set IV All Calves BCIA Adjusted
Weaning Weight	-.04[a]	.06	.09	.02
	.62[b]	.46	.23	.78
Weaning Condition	.04	-.01	-.04	-.05
	.63	.94	.55	.50
Weaning Grade	-.01	.08	.01	.02
	.84	.32	.84	.83
12-Month Weight	.06	.11	.15*	.12
	.42	.15	.04	.11
12-Month Condition	.06	.01	.03	.08
	.42	.84	.64	.28
12-Month Grade	.08	.07	.07	.02
	.31	.34	.33	.76
18-Month Weight	.10	.15*	.18**	.12†
	.21	.04	.01	.10
18-Month Condition	.24**	.06	.12	.13†
	.001	.45	.12	.07
18-Month Grade	.14†	.05	.08	-.01
	.06	.48	.26	.92

[a]Top number is the simple correlation.

[b]Bottom number is the level of significance.

†P < .10.

*P < .05.

**P < .01.

TABLE 2. "BEST MODEL" PREDICTION EQUATIONS FOR FIRST PROGENY WEANING WEIGHT[a]

	R^2	Level of Significance of Model	Significance of the Last Variable[c]
$Y = b_o$[b] + (6.02)LC	.057	.001	.001
$Y = b_o$ + (5.78)LC + (3.35)LG	.072	.002	.09
$Y = b_o$ + (6.18)LC + (4.83)LG + (-2.67)WG	.085	.002	.12
$Y = b_o$ + (6.17)LC + (5.19)LG + (-2.22)WG + (-.08)WW	.089	.003	.37
$Y = b_o$ + (5.88)LC + (4.74)LG + (-2.31)WG + (-.14)WW + (.07)LW	.095	.004	.29
$Y = b_o$ + (6.34)LC + (5.21)LG + (-1.93)WG + (-.13)WW + (.07)LW + (-1.43)YG	.097	.008	.59
$Y = b_o$ + (6.38)LC + (5.12)LG + (-1.98)WG + (-.15)WW + (.05)LW + (-1.51)YG + (.04)YW	.098	.010	.57
$Y = b_o$ + (6.68)LC + (4.91)LG + (-1.95)WG + (-.14)WW + (.05)LW + (-1.15)YG + (.05)YW + (-.99)YC	.099	.020	.70
$Y = b_o$ + (6.60)LC + (4.92)LG + (-2.08)WG + (-.15)WW + (.05)LW + (-1.11)YG + (.05)YW + (-1.18)YC + (.46)WC	.099	.040	.84

[a]Variables enter and leave the equation in order to achieve the maximum R^2 value.

[b]$b_o = 0$ for all equations.

[c]Level of significance associated with the additional reduction in variance due to fitting the variable(s) that achieve the maximum R^2.

PERFORMANCE OF FINNISH LANDRACE CROSSBRED EWES UNDER ACCELERATED LAMBING

D. R. Notter and J. S. Copenhaver

The improvement of the reproductive rate should be a primary objective in sheep production. An increase in the number of lambs marketed per year will result in a proportional reduction in overhead and ewe maintenance costs per lamb and should have a major favorable effect on profits. An increase in the annual reproductive rate can be achieved by increasing the number of lambs born per lambing or by increasing the number of lambings per year. In order to test the impact of both these approaches, the present study was designed to evaluate the performance of crossbred Finnish Landrace (Finn) ewes in an accelerated lambing system over a 6 year period from fall, 1972 to spring, 1978.

Materials and Methods

Seventy 1/2-Finn, 1/2-Rambouillet ewes, 90 1/4-Finn, 3/4-Rambouillet ewes and 19 1/2-Suffolk, 1/2-Rambouillet ewes were used in the study. The 1/2-Finn ewes were born in 1971, 1972 or 1973. The 1/4-Finn ewes were born in 1972 or 1973. The Suffolk x Rambouillet ewes were all born in 1973. A total of 1,122 exposures were recorded in the study and resulted in 834 lambings and 1,362 weaned lambs.

The ewes, located at Blacksburg, were allowed to lamb every 7 to 9 months (three times in two years), with lambings in September, April and January. The ewes were initially exposed for September lambing. Ewes that did not conceive at this exposure were reexposed for January lambing. Ewes that did conceive were allowed to lamb in September and were subsequently exposed for April lambing. This procedure was followed throughout the study and allowed the ewes to produce lambs as rapidly as possible. Ewes were removed from the study only if physically unsound or if they failed to lamb in 2 consecutive years.

At birth, litters of more than two lambs were almost always reduced to two lambs. Excess lambs were crossfostered or, more frequently, sold at birth. The lambs were early-weaned at about 35 days of age to maximize the likelihood of rapid rebreeding by the ewes. The lambs were then fed to an estimated constant degree of condition on an expanded metal feeding floor. The lambs were fed a 16% protein concentrate ration. All lambs were sired by Suffolk rams.

Results and Discussion

Table 1 shows the conception rate for each type of ewe in each season. The three breed groups were quite similar except when exposed for September lambing. For fall lambing, an increase in the fraction of Finn blood produced a definite increase in the conception rate. However, even the 1/2-Finn ewes conceived for September lambing only 60% of the time. Within each breed group, significant differences in the conception rate were observed among individual ewes. These differences provide a preliminary indication that selection to improve the conception rate may be successful.

Table 2 shows the number of lambs born per lambing for each type of ewe in each season. The 1/2-Finn ewes clearly surpassed both the other breed groups in lambing rate. However, the 1/4-Finn and Suffolk x Rambouillet ewes were similar in lambing rate. This result is somewhat surprising; most studies conducted in other places around the country have shown higher lambing rates for 1/4-Finn ewes when compared to domestic crossbred ewes.

Table 3 shows the birth weight, percentage death loss at birth, 45-day weight, postweaning daily gain, slaughter age and slaughter weight for lambs out of each ewe breed group. The lambs out of 1/2-Finn ewes were noticeably lighter at birth, at 45 days and at slaughter than lambs out of 1/4-Finn or Suffolk x Rambouillet ewes. The lambs out of the Suffolk x Rambouillet ewes grew somewhat faster than lambs out of 1/4-Finn ewes, but this difference was very small. The percentage death loss at birth was much smaller for lambs out of Finn-cross ewes than for lambs out of Suffolk x Rambouillet ewes, despite the fact that the Finn-cross ewes dropped more lambs per lambing.

The average weight of the Suffolk x Rambouillet ewes at the end of the study was 187 lb as compared to 172 lb for the 1/4-Finn ewes and 164 lb for the 1/2-Finn ewes. At the end of the study, 71% of the original 1/2-Finn ewes, 63% of the original 1/4-Finn ewes and 68% of the original Suffolk x Rambouillet ewes remained in the flock.

Table 4 summarizes the average annual performance of the 120 ewes that were still in the flock at the end of the study. This table shows the average number of lambs born, the average number of lambs weaned (actual and potential) and the average weight of lamb weaned (actual and potential) per year. The potential values (shown in parentheses in table 4) are estimated levels of performance if the lambs that were sold at birth had been saved and had performed (through artificial rearing or bottle feeding) at a level equal to the lambs that remained in the study. The 1/2-Finn ewes weaned about .35 more lambs per year than the 1/4-Finn ewes and the 1/4-Finn ewe weaned about .2 more lambs per year than the Suffolk x Rambouillet ewes. When the lambs were weaned at about 35 days of age, the 1/2-Finn ewes weaned about 10 lb more lamb per ewe per year than the 1/4-Finn and Suffolk x Rambouillet ewes, which were similar. Note that the advantage of the 1/2-Finn ewes in annual weight weaned was only about half that which could have been realized if the large number of triplet and quadruplet lambs dropped by these ewes could have been successfully raised.

In conclusion, the 1/4-Finn and Suffolk x Rambouillet ewes did not differ greatly in this study. The 1/4-Finn ewes appeared, however, to be slightly more prolific, to conceive somewhat more readily, and to have superior lamb survival rates, whereas the lambs from Suffolk x Rambouillet ewes grew slightly faster. In general, the 1/4-Finn ewe appears to be a very viable cross for use in Virginia and has the potential to make small, yet meaningful improvements in the fertility of the commercial ewe without necessitating major changes in management. The use of the 1/2-Finn ewes represents a major increase in the intensity of production, and will require some method of handling large numbers of lambs from multiple births. In this study, 36% of the total lambs dropped by 1/2-Finn ewes were born as triplets, 11% were born as quadruplets and 1% were born as quintuplets for a total of 48% born as triplets or greater. However, for those producers who can intensify their production to accomodate these additional lambs, the rewards can be considerable. Table 4 shows a potential increase in weight weaned per year for the 1/2-Finn ewe of 27% over the Suffolk x Rambouillet ewes.

TABLE 1. CONCEPTION RATE OF FINN AND DOMESTIC CROSSBRED EWES BY SEASON

Birth year	Ewe breed	Conception rate (%) for lambing in: January	April	September	Average
1971	1/2-Finn	94	79	47	73
1972	1/2-Finn	90	78	73	80
	1/4-Finn	91	77	58	76
1973	1/2-Finn	85	70	60	72
	1/4-Finn	88	87	45	73
	Suffolk x Rambouillet	93	79	38	70
	All breeds	90	79	53	74

TABLE 2. NUMBER OF LAMBS BORN PER LAMBING FOR FINN AND DOMESTIC CROSSBRED EWES BY SEASON

Birth year	Ewe breed	Number born per lambing in: January	April	September	Average
1971	1/2-Finn	2.95	3.24	2.41	2.88
1972	1/2-Finn	2.42	2.79	1.99	2.40
	1/4-Finn	2.03	2.16	1.53	1.90
1973	1/2-Finn	2.33	2.62	1.87	2.27
	1/4-Finn	1.82	2.11	1.50	1.81
	Suffolk x Rambouillet	1.73	1.85	1.71	1.77
	All breeds	2.21	2.46	1.84	2.17

TABLE 3. PERFORMANCE OF LAMBS OUT OF FINN AND DOMESTIC CROSSBRED EWES

Birth year	Breed group	Birth weight (lb)	Percent dead at birth	45-day weight (lb)	Postweaning daily gain (lb)	Slaughter age (days)	Slaughter weight (lb)
1971	1/2-Finn	7.4	4.6	34	.55	158	98
1972	1/2-Finn	8.0	8.2	35	.53	160	96
	1/4-Finn	9.6	6.5	39	.55	154	98
1973	1/2-Finn	8.1	6.5	36	.53	156	95
	1/4-Finn	9.8	3.3	39	.54	153	98
	Suffolk x Rambouillet	10.0	12.4	40	.55	151	98

TABLE 4. AVERAGE ANNUAL PERFORMANCE OF FINN AND DOMESTIC CROSSBRED EWES

Birth year	Breed group	Number born	Number weaned[a]	Weight weaned (lb)[a]
1971	1/2-Finn	3.41	2.59 (2.79)	89 (107)
1972	1/2-Finn	3.28	2.42 (2.81)	88 (103)
	1/4-Finn	2.38	2.07 (2.25)	79 (83)
1973	1/2-Finn	2.86	2.31 (2.58)	83 (93)
	1/4-Finn	2.20	1.93 (2.07)	74 (79)
	Suffolk x Rambouillet	2.03	1.73 (1.97)	71 (73)

[a]Values in parentheses represent the performance that could have been achieved if the lambs sold at birth had been kept and raised to weaning.

DIGESTIBILITY AND ACCEPTABILITY OF ENSILED SWINE WASTE AND GROUND CORN GRAIN FOR RUMINANTS

J. C. A. Berger, J. P. Fontenot, E. T. Kornegay and K. E. Webb, Jr.

The trend toward increasing numbers of total confinement swine operations has created a large waste disposal problem. Many of these total confinement facilities do not have sufficient land available to distribute the wastes.

Previous research at V.P.I. & S.U. has shown that feeding of swine waste is a potentially viable method of utilization. When swine waste was ensiled with ground orchardgrass hay and fed to sheep it was as palatable as ground orchardgrass hay fed alone. A previous small silo study reported good fermentation characteristics were observed when mixtures of 60 to 40 and 40 to 60 ratios of swine waste and orchardgrass hay were ensiled.

The objectives of this study were to determine the acceptability and nutritive value of swine waste and ground corn grain silages when fed to sheep.

Experimental Procedure

Swine waste was collected from sloped concrete floors at 3-day intervals,mixed with ground corn grain and ensiled in 55 gal steel drums lined with double thickness plastic liners and sealed for a minimum of 42 days. Ensiled mixtures used in both the acceptability and metabolism trials were 60 to 40 and 40 to 60 (swine waste to ground corn grain). A digestion trial was conducted using 30 crossbred wether lambs weighing 77 lb. All wethers were blocked by breed and weight and randomly assigned to treatment and pen. Diets for the metabolism and acceptability trials were: 1) basal - consisting of 50% corn-SBM (14% protein) and 50% ground mixed hay; 2) 80% basal and 20% of the ensiled 40 to 60 swine waste and ground corn mixture; 3) 80% basal and 20% of the ensiled 60 to 40 mixture; 4) 60% basal and 40% of the ensiled 40 to 60 mixture; and 5) 60% basal and 40% of the ensiled 60 to 40 mixture. All percentages are on a dry basis. The metabolism trial consisted of a 4-day transition, 10-day adaptation, and a 10-day collection period.

An acceptability trial was conducted using 30 crossbred wether lambs which had not previously been fed any of the rations. These lambs were blocked by breed and weight and randomly allotted to treatment and stalls. Diets fed were the same as those fed in the metabolism trial.

[1]Appreciation is expressed to the Virginia Agricultural Foundation for financial support of this research.

Results

The apparent digestion coefficients for dry matter, crude protein, organic matter and NFE increased linearly ($P < .01$) as the 40 to 60 and 60 to 40 mixtures were increased in the diets (table 1). Ether extract digestibility also increased linearly for sheep fed the 40 to 60 ($P < .01$) and 60 to 40 ($P < .05$) mixtures. Crude fiber and ash digestion coefficients were not significantly different.

Nitrogen retention, expressed as g/day and as percent of intake; was not significantly different between diets (table 1). Nitrogen retention expressed as a percent of absorbed nitrogen decreased linearly with the level of 60:40 silage ($P < .05$) in the ration. The same trend was observed in the 40:60 silage, but differences were not significant.

The dry matter intakes from the palatability trial are presented in table 2. Lambs fed the basal plus 20% of the 60:40 mixture and basal plus 40% of the 40:60 mixture consumed ($P < .01$) more feed on an actual and expressed as grams/$W_{kg}^{0.75}$/day basis than lambs fed the basal diet. The consumption of the other two diets was intermediate.

TABLE 1. APPARENT DIGESTIBILITY AND NITROGEN UTILIZATION OF PROXIMATE COMPONENTS OF RATIONS CONTAINING ENSILED SWINE WASTE-GROUND CORN GRAIN BY SHEEP[a]

		Diets				
		Level of 40:60 silage[b]		Level of 60:40 silage[b]		
Item	Basal	20%	40%	20%	40%	SEM
Apparent digestibility[c]						
Dry matter[de]	67.6	73.2	76.5	73.3	74.8	.43
Crude protein[de]	56.2	60.4	63.0	63.5	62.6	.77
Ether extract[df]	64.0	69.6	73.8	70.8	76.1	.70
Crude fiber	55.9	62.9	58.7	60.8	59.9	.78
Ash	48.0	37.8	42.3	40.0	38.4	2.31
Organic matter[de]	68.2	74.4	77.7	74.6	76.4	.41
NFE[de]	74.2	80.0	84.1	80.5	83.2	.36
Nitrogen utilization[c]						
Nitrogen intake, g/day	12.06	12.40	12.73	12.75	13.45	0
Nitrogen excretion, g/day						
Fecal	5.28	4.91	4.71	4.64	5.03	.10
Urinary[de]	4.83	5.36	6.15	6.47	7.09	.11
Total[e]	10.11	10.27	10.86	11.11	12.12	.14
Nitrogen retention						
Grams per day	1.94	2.12	1.88	1.64	1.32	.14
Percent of intake	16.1	17.2	14.7	12.8	9.8	1.14
Percent of absorbed[f]	27.8	27.9	22.9	20.3	14.8	1.70

[a]Each value represents the mean of six animals.
[b]Level of 40:60 silage and 60:40 silage refers to the ratio of swine waste to ground mixture corn grain (as is basis) when initially ensiled.
[c]Diets containing the 40:60 silage were analyzed with the basal and diets containing the 60:40 silage were analyzed with the basal.
[d]Significant linear effect for diets containing 40:60 silage ($P < .01$).
[e]Significant linear effect for diets containing 60:40 silage ($P < .01$).
[f]Significant linear effect for diets containing 60:40 silage ($P < .05$).

TABLE 2. DRY MATTER INTAKE OF SHEEP FED RATIONS CONTAINING SWINE WASTE:GROUND CORN SILAGE

	Diets[a] (dry basis)					
Item	Basal	80% basal + 20% (40:60) silage	80% basal + 20% (60:40) silage	60% basal + 40% (40:60) silage	60% basal + 40% (60:40) silage	SEM
Kilograms per day	1.24[c]	1.30[cd]	1.60[e]	1.53[de]	1.41[cde]	.06
Grams per $W_{kg}^{0.75}$ per day	88.02[c]	91.68[cd]	113.63[e]	111.03[de]	97.63[cde]	4.74

[a]Each value represents the mean of six animals.

[b]Diets were: basal (50% orchardgrass hay + 46.5% corn + 3.0% soybean meal + .5% limestone); 80% basal + 20% (40:60 ensiled mixture of 40 parts swine waste and 60 parts ground corn grain); 80% basal + 20% (60:40 ensiled mixture of 60 parts swine waste and 40 parts ground corn grain); 60% basal + 40% (40:60 ensiled mixture) described above, and 60% basal + 40% (60:40 ensiled mixture) described above.

[cde]Means in the same row with different superscripts are significantly different.

PERFORMANCE OF HEIFERS FED CORN SILAGE SUPPLEMENTED WITH DEEP STACKED OR ENSILED BROILER LITTER[1]

G. R. Dana, J. P. Fontenot, M. D. Hovatter, K. E. Webb, Jr. and W. D. Lamm

Broiler litter has been used as a feedstuff for cattle by researchers and producers. A variety of processing methods are effective for pathogen elimination and good storage characteristics. Previous work at the Shenandoah Valley Research Station has shown that ensiling corn forage and broiler litter in a 70 to 30 ratio, dry basis, produces a high quality silage. Cattle fed this ensiled mixture perform as well as those fed a conventional high corn silage ration supplemented with soybean meal.

Although mixing corn forage and broiler litter at ensiling is a good method to utilize broiler litter, it may not be a feasible method for all producers. Another way in which broiler litter could be handled would be to store it over a period of time and then mix it with corn silage at the time of feeding.

An experiment was started with broiler litter processed by either deep stacking it without additional moisture or ensiling it with water added to attain a moisture level of 40%. This report is a summary of the first 124 days of the experiment.

Experimental Procedure

Approximately 40 tons of fresh, wood shaving base broiler litter were transported from Rockingham County to Blacksburg, Approximately one-half of the litter was deep stacked in a covered building, open on all sides at a depth of approximately 4 feet without packing. The remainder of the litter was ensiled under anaerobic conditions in an 8 mil thickness plastic bag measuring 10 feet in diameter by 45 feet in length. A moisture level of 40% was achieved by adding water to the litter and mixed in 2 ton batches in a scale eauipped mixing wagon, before ensiling. Ensiling was with Silo-press equipment.[2] The litter was fed after it had been deep stacked or ensiled for a minimum of 6 weeks.

A feeding trial was conducted with 30 straightbred and crossbred weanling beef heifers housed in six partially covered lots of equal dimensions with groups of five animals per lot. Two pens were fed each of three rations. The rations consisted of a full feed of corn silage from a

[1]Appreciation is expressed to Rocco, Inc., Harrisonburg, Va. for supplying the broiler litter.
[2]Midwest Silopress, Inc., Sergeant Bluff, Iowa.

concrete stave upright silo and the following supplements: 1) Deep stacked broiler litter substituted for 30% of the corn silage dry matter; 2) ensiled broiler litter substituted for 30% of the total silage dry matter and 3) soybean meal plus defluorinated phosphate supplementation (control ration). Ground corn grain was fed at the level of 1% of bodyweight starting after the cattle had been on test for 98 days.

The corn silage, corn and the deep stacked litter, ensiled litter or soybean meal supplement were weighed and mixed in the feed bunks at each feeding. All lots of cattle were full fed, with refusals weighed and fresh ration fed twice daily. Fresh water was also available at all times. Cattle were weighed every 14 days.

The litter was sampled whenever it was removed from the stack or the plastic bag silo. The corn silage was sampled once per week. The soybean meal was sampled each time it was premixed with the defluorinated phosphate.

Results

Dry matter and crude protein of ration ingredients are given in table 1. The corn silage was of good quality, containing 38.2% dry matter and 8.2% crude protein (dry basis). The crude protein tended to be higher for the deep stacked litter than for the ensiled litter, 35% vs. 31.4%, respectively, dry basis.

The dry matter content of the litter rations (1 and 2) was similar, and was higher than for the control ration. The control ration provided 12.6% crude protein, dry basis. The litter sources were added at quantities that provided excess crude protein.

The trial is still in progress. Performance data of the heifers fed the three rations after 112 days are given in table 2. Dry matter intake, expressed as pounds per day, was highest for the cattle fed corn silage and deep stacked litter (16.3), and lowest for those fed corn silage and soybean meal (12.8). Average daily gain ranged from 1.91 lb for the cattle fed the deep stacked litter to values of 1.77 and 1.76 lb for those fed ensiled litter and soybean meal, respectively. Dry matter intake per pound of gain was similar for heifers fed both the deep stacked litter and ensiled litter rations (8.51 and 8.31 lb, respectively). The value for heifers fed the control ration was 7.27 lb dry matter per pound of gain.

TABLE 1. COMPOSITION OF RATION INGREDIENTS

Item	Dry matter	Crude protein[a]
	%	%
Corn silage	38.2	8.18
Deep stacked litter	79.5	35.0
Ensiled litter	60.5	31.4
Soybean meal	89.0	48.7
Corn grain	89.0	-

[a]Dry basis.

TABLE 2. PERFORMANCE OF HEIFERS ON EXPERIMENTAL RATIONS[a]

Item	Corn silage & deep stack litter	Corn silage & ensiled litter	Corn silage & soybean meal
Initial wt., lb	450	449	462
Wt., 124 days, lb	687	669	680
Daily gain, lb/day	1.91	1.77	1.76
Average daily intake lb/day[b]			
Corn silage	27.8	24.8	27.0
Soybean meal			1.5
Ensiled litter		6.8	
Deep stack litter	5.7		
Corn grain[c]	1.3	1.3	1.3
Dry matter intake, lb/day	16.3	14.7	12.8
Feed efficiency[b]			
Corn silage	14.50	14.01	15.37
Soybean meal			0.83
Ensiled litter		3.82	
Deep stack litter	2.96		
Corn grain	0.69	0.72	0.74
Dry matter/lb. gain, lb	8.51	8.31	7.27

[a]10 animals per ration (2 pens of 5 head).
[b]As fed basis.
[c]Fed only during last 28 days.

ENSILED CORN FORAGE AND BROILER LITTER AND ZERANOL IMPLANT FOR FINISHING HEIFERS[1]

W. H. McClure, J. P. Fontenot and K. E. Webb, Jr.

Weanling calves can be finished on a ration of high quality corn silage, limited grain and protein supplement. Broiler litter contains about 30% crude protein, dry basis, and the nitrogen is efficiently utilized by ruminants. One promising method of using broiler litter is to ensile it with corn forage, and good ensiling occurs when 30% broiler litter, dry basis, is mixed with corn forage at ensiling time.

A three-year study was started in 1975 and concluded in 1978 to study the performance of fattening heifers fed corn silage or corn-litter silage, and 1% bodyweight of concentrates, with or without soybean meal supplementation. The results of the first 2 years were given in previous research reports.

Implanting growing and finishing cattle with zeranol (trade name: Ralgro) has been shown to result in increased rate and efficiency of gain. During the last year (1977-78) of the trial the effect of the zeranol implants was studied in cattle fed rations with and without broiler litter.

Experimental Procedure

Forty-eight straight bred and crossbred heifers were grouped according to breeding and weight and allotted to two replications of four pens of six head each. Four pens were fed regular corn silage and four were fed a silage containing 70% corn forage and 30% broiler litter, dry basis. With each kind of silage two pens were not fed any supplemental protein and two were fed 2 lb soybean meal per head per day. Sufficient grain was fed to provide a total concentrate (grain plus protein supplement) level of about 1% bodyweight. The silages were full-fed. The heifers from one pen of each of the four treatments were implanted with a 36 mg implant of zeranol at the beginning of the 1977-78 test. Supplemental vitamin A was provided in corn or soybean meal at the level of 20,000 I.U. per day.

The broiler litter contained 75% dry matter and the corn forage combined with it contained 32% dry matter. The proportions used to give a level of 30% litter, dry basis, in the silage were 84% corn forage and 16% broiler litter. The litter was placed on top of each load of corn forage with a front-end loader. The capacity of the front-end loader had been calibrated by weighing a number of scoops. Likewise, a number of loads of corn forage had been weighed.

[1]Appreciation is expressed to IMC-Chemical Group, Terre Haute, Indiana for supporting this work in part by a grant-in-aid and supplying the zeranol implants and to Rocco, Harrisonburg, Virginia for supplying the broiler litter.

All heifers were weighed initially, at monthly intervals and at the end of the trial. At the end of the trial the cattle were slaughtered and carcass data were obtained.

Results

The corn forage-litter mixture ensiled well and was readily accepted by the heifers. Mixing of the corn forage and litter occurred as the forage wagon was emptied into the blower, and during the blowing of the mixture into the silo. The chemical composition of the feeds is shown in table 1. The protein content of the corn silage was 10.6%, dry basis. Substituting broiler litter for 30% of the dry matter of the corn forage increased the level of protein to 14.7%, dry basis.

Results of the 1977-78 test are shown in table 2. Performance of all cattle was better for the third year of the test than for the two preceding years. Rate of gain was lowest for the cattle fed no protein supplement (1.99 lb per day). Supplementing this with soybean meal increased daily gain to 2.41 lb per day. Daily gains of heifers fed the corn-litter silage were 2.53 lb. Supplementing the ration with soybean meal did not increase rate of gain. In fact, the rate of gain tended to be lower (2.39 lb per day), compared to that of comparable heifers not fed soybean meal. Carcass grades were low to average choice for the cattle fed the four rations.

A comparison of heifers implanted with zeranol and those not implanted during the 1977-78 test is shown in table 3. The heifers receiving the implant had a daily gain advantage of .2 lb per day. The improvement in gain was greater for the cattle fed corn-litter silage than for those fed corn silage (table 4). The improvement in gain was 0.28 lb per day for cattle fed litter and only 0.12 lb per day for those not fed litter. Less concentrates were required per pound of gain for the zeranol implanted heifers, and differences were larger for the heifers fed litter. The amounts of silage per pound of gain were similar for the control and implanted heifers, due to the low silage intake by the non-implanted heifers fed the unsupplemented corn silage ration. Silage per pound of gain was lower for the implanted heifers which were fed litter-corn silage (12.6 _vs_. 11.2 lb).

Combined results of the 3 years of the test are shown in table 5. Heifers receiving corn silage with no protein supplement had the lowest gains each year, with a 1.65 lb per day average for the 3 years. Addition of protein supplement to the corn silage increased gains to 2.14 lb per day. The heifers receiving corn-litter silage gained 2.25 lb per day, and when soybean meal was added to the corn-litter silage, there was no substantial improvement in gains (2.25 _vs_. 2.27 lb/day).

The heifers receiving corn silage at less silage than those receiving corn-litter silage and had slightly lower silage per pound of gain. Total concentrates (grain and soybean meal) per pound of gain was highest for the heifers receiving corn silage and no soybean meal (4.7 lb).

Values for the other three groups were similar.

Carcass grades and dressing percentages tended to be higher for the heifers fed corn-litter silage, compared to those fed regular corn silage.

In conclusion, it appears that broiler litter ensiled with corn forage can completely replace protein supplement in a ration for fattening beef cattle, at substantial savings in feed cost, and would be a good method to process the waste. Palatability of the corn-litter silage appeared to be no problem and actually there were indications that it was more palatable than regular corn silage. Heifers implanted with zeranol gained at a faster rate than those not implanted, and there is some indication that the response was greater when fattening heifers were fed corn-litter silage.

TABLE 1. CHEMICAL COMPOSITION OF FEEDS

Feed	Dry matter	Composition of dry matter: Crude protein	Crude fiber	Ether extract	Ash	NFE
	%	%	%	%	%	%
Corn silage	33.3	10.6	21.3	2.6	3.5	62.2
Corn-litter silage	39.8	14.7	19.7	2.5	9.6	53.3
Corn grain	88.5	10.2	5.1	3.3	1.6	79.9
Soybean meal	90.8	53.0	5.1	3.1	4.9	34.0

TABLE 2. FEEDING ENSILED CORN-BROILER LITTER SILAGE TO FATTENING HEIFERS 1977-78

Item	Corn silage		Corn-litter silage	
	No SBM[a]	SBM[a]	No SBM[a]	SBM[a]
Initial wt., lb.	508	502	503	501
Final wt., lb.	857	924	946	918
Daily gain, lb.	1.99	2.41	2.53	2.39
Feed/head/day, lb.				
Silage	25.4	28.4	30.2	28.0
Grain	8.3	7.0	8.9	7.0
Soybean meal		2.0		2.0
Feed/lb gain, lb.				
Silage	12.7	11.6	12.0	11.7
Grain	4.2	2.9	3.6	2.9
Soybean meal		.8		.8
Carcass quality grade[b]	12.2	12.2	12.5	13.0
Dressing %	58.0	59.0	59.0	60.0
Loineye muscle area, sq. in.	10.2	11.1	10.1	10.6
Backfat thickness, in.	.44	.43	.56	.54

[a]Soybean meal.
[b]Code: 11=high good; 12=low choice; 13=average choice, etc.

TABLE 3. EFFECT OF IMPLANTING ZERANOL TO FINISHING HEIFERS

Item	Implant	
	None	Zeranol
Initial wt., lb.	504	503
Final wt., lb.	894	929
Daily gain, lb.	2.23	2.43
Feed/head/day, lb.		
Silage	26.8	29.0
Grain	7.7	7.8
Soybean meal	1.0	1.0
Feed/lb gain, lb.		
Silage	12.0	12.0
Grain	3.5	3.3
Soybean meal	.5	.5
Carcass quality grade[a]	12.8	12.1
Dressing %	59.0	59.0
Loineye muscle area, sq. in.	10.3	10.7
Backfat thickness, in.	.50	.48

[a]Code: 11=high good; 12=low choice; 13=average choice; etc.

TABLE 4 . FEEDING ENSILED-CORN BROILER LITTER SILAGE AND IMPLANTING ZERANOL. 1977-78

Silage	Corn silage				Corn-litter silage			
Supplement	No soybean meal		Soybean meal		No soybean meal		Soybean meal	
Implant	None	Zeranol	None	Zeranol	None	Zeranol	None	Zeranol
Initial wt., lb.	506	511	503	502	505	501	501	500
Final wt., lb.	848	866	911	938	926	966	891	945
Daily gain, lb.	1.96	2.03	2.33	2.49	2.41	2.66	2.23	2.54
Feed/head/day, lb.								
Silage	22.2	28.5	26.7	29.2	30.2	30.2	28.0	28.0
Grain	8.3	8.3	6.8	7.0	8.8	9.0	6.9	7.0
Soybean meal			2.0	2.0			2.0	2.0
Feed/lb. gain, lb.								
Silage	11.3	14.0	11.5	11.7	12.5	11.4	12.6	11.0
Grain	4.2	4.1	2.9	2.8	3.7	3.4	3.1	2.8
Soybean meal			0.9	0.8			0.9	0.8
Carcass quality grade[a]	12.8	11.7	12.1	12.3	13.0	12.0	13.3	12.7
Dressing %	58	58	58	59	59	59	60	59
Loineye muscle area, sq. in.	10.0	10.3	10.8	11.4	9.9	10.3	10.6	10.7
Backfat thickness, in.	.47	.41	.40	.46	.54	.58	.60	.48

[a]Code: 11=high good; 12=low choice; 13=average choice; etc.

TABLE 5. FEEDING ENSILED CORN-BROILER LITTER SILAGE TO FATTENING HEIFERS 3-YR. SUMMARY

Item	Corn silage		Corn silage-litter	
	No SBM[a]	SBM[a]	No SBM[a]	SBM[a]
Initial wt., lb.	500	509	514	509
Final wt., lb.	795	900	922	918
Daily gain, lb.	1.65	2.14	2.25	2.27
Feed/head/day				
Silage	18.4	22.7	26.8	26.1
Grain	7.9	6.5	8.6	6.7
Soybean meal		2.0		2.0
Feed/lb gain, lb.				
Silage	10.9	10.3	11.7	11.2
Grain	4.7	2.9	3.7	2.9
Soybean meal		.9		.9
Carcass quality grade[b]	11.6[c]	11.5	12.4	12.6
Dressing %	58.0[c]	57.0	59.0	60.0
Loineye muscle area, sq. in.	9.62[c]	10.32	10.15	10.49
Backfat thickness	.60[c]	.70	.76	.79

[a]Soybean meal.
[b]Code: 11=high good; 12=low choice; 13=average choice, etc.
[c]Data for only last 2 years.

DIFFERENT LEVELS OF ENSILED AND DEEP STACKED BROILER LITTER FOR GROWING CATTLE[1]

M. D. Hovatter, W. Sheehan, G. R. Dana, J. P. Fontenot, K. E. Webb, Jr. and W. D. Lamm

Broiler litter has been established as a valuable source of protein and minerals for ruminants when processed and fed properly. Processing methods which result in pathogen elimination include heat and chemical treatment and ensiling. Deep stacking broiler litter in a covered structure results in considerable heat production and pathogen elimination, making it a potential processing method that requires a minimum of investment and labor. The optimum moisture for ensiling broiler litter has been shown to be about 40%. Ensiling or deep stacking litter at the time of cleaning poultry houses would result in more flexibility than ensiling the waste with corn forage in the fall.

Insufficient data are available concerning the effect of incorporating different levels of broiler litter on performance of growing cattle.

A preliminary short term experiment was conducted with cattle fed different levels of deep stacked broiler litter in dry and high silage rations. The results indicated that palatability and performance were quite satisfactory if the level of litter did not exceed 40% of the dry matter. Following this preliminary experiment, an experiment was initiated to study the effect of feeding different levels of deep stacked and ensiled broiler litter in dry ground rations. Changes occurring during deep stacking were also measured.

Experimental Procedure

Approximately 40 tons of wood shaving base broiler litter was obtained from one commercial broiler house after six flocks of chickens were grown on the litter. One half of the litter was stacked at a depth of 4 ft in a covered building open on all sides. The stack was approximately 10 ft wide and 30 ft long.

Six thermistor probes were placed at alternating depths of 18" and 32" at different locations of the stack to measure temperature changes following stacking. Temperatures were measured daily for 42 days from these sites. Samples of the litter were taken at weekly intervals from randomly allotted areas of the stack between 12" and 48" from the surface. Each sample was used for microbiological assays and frozen for later analysis. The second half of the litter was adjusted to a moisture level of 40% by the addition of water, then ensiled with a large bag silopress in an 8 mm plastic bag for 42 days.

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[1]Appreciation is expressed to Rocco, Inc., Harrisonburg, Va. for supplying the broiler litter.

Thirty-five crossbred weanling steers and seven straightbred weanling heifers were blocked according to weight, breed and sex. The seven animals within each of the six blocks were allotted at random to the following seven rations consisting of 1) 0% ensiled litter, 2) 20% ensiled litter, 3) 40% ensiled litter, 4) 60% ensiled litter, 5) 20% deep stacked litter, 6) 40% deep stacked litter, and 7) 60% deep stacked litter. The basal ration was formulated to contain 13% crude protein, 72% TDN, 0.54% calcium and 0.41% phosphorus. The litter levels were substituted for the basal ration on a dry basis.

Steers and heifers were kept in individual stalls and self fed the rations from 3:30 pm to 7:30 am, then turned out into concrete exercise lots with access to water and trace mineralized salt for 8 hr each day. Feed refusals were collected and weighed for daily intake calculations. Each animal was weighed at the beginning of the trial and at 14 day intervals. The cattle were administered 1 million I.U. vitamin A at the beginning of the trial.

Results

Results from the deep stack temperature measurements are presented in table 2. Initial temperatures were 28° and 29°C for the 18" and 32" depths, respectively. A peak temperature of 51°C was reached on the eighth day for the 32" depth, while a peak temperature of 50°C was reached on the fourth day at the 18" depth. The temperatures of both levels generally decreased for the remainder of the 42-day period.

Microbiological assays on initial samples gave counts of 1×10^4 coliform colonies and 1×10^4 fecal coliforms per gram of litter (table 3). Tests for Salmonella, Shigella and Proteus were negative in all samples. After 1 week of deep stacking the litter tested negative for coliforms and fecal coliforms.

Results of the feeding trial which was for 126 days are presented in table 4. Average dry matter intake was not decreased by including 20 or 40% litter, dry basis, in the ration. In fact, the intake values were a little higher than for the control ration. When the level of litter was increased to 60% of the dry matter, a decrease in dry matter intake resulted which was more severe for the cattle fed the ensiled litter.

Rate of gain for cattle fed 20% ensiled or deep stacked litter tended to be higher than for those fed the control ration. The values were 2.37 and 2.35 lb per day for cattle fed ensiled and deep stacked litter, respectively, compared to 2.16 lb per day for the control cattle. When the level of litter was increased to 40% daily gains were similar to that of cattle fed the basal ration. The rate of gain was decreased markedly when the level of litter was increased to 60%, dry basis. The values were 1.65 lb per day for the cattle fed deep stacked and 1.14 lb per day for those fed ensiled litter. The difference in daily gain between the cattle fed 60% ensiled and deep stacked litter was related to the difference in dry matter intake.

Feed efficiency of the cattle fed 20% litter was similar as for those fed the control ration. When litter was included at 40 and 60%, dry basis,feed efficiency was lowered, reflecting differences in daily gain.

TABLE 1. CHEMICAL COMPOSITION OF FEEDS

Feed	Dry matter	Crude protein[a]
	%	%
Control ration	88.7	13.1
Ensiled litter	60.4	31.9
Deep stacked litter	82.3	31.8

[a]Dry matter basis.

TABLE 2. TEMPERATURE OF DEEP STACKED BROILER LITTER

Day no.	Probe level[a] 18 in	32 in
0	28	29
2	47	34
4	50	43
6	49	50
8	49	51
10	44	49
12	42	47
14	42	46
16	41	44
20	39	43
24	36	42
30	32	40
36	34	40
42	30	38

[a]From top of stack.

TABLE 3. MICROBIOLOGICAL COUNTS OF DEEP STACKED BROILER LITTER

Week	Coliform colonies/gram		Salmonella	Shigella	Proteus
	Total	Fecal			
0	10^4	10^4	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-

TABLE 4. PERFORMANCE OF WEANLING CALVES FED DIFFERENT LEVELS OF BROILER LITTER
126 DAYS

	Rations						
	Level of ensiled litter[a]				Level of deep stacked litter[a]		
Item	0 (basal)	20	40	60	20	40	60
Initial wt., lb	438	439	433	439	426	451	438
Final wt., lb	710	738	710	583	722	710	646
Daily gain	2.16	2.37	2.20	1.14	2.35	2.06	1.65
Dry matter intake per day, lb	15.5	17.3	16.5	11.7	16.5	15.9	14.6
Dry matter/lb gain, lb.	7.26	7.34	7.65	10.9	7.12	7.83	8.88

[a]Dry basis.

FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF BULLS AND HEIFERS FED THREE ENERGY LEVELS[1]

W. D. Lamm and R. F. Kelly

The objectives of this study were to compare the feedlot performance and carcass characteristics of weanling bulls and heifers fed to slaughter weight and grade on corn silage-based rations supplemented with varying amounts of corn grain.

Experimental Procedure

Thirty-six bull and 39 heifer calves were blocked by weight and breed within sex and randomly assigned within block to one of three dietary treatments, with two replications of six bulls and six or seven heifers per treatment.

The calves were sired by Angus bulls and were progeny of Angus or Angus x Holstein dams. They were born between January 18 and March 28, and grazed spring, summer and fall pastures with their dams without creep feed until weaned October 18. At weaning they were fed grass-legume hay until November 15, and then were fed corn silage *ad libitum*. One week after weaning they were moved from open lots to a confinement feedlot where they remained until slaughtered.

The dietary treatments fed once daily were 1) corn silage (CS) full-fed (low energy) 2) CS full-fed + cracked corn grain (CCG) fed at 1% of body weight (intermediate energy) and 3) CS (10 lbs/day) + CCG full-fed (high energy). All calves were fed 2 lbs. soybean meal and a commercially available vitamin-mineral mixture. Water and salt were available *ad libitum*. The ration ingredients were sampled weekly for proximate analysis throughout the study. Metabolizable energy values were obtained from the N.R.C. (1976) feed composition tables for beef cattle. Initial, final and 28-day interim unshrunk weights were obtained.

The bulls were fed in pens located in the west half of the feeding facility and heifers in the east half. No heat suppressant was used for the heifers. When the average of the animals within a sex receiving a particular treatment visually appeared to be capable of USDA quality grading low choice, these animals were sent to a local slaughter plant.

After hot carcass weights were obtained, the carcasses were allowed to chill for 48 hr prior to being graded by a qualified meats researcher according to Official United States Standards for Grades of Carcass Beef (1975). Other data recorded included fat cover over the *longissimus* muscle perpendicular to the outside surface at a point three-fourths the length of the rib-eye cross-section from the chine bone side; *longissimus* muscle area measured on the cross-section of the rib-eye between the 12th and 13th ribs; visual estimate of internal fat percentage in the kidney, pelvic and heart regions; and yield grade calculated by Official United States Standards for Grades of Carcass Beef (1975).

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[1]Appreciation is expressed to Henry Dickerson, Dave Gibson and Alan Lee for care of the experimental animals.

Randomly, within sex, breed and dietary treatment, the 9-10-11 rib section of the wholesale rib was removed from one half of each carcass and physically separated into closely trimmed lean, excess fat and bone. The percentage of each was calculated. The 6-7-8 rib sections were cooked until a minimum temperature of 76.7 C, monitored by thermocouples, was attained. After removal from the oven, the temperature was further monitored until it peaked and began descending. The longissimus muscle was removed from the roast and sliced into thicknesses of .64 cm. Three cores, each 2.54 cm in diameter, were taken from each slice for organoleptic evaluation by eight untrained panelists. The highest and lowest scores were discarded, so six scores were tabulated. Panelists evaluated tenderness, juiciness, flavor and overall acceptability. In addition, three core samples, 2.54 x 1.27 cm from each roast were sheared perpendicular to the muscle fibers by the Warner-Bratzler and Allo-Kramer shearing devices. Kilograms of force required to shear the core were noted. Three shears by the Warner-Bratzler were made on each core, hence nine observations were obtained for each roast. Evaporation, dripping and total cooking losses were determined.

Results and Discussion

The feedlot performance of bulls and heifers is shown in table 1. Bulls weighed 48 and 161 lbs. more than heifers at the start and end of the trial, respectively, and gained 20% faster than heifers (3.06 vs 2.44 lb) when data across dietary treatments within sex were pooled. Bulls were 15% more efficient in the conversion of ration dry matter to live weight gain than heifers (5.94 vs 6.92). Metabolizable energy required per lb live weight gain also favored bulls (7.60 vs 8.79 Mcal).

Hot carcass weight, dressing percent, longissimus muscle area, kidney, pelvic and heart fat percent and yield grade all favored bulls compared to heifers (table 2). Quality grades were higher for heifers and they tended to have more 12th rib fat thickness than bulls.

The physical separation of the 9-10-11 rib sections (table 3) indicated bulls had less fat trim but higher percents of lean bone than heifers. Cooking loss as evaporation was higher for bulls, whereas dripping loss was lower and total losses were not different than those of heifers. Tenderness and juiciness ratings by taste panel members were more desirable for heifers than bulls and there was a trend for heifers to have more desirable flavor and overall acceptability. There was a tendency for heifers to have lower shear values than bulls.

The effect of dietary energy level upon the feedlot performance of bulls is given in table 4. Bulls fed the high energy diet (treatment 3) were on feed for the shortest time period (168 days) and had the fastest rate of gain (3.43 vs 2.86 lbs) during the trial. Cattle on this treatment were more efficient in the conversion of feed fry matter to live weight gain than those on treatment 2 but were similar to those on treatment 1 (low energy). When efficiency was measured by calculated metabolizable energy required per lb gain, the low energy ration was most efficient. Treatment 1 required the greatest number of days on feed (196) and gained the slowest (2.66 vs 3.26 lbs). Treatment 2 tended to be intermediate in days on feed (174) and rate of gain (3.06 vs 2.66 and 3.43 lbs) compared to treatments 1 and 3. Dry matter required per lb gain was higher for treatment 2 than treatment 3 and tended to be higher than treatment 1.

No differences in slaughter weight, carcass weight, dressing percent and quality grade were noted among bulls fed the three dietary treatments, although there was an apparent visual overestimation of fatness in bulls fed treatment 1, as indicated by quality grade (table 5). Bulls fed the low energy diet had higher cutability (lower yield grade number) which reflected their tendency to be less fat and to have more longissimus muscle area than treatments 2 and 3.

No differences were detected in physical separation of ribs, cooking losses, taste panel scores and shear values among bulls fed the different dietary treatments (table 6).

Heifer feedlot performance (table 4) followed a similar trend to that observed in the bulls. Heifers fed the low energy ration tended to gain slower but were similar in feed dry matter utilization to those heifers fed the other diets. Metabolizable energy required per lb gain favored the low energy treatment.

No differences were noted between treatments for most of the carcass parameters studied (table 5). There was a trend for heifers fed treatment 1 to be less fat than heifers fed treatments 2 and 3, although they were on feed 28 days longer. As observed in the bulls, heifers fed the low energy ration had more longissimus muscle area than those fed the other rations. This effect may be confounded with age since these heifers were older at slaughter.

Taste panel evaluations and sheer values (table 6) tended to favor heifers fed the intermediate energy ration (treatment 2). Most values for heifers fed any of the rations were more favorable than for corresponding values from bull carcasses.

From this study it appears that bulls can provide a considerable saving in feed dry matter required per lb gain (14%) and still produce carcasses as acceptable as heifers.

TABLE 1. FEEDLOT PERFORMANCE OF BULLS AND HEIFERS

Item	Sex Group	
	Bulls	Heifers
No. of pens	6	6
No. of animals	36	39
Days on feed	179	177
Age at slaughter, days	469	462
Initial wt., lb	541.0	493.2
Final wt., lb	1084.8	924.7
Total gain, lg	543.0	431.5
Daily gain, lb	3.06	2.44
Dry matter per lb gain, lb	5.94	6.92
Metabolizable energy per lb gain, Mcal	7.60	8.79

TABLE 2. CARCASS CHARACTERISTICS OF BULLS AND HEIFERS

Item	Sex group	
	Bulls	Heifers
No. of carcasses	33	39
Age at slaughter, days	469	462
Slaughter wt., lb	1084.8	924.7
Carcass wt., lb	656.0	548.5
Dressing %	60.1	59.2
Quality grade[a]	10.0	11.7
Fat thickness 12th rib, cm	.79	.94
Longissimus muscle area, cm^2	80.2	69.0
Kidney, pelvic and heart fat, %	2.06	2.68
Yield grade	2.2	2.6

[a]10 = average good, 11 = high good, 12 = low choice.

TABLE 3. EVALUATION OF BULL AND HEIFER CARCASSES

Item	Bulls	Heifers
No. of carcasses	23	17
Physical separation of 9-10-11 rib section		
Lean, %	57.8	54.2
Fat, %	25.5	30.3
Bone, %	16.8	15.5
Cooking losses		
Evaporation, %	25.4	22.9
Drippings, %	6.4	7.9
Total, %	31.8	30.8
Taste panel scores		
Tenderness[a]	2.4	2.0
Juiciness[b]	2.8	2.4
Flavor[c]	2.2	2.0
Overall acceptability[d]	2.4	2.2
Warner-Bratzler shear, kg	3.35	3.06
Kramer shear, kg	3.64	3.26

[a]1 = very tender, 5 = very tough.

[b]1 = very juicy, 5 = very dry.

[c]1 = very tasty, 5 = strong off-flavor.

[d]1 = very acceptable, 5 = very objectionable.

TABLE 4. FEEDLOT PERFORMANCE OF BULLS AND HEIFERS FED THREE ENERGY LEVELS

Item	Ration energy level, Bulls			Ration energy level, Heifers		
	Low	Intermediate	High	Low	Intermediate	High
No. of pens	2	2	2	2	2	2
No. of animals	12	12	12	13	13	13
Days on feed	196	174	168	196	168	168
Initial wt., lb.	532.8	544.7	546.5	492.8	504.9	481.8
Final wt., lb.	1056.9	1075.8	1121.8	937.4	921.1	915.2
Total gain, lb.	524.1	531.1	572.3	444.6	416.2	433.4
Daily gain, lb.	2.66	3.06	3.43	2.27	2.49	2.57
Daily feed consumption						
Corn silage, lb.	31.5	25.1	10.8	31.2	25.1	10.6
Corn grain, lb.		7.3	14.7		6.2	11.4
Soybean meal, lb.	1.94	1.91	1.91	1.94	1.91	1.98
Vitamin-mineral mix, lb.	.09	.09	.09	.09	.09	.09
Dry matter, lb.	15.93	19.38	19.49	15.82	18.44	16.57
Dry matter per lb. gain, lb.	5.94	6.28	5.59	6.92	7.42	6.42
Metabolizable energy per lb. gain, Mcal	6.94	8.04	7.83	8.11	9.41	8.84

TABLE 5. CARCASS CHARACTERISTICS OF BULLS AND HEIFERS FED THREE ENERGY LEVELS

Item	Ration energy level, Bulls			Ration energy level, Heifers		
	Low	Intermediate	High	Low	Intermediate	High
Age at slaughter, days	478	482	445	483	454	450
Slaughter wt., lb.	1056.9	1075.8	1121.8	937.4	921.1	915.2
Carcass wt., lb.	641.3	656.7	670.1	554.4	546.3	544.9
Dressing %	60.6	60.1	59.5	59.1	59.3	59.5
Quality grade	9.7	10.2	10.2	11.7	11.9	11.5
Fat thickness 12th rib, cm	.54	.80	1.03	.76	1.04	1.04
Longissimus muscle area, cm^2	83.4	76.2	80.9	74.3	65.0	67.6
Kidney, pelvic and heart fat, %	1.47	2.35	2.35	2.38	2.64	3.01
Yield grade	1.6	2.5	2.6	2.1	2.9	2.9

TABLE 6. EVALUATION OF BULL AND HEIFER CARCASSES

Item	Ration energy levels, Bulls			Ration energy levels, Heifers		
	Low	Intermediate	High	Low	Intermediate	High
No. of carcasses	5	11	7	5	7	5
Physical separation of 9-10-11 rib section						
Lean, %	58.7	56.0	58.8	54.9	52.6	55.0
Fat, %	23.1	28.0	25.2	29.0	31.4	30.6
Bone, %	18.1	16.0	16.4	16.1	16.0	14.4
Cooking losses						
Evaporation, %	26.0	24.3	25.9	24.5	22.6	21.6
Drippings, %	5.6	6.4	7.2	7.2	8.6	8.0
Total, %	31.6	30.7	33.1	31.7	31.2	29.6
Taste panel scores						
Tenderness[a]	2.4	2.4	2.3	2.1	1.7	2.2
Juiciness[b]	2.8	2.8	2.8	2.3	2.3	2.6
Flavor[c]	2.1	2.3	2.2	2.1	2.0	2.0
Overall acceptability[d]	2.4	2.3	2.4	2.3	1.8	2.4
Warner-Bratzler shear, kg	3.58	3.72	2.75	2.96	2.59	3.61
Kramer shear, kg	4.45	3.69	2.79	3.30	2.56	3.94

[a] 1 = very tender, 5 = very tough.

[b] 1 = very juicy, 5 = very dry.

[c] 1 = very tasty, 5 = strong off-flavor.

[d] 1 = very acceptable, 5 = very objectionable.

ENSILING CHARACTERISTICS AND NUTRITIONAL VALUE OF CATTLE WASTE ENSILED WITH RYE STRAW AT VARIOUS DRY MATTER AND SODIUM HYDROXIDE TREATMENT LEVELS

G. E. Aines, W. D. Lamm, K. E. Webb, Jr. and J. P. Fontenot

Increasing demands by man for cereal grains have led to concerns about the future of these grains in ruminant rations. Additionally, increased concerns over environmental impacts of animal waste disposal have led to interest in animal waste as a potential nutrient source for ruminants. Coupled with this interest has been the desire to utilize crop residues as ruminant feed. These by-products are generally poorly digested by ruminants due to their high fiber and lignin content. Attempts to increase their potential by increasing digestibility have been undertaken and the most promising process appears to be treatment with alkali, especially sodium hydroxide (NaOH). The objective of this study was to incorporate these concepts into a single program.

Experimental Procedure

A two-phase experiment was conducted. The first phase was a small silo study that incorporated a 2 x 3 x 2 factorial design with 6 silos per treatment. Cattle waste and ground rye straw were mixed in a 60:40 ratio, wet basis. Two types of cattle waste were used: 1) high-roughage waste, from animals fed a full feed of corn silage with 2 lbs. soybean meal/head/day and 2) high-concentrate waste, from animals fed a full feed of cracked corn grain plus 10 lbs. of corn silage and 2 lbs. soybean meal/head/day.

The wastelages (60:40 mixes) were then adjusted to dry matters of either 30%, 40% or 50% with water and were treated with either 0% or 4% NaOH, dry basis. The mixtures were ensiled for a minimum of 42 days in 3.8 l laboratory silos triple-lined with polyethylene bags. Upon opening, the silos were tested for dry matter and the presence of coliform organisms, Proteus, Salmonella and Shigella. Extracts were prepared for pH determination and then frozen for subsequent analysis for lactic acid. In vitro dry matter digestibility (IVDMD) was determined on the wastelages. Based on the results of these tests, six wastelages and a control diet were selected for use in a lamb metabolism study.

The second phase of this study was a digestibility and nitrogen metabolism trial using six crossbred wethers per treatment. The experimental mixtures were blended in a scale-equipped mixer wagon and ensiled in 55 gallon steel drums double-lined with 8 mil thick polyethylene bags. High concentrate wastelages ensiled at 50% and 30% dry matter each treated with 0% and 4% NaOH (dry basis) and high-roughage wastelages ensiled at 50% dry matter treated with 0% and 4% NaOH were used in the trials. These wastelages were selected in order to look at potential effects on in vivo digestibility due to differences in waste source, dry matter level and NaOH treatment. A control diet of rye straw ensiled at 40% dry matter was used.

The animals were blocked by weight and breed and randomly allotted to treatments. The trial consisted of 3 day adaptation, 5 day transition, 10 day preliminary and 10 day collection periods. All animals received water ad libitum except during the two, two hour feeding periods. The animals were fed at 7:00 AM and 7:00 PM. The wethers received supplemental Vitamin A and calcium plus 10 gm of trace mineralized salt per day. Lambs were fed to provide 450 gm of organic matter intake per head daily.

On the last day of the collection period rumen fluid samples were obtained by stomach tube and blood was sampled by jugular puncture. The rumen and blood samples were taken at 2 and 6 hours post feeding, respectively.

Results and Discussion

Table 1 shows the results of the small silo study for a pH (pre- and post-ensiling), dry matter, lactic acid and in vitro dry matter digestibility. Addition of NaOH increased pre-ensiling pH levels above 7 in all cases. Acid production during ensiling of the 4% NaOH-treated high-concentrate wastelages lowered the pH values of those wastelages to a pH of approximately 5. High lactic acid values support this change. Lactic acid values tended to decrease with increasing dry matter levels. The pH values for the 4% NaOH-treated high-roughage wastelages also decreased, but not to the extent of the high-concentrate wastelages. In no case did the pH values decrease below neutrality. The lack of acid production is shown by the low lactic acid values. The pH values for the wastelages ranged from 4.1 to 4.2 in the high-concentrate and high-roughage wastelages without NaOH treatment.

Addition of NaOH resulted in considerable increases in IVDMD over the untreated wastelages while waste source and dry matter level had little effect on IVDMD regardless of the level of NaOH. In vitro dry matter digestibility of high-roughage wastelages increased by 10.1% and high-concentrate wastelages increased by 11.3% with 4% NaOH treatment.

Pre- and post-ensiling microbial counts are recorded in table 2. Total and fecal coliforms were apparently eliminated by treatment with NaOH in the pre-ensiled material. Following ensiling, total and fecal coliforms were only found at very low counts in the 4% NaOH treated high-roughage wastelage which had pH values over 7. Proteus organisms were found in small numbers in wastelages with post-ensiling pH values over 5.

In the metabolism study, 50% dry matter is used to describe the wastelage in which the calculated dry matter level was determined by the dry matter levels of the two components. The actual dry matter levels are shown in table 3.

Table 3 also shows the in vivo dry matter, organic matter, crude fiber and crude protein digestibility values. Addition of NaOH improved digestibility values for dry matter, organic matter and crude fiber by 10.9%, 8.8% and 14.2%, respectively (averaged across treatments). Crude protein digestibility was decreased across treatments by an average of 15.3% with the addition of NaOH.

Nitrogen metabolism data are presented in table 4. All but 2 animals were in negative nitrogen balance during the collection period. There appeared to be a trend for lambs fed NaOH-treated wastelage to absorb less nitrogen as a percent of intake. No ill effects were seen in the animals due to microbial contamination of the feeds. All animals lost weight while on trial.

Summary

Treatment of the wastelages with NaOH increased *in vivo* dry matter, organic matter and crude fiber digestibility compared to the untreated wastelage. However, NaOH treatment decreased crude protein digestibility. Addition of NaOH also increased the pH of the material prior to ensiling and many have aided in the elimination of pathogenic organisms. After ensiling, the high-concentrate NaOH-treated wastelages showed pH values of approximately 5 as compared to the untreated high-concentrate wastelage with pH values around 4. Small numbers of Proteus organisms were found in wastelages with pH 5 and above. The high-roughage NaOH-treated wastelage did not show the dramatic decrease in pH after ensiling and both coliform and Proteus organisms were found at low levels. In addition, nitrogen in the high-roughage wastelages was not utilized as efficiently as nitrogen in the high-concentrage wastelages.

TABLE 1. ENSILING CHARACTERISTICS AND *IN VITRO* DRY MATTER DIGESTIBILITIES, SMALL SILO STUDY

Treatment	Dry Matter	pH	Lactic acid, % of DM	IVDMD[a]
Initial Mixtures	%			%
HC[b]-30[c]-0[d]	28.0	4.24	-	-
HC -30 -4	28.5	9.76	-	-
HC -40 -0	38.4	4.13	-	-
HC -40 -4	-	9.71	-	-
HC -50 -0	47.5	4.25	-	-
HC -50 -4	-	7.10	-	-
HR[b]-30 -0	27.5	4.33	-	-
HR -30 -4	29.1	8.97	-	-
HR -40 -0	37.4	4.37	-	-
HR -40 -4	40.8	8.80	-	-
HR -50 -0	46.1	4.76	-	-
HR -50 -4	52.1	8.93	-	-
Rye Straw	98.1	-	-	-
Cattle Waste				
High-concentrate	26.4	5.45	-	-
High-roughage	18.5	7.30	-	-
Ensiled Mixtures				
HC -30 -0	28.18	4.21	7.14	55.99
HC -30 -4	28.13	5.10	7.46	68.72
HC -40 -0	38.65	4.16	7.27	55.95
HC -40 -4	37.75	5.18	6.38	67.91
HC -50 -0	47.68	4.20	6.48	58.99
HC -50 -4	46.93	5.10	5.93	68.20
HR -30 -0	28.52	4.10	6.41	54.05
HR -30 -4	28.42	7.01	0.41	66.39
HR -40 -0	37.82	4.10	6.90	54.60
HR -40 -4	38.64	7.90	0.18	63.65
HR -50 -0	48.89	4.22	5.74	56.74
HR -50 -4	47.92	7.80	0.28	65.74

[a] *In vitro* dry matter digestibility adjusted for NaOH content of silage.

[b] High-concentrate (HC) and High-roughage (HR) cattle waste.

[c] Dry matter %.

[d] NaOH level (dry basis)

TABLE 2. PRE- AND POST-ENSILING VALUES FOR TOTAL COLIFORMS, FECAL COLIFORMS, PROTEUS, SALMONELLA AND SHIGELLA ORGANISMS, SMALL SILO STUDY

Treatment	Total Coliforms[a]		Fecal Coliforms[a]		Proteus		Salmonella		Shigella	
	Pre[b]	Post[b]	Pre	Post	Pre	Post	Pre	Post	Pre	Post
HC[c]-30[d]-0[e]	28.5×10^3	—	44.0×10^3	—	+	-	-	-	-	-
HC -30 -4	—	—	—	—	-	**	-	-	-	-
HC -40 -0	47.0×10^3	—	60.5×10^3	—	+	-	-	-	-	-
HC -40 -4	—	—	—	—	-	**	-	-	-	-
HC -50 -0	55.0×10^3	—	36.5×10^3	—	+	-	-	-	-	-
HC -50 -4	—	—	—	—	-	**	-	-	-	-
HR[c]-30 -0	10.45×10^3	—	19.1×10^4	—	+	-	-	-	-	-
HR -30 -4	—	*	—	*	-	**	-	-	-	-
HR -40 -0	75.0×10^3	—	14.1×10^4	—	+	-	-	-	-	-
HR -40 -4	—	*	—	*	+	**	-	-	-	-
HR -50 -0	99.5×10^3	—	30.0×10^3	—	+	-	-	-	-	-
HR -50 -4	—	*	—	*	+	**	-	-	-	-

[a]Bacteria/gm of wastelage.

[b]Pre = pre-ensiled; post = post-ensiled.

[c]High-concentrate (HC) and high-roughage (HR) cattle waste.

[d]Dry matter %.

[e]NaOH level (dry basis).

*Small numbers of total and fecal coliforms found consistently at levels less than 100 bacteria/gm wastelage.

**Small numbers of Proteus colonies found consistently.

TABLE 3. DIGESTIBILITY DATA, LAMB METABOLISM STUDY

Treatment	Dry Matter	Digestibility: Dry Matter	Organic Matter	Crude Fiber[a]	Crude Protein[a]
	%	%	%	%	%
Control	37.1	30.65	32.89	41.73	27.39
HC[b]-30[c]-0[d]	28.41	33.08	34.98	40.12	55.19
HC -30 -4	29.17	44.75	43.93	56.51	45.95
HC -50 -0	40.94	33.88	35.54	42.59	56.37
HC -50 -4	43.48	42.68	45.35	55.79	38.50
HR[b]-50 -0	40.73	29.72	31.62	39.83	42.29[e]
HR -50 -4	42.79	41.82	39.25	52.85	23.46

[a]Expressed as a % of dry matter.
[b]High-concentrate (HC) and high-roughage (HR) cattle waste.
[c]Dry matter %.
[d]NaOH level (dry basis).
[e]Based on five observations.

TABLE 4. NITROGEN BALANCE DATA, LAMB METABOLISM STUDY

Item	Ration Treatments						
	Control	HC[a]-30[b]-0[c]	HC-30-4	HC-50-0	HC-50-4	HR[a]-50-0	HR-50-4
Intake N, g/day	4.38	9.84	10.02	9.64	8.44	6.73	6.41
Fecal N, g/day	3.17	4.41	4.99	4.34	4.71	5.36	4.89
Urinary N, g/day	4.21	7.30	5.86	6.75	5.51	6.04	4.31
gN absorbed/day	1.21	5.43	5.04	5.30	3.73	1.34	1.52
gN retained/day	-2.99	-1.87	-.82	-1.45	-1.77	-4.69	-2.79
% of intake retained	-68.29	-19.12	-7.99	-14.57	-21.15	-69.75	-43.57
% of intake absorbed	27.33	55.19	50.16	54.97	44.08	19.84	23.67
% of absorbed retained	-264.57	-35.23	-15.67	-25.14	-50.40	-348.59	-184.23

[a]High-concentrate (HC) and high-roughage (HR) cattle waste.

[b]Dry matter %.

[c]NaOH level (dry basis).

UTILIZATION OF ABOMASALLY INFUSED RNA AND DNA BY SHEEP

J. L. Hale, K. E. Webb, Jr. and J. P. Fontenot

A considerable amount of the dietary nitrogen of ruminants is converted to bacterial nucleic acid nitrogen in the rumen. Thus, bacterial nucleic acid nitrogen comprises a significant amount of the total nitrogen in the digesta passing through the intestinal tract of the ruminant. Research on the utilization of these nucleic acids has created a controversy as to their nutritional value to the host animal. It was the objective of this study to compare the utilization of nitrogen from RNA, DNA and a combination of RNA and DNA with that of soy protein.

Experimental Procedure

Fifteen abomasally cannulated, growing wether lambs were used in two metabolism trials. The animals were blocked by weight and breeding and randomly assigned with block to one of five treatments for the first trial and were rerandomized within blocks for the second trial with the restriction that no animal receive the same treatment in both trials. False bottom metabolism stalls were used for separate collection of urine and feces. All lambs were fed 350 g, twice daily, of a basal ration supplying 42.5 g dietary crude protein per day (table 1). Also the lambs received, twice daily, abomasal infusions of either soy protein, RNA, DNA, a one to one combination of RNA and DNA, or a sham infusion. The sham infusion was tris buffer which was the solvent used to dissolve the RNA and DNA and was also used as a carrier for the soy protein. With the exception of the sham, the infusions were calculated to be isonitrogenous, supplying 15.6 g crude protein equivalent per day. Infusions were made at the beginning of each feeding period.

Following a 10-day preliminary period, all urine and feces were collected during a 10-day collection period. Blood samples were obtained by jugular puncture at 6 and 12 hr post feeding on the last day of each trial. Proximate analyses were performed on all feed and fecal samples. Urine samples were analyzed for the following nitrogen components: urea, allantoin, creatinine and ammonia. Blood samples were analyzed for serum total protein and blood urea nitrogen.

Data were analyzed for statistical differences using ANOV procedures and differences among means were tested using Duncan's Multiple Range.

Results and Discussion

Apparent digestibilities for dry matter, crude fiber, crude protein, ether extract, nitrogen free extract and organic matter are shown in Table 2. No significant differences were observed for dry matter, crude fiber, ether extract, NFE or organic matter digestibilities. Crude fiber digestibility for those animals receiving the soy and nucleic acid infusions tended to be higher than for those animals receiving the sham only. The additional nitrogen from the soy and nucleic acid infusions could have enhanced cellulose digestion in the cecum and colon. Ether extract digestibility tended to be greater for the sham infusion as compared to the other infusions. Apparent digestibility of crude protein was lowest ($P < .05$) for the sham infusion.

Infusing soy protein resulted in a higher ($P < .05$) crude protein digestibility than infusing either DNA or the combination of RNA and DNA. The infusion of RNA resulted in an intermediate value.

Nitrogen intake, excretion, absorption and retention data are shown in table 3. Nitrogen intake for the sham was 7.7g per day while the nitrogen infusions of soy, RNA, DNA, and the combination of RNA and DNA supplied an additional 2.5 g of nitrogen per day for a total nitrogen intake of approximately 10.5 g per day. Urinary nitrogen excretion in g per day was greater ($P < .05$) for the nitrogen infusions as compared to the sham. Urinary nitrogen excretion was higher for the DNA infusion than for either the soy or the combination of RNA and DNA but was not different from the RNA infusion ($P < .05$). Fecal nitrogen excretion was highest ($P < .05$) for the DNA and combination of RNA and DNA while the sham, soy and RNA infusions were not different. Total nitrogen excretion was higher ($P < .05$) for the nitrogen infusions than for the sham. Among the nitrogen infusions, DNA had the largest total excretion, soy the least and RNA and the combination of RNA and DNA intermediate ($P < .05$).

Nitrogen absorption when expressed as g per day was lowest ($P < .05$) for the sham infusion. Differences among nitrogen sources were not significant. Nitrogen absorption, expressed as percent of intake, for the nucleic acid infusions was higher ($P < .05$) than the sham value. Infusing soy protein resulted in the greatest absorption of nitrogen among the nitrogen sources and infusing DNA and the combimation of RNA and DNA the least ($P < .05$).

Nitrogen retention when expressed as g per day tended to be elevated for the nucleic acid infusions as compared to the sham treatment. The soy infusion had a higher ($P < .1$) retention value than either the RNA or DNA treatments, but was not different from the combination of RNA and DNA. When expressed as percent of intake or as percent of absorbed no significant differences in nitrogen retention were observed among treatments.

Urinary nitrogen components are presented in table 4. Urinary urea nitrogen values for the nitrogen infusions were higher ($P < .05$) than the sham. The values for the combination of RNA and DNA were lower ($P < .05$) than the other nitrogen infusions. Urea nitrogen accounted for the largest proportion of the nitrogen excreted in the urine.

Allantoin nitrogen values were elevated ($P < .05$) for each of the nucleic acid infusions as compared to the soy and sham. This is indicative of an increased purine catabolism associated with the nucleic acid infusions. No significant differences were observed for the excretion of creatinine nitrogen. An approximate three-fold increase in the excretion of ammonia nitrogen was observed with the infusion of the nucleic acids ($P < .05$).

"Other" nitrogen in the urine, nitrogen which was not identified, was not significantly different across all treatments. A larger proportion was unidentified in the sham infusion compared to the other treatments.

Blood urea nitrogen concentrations were not affected by time (table 5). Values were highest ($P < .05$) for RNA and DNA infusions and lowest for the sham, with soy and the combination of RNA and DNA values being intermediate. Serum protein concentrations were neither affected by treatment nor time (table 6).

Summary

The data from this experiement tends to indicate that the portion of dietary nitrogen which is converted to microbial nucleic acids by rumen microorganisms is probably of limited value to the host animal's metabolism. The principal contribution of this nitrogen fraction appears to be associated with microbial metabolism, thus indirectly serving the host animal. Some modest utilization of these nucleic acids may occur in the host animal, especially as indicated by the results obtained when the combination of RNA and DNA was infused.

TABLE 1. COMPOSITION OF BASAL SHEEP DIET.

Item	Amount in Diet
Ingredient composition, %	
Corn, dent yellow, grain (4), IRN 4-02-935	48.73
Cob Fractions[a]	39.11
Sugar cane, molasses, mn 48 invert sugar, mn 79.5 degrees brix, (4), IRN 4-04-696	5.00
Orchard grass, hay, S-C, cut 1 (1), IRN 1-03-433	5.00
Phosphate, defluorinated grnd., mn 1 ptF per 100 pt P, (6), IRN 6-01-780	1.16
Iodized salt (6)	1.00
Vitamin A palmitate, commercial (7), IRN 7-05-143[b]	+
Chemical Composition	
Dry matter, %	91.86
Composition of dry matter, %	
Crude protein	7.00
Nitrogen	1.12
Crude fiber	19.35
Ether extract	2.21
Ash	4.73
NFE	66.72

[a]Number 4 cob fraction, the Andersons, Maumee, Ohio.

[b]1,100 I.U. per kilogram of ration.

TABLE 2. APPARENT DIGESTIBILITIES OF PROXIMATE COMPONENTS.

	Abomasal infusion				
Component, %	Sham	Soy	RNA	DNA	RNA-DNA
Dry matter	67.53	72.32	70.93	68.31	68.51
Crude fiber	55.42	63.61	65.09	61.38	61.95
Crude protein	45.82[a]	61.74[c]	58.34[b,c]	54.92[b]	53.40[b]
Ether extract	81.44	78.76	78.81	76.04	77.31
N.F.E.	74.47	76.93	75.99	74.88	74.93
O.M.	68.58	69.69	72.10	70.21	70.32

[a,b,c]Means in the same row with different superscripts are different ($P < .05$).

TABLE 3. NITROGEN INTAKE, EXCRETION, ABSORPTION AND RETENTION.

Item	Abomasal infusion					
	Sham	Soy	RNA	DNA	RNA-DNA	S.E.[a]
Total nitrogen intake, g/day	7.74	10.20	10.21	10.79	10.55	.000
Nitrogen excretion, g/day						
Urinary	2.39[b]	3.98[c]	4.33[c,d]	4.54[d]	3.92[c]	.069
Fecal	4.19[b]	3.99[b]	4.27[b]	4.88[c]	4.92[c]	.077
Total	6.58[b]	7.96[c]	8.60[c,d]	9.45[e]	8.84[d,e]	.183
Nitrogen absorption						
Grams/day	3.55[b]	6.21[c]	5.94[c]	5.90[c]	5.64[c]	.080
Percent of intake	45.82[b]	60.90[d]	58.17[c,d]	54.76[c]	53.40[c]	.728
Nitrogen retention						
Grams/day	1.16[f]	2.23[g]	1.61[f]	1.34[f]	1.71[f,g]	.101
Percent of intake	14.92	21.81	15.76	12.40	16.18	.959
Percent of absorbed	32.62	35.75	27.17	22.86	30.12	1.56

[a] Standard error of means.

[b,c,d,e] Means in the same row with different superscripts are different (P < .05).

[f,g] Means in the same row with different superscripts are different (P < .1).

TABLE 4. UREA, ALLANTOIN, CREATININE, AMMONIA, AND OTHER NITROGEN EXCRETION IN THE URINE

	Abomasal infusion					
Nitrogen component, g/day	Sham	Soy	RNA	DNA	RNA-DNA	S.E.[a]
Urea	.48[b]	2.27[d]	2.15[d]	2.51[d]	1.69[c]	.063
Allantoin	.19[b]	.21[b]	.54[c]	.62[c]	.54[c]	.015
Creatinine	.26	.32	.33	.37	.32	.011
Ammonia	.018[b]	.031[b]	.082[c]	.093[c]	.101[c]	.0064
Other	1.45	1.15	1.23	.97	1.28	.063

[a]Standard error of means.

[b.c.d.]meams in the same row with different superscripts are different ($P < .05$).

TABLE 5. BLOOD UREA NITROGEN CONCENTRATIONS AT 6 AND 12 HOURS POST FEEDING.

Abomasal infusion	Concentration 6 hours	12 hours	Mean
Sham	6.06	6.00	6.03[c]
Soy	8.12	7.38	7.75[d,e]
RNA	7.91	8.11	8.01[e]
DNA	8.21	7.67	7.94[e]
RNA-DNA	7.04	6.80	6.93[c,d]
S.E.[a]	.298	.249	.1443

[a]Standard error of means.

[b,c,d]Means in the same column with different superscripts are different.

TABLE 6. SERUM PROTEIN CONCENTRATIONS AT 6 AND 12 HOURS POST FEEDING

Abomasal infusion	Concentration		
	6 hours	12 hours	Mean
	-----------	mg/100 ml	-----------
Sham	7.66	7.49	7.57
Soy	7.15	7.43	7.29
RNA	7.53	7.23	7.38
DNA	7.72	7.42	7.57
RNA-DNA	7.19	7.43	7.31
S.E.[a]	.124	.094	.060

[a]Standard error of means.

PERFORMANCE AND LIVER COPPER LEVELS OF BEEF COWS FED BROILER LITTER[1]

K. E. Webb, Jr., J. P. Fontenot and W. H. McClure

Broiler litter, a solid waste from the poultry industry, has been shown to have substantial nutritive value. To date, however, the Food and Drug Administration does not sanction the use of broiler litter or any other animal waste as a feed ingredient. Some of their primary concerns are related to drug residues and heavy metal residues. In the 1974 Livestock Research Report (V.P.I. & S.U. Res. Div. Rep. 158) the results of an experiment of feeding broiler litter to cows was discussed. In that report it was indicated that feeding as high as 80% broiler litter as a wintering ration had no detrimental effects on the performance of cows. The present study was initiated at the Shenandoah Valley Research Station in December of 1972 and will continue for several years to evaluate the effect of long-term feeding of broiler litter on the performance of cows and upon the accumulation of copper in the liver of cows. Preliminary results of this experiment were presented in the 1974, 1975, 1976, 1977, and 1978 Reports.

Experimental Procedure

Forty-two weanling heifers were allotted at random by weight and breeding to three lots. The first winter (1972-73) the animals in lot 1 were fed 8.5 lb of mixed hay, 3 lb ear corn and 1 lb of a complex urea supplement per head per day. The animals in lots 2 and 3 were self-fed a mixture of 50% broiler litter and 50% ear corn. Copper was added to the ration in lot 3 to supply an additional 100 ppm copper. During the second and third winters the heifers were fed the following rations: lot 1 - Hay; lot 2 - 75% broiler litter, 25% ground ear corn; and lot 3 - 75% broiler litter, 25% ground ear corn and 160 ppm supplemental copper. During subsequent winters the cows were fed the following rations: lot 1 - hay; lot 2 - 80% broiler litter, 20% ground shelled corn; lot 3 - 80% broiler litter, 20% ground shelled corn and 160 ppm supplemental copper. The litter used was removed from broiler houses bedded with wood shavings and was stacked in an open shed to go through a heat prior to feeding. The rations were fed in such amounts as to supply the TDN requirements. The 1976 and 1977 grazing seasons were poor and the cows entered the winter in a thin condition. Therefore, the amounts of each ration fed were increased. In addition, the cattle on both litter rations received 2 lb and 3 lb/head/day of long hay during 1976 and 1977, respectively.

The cattle were kept in small lots to minimize grazing. The cattle were weighed at 28-day intervals and feed consumption was recorded. Liver samples were obtained by biopsy each fall before the cattle were put on the wintering feed and each spring before they were turned to pasture. The cattle grazed as a group during the summer on native pastures. The cattle were bred for the first time in the summer of 1974 and calved in the late winter and early spring of 1975. These calves

[1] The broiler litter was supplied by Rocco, Harrisonburg, Virginia.

were weaned November 25, 1975. At the time of this report, the cattle have the fifth calf crop on the ground. Liver samples are obtained in the fall and in the spring of each year.

Results

Data on ration consumption, average daily gain and calving performance are presented in table 1. As can be seen from the data in the table, ration consumption by the cattle is quite good and there are no particular trends for any of the rations. Average daily gains tend to indicate that the cattle fed litter rations gained slightly better during the first two wintering periods. However, the control cattle compensated for their slower winter gains during the summer grazing periods. The average daily gains listed for the period December 5, 1974 to April 24, 1975 show a loss in weight which reflects the loss from calving of the heifers. During the fourth wintering period the cows fed the litter ration supplemented with copper gained slightly while the other two groups lost weight. During the fifth wintering period all groups lost small amounts of weight. During the 1977-78 winter, cows fed hay gained somewhat more than those fed litter. The negative gain in the litter plus corn plus copper treatment includes the weights of two cows that calved prior to April 4, 1978.

Calving performance for the first four calf crops was quite good. The numbers of calves born show no detrimental effect of feeding broiler litter or broiler litter plus additional copper. Likewise, birth weights and weaning weights of the calves do not indicate any detrimental effect of feeding broiler litter.

The effect of feeding broiler litter on liver copper levels is presented in table 2. As can be seen from the data in this table, liver copper levels are highest in the spring following the feeding of broiler litter during the winter period. The levels of liver copper were lowest in the animals fed the conventional hay ration and highest for those animals fed the litter plus corn plus copper ration with the values for the litter plus corn ration being intermediate. It will be noted that at the end of the winter feeding periods copper is elevated in the liver of animals fed litter, especially those fed additional copper. However, these levels are not high enough to suspect a toxicity problem. By the end of the summer grazing period, the liver copper levels decline markedly. This experiment is still in progress and to date no detrimental effects of feeding broiler litter as wintering feed have been observed in these animals. This study will continue for several more years.

TABLE 1. EFFECT OF FEEDING BROILER LITTER TO HEIFERS ON RATION CONSUMPTION, AVERAGE DAILY GAIN AND CALVING PERFORMANCE

Parameter	Wintering ration: Hay	Litter + corn	Litter + corn + copper
No. of cows[a]	14(12)	14(12)	14(12)
Ration consumption, lb/head/day			
12-31-72 to 5-10-73	12.3	11.4	13.4
1-7-74 to 4-15-74	16.5	16.1	17.2
12-5-74 to 4-24-75	14.5	13.0	12.8
12-18-75 to 4-16-76	17.2	13.8	15.6
12-28-76 to 4-18-77[b]	21.7	18.9	20.0
12-8-77 to 4-4-78[c]	20.1	17.6	18.4
Average daily gain, lb.			
12-13-72 to 5-10-73	.58	.84	.90
1-7-74 to 4-15-74	.53	1.06	1.09
12-5-74 to 4-24-75[d]	-1.24	-1.36	-1.12
12-18-75 to 4-16-76	-.08	-.11	.25
12-28-76 to 4-19-77[e]	-.18	-.12	-.11
12-8-77 to 4-6-78[f]	.61	.28	-.09
Calving performances[g]			
No. calves born	44	41	42
Birth wt. of calves, lb	72	72	72
Weaning wt. of calves, lb	346	336	369

[a]Numbers in parentheses indicate number of cows remaining on experiment as of 12-2-78.
[b]Includes 2 lb of hay per head per day from 1-25-77 to 4-18-77 for the litter + corn and litter + corn + copper treatments.
[c]Includes 3 lb of hay per head per day from 1-9-78 to 4-4-78 for the litter + corn and litter + corn + copper treatments.
[d]Includes loss of weight due to calving.
[e]Three cows in the group fed hay and two cows in each of the other two groups had calved prior to 4-19-77.
[f]Two cows in the litter + corn + copper group calved prior to 4-6-78.
[g]Data from 1975, 1976, 1977 and 1978 calf crops.

TABLE 2. EFFECT OF FEEDING BROILER LITTER TO HEIFERS ON LIVER COPPER LEVELS

	Wintering ration		
Sampling date	Hay	Litter + corn	Litter + corn + copper
	ppm[a]		
12-12-72	44.8	31.9	27.6
5-4-73	109.8	300.2	773.0
12-2-73	68.6	106.7	158.0
4-17-74	73.0	197.3	729.5
12-4-74	136.1	178.5	239.3
4-29-75	51.1	251.1	669.8
12-11-75	56.1	83.6	189.8
4-16-76	37.6	706.0	1134.5
12-14-76	27.0	187.8	219.0
4-26-77	34.5	757.3	964.4
12-7-77	19.8	154.3	186.3
4-6-78	53.6	1263.9	1726.7
12-21-78	52.5	282.8	278.6

[a]Dry basis.

UREA, CALCIUM, POTASSIUM AND SULFUR TREATMENT OF WHOLE CORN

L. L. Koeln, K. E. Webb, Jr. and J. P. Fontenot

Experiments with lambs indicate that there are many advantages to feeding whole grains. There is no reduction in performance and processing costs are greatly reduced. Whole grains appear to stimulate rumination thus avoiding some of the potential problems of acidosis associated with feeding ground grain. Most cereal grains are not adequate in nitrogen or mineral content to meet requirements of many ruminants, therefore, supplementation is essential. Urea, the most widely used source of non-protein nitrogen (NPN) in ruminant diets has not been successfully fed in the crystalline form with whole grains. Urea crystals tend to segregate from the grain and because of taste are rejected by animals. Molasses based liquid supplements containing NPN have enjoyed some success but intake problems are frequent. Attempts have been made to provide a means of feeding urea with whole grains. Researchers have attempted to improve urea utilization by slowing ammonia release rate and providing an available source of carbohydrate. Most of these products involved heat treatment and extensive processing which is economically infeasible.

The purpose of the present study is to develop a means of supplementing whole corn grain with nitrogen, calcium, potassium and sulfur to meet the nutritional requirements of growing-finishing lambs.

Experimental Procedure

Several compounds were considered as calcium, potassium or sulfur sources on the basis of their solubility, compatability and availability along with urea to produce a liquid supplement which when soaked into corn grain would provide a final product which would meet the NRC requirements of growing-finishing lambs. Several water soluble compounds (table 1) which contained relatively high amounts of the element in question and which were readily available were combined in solution to determine their compatability. These compounds were mixed in a ratio, which along with corn grain, would meet the requirements of growing-finishing lambs. Sulfur was added at 10% of the added nitrogen. The combination that could be dissolved in the least water was selected.

As a result of the solubility trial calcium chloride, potassium acetate and sodium thiosulfate were combined with urea in a water solution (table 2). The low solubility of calcium when combined with the other salts was the factor which determined the minimum water volume or conversely the maximum mineral concentration. When the four compounds are combined into solution, impregnating 100 g of corn dry matter with 11 ml of this solution results in a product which meets the needs of growing-finishing lambs. A lesser volume of water is required if a calcium chloride solution is made separate from the other salts. Then impregnating 100 g of corn dry matter with 3.7 ml of a calcium chloride solution followed by 2.8 ml of a solution containing the other salts results in a similar final product as above. The former offers the advantage of one addition while the latter adds less water which must be subsequently removed.

For the sake of brevity, the description of treatments presented in table 3 will be referenced for discussions related to the four experiments.

<u>Experiment 1</u>

The effects of air drying were evaluated using six replicates of each treatment. A 1200 g sample of dry corn, containing approximately 90% dry matter, was treated with one of the two urea-mineral mixtures (treatments 2 and 3) or with water (treatment 4). Samples were mixed on a horizontal rolling device in cylindrical plastic containers until no visible sign of liquid was observed on the container (20 minutes). The samples were then placed in metal cans with false bottoms constructed of screen wire to simulate grain drying bins. Ambient air was passed through each sample at a rate to provide a face velocity of approximately 570 l per minute. Treated corn reached a storable dry matter (at least 88%) after being subjected to this air flow for 24 hours.

<u>Experiment 2</u>

Effects of heat drying were evaluated using six replicates of each treatment. Samples of 500 g of dry corn, containing 85% dry matter, were prepared in a similar manner as above, placed in 14 x 14 x 6 cm wire baskets and allowed to dry in a 95 C oven to simulate the heat drying of grain. A preliminary trial indicated that 1 hr was sufficient time to restore corn to a storable dry matter.

<u>Experimenta 3 and 4</u>

Experiments 1 and 2 were repeated except that freshly harvested high moisture corn (approximately 83% dry matter) was used.

<u>Analyses for experiments 1-4</u>

After drying samples were taken from each container for dry matter and mold analysis. A 100 g sample of each replicate of treatments 2, 3 and 4 plus a sample of the initial untreated corn (treatment 1) was washed with 250 ml of deionized water for 5 seconds. Samples were then oven dried and these along with unwashed samples were analyzed for dry matter and nitrogen content. All samples were analyzed for calcium, potassium and sulfur.

An <u>in vitro</u> system was used to evaluate ammonia release rate. Preliminary runs were conducted to determine technique and sampling time to be used. Six treatments were evaluated using six replicates each (table 3). Twenty-five grams of corn dry matter was placed in a 500 ml Erlenmeyer flask containing 250 ml of inoculum. Rumen fluid, collected from a fistulated steer 2 hr after the morning feeding, was strained through eight layers of cheesecloth and mixed in a 1:4 ratio with McDougal's buffer that was adjusted to pH 6.9. Flasks were provided with a constant atmosphere of CO_2 and were incubated in a 37 C water bath. Flasks were equipped with a 10 ml syringe for sampling. Samplings of 5 ml were taken after .25, .50, 1, 2, 3, 4, 5, 6, 12, 18 and 24 hr incubation. Ammonia concentration was determined in duplicate by microdiffusion analysis. The pH of the final fluid, after 24 hr incubation, was determined electrometrically. This fluid was retained to be analyzed for protein and non-protein nitrogen by Kjeldahl analysis. <u>In vitro</u> dry matter disappearance was also determined.

Results

In experiment 1, the dry matter content of the untreated corn (treatment 1) was 89.9%. After treatment and drying for 24 hr, percent dry matter was 91.94, 92.2 and 91.58 for treatments 2, 3 and 4, respectively. The initial dry matter for untreated corn in experiment 2 was 85%. After treatment and drying for 1 hr at 95 C the percent dry matter was 88.98, 89.42 88.78 for treatments 2, 3 and 4, respectively. The rapid absorption of urea mixtures by corn and the subsequent rapid removal of added moisture may make it possible to add the substances during the normal grain handling processes.

The nitrogen values for air dried and oven dried corn are given in tables 4 and 5. Treating corn with urea provided an additional .28% nitrogen on a dry matter basis. After washing an average of 97 and 95% of the nitrogen was recovered from air dried (experiment 1) and oven dried (experiment 2) corn, respectively. This indicates that most of the urea was absorbed into corn, not merely adhering to the surface of the kernels.

In experiments 3 and 4, high moisture corn did not absorb water or the urea-mineral mixtures as well as corn with approximately 90% dry matter. The corn was mixed with solutions for 1 hr but a considerable amount of liquid still remained in the container. The nitrogen and *in vitro* results of these experiments are not available at this time. The initial dry matter content of this corn was 82.6%. The percent dry matter for treatments 2, 3 and 4 after air drying were 93.03, 93.08 and 93.31, respectively. Similar values for oven drying were 90.77, 91.03 and 90.35, respectively. All corn samples are presently being analyzed for calcium, potassium and sulfur.

Figure 1 illustrates the results of *in vitro* incubation of air dried corn. This graph shows lower ammonia levels for treated corn during the initial 8 hr of incubation. The ammonia concentration tended to remain high throughout the remainder of the period. This *in vitro* technique indicated that ammonia release rate from urea was slowed substantially by this method. When urea was absorbed, as in treatments 2 and 3, the initial rate of ammonia release was lower than when a urea solution (treatments 5 and 6) was provided. When a urea solution was used, the peak ammonia concentration occurring at 5 hr was considerably high than either of the impregnated corns. The pH of fluid remaining after 24 hr ranged between 6.63 and 7.00 with most values being between 6.8 and 6.9. The percent *in vitro* dry matter disappearance was similar for all treatments.

Metabolism trials with lambs will be conducted to determine the effects of treated corn on ammonia release rate and nitrogen retention *in vivo*. Presently sheep are in the urea adaptation phase of this trial.

This method of impregnating corn with urea may provide a method for feeding whole grains with urea supplementation. Feeding of urea with whole grains has not been successful since urea crystals segregate from whole grains and because of taste are rejected by the animal, however, researchers have found no palatability problems with urea treated grains fed to lambs.

TABLE 1. COMPOUNDS COMPARED AS POTENTIAL SOURCES OF CALCIUM, POTASSIUM OR SULFUR

Compound	% Mineral provided	
Calcium propionate	19.62% Ca	
Calcium chloride	36.11% Ca	
Potassium sulfate	44.87% K	18.4% S
Potassium acetate	39.84% K	
Potassium chloride	52.44% K	
Sodium thiosulfate	25.84% S	
Sulfuric acid	32.69% S	
Ammonium sulfate	24.26% S	

TABLE 2. COMPOSITION OF LIQUID SUPPLEMENT[a]

Compound	% of solution (w/v)
Urea	6.40
Calcium chloride	8.72
Potassium acetate	2.71
Sodium thiosulfate	1.12

[a]Impregnating 100 g corn dry matter with 11 ml of this solution will result in a product containing 1.92% nitrogen, .37% calcium, .50% potassium and .032% sulfur which meet the NRC (1975) requirements for finishing lambs.

TABLE 3. DESCRIPTION OF TREATMENTS USED IN THE *IN VITRO* EVALUATION OF AMMONIA RELEASE

Treatment no.	Description
1	Whole shelled corn untreated
2[a]	Whole shelled corn impregnated with urea, calcium chloride, potassium acetate and sodium thiosulfate (11 ml solution per 100 g corn dry matter)
3[b]	Whole shelled corn impregnated with urea, calcium chloride, potassium acetate and sodium thiosulfate (6.5 ml solution per 100 g corn dry matter)
4[c]	Whole shelled corn treated with water
5	Whole shelled corn plus urea, calcium chloride, potassium acetate and sodium thiosulfate added in a 1 ml solution to *in vitro* inoculum
6	Whole shelled corn with urea added in a 1 ml solution to *in vitro* inoculum

[a]Treatment 2 was prepared by making a single addition of a solution (11 ml) containing urea, calcium chloride, potassium acetate and sodium thiosulfate to 100 g corn dry matter.

[b]Treatment 3 was prepared by adding two solutions to 100 g corn dry matter. One solution (3.7 ml) contained only calcium chloride. Urea, potassium acetate and sodium thiosulfate were added by a second solution (2.8 ml).

[c]Treatment 4 was prepared by adding 11 ml water instead of the urea-mineral mixture to 100 g corn dry matter.

TABLE 4. EFFECT OF TREATMENT AND WASHING ON NITROGEN CONTENT OF AIR DRIED CORN

Treatment[a]	% N, dry basis		% N recovered
	Unwashed	Washed	
1	1.56	1.60	102.6
2	1.85	1.79	96.8
3	1.83	1.77	96.7
4	1.62	1.58	97.5

[a]Treatments were as follows: 1) whole shelled corn, 2) whole shelled corn impregnated with urea, calcium chloride, potassium acetate and sodium thiosulfate (11 ml solution per 100 g corn dry matter), 3) whole shelled corn impregnated with urea, calcium chloride, potassium acetate and sodium thiosulfate (6.5 ml solution per 100 g corn dry matter) and 4) whole shelled corn treated with water.

TABLE 5. EFFECT OF TREATMENT AND WASHING ON NITROGEN CONTENT OF OVEN DRIED CORN

Treatment[a]	% N, dry basis		% N recovered
	Unwashed	Washed	
1	1.52	1.56	102.6
2	1.82	1.73	95.0
3	1.77	1.69	95.5
4	1.52	1.50	98.7

[a]Same as footnote in table 4.

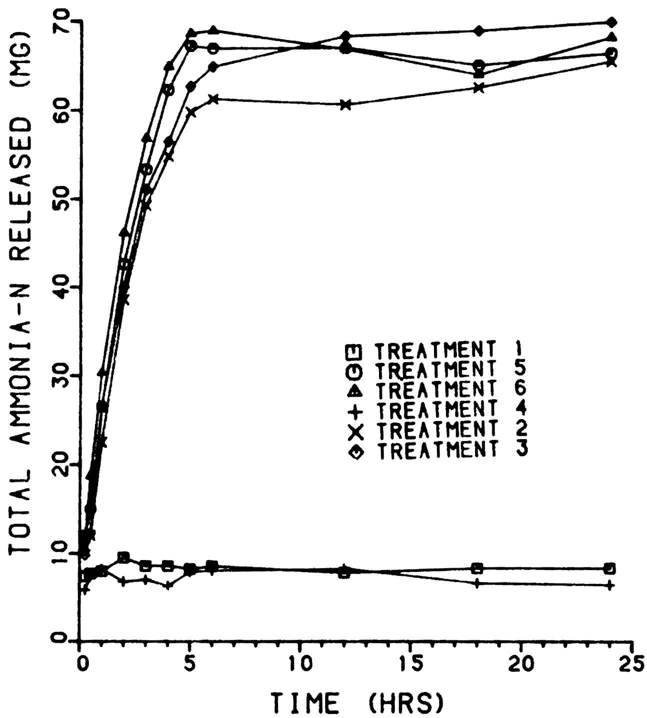

Figure 1. Total ammonia nitrogen released during *in vitro* incubation. A description of each treatment is presented in table 3.

CORN GRAIN AND SODIUM BICARBONATE LEVELS IN HIGH CORN SILAGE RATIONS FOR BULLS

D. A. Danilson, G. L. Minish and K. E. Webb, Jr.

Introduction

This report is a supplement to the data reported in the 1977-78 VPI&SU Research Division Report 174.

Previous research has shown improved performance from the addition of supplemental energy to high corn silage diets for steers and heifers. However, information of this nature is unavailable for performance tested bulls on 140-day feed test. In addition, the use of sodium bicarbonate ($NaHCO_3$) as a feed additive in beef cattle rations has prompted recent interest, especially when fed with high energy-high concentrate diets. Results, however, have been extremely variable in terms of its effect on performance, feed efficiency and ruminal fluid characteristics. Against this background, it appeared logical to evaluate the effect of different energy levels and $NaHCO_3$ levels in high corn silage diets on the total performance and ruminal fluid characteristics of bulls on feed test.

Procedures

Research was conducted on bulls from the VPI&SU teaching and research herds. Twenty-four weanling bull calves ranging in age from 200 to 240 days were blocked by breed, age and weight and allotted to one of four pens. Bulls were placed on 140-day feed test beginning on November 21, 1977, and ending April 10, 1978. All bulls were subjected to a 21-day preliminary period during which an all corn silage ration was fed. Individual 2-day weights were taken at the start and end of the experiment. Period weights were taken at 28 day intervals to monitor performance and were used to adjust shelled corn and $NaHCO_3$ intakes. A 2 x 2 factorial arrangement was used to compare added corn grain level and $NaHCO_3$ with bulls on 140-day performance test. Design of the energy treatments was as follows: Treatment I consisted of a full feed of corn silage, 1% of body weight as shelled corn and .91 kg of supplement (44% soybean meal) per head daily; Treatment II received 1.5% of body weight as shelled corn and .91 kg of protein supplement per head daily. One half of the bulls within each energy treatment received 15.6 g per 100 kg body weight of $NaHCO_3$ and the remaining half received no $NaHCO_3$. All lots were provided a free choice salt mineral mix of trace mineralized salt, ground limestone and defluorinated rock phosphate in a 1:1:1 ratio. Rumen fluid samples were collected at 3 hours following the morning feeding at the conclusion of the feeding trial on day 140. Scrotal circumference measurements were taken periodically and the bulls were electro-ejaculated at the termination of the 140-day feed test and the semen was evaluated for motility and morphological characteristics.

Results

When two concentrate levels were fed, 1 versus 1.5% of body weight as cracked corn, to a full feed corn silage (45% dry matter), average daily gains were 6.6% greater for bulls fed the 1% corn grain level. This was statistically significant at the $P < .05$ level. Little difference existed in the dry matter consumption between energy treatments.

Sodium bicarbonate supplementation produced lower ($P < .05$) average daily gains. This was possibly due to a 3.8% reduction in dry matter intake associated with the bicarbonate rations.

Rumen fluid analyses at 140 days, 3 hr post-feeding revealed that acetate ($P < .05$) and the acetate-propionate ratio were higher and propionate and pH ($P < .01$) lower for bulls fed the 1% corn grain level. Sodium bicarbonate supplementation resulted in no significant differences in the above mentioned factors.

Results of the final fertility examination of the bulls indicated that all except one individual were acceptable in terms of semen quality immediately following the test. There appeared to be no relationship between either level of corn grain or $NaHCO_3$ supplementation upon any of the fertility factors examined.

Summary

From this study, it appears that a ration composed of a full feed of corn silage, .91 kg soybean meal and supplemented with 1% body weight corn grain will produce optimum performance in bulls. This agrees with earlier work conducted with feedlot steers.

Sodium bicarbonate ($NaHCO_3$) was not effective in improving the performance or feed efficiency of bulls in this test. In fact, $NaHCO_3$ resulted in lower gains and less total dry matter consumed as compared to bulls on the control treatment.

TABLE 1. PERFORMANCE OF BULLS ON HIGH CORN SILAGE RATIONS FED WITH DIFFERENT LEVELS OF CORN GRAIN[a] AND SODIUM BICARBONATE ($NaHCO_3$)[b]

	Concentrate, % body weight				
	1.0		1.5		
Item	none	$NaHCO_3$	none	$NaHCO_3$	S.E.[c]
No. animals	6	6	6	6	
Days on test	140	140	140	140	
Av. initial wt., kg	264	271	275	265	± 3.3
Av. final wt., kg	474	465	468	452	± 3.7
Av. daily gain, kg[de]	1.50	1.39	1.38	1.33	± .015
Daily feed intake, kg[f]	8.91	8.76	9.39	9.03	
Silage, kg	4.79	4.59	3.65	3.31	
Corn, kg	3.31	3.30	4.93	4.85	
SBM, kg	.81	.81	.81	.81	
$NaHCO_3$, gm	0.0	60.6	0.0	59.7	
Daily TDN intake, kg	7.08	6.97	7.70	7.45	
Feed/gain	5.94	6.30	6.80	7.45	
TDN/gain	4.72	5.03	5.59	5.60	

[a]Corn grain levels formulated as 1.0% and 1.5% of body weight.
[b]Sodium bicarbonate ($NaHCO_3$) supplemented at level of 15.6 g per 100 kg body weight.
[c]Standard error of means with 23 degrees of freedom.
[d]Means for concentrate level are different ($P < .05$).
[e]Means for level of $NaHCO_3$ are different ($P < .05$).
[f]Intake values compiled on a pen basis and presented as kilograms of dry matter per head per day.

TABLE 2. PERFORMANCE OF BULLS ON TWO DIFFERENT LEVELS OF CORN GRAIN SUPPLEMENTATION IN CORN SILAGE DIETS

Item	Corn grain level[a] 1.0%	1.5%	S.E.
Initial wt., kg	267	270	± 3.3
Final wt., kg	469	460	± 3.7
Daily gain, kg[b]	1.45	1.36	± .015
Daily feed intake, kg[c]	8.84	9.21	
Feed/gain, kg	6.12	6.80	
TDN/gain, kg	4.89	5.53	

[a]Corn grain levels formulated as 1.0% and 1.5% of body weight.
[b]Means for corn grain level are different ($P < .05$).
[c]Intake values compiled on a pen basis and given as kg dry matter.

TABLE 3. EFFECT OF SODIUM BICARBONATE ($NaHCO_3$) ON THE PERFORMANCE OF BULLS FED CORN GRAIN-CORN SILAGE DIETS[a]

Item	$NaHCO_3$	Control	S.E.
Initial wt., kg	268	269	± 3.3
Final wt., kg	458	481	± 3.8
Daily gain, kg[b]	1.38	1.44	± .013
Daily feed intake, kg[c]	8.80	9.10	
Feed/gain, kg	6.38	6.32	
TDN/gain, kg	5.25	5.16	

[a]Sodium bicarbonate supplemented at level of 15.6 g per 100 kg body weight.
[b]Means for level of $NaHCO_3$ are different ($P < .05$).
[c]Intake values compiled on a pen basis and given as kg dry matter.

TABLE 4. VFA CONCENTRATION IN RUMEN FLUID FROM BULLS FED 1.0 VS 1.5% CORN GRAIN

Item	Treatment 1.0%	1.5%	S.E.
VFA, μmoles/ml			
Acetic[a]	59.3	48.7	± 2.28
Propionic	19.9	18.0	± .94
Butyric	11.2	10.7	± .35
Valeric	1.5	1.6	± .08
Isobutyric[a]	1.2	1.0	± .03
Isovaleric	2.8	2.5	± .14
Total[a]	97.6	82.4	± 3.06

[a]Means are different for corn grain level ($P < .05$).

TABLE 5. VFA CONCENTRATION IN RUMEN FLUID FROM BULLS FED DIFFERENT LEVELS OF SODIUM BICARBONATE

Item	Treatment $NaHCO_3$	Control	S.E.
VFA, μmoles/ml			
Acetic	53.5	54.4	± 2.28
Propionic	18.3	19.6	± .94
Butyric	11.5	10.7	± .35
Valeric	1.5	1.6	± .08
Isobutyric	1.1	1.1	± .03
Isovaleric	2.7	2.5	± .14
Total	88.6	89.6	± 3.06

VALUE OF SUPPLEMENTAL CONCENTRATE WITH AND WITHOUT MONENSIN FOR WINTERING LIGHT CALVES ON STOCKPILED FESCUE

H. J. Gerken, Jr. and W. H. McClure

Stockpiled tall fescue can be utilized to reduce the amount of stored feed needed to maintain a beef cow during the winter. It can also be used as winter feed for light calves. The amount and kind of supplemental feed that would be beneficial to calves wintered on this forage is uncertain. In a previous trial conducted at the Shenandoah Valley Research Station, calves wintered on stockpiled fescue gained 1.13 lb per day for 112 days. Calves grazing stockpiled fescue and fed ground corn at 1% of their bodyweight (4.4 lb/day) gained 1.46 lb per day.

The feed additive, monensin, has been shown to increase feed efficiency when used in cattle fattening rations. When used in high forage rations, both feed efficiency and rate of gain are increased. Rate of gain of grazing cattle has been increased by approximately 0.2 lb per day through the addition of monensin (200 mg per head per day) to limited amounts of supplemental concentrates.

The question arises as to whether or not weaned calves being wintered on stockpiled fescue pasture would benefit from the addition of monensin.

Experimental Procedure

A trial comparing three winter feeding treatments was conducted at the Shenandoah Valley Research Station during the winter of 1979. Comparisons were (Treatment 1) stockpiled fescue, (Treatment 2) stockpiled fescue plus 2 lb of concentrate daily, and (Treatment 3) stockpiled fescue plus 2 lb of concentrate containing monensin. Forty-six lightweight steer and heifer calves were allotted according to weight, sex, breed and previous treatment into three treatment groups. The calves were weaned in December and started on test on January 4. All calves were injected with 500,000 I.U. of vitamin A at the start of the trial. The trial lasted 112 days, concluding on April 26. Calves were weighed at 14-day intervals and rotated among three similar pastures at biweekly intervals. Average quality mixed hay was fed to all treatment groups when snow covered the ground at the rate of approximately 10 lb per head per day. The group receiving no supplemental concentrate was fed additional hay according to appetite. All treatment groups were fed considerable hay during February and early March due to snow and ice cover on available forage.

The supplemental concentrate was a commercially prepared pelleted supplement containing 12% crude protein. The monensin supplement contained 100 mg of monensin per lb. The supplemental concentrate was fed once daily in wooden troughs at the rate of 2 lb per head. During a 5 day introductory period the level of feeding was 1 lb per day. Salt and minerals were available to all calves in covered self-feeders. Stockpiled fescue sampled on January 4 analyzed 11% crude protein and 59.5% TDN on a 100% dry matter basis.

Results

Results of the test are shown in Table 1. Calves receiving only stockpiled fescue and hay gained at an average rate of 0.66 lb per day for the 112 day trial period. Those fed 2 lb per day of supplemental concentrate feed gained an average of 1.16 lb per day. Those receiving the supplemental feed plus monensin gained an average of 1.30 lb per day. Average initial weights, final weights and total period gains were Treatment 1 - 420, 494, 74 lb; Treatment 2 - 421, 551, 130 lb and Treatment 3 - 418, 564, 146 lb. Average condition scores at the end of the experiment were 5.4, 6.8 and 6.9 respectively on a scale in which 10 equals average good. Although there was an apparent difference in condition by visual appraisal and a significant treatment effect ($P < .01$) on final weight and average daily gain, all calves were in satisfactory condition to go on summer pasture and make good summer gains.

Appreciation is expressed to Augusta Cooperative Farm Bureau, Staunton, Va. and Elanco, Indianapolis, Indiana for supplying the supplemental feed and monensin used in this experiment.

TABLE 1 - VALUE SUPPLEMENTAL CONCENTRATE ON STOCKPILED FESCUE

	Treatment 1 Stockpiled fescue plus hay	Treatment 2 Stockpiled fescue plus hay plus concentrate	Treatment 3 Stockpiled fescue plus hay plus concentrate plus monensin
No. head	14	14	14
Wt. 1-4-79, lb	420	421	418
Wt. 4-26-79, lb	494	551	564
Avg. daily gain, lb	0.66	1.16	1.30
Condition score	5.43	6.82	6.86
Concentrate, lb/head	0	219	219
Hay, lb/head	819	304	294

BONE CHARACTERISTICS OF DEVELOPING BOARS AS INFLUENCED BY RESTRICTED GROWTH RATE AND ELEVATED MINERAL AND VITAMIN LEVELS[1]

G. A. Kesel, D. F. Calabotta, J. W. Knight,
H. P. Veit, D. R. Notter and E. T. Kornegay

In this era of intensification of production systems and a shrinking margin of profit, structural unsoundness in swine is a problem of increasing perplexity to the modern swine producer. Research information which may lead to the development of measures to reduce and/or correct the problem offer great economic advantages to the swine producer. Although the etiology is poorly defined, leg weakness in swine can be attributed to an accumulation of nutritional, genetic and environmental factors, with the contribution of each not yet fully understood.

The severity of the problem seems to be amplified in fast growing, heavily muscled animals. In other words, the problem is greatest in the meat-type hog typically selected today. Generally, the fastest growing, best muscled boars are selected to go into the breeding herd. These are the very ones most prone to leg weakness. This may be because these rapidly growing individuals, if fed the type of diet typical of growing-finishing hogs, may actually be receiving a diet inadequate to meet the mineral and vitamin needs imposed by their increased growth rate and greater muscle: bone ratio.

While the daily feeding requirements for the developing boar have not been fully defined, the use of elevated minerals and vitamins in conjunction with restricted feed intake offers a base upon which to compare variations in bone characteristics.

This study was undertaken to measure the influence of rapid and slow growth rates and of elevated mineral and vitamin levels on selected compositional parameters of the middle metacarpal bone. Parameters measured included metacarpal weight and length, bone breaking strength, fat content and percent fat free bone ash.

Materials and Methods

A total of 80 crossbred boars were randomly assigned in equal numbers to one of four dietary treatment groups in a 2 x 2 factorial design. Treatments were as follows:

- Treatment 1 = *ad libitum* intake and National Research Council (NRC) mineral and vitamins.
- Treatment 2 = restricted intake (75% of *ad lib* group) and NRC minerals and vitamins.
- Treatment 3 = *ad libitum* intake and 150% NRC minerals and vitamins.
- Treatment 4 = restricted intake (75% of *ad lib* group) and 150% NRC minerals and vitamins.

[1] Appreciation is expressed to John Lee Pratt Animal Nutrition Program for financial support and to Borden Chemical Co., Norfolk, Va., Agricultural Processing, Salem, Va., and Calcium Carbonate, Quincy, Ill., for ingredients; to Ken Bryant and Duke Reynolds for animal care and Deborah Tanguy and Helen Bartlett for laboratory assistance.

This design facilitated a comparison of bone growth and bone compositional components between "slow growing" (treatments 2 and 4) and "fast growing" (treatments 1 and 3) boars.

Of the 20 boars assigned to each treatment group, 15 were euthanatized at 10 ± 3 day intervals from 80 to 220 days of age (inclusive). The additional five boars in each treatment group were examined radiologically at eight time intervals during this period and necropsied at 220 ± 2 days of age. For the purpose of this report, the data is reported by energy and by mineral and vitamin levels only.

At necropsy, a middle metacarpal bone was removed from each fore leg of all boars and frozen at -20 C. The bones were subsequently freed from all extraneous connective tissue, weighed and measured. Bone breaking strength was determined and peak values recorded.

Following breaking, the metacarpal bones were bisected and the proximal half used for analysis. The bones were crushed and dried at 75 C for five days. Percent ether extracts and percent fat free ash in the bone was determined.

The data was adjusted for age and weight at necropsy and tested by the least squares method of analysis.

Results and Discussion

Restricting the energy intake to 75% of the full fed treatments produced a significantly longer ($P < .01$) overall length of the middle metacarpal bone. No significant differences ($P > .10$) were found on the metacarpal weight, bone breaking strength or ether extract due to the differing energy levels. A slightly higher metacarpal breaking strength was found in the full fed energy levels (303.4 ± 7.5 lb) as compared to 297.0 ± 7.5 lb in the restricted levels, however, this was not significant ($P > .10$).

Elevated mineral and vitamin levels (150% of NRC requirements) produced a significantly higher ($P < .01$) metacarpal bone breaking strength. Also, a significantly higher ($P < .05$) percent fat free bone ash and a lower ($P < .05$) ether extract was observed in the 150% NRC vitamins and minerals group. No differences ($P > .10$) were detected in weight or length of the metacarpals.

A significant interaction ($P < .05$) was found between the energy levels and the vitamin and mineral levels for the bone breaking strength. The mean values for bone breaking strength were 268 ± 10 lb for treatment 1, 285 ± 10 lb for treatment 2, 339 ± 11 lb for treatment 3 and 309 ± 11 for treatment 4. The breaking strength was greatest for the full fed animals receiving the 150% NRC vitamin and mineral levels, and lowest for full fed animals receiving the NRC vitamin and mineral levels. Accordingly, the restricted animals fed the 150% NRC vitamin and mineral levels had a higher breaking strength than did the restricted animals fed the NRC vitamin and mineral levels.

Restricting growth rate by decreasing the energy intake to 75% that of the full fed treatments produced a longer metacarpal bone. Numerous factors could have contributed to this result. One possibility under consideration is the possibility that more of the minerals absorbed from the diet were used to produce bone instead of muscle tissue. Although our design was not such that a conclusive inferrence could be drawn from the data obtained, it is possible that the decreased muscle tissue formation in the restricted energy group may have caused a decreased demand on the circulating minerals by the muscle tissue enabling the osteoblasts to produce a greater quantity of bone tissue.

The use of elevated vitamins and minerals (150% NRC) did produce a stronger, higher mineral content bone containing less fat than did the animals fed the NRC requirements. This indicates that the elevated minerals in the diet were utilized by the animal for greater bone tissue formation.

A COMPARISON OF VARIOUS METACARPAL MEASUREMENTS OBTAINED FROM BOARS FED TWO LEVELS OF ENERGY AND VITAMINS AND MINERALS[a]

	Energy		Minerals and vitamins	
Variable[b]	*Ad lib* fed	Restrict fed	NRC requirement	150% NRC
No. of metacarpals	78	77	80	75
Weight, g	21.5 ± .3[c]	21.2 ± .3	21.1 ± .3	21.77 ± .3
Length, cm	7.13 ± .06**	7.48 ± .06	7.28 ± .05	7.34 ± .06
Breaking strength†,lb	303 ± 7	297 ± 7	276 ± 7**	324 ± 7
Ether extract, %	26.9 ± .4	26.1 ± .5	27.5 ± .4*	25.5 ± .4
Fat free ash, %	60.8 ± .2	60.3 ± .2	60.3 ± .2*	60.8 ± .1

[a]Adjusted for age and weight at necropsy.
[b]All treatment comparisons made within energy level or within mineral and vitamin level.
[c]All values represent $\bar{X} \pm$ SEM.
*Treatment means differ (P <.05).
**Treatment means differ (P <.01).
†Significant energy X mineral and vitamin interaction.

PALATABILITY OF ANIMAL, VEGETABLE AND BLENDED FATS BY EQUINE[1]

V. A. Bowman, J. P. Fontenot, T. N. Meacham and K. E. Webb, Jr.

Energy is the most limiting nutrient for horses during strenuous exercise such as ranch work, endurance trail riding, rigid show competition and intensive training for racing. It is important that horses be fed adequate energy during these periods. The limited capacity of the digestive tract and potential problems from compaction and laminitis limit the amount of grain which can be safely fed. Fats supply 2.25 times as much available energy as carbohydrates, the main energy source in grains. Present evidence indicates that feeding fat decreases the hazards associated with feeding high energy rations to horses. The use of certain fats also improves hair coat quality and reduces dust in the ration.

Experimental Procedure

Ration Formulation Trials

Horses are naturally very picky eaters and subject to digestive upsets. Therefore, it was necessary to develop a palatable and nutritionally sound grain mixture prior to studying the acceptability of the grain mixtures containing different fats and oils.

Four 3-year old Saddlebred fillies and four Saddlebred geldings were used in cafeteria type preference trials. During each trial the animals were fed the mixtures in separate compartments of a feed trough in individual stalls. At each feeding the animals had access to the various mixtures during limited periods (20 min for the fillies and 15 min for the geldings twice per day). At the end of the feeding periods, refusals were weighed. The animals were group fed approximately 5.5 kg of long hay after the morning feeding. Except during the feeding periods, the animals were kept in large exercise lots with access to trace mineralized salt and water.

Trial 1. Wheat bran and dried beet pulp were investigated as carriers to absorb the fat in the grain mixture. This trial was conducted to test 15% corn oil in mixtures containing wheat bran and dried beet pulp in different combinations. The ingredient composition of the mixtures is given in table 1. The eight animals were fed 2480 g of each of mixtures 1 to 5 twice daily for 5 days.

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[1]Supported by grant-in-aid from John Lee Pratt Animal Nutrition Program.

Trial 2. The four fillies were used to compare the palatability of mixtures containing 5 and 20% wheat bran (mixtures 2 and 5, respectively, table 1).

Trial 3. An attempt was made to enhance the palatability of mixture 2 containing 15% dried beet pulp. The two mixtures tested were one containing 15% beet pulp and 5% wheat bran and one in which 5% molasses was substitued for the bran. The four fillies were allotted to the two mixtures in this trial.

During the ration formulation trials the physical characteristics of the diets were noted, the animals were observed for any abnormal behavior and the condition of the feces was noted.

Palatability Trials

Ration 6 (table 1) was adopted for the palatability trials. The palatability of the grain mixtures containing the following fats was studied: 1) Vegetable fats: corn oil, peanut oil, safflower and cottonseed oil; 2) Animal fats: inedible tallow, fancy bleached tallow and hydrolyzed tallow flakes; 3) Three blends of vegetable and animal fats.

The experimental procedures were similar for the three palatability trials. Four Saddlebred geldings and four fillies were used in the 15-day trials. Each animal was fed 1816 g of each mixture being tested during a trial twice daily. Feeding periods and management of animals were similar as in the previous ration formulation trials.

In each trial corn oil was used as the reference fat in order to compare the fats in all trials. The fats compared in each trial are given below.

Trial 4. Corn oil and blends 1, 2 and 3 were studied.

Trial 5. Corn oil, inedible tallow, fancy bleached tallow and hydrolyzed tallow flakes were compared. The hydrolyzed tallow was a dry flaky material with little or no smell or taste.

Trial 6. In trial 5 the horses consumed very little inedible and fancy bleached tallows. The hydrolyzed tallow is expensive and available in limited amounts, so it appeared necessary to differentiate between the palatability of the other two animal fats. Eight animals were offered the mixtures containing inedible and fancy bleached tallow.

Trial 7. Corn oil, peanut oil, safflower oil and cottonseed oil were used in this study.

Trial 8. This study was conducted to obtain a direct comparison of the relative palatability of the most preferred fat from each classification (animal, vegetable and blend). The eight animals were allotted to mixtures containing 15% corn oil, blend 3, peanut oil and inedible tallow.

The horses were self-fed the mixtures from 7:00 am to 1:00 pm and 4:00 pm to 7:00 pm in individual stalls. They were turned out for exercise from 1:00 to 4:00 pm and were fed grass hay at 0.75% of their body weight from 7:00 pm to 7:00 am. Composition of grain mixtures was as for previous trials 4 to 7.

Digestion Trials

Work has been initiated to determine the digestibility of the most palatable fats. Mature gelding ponies weighing approximately 250 kg are used in a randomized block design. Four diets are fed to each of two ponies in each trial. Composition of the complete ration is given in table 2. The diets consist of a basal and three diets containing 10% of each of the selected fats substituted into the ration.

One of the three 14-day digestion trials has been completed. Laboratory analyses are not complete.

Results

Ration Formulation Trials

Trial 1. The animals preferred the concentrate containing 20% wheat bran (table 3). However, wheat bran did not absorb the corn oil effectively, leaving the mixture greasy in appearance and feel. This concentrate also had potentially hazardous levels of calcium and phosphorus. The feces of the animals were quite soft and unformed.

Trial 2 and 3. When the animals were offered only one mixture with either 5% (mixture 2) or 20% (mixture 5) wheat bran, considerable amounts of mixture 2 were consumed (table 4). When 5% dry molasses was substituted for the wheat bran, more consistent consumption of the mixture was observed. The feces of the animals were normal. Thus, mixture 6 was used in the subsequent palatability trials.

Palatability Trials

The average data obtained are given in tables 6 to 8. In all trials mixtures with corn oil were preferred over the other mixtures.

Trial 4. Although the animals preferred the corn oil mixture, considerable amounts of the mixtures with the blends were consumed (table 5). It is interesting that the most palatable blend (no. 3) had the highest level of linoleic acid (30.8%).

Trial 5. The mixture containing corn oil comprised 64% of the total consumption. Of the animal fats only hydrolyzed tallow flakes were consumed in significant amounts (table 6).

Trial 6. When only mixtures containing 15% inedible and fancy bleached tallow were offered, a slight preference was recorded for inedible tallow (table 7).

Trial 7. The corn oil mixture accounted for 48% of the total consumption of fats from the vegetable origin. The peanut oil mixture was the second most preferred mixture with a total consumption of 25.5% (table 8).

The final ranking of the 10 fats, based on intakes relative to corn oil was as follows:

1. Corn oil
2. Hydrolyzed tallow flakes
3. Blend no. 3
4. Peanut oil
5. Safflower oil
6. Blend no. 2
7. Blend no. 1
8. Cottonseed oil
9. Inedible tallow
10. Fancy bleached tallow

Trial 8. When horses were allowed access to a mixture with only one fat, thus far, intake data indicate inedible tallow is most preferred, although it ranked next to last in the cafeteria type study (table 9).

TABLE 1. INGREDIENT COMPOSITION OF CONCENTRATE MIXTURES[a]

Ingredient	Mixture no.					
	1	2	3	4	5	6
	%	%	%	%	%	%
Corn grain	32.3	32.3	32.0	31.9	31.8	32.3
Oats grain	32.2	32.2	32.0	31.8	31.8	32.2
Corn oil	15.0	15.0	15.0	15.0	15.0	15.0
Wheat bran	0	5.0	10.0	15.0	20.0	0
Dried beet pulp	20.0	15.0	10.0	5.0	0	15.0
Limestone	0.4	0.5	1.0	1.3	1.4	0.5
Dicalcium phosphate	0.1	-	-	-	-	-
Molasses	-	-	-	-	-	5.0

[a]Vitamin A at 2200 I.U./kg concentrate.

TABLE 2. COMPOSITION OF RATIONS FOR DIGESTION TRIALS[a]

Ingredient	Basal	10% Fat
	%	%
Chopped alfalfa hay	29.41	26.47
Dried beet pulp	11.76	10.58
Molasses	5.88	5.29
Corn, cracked	26.48	23.83
Oats, crimped	26.47	23.83
Fat	0	10.00

[a]Vitamin A at 2200 I.U./kg.

TABLE 3. CONSUMPTION OF MIXTURES CONTAINING DIFFERENT LEVELS OF BEET PULP AND WHEAT BRAN. TRIAL 1

	Ration no.				
Filly no.	1	2	3	4	5
	Percent of total consumed				
34	.3	1.5	1.4	6.5	90.3
36	.5	2.5	6.1	18.6	72.3
37	0	.4	.6	1.7	97.3
38	.2	.2	.5	2.4	96.7
AVG.	.3	1.1	2.2	7.3	89.1

TABLE 4. CONSUMPTION PER DAY OF MIXTURES WITH DIFFERENT PROPORTIONS OF BEET PULP AND WHEAT BRAN TRIAL 2

	Ration 2		Ration 5	
Filly no.	Fed	Consumed	Fed	Consumed
	g/day			
34			3632	3026
36			3632	3632
37	3632	1230		
38	3632	2216		
AVG.		1723		3329

TABLE 5. PALATABILITY OF CONCENTRATE MIXTURES CONTAINING CORN OIL AND BLENDED FATS TRIAL 4

Fat source	Consumed G/day	Consumed Percent of total
Corn oil	756[a]	38.6[a]
Blends		
Blend 1	249	12.7
Blend 2	343	17.5
Blend 3	609	31.2

[a]Each value mean of eight animals.

TABLE 6. PALATABILITY OF CONCENTRATE MIXTURES CONTAINING CORN OIL AND ANIMAL FATS TRIAL 5

Fat source	Consumed G/day	Consumed Percent of total
Corn oil	1100[a]	64.1[a]
Inedible tallow	15	.9
Fancy bleached tallow	3	.2
Hydrolyzed tallow flakes	598	34.8

[a]Each value a mean of eight animals.

TABLE 7. PALATABILITY OF MIXTURES WITH TWO KINDS OF TALLOW
TRIAL 6

Fat source	Consumed G/day	Consumed Percent of total
Inedible tallow	960	54.3[a]
Fancy bleached tallow	809	45.7

[a]Each value a mean of eight animals.

TABLE 8. PALATABILITY OF MIXTURES WITH VEGETABLE FATS
TRIAL 7

Fat source	Consumed G/day	Consumed Percent of total
Corn oil	820[a]	48.10[a]
Peanut oil	436	25.52
Safflower oil	370	21.68
Cottonseed oil	80	4.70

[a]Each value a mean of eight animals.

TABLE 9. DAILY CONSUMPTION OF HAY AND GRAIN MIXTURES WITH DIFFERENT FATS. TRIAL 8

Fat source	Consumption, g/day	
	Hay	Concentrate
Corn oil	3108	4582
Peanut oil	3053	3759
Inedible tallow	2906	4897
Blended fat 1	3174	3699

Soybean Mill Run For Growing and Finishing Swine

E. T. Kornegay and K. L. Bryant[1]

Soybean mill run, known also as soybean hulls in the feed trade, is a by-product of the modern solvent processing of soybeans. They are high in crude fiber, 32 to 35%, and contain 11 to 13% crude protein. Traditionally high fiber by-products have not been used in swine diets, because of their poor utilization. Soybean hulls are well utilized by ruminants, but information concerning the digestibility and feeding value of soybean hulls for swine is limited. There continues to be a great deal of interest in the use of some fiber in swine diets, particularly the young pig.

In previously reported feeding trials at Virginia Tech, it found that up to 12% soybean hulls could be included in growing and finishing diets without reducing average daily gain. The optimal level in these trials appeared to be nearer to 6 to 7% where average daily gain was increased slightly and feed efficiency was equal to that of pigs fed the basal diet. Other feeding trials suggested that a response to the addition of soybean hulls is more likely when adequate and high protein levels are fed.

The objective of the present trials was to further evaluate the feeding value of soybean mill run in growing and finishing swine diets.

Experimental Procedures

One hundred-fifty-two crossbred pigs averaging 50.6 lb were used in three trials. Pigs were randomly assigned from outcome groups based on sex and weight to the diets containing 0, 7.5, 15.0 and 22.5% soybean mill run. A 16% crude protein diet consisting of corn and dehulled soybean meal fortified with minerals, vitamins and antibiotics was used in phase I (table 1). In phases II and III, the protein level of the diet was lowered to 14% by varying the proportions of corn and soybean meal. All diets were calculated to be isonitrogenous. Metabolizable energy decreased slightly when soybean mill run was included. The soybean mill run used in this study was analyzed to contain on an as received basis: 91.4% dry matter, 3.86 kcal/g gross energy, 10.8% crude protein, 52.9% cell walls, 38.5% cell content, 39.4% ADF, 34.9% cellulose, 13.4% hemicellulose, 4.4% lignin, .21% P, .55% Ca, .28% Mg, 11 ppm Cu, 266 ppm Fe, 87 ppm Zn and 40 ppm Mn.

Pigs were housed in an environmentally controlled building with partially slotted floor pens. Diets were offered free choice in self feeders and water was supplied by nipple waterers. Body weights and feed consumption were determined biweekly. Pen means were used as the experimental unit for the analysis of variance.

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[1]Appreciation is expressed to Domestic Feed Research Division, Central Soya Co., Inc., Decatur, IN 46733, and to Allied Mills Research, Libertyville, IL 60048.

Results

In phase I, average daily gain was significantly less for pigs fed the diet containing 22.5% soybean mill run as compared to pigs fed the basal diets (table 2). Gain was intermediate for pigs fed 7.5 and 15% soybean mill run. There was no difference in gain between pigs fed the various levels of soybean mill run in phase II, but during phase III gain was reduced as soybean mill run was added to the diet, although the differences were not statistically significant. Overall there appeared to be a linear reduction in gain as soybean mill run was added, but the linear and quadratic components were not significant.

Feed intake was not statistically different between diets, but appeared to increase in phases II and III as soybean mill run was added to the basal diet. In phases II and III and overall, feed per gain was greater ($P < .05$) for pigs fed the diet containing 22.5% soybean mill run as compared to pigs fed the basal diet. Feed per gain was intermediate for pigs fed the diet containing 7.5 and 15% soybean mill run.

Metabolizable energy per gain favored pigs fed 15 and 22.5% soybean run and was always lower for pigs fed 15% soybean mill run.

Summary

These results provide further evidences that soybean mill run, better known as soybean hulls, can be used in swine growing and finishing diets at levels up to 15% without significantly reducing pig performance.

TABLE 1. COMPOSITION OF DIETS (%).

Item	Inter'l Ref. No.	Soybean mill run, % — Phase I[a] 0	7.5	15.0	22.5	Phase II & III[b] 0	7.5	15.0	22.5
Ground corn	4-02-931	78.67	71.55	64.41	57.26	84.24	77.12	69.99	62.88
Soybean meal	5-04-612	18.85	18.56	18.29	18.02	13.77	13.49	13.20	12.91
Soybean mill run	5-04-595	0	7.50	15.00	22.50	0	7.50	15.00	22.50
Defluorinated phosphate	6-01-780	.95	1.00	1.06	1.13	.55	.61	.70	.74
Limestone	6-02-632	.74	.60	.45	.30	.75	.59	.42	.28
Salt		.30	.30	.30	.30	.30	.30	.30	.30
Trace mineral premix[c]		.06	.06	.06	.06	.06	.06	.06	.06
Vitamin premix[d]		.30	.30	.30	.30	.20	.20	.20	.20
Antibiotic[e]		.13	.13	.13	.13	.13	.13	.13	.13
Metabolizable energy, kcal/lb[f]		1453	1404	1357	1309	1461	1413	1366	1320

[a]Calculated to contain 16% protein, .65% Ca and .50% P (total) and fed to approximately 100 pounds.

[b]Calculated to contain: 14% protein, .51% Ca and .42% P (total) and fed from 100 lb to end of test.

[c]Contained (%): 20 Zn, 10 Fe, 5.5 Mn, 1.1 Cu and .15 I.

[d]Supplied (per kg of premix): 1.76 g riboflavin, 8.8 g pantothenic acid, 8.8 g niacin, 8.8 mg vitamin B_{12}, 176 g choline chloride, 1,760,00 IU Vitamin A, 176,000 IU Vitamin D_3, 4400 IU Vitamin E, 440 mg menadione dimethylprimidinol bisulfite (MPB) and 40 mg selenium.

[e]Contained 10 g per lb of Virginiamycin.

[f]The following M.E. values were used for corn, soybean meal and soybean mill run, respectively, 1498, 1448 and 849 kcal/lb. The values for soybean mill run was obtained from Kornegay (1978).

TABLE 2. AVERAGE DAILY GAIN, DAILY FEED INTAKE DAILY METABOLIZABLE ENERGY INTAKE, FEED PER GAIN AND METABOLIZABLE ENERGY PER GAIN OF PIGS FED CORN-DEHULLED SOYBEAN MEAL DIETS CONTAINING GRADED LEVELS OF SOYBEAN MILL RUN. TRIALS 1, 2 AND 3.

Soybean mill run, %	Avg daily gain, lb	Avg daily feed, lb	Avg daily M.E., kcal	Feed per gain	M.E., kcal per pound gain
		Phase 1[a,b]			
0	1.64[c]	4.54	6597	2.77	4023
7.5	1.58[cd]	4.44	6234	2.81	3946
15.0	1.58[cd]	4.43	6012	2.80	3805
22.5	1.52[d]	4.45	5825	2.94	3832
		Phase II			
0	1.47	4.51	6589	3.07[c]	4482
7.5	1.49	4.69	6627	3.15[cd]	4448
15.0	1.50	4.71	6434	3.14[cd]	4289
22.5	1.47	4.80	6336	3.27[d]	4310
		Phase III			
0	1.51	5.04	7363	3.34[c]	4876
7.5	1.42	5.14	7263	3.62[cd]	5115
15.0	1.38	5.16	7049	3.74[de]	5108
22.5	1.33	5.22	6890	3.92[e]	5180
		Overall			
0	1.52	4.68	6823	3.08[c]	4489
7.5	1.48	4.78	6740	3.23[cd]	4554
15.0	1.47	4.79	6457	3.26[de]	4393
22.5	1.43	4.86	6396	3.40[e]	4473

[a]There were 38 pigs per treatment: four pens (three pigs/pen) per treatment in trial 1; four pens (four pigs/pen) per treatment in trial 2; one pen (ten pigs/pen) per treatment in trial 3.

[b]Average initial weight was 50.6 pounds. Pigs in trials 1 and 2 were on test for all phases (204 lb final weight), while pigs in trial 3 were terminated at approximately 152 pounds.

[cde]Means with different superscripts letter within columns and phases are different ($P < .05$). Pens were used as the experimental unit.

Soybean Mill Run in Starter Diets for Weaned Pigs Housed in Triple-Deck Cages

S. R. Arthur, C. L. Gaines, K. L. Bryant and E. T. Kornegay[1]

Weaning is a most critical and stressful period in the life of the baby pig. The environmental and nutrition needs of the weaned pig must be satisfied.

Decking can provide a means of improving management of weaned pigs, although increased nursery density is the major advantage of decking. Decked pigs can be easily observed and cared for.

The development of an adequate nutritional program is equally as important as housing. The diet must be palatable to the weaned pig, must be highly digestible and must meet his nutritional requirements.

Scouring is often a major problem during the postweaning period. Some recent research reports suggest that the addition of oats, a fibrous grain, to starter diets reduced the incidence of diarrhea and improved survival rate. Soybean mill run, a by-product of the manufacture of dehulled soybean meal, is high in fiber (32-35%) and contains 11-13% crude protein. It has been found by Virginia Tech researchers to be of value to growing and finishing hogs when used at levels of 7 to 14% in the diet. Ordinarily, high fiber products, such as oats and soybean mill run are poorly utilized by nonruminants.

The objective of this study was to evaluate the use of soybean mill run in starter diets for young pigs housed in a triple-deck nursery.

Experimental Procedure

Two trials using 66 crossbred weanling pigs were conducted. The pigs were randomly assigned from outcome groups based on sex and weight to six 3 x 4 ft cages. There were five pigs per cage in trial 1, and with six pigs per cage in trial 2. In each trial, soybean mill run was included in the basal starter diet at a level of 0 and 10 percent (table 1). Both diets were fed on each deck. A 22% crude protein corn-soybean meal diet with 10% dried whole whey was fed until the average pen weight reached 15 lb; then a 20% crude protein corn-soybean meal diet with 10% dried whole whey was fed to an average pen weight of 25 lb; for the remainder of the test, an 18% crude protein corn-soybean meal diet without whey was fed. The 22% crude protein diet was reground using a hammermill with an 1.65 mm screen to prevent selective eating.

The cages were housed in an environmentally controlled solar-heated triple-deck nursery. There were two stacks of three cages each. A plan view of the nursery is shown in figure 1. A rubber mat was placed in the front of each cage to encourage pigs to dung in the rear of the cage, to allow the starter diet to be sprinkled outside the feeder to instigate eating, and to prevent feed wastage. Nipple waterers were located at the rear of the cage, which also encouraged pigs to develop a proper dunging pattern.

[1]Appreciation is expressed to the VA Pork Industry Commission for partial financial support and to Central Soya Co, Inc., Decatur, IN 46733 for supplying the soybean mill run.

The relative humidity ranged from 50 to 70 in these tests. Based on fan speed, the ventilation rate from the first to seventh week was 5 to 12 CFM per pig. Temperature from the first to last week was 85 to 75°F with the bottom deck 3 to 4°F lower than the top deck. Continuous light was supplied by a 25 watt bulb.

Pigs were weighed weekly. Cleanliness scores, fecal firmness, and dunging patterns were also noted on the weekly weigh day. Total feed consumption was also recorded weekly. At the end of the test, feet pads were scored from 1 to 5 with 1 given for pads with no cuts or abrasions and 5 given for pads with numerous cuts or abrasions. Average daily gain, average daily feed intake, and feed per unit of gain were calculated. Trial 1 lasted 7 weeks and trial 2 for 6 weeks. The data in this study was analyzed for statistical significance by the use of the least squares analysis of variance method with pen means used as the experimental unit.

Results

The addition of 10% soybean mill run to the starter diet had no significant effect upon average daily gain for any time period (table 2 and figure 2). During the 0 to 7 and 15 to 21 day periods, average daily feed intake was reduced ($P < .05$ and $P < .01$, respectively); however, there were no differences during the other time periods. A trend ($P < .10$) occurred during the 43 to 49 day period towards better efficiency for the pigs fed the starter diet without soybean mill run. However, overall average daily gain, feed intake and feed per gain were not different for pigs fed the starter diets with or without 10% soybean mill run.

Overall, there was no difference ($P > .10$) between pigs housed on the three levels for average daily gain, feed intake, and feed per gain (table 2 and figure 2). During the 29 to 35 day period, average daily gain was higher ($P < .10$) for pigs housed on the bottom deck as compared to pigs housed on the middle deck. Gain of pigs housed on the top deck was intermediate. Average daily feed intake was lower ($P < .01$) for pigs housed on the middle deck during the 15 to 21 day period.

The pigs exhibited normal foot pad scores with very few lesions noted (table 3). Cleanliness scores of the pigs indicated that the pigs housed on the bottom deck became more soiled as the study progressed and they became more crowded. The pigs dunged in the rear of the cage throughout the study with normal fecal consistency.

The addition of soybean mill run to starter diets did not significantly effect average daily gain, feed intake, and feed per gain. Further, the data supports the fact that decking is an effective means by which a producer may increase density without sacrificing pig performance.

Summary

Two trials were conducted to evaluate the use of soybean mill run in starter diets for young pigs housed in a triple-deck nursery. Overall average daily gain, feed intake and feed per gain were not different for pigs fed the starter diets with or without 10% soybean mill run. Furthermore, there was no difference in the overall performance of pigs housed on the top, middle or bottom decks.

TABLE 1. COMPOSITION OF DIETS (%).

Item	Inter'l Ref. No.	Crude Protein, % 22[a] 0%[d]	22[a] 10%[d]	20[b] 0%	20[b] 10%	18[c] 0%	18[c] 10%
Ground corn	4-02-931	54.61	45.11	59.64	50.14	74.08	64.59
Soybean meal	5-04-612	32.71	32.35	27.73	27.73	23.37	22.99
Soybean mill run	5-04-595	---	10.00	---	10.00	---	10.00
Dried whole whey	4-01-182	10.00	10.00	10.00	10.00	---	---
Limestone	6-02-632	.75	.60	.75	.61	.58	.45
Defluorinated phosphate	6-01-780	1.03	1.03	1.03	1.03	1.09	1.09
Salt		.30	.30	.30	.30	.30	.30
Trace mineral premix[e]		.10	.10	.10	.10	.10	.10
Vitamin premix[f]		.25	.25	.25	.25	.25	.25
Antibiotics[g]		.25	.25	.25	.25	.25	.25

[a]Calculated to contain 22% protein, .80% Ca and .60% P (total).
[b]Calculated to contain 20% protein, .79% Ca and .59% P (total).
[c]Calculated to contain 18% protein, .64% Ca and .54% P (total).
[d]Percent of soybean mill run.
[e]Contained (%): 20 Zn, 10 Fe, 5.5 Mn, 1.1 Cu and .15 I.
[f]Supplied (per kilogram of premix): 1.76 g riboflavin, 8.8 g pantothenic acid, 8.8 g niacin, 8.8 mg vitamin B_{12}, 176 g choline chloride, 1,760,000 IU vitamin A, 176,000 IU vitamin D_3, 4400 IU vitamin E, 440 mg menadione dimethylprimidinal bisulfite (MPB) and 40 mg selenium.
[g]Contained (per kg of premix): 44 g chlortetracycline, 22 g penicillin and 44 g sulfamethazine.

TABLE 2. WEEKLY AVERAGE DAILY GAIN, FEED INTAKE AND FEED PER GAIN OF PIGS ON SOYBEAN MILL STARTER DIET STUDY HOUSED IN TRIPLE DECK NURSERY. TRIALS 1 AND 2.

	Main Effects						
Postweaning	Diets[a]			Decks[b]			
period, days	SF[c]	SNF[c]	S.E.[d]	T	M	B	S.E.[d]
Avg init. wt, lb	10.1	10.0	.04	10.0	9.9	10.1	.05
Avg final wt, lb	39.0	40.8	1.30	40.9	38.2	40.5	1.60
Avg init. age, days	20.7	21.3	.32	21.3	21.2	20.6	.40
Avg daily gain, lb							
0 - 7	.07	.11	.02	.12	.09	.07	.03
8 -14	.40	.41	.03	.44	.40	.40	.04
15-21	.48	.53	.03	.55	.43	.53	.04
22-28	.79	.79	.05	.83	.72	.82	.06
29-35	.94	.99	.03	.99[ef]	.90[e]	1.03[f]	.04
36-42	.90	.93	.08	.92	1.00	.84	.10
43-49	1.10	1.30	.08	1.20	1.06	1.34	.10
Overall	.64	.68	.03	.68	.63	.67	.03
Avg daily feed intake, lb							
0 - 7	.25[e]	.31[f]	.15	.28	.27	.29	.02
8 -14	.57	.56	.05	.61	.53	.55	.06
15-21	.80[e]	.90[f]	.02	.93[f]	.77[e]	.85[ef]	.02
22-29	1.20	1.29	.07	1.38	1.12	1.25	.08
29-35	1.59	1.66	.06	1.71	1.50	1.68	.08
36-42	1.91	1.98	.14	1.97	1.98	1.89	.17
43-49	1.94	1.73	.17	1.87	1.50	2.14	.21
Overall	1.14	1.18	.04	1.22	1.09	1.18	.05
Feed per unit of gain							
0 - 7	3.57	2.82	2.08	2.33	3.00	4.14	2.55
8 -14	1.53	1.52	.17	1.41	1.45	1.71	.21
15-21	1.79	1.85	.12	1.71	1.92	1.84	.15
22-28	1.56	1.67	.06	1.69	1.62	1.55	.08
29-35	1.65	1.65	.06	1.69	1.66	1.59	.07
36-42	2.11	2.11	.10	2.16	1.92	2.24	.12
43-49	1.74[g]	1.36	.05	1.62	1.44	1.61	.06
Overall	1.76	1.72	.04	1.77	1.71	1.74	.04

[a] There were six cages per mean (5 pigs per cage in trial 1 and 6 pigs per cage in trial 2).
[b] There were four cages per mean.
[c] SF = Starter diet with fiber; SNF = Starter diet without fiber.
[d] Standard error of mean for individual average daily gain and for pen average daily feed intake and feed per gain.
[ef] Means within main effects with different superscript letters are different ($P < .05$).
[g] Trend ($P < .10$) for diets to be different.

TABLE 3. PAD, CLEANLINESS AND FECAL FIRMNESS SCORES OF PIGS ON SOYBEAN MILL STARTER DIET STUDY HOUSED IN TRIPLE DECK NURSERY. TRIALS 1 AND 2.

	Main Effects				
	Diets[a]		Decks[b]		
	SF[c]	SNF[c]	T	M	B
Pad scores[d]	1.2	1.1	1.1	1.2	1.2
Cleanliness[e]					
Week 2	.2	.5	0	0	1.0
3	.2	.2	0	0	.5
4	.3	.5	0	.3	1.0
5[f]	.7	1.0	0	.5	2.0
6[f]	1.0	1.0	0	1.0	2.0
7[f]	2.0	2.0	1	2.0	3.0
Fecal firmness[g]					
Week 2	1.3	1.0	1.3	1.3	1.0
3	1.3	1.0	1.3	1.3	1.0
4	1.0	1.0	1.0	1.0	1.0
5[f]	1.0	1.0	1.0	1.0	1.0
6[f]	1.0	1.0	1.0	1.0	1.0
7[f]	1.0	1.0	1.0	1.0	1.0

[a]There were six cages per mean (5 pigs per cage in trial 1 and 6 pigs per mean in trial 2).
[b]There were four cages per mean.
[c]SF = Starter diet with fiber; SNF = Starter diet without fiber.
[d]Pads were scored 1 to 5 with 1 being normal and 5 the worst.
[e]Cleanliness was scored as follows: Clean = 0, Soiled = 1, Dirty = 2, Very dirty = 3.
[f]Values for only trial 1.
[g]Fecal firmness was scored as follows: Normal = 1, Soft = 2, Hard = 3.

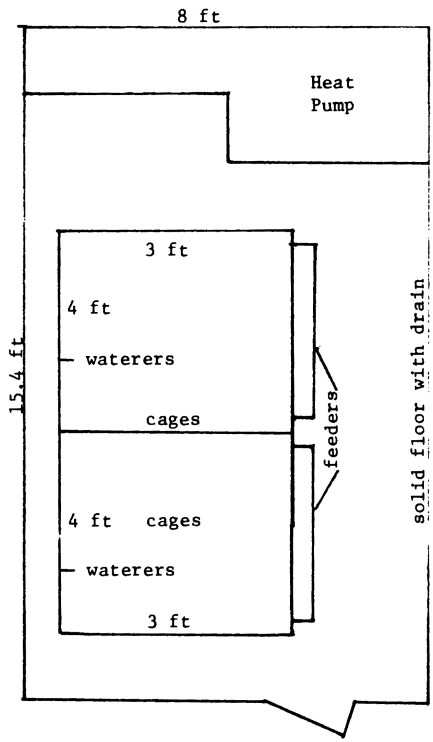

Figure 1. Plan view of nursery.

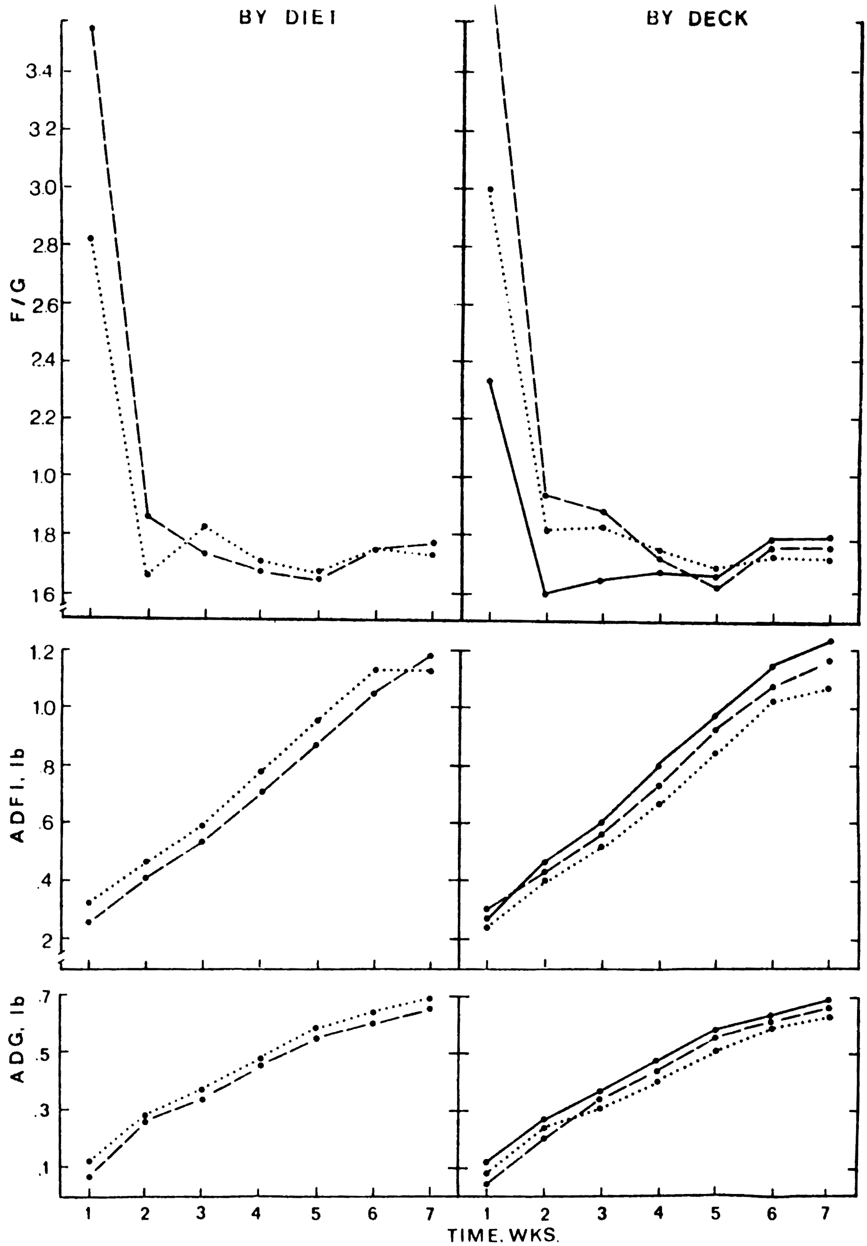

Figure 2. Accumulative average daily gain (ADG), average daily feed intake (ADFI) and feed per gain (F/G) for pigs fed starter diets with 0 (.....) and 10% (———) soybean mill run housed in triple-deck nursery (top ———, middle ...., bottom ----).

INFLUENCE OF RESTRICTED GROWTH RATE AND ELEVATED LEVELS OF MINERAL AND VITAMINS ON FEET AND LEG CHARACTERISTICS, SOUNDNESS SCORES AND FEEDLOT PERFORMANCE IN DEVELOPING GILTS

D. F. Calabotta, G. A. Kesel, H. R. Thomas, J. W. Knight, H. P. Veit, D. R. Notter and E. T. Kornegay[1]

Structural unsoundness, also known as leg weakness, is causing increased concern for the swine industry. The economic implications of the abnormality become especially apparent when one considers that approximately 30% of the breeding herd is culled each year because of this disorder. The condition may be the result of unfavorable confinement conditions, nutritional imbalances, and/or the industry's present practice of selecting for fast-growing, heavily-muscled pigs. Possible solutions to this problem seem to be scanty and questionable due to the complexity of the condition, since it may be affected by any or all of the above factors.

It was, therefore, the objective of this study to determine the influences of increased mineral and vitamin levels and of reduced growth rate (reduced energy intake) during growth and development on feet and pad scores, overall soundness scores and performance.

Experimental Methods

A 2 x 2 factorial design was utilized in which 96 weanling crossbred gilts (four to five weeks of age) were assigned to outcome groups based on weight and litter. Animals from these groups were then randomly allotted to the following dietary treatments:

I. _Ad libitum_ intake - National Research Council (NRC) daily minerals and vitamins
II. 75% of _ad libitum_ - NRC daily minerals and vitamins
III. _Ad libitum_ intake - 150% of NRC daily minerals and vitamins
IV. 75% of _ad libitum_ intake - 150% of NRC daily minerals and vitamins

There were six replications per treatment and four pigs per pen for a total of 24 pigs per treatment. All gilts were confinement reared on partially slotted concrete floors and given access to drinking water throughout the duration of the study.

The feeding schedule from weaning to 100 kg can be seen in table 1. The protein and energy source for all phases of the growth period was 44% soybean meal and corn, respectively, with the exception of the creep diet (weaning to 10 kg) which contained 10% dried whey. Diets were formulated to meet all nutrient requirements of the pig at all phases of growth.

[1]Appreciation is expressed to the John Lee Pratt Animal Nutrition Program for financial support; to Borden Chemcial Co., Norfolk, VA and Calcium Carbonate Co., Quincy, IL, for supplying the ingredients; to Charlie Babb and Carl Eure for caring for the animals.

As shown in table 1, two of the dietary treatments were restricted fed 75% of ad libitum intake. A feed intake curve which was ascertained in a previous study under similar conditions was used to predict the intake of ad libitum fed pigs for the subsequent two weeks. Pigs which were restricted fed were given 75% of the predicted intake. Feed intake of the ad libitum fed animals was monitored biweekly and adjustments made every two weeks. This method of restriction was continued throughout the study. It should be noted that when the dietary intake was restricted, energy was the only limiting nutrient. Therefore, all other nutrients were increased accordingly to maintain nutrient consistency among pigs.

Feet and leg measurements were taken and lesions, if observed, were characterized at 37, 119 and 185 days of age (7.2, 48.9 and 92.5 kg). Pigs in each pen were randomly selected and denoted as being either "right-left" or "left-right", thus two pigs in each pen were "right-left" and two pigs were "left-right". Pigs designated as "right-left" had their right fore and left hind feet and legs measured and characterized while those designated as "left right" had their left fore and right hind feet and legs measured and characterized. These initial limb designations were used in all subsequent periods.

Several measurements from each toe of each foot were taken (see figure 1) using an Omega caliper[2] calibrated in millimeters. As illustrated, four measurements were taken on each toe of each foot. Several calculations were performed on the data to obtain values that might be important in evaluating the overall soundness of the animals. These values included:

(a) The percent of horn for the medial (inside) toe of the fore (RF14I), the lateral (outside) toe of the fore (RF14O), the medial toe of the hind (RH14I), and the lateral toe of the hind (RH14O) was obtained by dividing measurement 1 by measurement 4 and multiplying by 100.

(b) The area of the base of the medial toe of the fore (FARI), the lateral toe of the fore (FARO), the medial toe of the hind (HARI), and the lateral toe of the hind (HARO) obtained by multiplying measurement 2 by 4.

(c) The volume of the medial toe of the fore (FVOLI), the lateral toe of the fore (FVOLO), the medial toe of the hind (HVOLI) and the lateral toe of the hind (HVOLO) obtained by multiplying measurement 2 by 4 by 3.

The following assumptions were made concerning the above measurements: (1) that the shape of the base of the toe is rectangular in nature; (2) that the entire toe, encompassed by the horn process was imagined to be a rectangular cube, thus, estimation of its volume from the raw data could be accomplished; (3) that any deviation in toe shape from the stated geometrical figures in 1 and 2 was consistent among pigs; therefore, although an exact value for percent of horn, area and volume may not have been obtained, a somewhat constant estimation of these values was maintained.

A tape measure calibrated in centimeters was used for all bone measurements. Lengths were measured by palpating the joints at each end of the desired bone to determine its endpoints which were then measured and recorded. The bones measured included the third metacarpal (MC), ulna (U) and the circumference of the fore leg measured proximally to the accessory carpal and immediately distal to the distal end of the ulna around the styloid process (CIRCF), third

[2]Stock # 110; Omega Percision Tools, Inc., New Hyde Park, NY 11040.

metatarsal (MT), tibia (T) and the circumference of the hind leg taken distally to the hock joint (CIRCH). The ratio of MC to U (RMCU) and MT to T (RMTT) was calculated.

The pads and hooves of each pig were observed and any lesions or abnormalities recorded. A scale of 0 to 3 was used to describe the lesions with 0 indicating the absence of lesions and 3 indicating those which would most likely preclude normal locomotion. Thus, each foot was given four scores (inside toe pad, inside toe hoof, outside toe pad, outside toe hoof). These scores were subsequently averaged to obtain a mean overall lesion score for the particular foot (fore or hind).

Performance data was collected during all 5 phases of the growing period at bimonthly intervals. Average daily feed and feed per gain were calculated as pen averages.

Results

Performance: The restriction program was successful in reducing growth rate as restricted pigs consistenly ate less, gained less and weighed less throughout the growing period than did ad libitum fed pigs (table 2 and figure 2). Mineral and vitamin levels had little effect on average daily gain.

During phase one, the ad libitum fed pigs were more efficient ($P < .001$) than the restricted fed pigs (1.85 vs 2.12 kg feed per kg gain), however, at the end of phase three, the restricted fed pigs were more efficient ($P < .05$) than the ad libitum fed pigs (2.42 vs 2.49).

With the exception of periods 1 and 2 when average daily gain was greater ($P < .10$) for the NRC levels of minerals and vitamins, average daily gain and average daily feed intake were not affected by mineral and vitamin levels. Mineral and vitamin levels did not appear to affect feed efficiency throughout the first four phases of the growing period. However, the cumulative feed efficiency at the end of phase five revealed that the high mineral and vitamin group was more efficient ($P < .05$) than the NRC mineral group (2.94 vs 3.02).

Measurements: Percent horn was lower ($P < .05$) at period 2 for the RF14I and at period 3 for the RF140 for pigs fed the high level of minerals and vitamins as compared to pigs fed NRC level of minerals and vitamins (table 3). Differences were not significant ($P > .10$) during the other periods for the RF14I and RF140. One might speculate that the high level of minerals and vitamins stimulated increased proliferation of the pad, which might account for the decrease percent horn seen in animals fed the high mineral and vitamin levels. Energy levels did not affect the percent horn of the front or hind toes. Also, the percent horn for the hind toes (RH14I and RH140) was not affected by mineral and vitamin levels.

The volume of the FVOLI during period 2 was greater ($P < .05$) for the ad libitum fed as compared to the restricted animals (24.5 vs 22.7 cm^3). Similar results were observed during the second (23.2 vs 21.9 cm^3; P .10) and third (30.8 vs 28.6 cm^3; $P < .10$) periods for the HVOLI. The values observed are consistent with the fact that the restricted fed pigs grew slower and, therefore, had smaller toes.

The calculated areas of the FARI and FARO were not affected by either energy or mineral and vitamin levels (table 3).

The average front foot score (AFFS) was initially (period 1) higher ($P < .05$) for the ad libitum fed pigs as compared to the restricted fed pigs which probably indicates random chance of assignment. There were no differences in the two subsequent periods. Also, the average hind foot scores (AHFS) were not affected by energy level. Pigs fed the higher level of minerals and vitamins had higher ($P < .05$) AFFS in the third period than those pigs on the lower mineral and vitamin levels. There were no differences ($P < .01$) in any of the periods for the average hind foot score (AHFS).

The mean ratio of metacarpal to ulna (RMCU) and metatarsal to tibia (RMTT) was not significantly different between treatments for the three different periods.

The circumference of the fore (CIRCF) and hind (CIRCH) leg was larger ($P < .001$) in periods 2 and 3 for ad libitum fed as compared to restricted fed pigs (table 5). There were no differences ($P > .10$) between mineral and vitamin levels for CIRCF and CIRCH at any of the periods. An energy-mineral interaction for CIRCH was noted in the first period (table 5), with both "high energy - high mineral" and "low energy - low mineral" pigs having larger measurements ($P < .05$) than either "high energy - low mineral" or "low energy - high mineral" pigs. The relevance of this is unknown and may be due to random assignment of pigs to treatments.

Summary

Restricted pigs gained less and grew slower than ad libitum fed pigs during the five phases of the growth period. Mineral and vitamin levels did not affect the performance of pigs throughout the first four weeks of the growing period; however, the cumulative calculation for phase five revealed that pigs on the high mineral and vitamin level were more efficient ($P < .05$) compared with those on NRC levels of minerals and vitamins.

Percent horn for the front toes was reduced by the higher mineral and vitamin level for two of the four periods, however, no effect was seen with varying energy levels. Toe volume was significantly affected by energy levels, however, mineral and vitamin levels had no effect.

Feet scores for ad libitum fed pigs did not significantly ($P > .10$) differ from restricted fed pigs. Mineral and vitamin levels seemed to affect the feet scores of pigs in the third period with "high mineral" pigs showing a greater number of lesions.

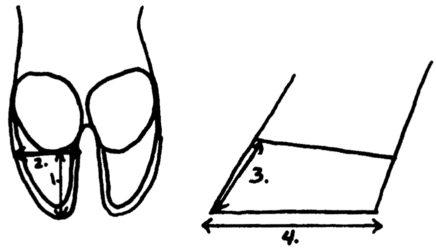

Figure 1. (1) measurement taken from the distal periphery of the pad to the tip of the toe; (2) taken across the widest part of the toe along the distal periphery of the pad; (3) taken from the coronet band to the tip of the toe; and (4) taken from the proximal periphery of the pad to the tip of the toe.

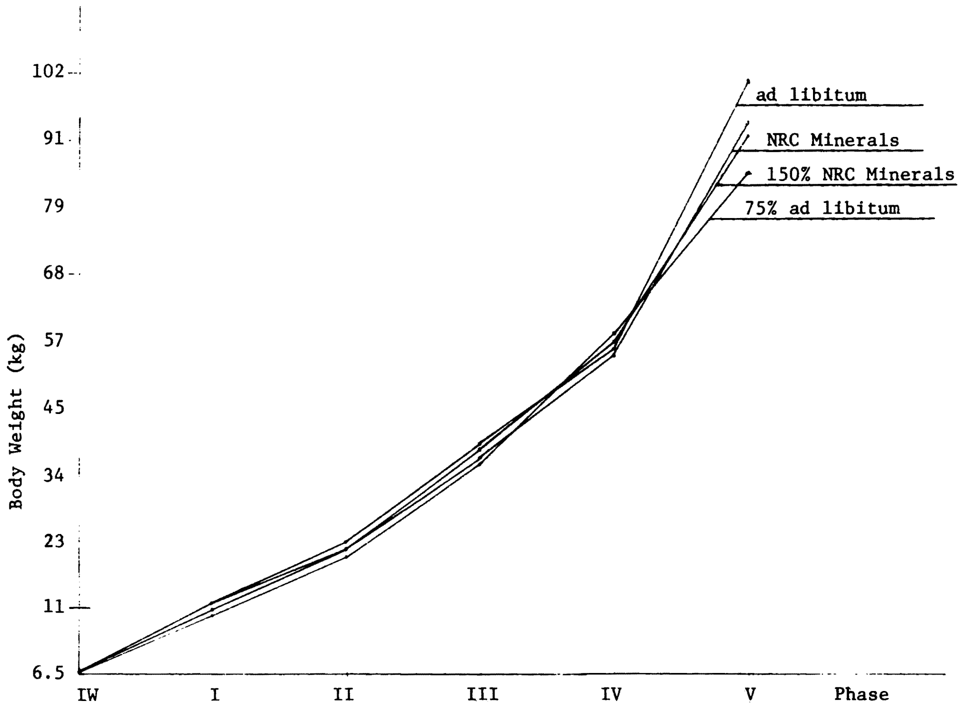

Figure 2. Body weights for five phases of the growth period associated with the four different main effects shown above.

Table 1. Calcium (Ca), Phosphorus (P) and Crude Protein (CP) Levels fed to Gilts from Weaning to 100 Kilograms

		NRC						150% of NRC					
		Ad libitum			75% of *ad lib*[a]			*Ad libitum*			75% of *ad lib*		
Item	Phase	Ca	P	C.P.(%)	Ca	P	C.P.(%)	Ca	P	C.P.(%)	Ca	P	C.P.(%)
Weaning to 10 kg*	I	.80	.60	20.0	1.06	.80	26.6	1.20	.90	20.0	1.60	1.20	26.6
10 to 20 kg	II	.65	.55	18.0	.86	.73	24.0	.98	.83	18.0	1.30	1.10	24.0
20 to 35 kg	III	.60	.50	16.0	.80	.67	21.3	.80	.75	16.0	1.20	1.00	21.3
35 to 60 kg	IV	.55	.45	16.0	.73	.60	21.3	.83	.68	16.0	1.10	.90	21.3
60 to 100 kg	V	.50	.40	14.0	.67	.53	18.6	.75	.60	14.0	1.00	.80	18.6

*Fed as a creep diet.
[a]Where diets were restricted, an elevated level of mineral and vitamin and crude protein was used to maintain constant daily intake of these constituents.

Table 2. Initial Weight, Average Daily Gain (ADG), Average Daily Feed Intake (ADF) and Feed Per Gain (F/G) During Five Phases of Growth for Gilts Fed Two Levels of Energy and Minerals and Vitamins

Item	Ad libitum intake	75% of ad libitum intake	NRC	150% of NRC	Significance Energy	Significance Min-V
Initial wt (kg)	6.60 ± .11	6.53 ± .10	6.54 ± .11	6.54 ± .10		
Phase I (weaning to 10 kg)						
ADG, kg	.24 ± .01[a]	.20 ± .01	.23 ± .01	.21 ± .01	**	T
ADF, kg[b]	.45 ± .02	.39 ± .02	.43 ± .02	.40 ± .02		
F/G[b]	1.85 ± .14	2.12 ± .14	1.90 ± .14	2.07 ± .14	***	
Phase II (10 to 20 kg)						
ADG, kg	.53 ± .08	.56 ± .08	.64 ± .08	.44 ± .08		T
ADF, kg	1.12 ± .03	.86 ± .03	.98 ± .03	.99 ± .03		
F/G	2.16 ± .13	2.42 ± .13	2.30 ± .13	2.28 ± .13		
Phase II Cum (Phases I - II)						
ADG, kg[c]	.39 ± .01	.29 ± .01	.33 ± .01	.34 ± .01	***	
ADF, kg	.79 ± .03	.66 ± .03	.72 ± .03	.73 ± .03	***	
F/G	2.06 ± .07	2.27 ± .07	2.17 ± .07	2.16 ± .07		
Phase III (20 to 35 kg)						
ADG, kg	.60 ± .02	.57 ± .02	.59 ± .02	.58 ± .02		
ADF, kg	1.50 ± .05	1.37 ± .05	1.46 ± .05	1.40 ± .05	**	
F/G	2.49 ± .09	2.42 ± .09	2.49 ± .09	2.42 ± .09	*	
Phase III Cum (Phases I - III)						
ADG, kg	.46 ± .01	.39 ± .01	.43 ± .01	.43 ± .01	***	
ADF, kg	1.05 ± .02	.89 ± .02	.98 ± .02	.97 ± .02		
F/G	2.28 ± .05	2.28 ± .05	2.30 ± .05	2.26 ± .05		
Phase IV (35 to 60 kg)						
ADG, kg	.68 ± .02	.64 ± .02	.67 ± .02	.66 ± .02	*	
ADF, kg	2.00 ± .05	1.74 ± .05	1.92 ± .05	1.83 ± .05	***	
F/G	2.91 ± .08	2.81 ± .08	2.94 ± .08	2.78 ± .08		
Phase IV Cum (Phases I - IV)						
ADG, kg	.54 ± .01	.47 ± .01	.50 ± .01	.49 ± .01	***	
ADF, kg	1.30 ± .02	1.16 ± .02	1.27 ± .02	1.20 ± .02	**	
F/G	2.49 ± .03	2.48 ± .03	2.53 ± .03	2.45 ± .03		
Phase V (60 to 100 kg)						
ADG, kg	.67 ± .02	.63 ± .02	.65 ± .02	.64 ± .02		
ADF, kg	2.66 ± .16	2.38 ± .16	2.48 ± .16	2.56 ± .16	***	*
F/G	3.94 ± .08	3.79 ± .08	3.73 ± .08	4.00 ± .08		T
Phase V Cum (Phases I - V)						
ADG, kg	.60 ± .01	.50 ± .01	.56 ± .01	.54 ± .01	***	
ADF, kg	1.87 ± .04	1.42 ± .04	1.69 ± .04	1.60 ± .04		
F/G	3.11 ± .06	2.85 ± .06	3.02 ± .06	2.94 ± .06		*

*(P< .05); **(P< .01); ***(P< .001); T(P< .10)

[a]Least square means ± S.E.M.

[b]All ADF and F/G values were calculated based on pen means (4 pigs per pen with 12 pens per main effect).

[c]Indicates a significant (P< .05) energy x mineral and vitamins interaction for the particul item.

Table 3. Percent Horn, Toe Volume, and Toe Base Area for Gilts Fed Two Levels of Energy and Minerals and Vitamins

Item	Period	*Ad libitum* intake	75% of *ad libitum* intake	NRC Minerals and Vitamins	150% of NRC Minerals and Vitamins	Significance Energy	Significance Min-Vit
Front in-	1	44.0 ± .	43.2 ± .7	43.4 ± .7	43.7 ± .70		
side horn	2	40.2 ± .9	40.4 ± .9	41.4 ± .8	39.1 ± .80		*
toe, %	3	42.3 ± .9	42.9 ± .8	42.6 ± .7	42.6 ± .70		
Front out-	1	42.0 ± .9	41.2 ± .9	41.7 ± .9	41.5 ± .90		
side horn	2	38.4 ± 1.0	38.4 ± .9	38.5 ± .8	38.3 ± .80		
toe, %	3	42.8 ± 1.0	41.7 ± .9	43.5 ± .8	41.0 ± .80		*
Hind inside	1	44.8 ± .7	44.1 ± .7	44.4 ± .7	44.5 ± .80		
horn toe, %	2	42.9 ± .9	41.3 ± .9	42.2 ± .8	42.0 ± .80		
	3	41.1 ± 1.2	40.3 ± 1.1	40.1 ± .9	41.3 ± .90		
Hind out-	1	41.8 ± .6	42.2 ± .6	42.5 ± .6	41.5 ± .50		
side horn	2	42.5 ± .8	41.2 ± .7	42.3 ± .7	41.3 ± .70		
toe, %	3	40.7 ± 1.0	42.5 ± .9	41.6 ± .8	41.6 ± .80		
Front in-	1	4.4 ± .1	4.6 ± .1	4.5 ± .1	4.4 ± .11		
side toe	2	24.5 ± .5	22.7 ± .5	23.7 ± .5	23.5 ± .51	*	
vol, cm^3	3	40.1 ± 1.1	38.1 ± 1.0	39.8 ± .9	38.4 ± .84		
Front out-	1	4.6 ± .1	4.6 ± .1	4.7 ± .1	4.5 ± .11		
side toe	2	26.4 ± .5	25.7 ± .5	26.4 ± .5	25.7 ± .48		
vol, cm^3	3	45.1 ± 1.2	44.5 ± 1.1	44.0 ± 1.0	45.6 ± .94		
Hind inside	1	4.1 ± .1	4.1 ± .1	42.0 ± .1	4.0 ± .11		
toe vol,	2	23.2 ± .4	21.9 ± .4	22.5 ± .4	22.6 ± .41	T	
cm^3	3	30.8 ± .8	28.6 ± .7	29.3 ± .6	30.1 ± .60	T	
Hind out-	1	4.5 ± .1	4.4 ± .1	4.6 ± .1	4.3 ± .11		
side toe	2	26.4 ± .5	26.3 ± .4	26.2 ± .5	26.4 ± .45		
vol cm^3	3	35.2 ± .7	36.9 ± .7	35.7 ± .6	36.4 ± .57	T	
Front inside	1	2.4 ± .0	2.5 ± .0	2.5 ± .0	2.5 ± .04		
toe base	2	7.4 ± .1	7.0 ± .1	7.2 ± .1	7.2 ± .11		
area cm^2	3	10.3 ± .2	9.9 ± .1	10.2 ± .2	9.9 ± .25		
Front outside	1	2.6 ± .0	2.6 ± .0	2.6 ± .1	2.6 ± .15		
toe base	2	8.2 ± .1	7.9 ± .1	8.1 ± .1	7.9 ± .11		
area cm^2	3	11.6 ± .2	11.5 ± .2	11.3 ± .2	11.7 ± .27		
Hind inside	1	2.2 ± .0	2.2 ± .0	2.2 ± .0	2.2 ± .04		
toe base	2	6.3 ± .1	6.1 ± .1	6.2 ± .1	6.2 ± .19		
area cm^2	3	9.0 ± .1	8.9 ± .1	8.8 ± .1	9.1 ± .13		
Hind outside	1	3.0 ± .0	2.3 ± .0	2.4 ± .0	2.3 ± .04		
toe base	2	7.0 ± .1	7.1 ± .1	7.1 ± .1	7.1 ± .19		
area cm^2	3	11.0 ± .2	10.9 ± .2	10.8 ± .2	11.0 ± .25		

*($P < .05$), T($P < .10$)

[a] Least square means ± S.E.M. There were 48, 48, 48 and 48 pigs for period 1; 41, 45, 42 and 44 for period 2; and 39, 45, 40 and 44 for period 3 for the *ad libitum* pigs, 75% of *ad libitum*; NRC minerals and vitamins and 150% of NRC minerals and vitamins group, respectively.

Table 4. Average Front (AFFS) and Hind Foot (AHFS) Scores for Gilts Fed Two Levels of Energy and Minerals and Vitamins during the Growth Period[a]

	Period	*Ad libitum* intake	75% of *ad libitum* intake	NRC minerals and vitamins	150% of NRC minerals and vitamins	Significance Energy	Significance Min-Vit
AFFS	1	.16 ± .04[b]	.05 ± .04	.11 ± .04	.10 ± .04	*	
	2	.14 ± .05	.12 ± .05	.12 ± .05	.14 ± .04		
	3	.20 ± .05	.30 ± .05	.19 ± .04	.31 ± .04		*
AHFS	1	.22 ± .06	.17 ± .06	.25 ± .06	.14 ± .06		
	2	.05 ± .03	.06 ± .02	.07 ± .03	.03 ± .03		
	3	.23 ± .05	.19 ± .05	.24 ± .04	.18 ± .04		

*(P .05).

[a]Scores were assigned on the basis of 0 indicating no lesions and 3 indicating severe lesions.

[b]Least square means ± S.E.M. There were 48, 48, 48 and 48 pigs for period 1; 41, 45, 42 and 44 for period 2; and 39, 45, 40 and 44 for period 3 for the *ad libitum* pigs, 75% of *ad libitum*, NRC minerals and vitamins and 150% of NRC minerals and vitamins groups, respectively.

Table 5. Ratio of Metacarpal to Ulna (RMCU), Ratio of Metatarsal to Tibia (RMTT) and Circumference of the Fore Limb (CIRCF) and Hind Limb (CIRCH) for Gilts Fed Two Levels of Energy and Minerals and Vitamins during the Growing Period.

Item	Period	Ad libitum intake	75% of ad libitum intake	NRC minerals and vitamins	150% of NRC minerals and vitamins	Significance Energy	Significance Min-Vet
RMCU	1	.43 ± .01	.44 ± .01	.43 ± .00	.43 ± .01		
	2	.53 ± .10	.49 ± .09	.57 ± .08	.45 ± .08		
	3	.39 ± .01	.39 ± .00	.40 ± .00	.39 ± .01		T
RMTT	1	.62 ± .03	.57 ± .02	.63 ± .02	.56 ± .03		
	2	.55 ± .01	.55 ± .00	.5 ± .00	.55 ± .01		
	3	.58 ± .02	.60 ± .01	.59 ± .01	.5 ± .01		
CIRCF	1[b]	10.04 ± .09	10.09 ± .08	10.1 ± .08	10.02 ± .09		
(cm)	2	17.72 ± .11	16.74 ± .10	17.27 ± .11	17.19 ± .10	***	
	3	21.33 ± .13	20.32 ± .13	20.74 ± .14	20.91 ± .14	***	
CIRCH	1	10.00 ± .13	10.24 ± .13	10.17 ± .13	10.17 ± .13		
(cm)	2	18.22 ± .12	17.41 ± .11	17.68 ± .11	17.84 ± .11	***	
	3	20.63 ± .19	19.56 ± .18	20.30 ± .19	19.88 ± .19	***	

*P < .05; **P < .001; [T]P < .10

[a]Least square means ± S.E.M.

[b]Indicates a significant energy x mineral and vitamin interaction for this particular variable and time period; P < .05. There were 48, 48, 48 and 48 pigs for period 1; 41, 45, 42 and 44 for period 2; and 39, 45, 40 and 44 for period 3 for the <u>ad libitum</u> pigs, 75% of <u>ad libitum</u>, NRC minerals and vitamins and 150% of NRC minerals and vitamins group, respectively.

Digestibility of Soybean Mill Run by Sows

E. T. Kornegay[a]

Previously it was reported using 100 lb barrows (1977 Livestock Research Report) that the digestion coefficients for dry matter, energy, crude protein, ether extract, NFE, cell content and ash decreased as soybean hulls were substituted for a 13% protein basal diet containing 63% corn, 20% oats, 5% dehydrated alfalfa meal, 10% soybean meal plus minerals and vitamins. Digestion coefficients for acid detergent fiber, cellulose and lignin were increased as soybean hulls were substituted for the basal diet. There was a trend for crude fiber digestion to increase as hulls were substituted while the digestion of cell walls and hemicellulose was unaffected.

It is believed that sows may be able to better utilize soybean hulls than market barrows. The purpose of this study was to determine the digestibility of soybean mill run (known in the feed trade as hulls) when fed to gestating sows.

Experimental Procedures

Twenty-four crossbred gestating sows were used in two digestion trials. The four dietary treatments were 0, 7.5, 15 and 30% soybean mill run substituted for a 13% crude protein basal diet (table 1). The basal diet was analyzed to contain (as fed basis): 89.8% dry matter, 12.9% crude protein, 1759 kcal gross energy per pound, 12.6% cell walls, 77.2% cell content, 6.6% ADF, 1.8% lignin, 4.7% cellulose and 6.0% hemicellulose. Soybean mill run was analyzed to contain (as fed basis): 91.4% dry matter, 10.8% crude protein, 1752 kcal gross energy per pound, 52.9% cell walls, 38.5% cell content, 39.4% ADF, 4.4% lignin, 34.9% cellulose and 13.4% hemicellulose.

Sows were placed in stainless steel metabolism cages and allowed a 5-day preliminary period to adapt to the cages. During this time only the basal diet was fed. The sows were fed the experimental diets for an adjustment period of 5-days before the first 5-day collection period was begun. A second 5-day collection period (same assignment of treatments) was begun one day after the first collection period was completed. The sows were fed 4 lb of the diet in two equal feeding. At the time of feeding, water was added to the diet and it was fed in the form of a gruel. Sows were allowed 1 hr to eat after which refusals (only rarely were there any) were collected and sufficient fresh water was placed in the trought so that a small amount was left at the next feeding. Total urine and feces were collected and processed as described previously (1977 Livestock Research Report, p. 126). Laboratory procedures were described by Kornegay (1978).

[a]Appreciation is expressed to Mr. Ken L. Bryant for feeding and caring for for the sows and for collecting samples, to Mrs. Helen Bartlett and Ms. Linda Sparks for laboratory analysis, to Dr. K. E. Webb, Jr. for advise on laboratory methods and to Allied Mills Research, Libertyville, IL 60048 for supplying soybean mill run.

Results

Energy, protein and Van Soest digestion coefficients are presented in table 2. Digestion coefficients were depressed ($P < .05$) for dry matter, digestible energy, crude protein and cell content when soybean mill run was substituted for the basal diet. These results are in agreement with the report by Kornegay (1978), but the magnitude of the decrease is only approximately one-half that observed previously for growing barrows. Digestion coefficients for cell walls, ADF, hemicellulose, cellulose and lignin were increased as soybean mill run was substituted for the basal diet. Kornegay (1978) reported no difference in the digestibility of cell walls and hemicellulose but did report an improvement in digestibility of ADF, cellulose and lignin as soybean hulls were substituted for a similar basal diet. Nitrogen retention as a percent of nitrogen intake and as a percent of nitrogen digested was not influenced by the level of soybean mill run substituted The digestion coefficients for ADF and cellulose were higher for sows than reported by Kornegay (1978) for growing barrows.

An analysis of the data for this study will continue. Digestion coefficients will be calculated by the difference method for the various components. Also digestion coefficients for metabolizable energy will be determined and the nitrogen content of the ADF component is being determined.

Summary

Soybean mill run appeared to be well digested by gestating sows although the digestibility of dry matter, digestible energy, crude protein and cell content decreased as the soybean mill run was substituted for the basal diet containing corn, oats, alfalfa meal and soybean meal. The fibrous components, cell walls, acid detergent fiber, hemicellulose, cellulose and lignin, of soybean mill run were more digestible than those in the basal diet.

Literature Cited

Kornegay, E. T. 1978. Feeding value and digestibility of soybean hulls for swine. J. Anim. Sci. 44:1272.

Table 1. Composition of the Basal Diet[a]

Items	Int'l Number	%
Ground corn	4-02-931	64.42
Ground oats	4-03-388	20.00
Soybean meal	5-04-612	8.42
Dehyd. alfalfa meal	1-00-023	5.00
Defluorinated phosphate	6-01-780	1.00
Limestone	6-02-632	.50
Vitamin-Se premix[b]		.20
Swine trace mineral salt[c]		.40

[a]Calculated to contain 13% protein, .65% Ca and .5% total P.
[b]Supplied (per kilogram of premix): 1.32 g riboflavin, 6.8 g pantothenic acid, 6.8 g niacin, 10.6 mg vitamin B_{12}, 220 g choline chloride, 13,200,000 IU vitamin A, 220,000 IU vitamin D, 2,200 IU vitamin E, 330 mg MPB (vit. K) and 40 mg Se.
[c]Contained (%): Co .01, Cu .10 Fe .50, 1.01, Mn .80, Zn 1.0, sulfur .24, NaCl (balance).

Table 2. Energy, Protein and Van Soest Digestion Coefficients of Diets Containing Soybean Mill Run.

Items	Soybean mill run, %				S.E.[a]
	0	7.5	15	30	
Dry matter	86.2[b]	84.3[c]	83.5[c]	83.9[c]	.6
Digestible energy	85.2[b]	83.2[c]	82.4[c]	82.7[c]	.7
Crude protein (NX6.25)	85.4[b]	82.1[c]	80.3[cd]	79.1[d]	.8
Nitrogen retention[f]	22.4	27.6	28.3	22.0	3.1
Nitrogen retention[g]	26.2	34.0	35.1	27.4	3.7
Cell content	91.7[b]	90.2[c]	89.8[c]	88.1[d]	.4
Cell wall	53.0[b]	56.5[bc]	58.6[c]	71.7[d]	1.7
Acid detergent fiber	48.9[b]	56.2[c]	61.4[d]	74.5[e]	1.7
Hemicellulose	57.4[b]	56.9[b]	54.1[b]	66.3[e]	2.0
Cellulose	52.4[b]	61.9[c]	67.5[d]	79.6[e]	1.7
Lignin	47.6[b]	45.6[b]	46.9[b]	55.5[c]	2.1

[a]Standard error of the mean (n=12)

[b,c,d,e]Means with different superscript letters are different ($P < .05$).

[f]Percent of intake

[g]Percent of digested

Supplemental Biotin for Swine. I. Performance, Hair and Structural Soundness Scores for Developing Gilts[1]

K. L. Bryant, J. W. Knight and E. T. Kornegay

Lameness resulting from various feet and leg problems is of major importance in the swine industry. The severity of the problem appears to have increased during the past several years, concurrent with increased confinement.

Biotin has been implicated as a factor in lameness and indeed does have a key role in maintaining normal skin, hair and foot pads. Until recently, the biotin present in feedstuffs coupled with biotin synthesized in the intestinal tract was thought adequate to meet the animal's needs. Reported field cases of biotin deficiencies, a majority of which have involved animals housed in total confinement facilities, have resulted in increased pressure to supplement swine diets with biotin.

The purpose of this study was to examine the effects of supplemental biotin for developing gilts. This paper, the first of a series of papers, will present the performance data, hair and structural soundness scores for gilts fed two levels of supplemental biotin.

Experimental Procedures

In two separate trials, 80 crossbred gilts were alloted to eight groups based on body weight and ancestry. These eight groups were randomly assigned to either 0 or 220 micrograms of supplemental biotin per kilogram of diet. In trial 1, three gilts (one on the 0 level and two on the 220 μg level) were removed during the first three weeks due to extreme losses in body weight.

All gilts received the same basal diets based on body weight (table 1). Protein, calcium and phosphorus levels were adjusted as the gilts grew according to recent National Research Council (NRC) requirements. Rovimix (220 μg D-biotin/kg) provided the source of supplemental biotin for the 220 μg diet. Feed and water were provided *ad libitum* using automatic feeders and waterers.

All gilts were housed in an environmentally controlled nursery, containing expanded metal floors, until they weighed approximately 45 kilograms. The gilts were then moved to a partial-slotted floor growing-finishing barn where they remained until completion of the test. Body weight gains, feed consumption, and feed per gain ratios were determined every 14 days.

A committee of three, working individually, evaluated each gilt for hair coat and structural soundness. Based on visual observation, each gilt received a score of 1-5 with 1 being very good and 5 very poor. Hair scores were determined initially and at the end of the test while soundness scores were determined only upon completion of the test.

[1]Appreciation is expressed to Duke Reynolds, Dave Calabotta and Greg Kesel for assistance in collecting the data and to Hoffmann-La Roche, Inc. for supplying the biotin.

Results and Discussion

Performance, hair and structural soundness scores for gilts fed diets with (220 μg/kg) and without supplemental biotin are presented in table 2.

Daily gain, daily feed and feed per gain were not different ($P < .05$) between gilts fed diets with and without supplemental biotin. These results are in agreement with those reported by Combs (1967), Hanke and Meade (1971), Meade (1971) and Peo et al. (1970). In these studies the level of supplemental biotin varied from 55 to 880 μg per kilogram of diet. However, a field trial in Colorado (Adams, 1967) with specific pathogenic free pigs showed a 15% increase in daily gain and feed efficiency when 110 μg of D-biotin per kilogram of diet were added to a corn-milo-soybean meal diet. None of the pigs showed clinical signs of a biotin deficiency, however, about 10% of their dams did.

Hair and structural soundness scores were not affected ($P < .05$) by level of supplemental biotin. Cunha (1968), reported results from a field trial where biotin supplementation had been helpful in alleviating hindleg problems, such as stiffness and squatness.

Comparisons between trials revealed a significant ($P < .01$) trial effect for initial body weight, initial age, daily gain, daily feed and feed per gain. This significant difference in performance was probably due to the difference in initial age and weight between trials. Structural soundness scores were also significantly ($P < .05$) affected by trial.

Based upon the results of these two trials, it does not appear that biotin supplementation of corn-soybean meal diets for growing-finishing gilts will improve performance.

Summary

Two 20-week feeding trials using 160 gilts were conducted to evaluate the performance of gilts fed two levels (0 and 220 μg/kg diet) of supplemental biotin in corn-soybean meal diets. Daily gain, daily feed, feed per gain, hair scores, and structural soundness scores were unaffected ($P < .05$) by level of supplemental biotin.

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TABLE 1. PERCENT COMPOSITION OF BASAL DIETS FOR TRIALS 1 AND 2[a].

Ingredients, %	IRN	Feeding Period 4.5-6.8 kg	6.8-10 kg	10-20 kg	20-45 kg	45-100 kg
Ground corn	4-02-931	54.61	59.39	73.66	79.15	84.78
Soybean meal	5-04-612	32.71	27.93	23.70	18.62	13.47
Dry whole whey	4-01-182	10.00	10.00	---	---	---
Deflourinated phosphate	6-01-780	1.03	1.03	1.09	.90	.44
Limestone	6-02-632	.75	.58	.64	.64	.81
Salt	6-14-013	.30	.30	.30	.30	.30
Trace mineral premix[b]		.10	.10	.08	.06	.05
Vitamin-Selenium premix[c]		.25	.25	.25	.20	.15
Antibiotics[d]		.25	.25	.25	.13	.13
Protein, %		22.00	20.00	18.00	16.00	14.00
Calcium, %		.80	.80	.65	.60	.54
Phosphorus, %		.60	.60	.55	.50	.40

[a]Biotin added at .10% to provide 220 μg biotin/kg diet. Generously supplied by Hoffmann-La Roche Company, Nutley, NJ.
[b]Contained (%): 20 Zn, 10 Fe, 5.5 Mn, 1.1 Cu and .15 I.
[c]Supplied (per kilogram of premix): 1.76 g riboflavin, 8.8 g pantothenic acid, 8.8 g niacin, 8.8 mg vitamin B_{12}, 176 g choline chloride, k,760,000 IU vitamin A, 176,000 IU vitamin D_3, 4400 IU vitamin E, 440 mg menadione dimethylprimidinol bisulfite (MPB) and 40 mg Se.
[d]4.5-20 kg: ASP-250; 20-100 kg: Virginiamycin.

TABLE 2. PERFORMANCE, HAIR AND STRUCTURAL SOUNDNESS SCORES OF GILTS FED TWO LEVELS OF SUPPLEMENTAL BIOTIN[a]

Criteria	Trial 1		Trial 2		Trials 1 & 2 Combined	
	0[b]	220	0	220	0	220
No. of pigs	39	38	40	40	79	78
Initial wt, kg[c]	8.17 $\pm$ .11	8.15 $\pm$ .12	5.55 $\pm$ .05	5.59 $\pm$ .05	6.86 $\pm$ .10	6.87 $\pm$ .10
Initial age, days[c]	36.36 $\pm$ .59	36.23 $\pm$ .59	24.50 $\pm$ .44	24.60 $\pm$ .44	30.40 $\pm$ .51	30.40 $\pm$ .50
Daily gain, kg[c]	.59 $\pm$ .01	.61 $\pm$ .01	.55 $\pm$ .01	.55 $\pm$ .01	.57 $\pm$ .00	.58 $\pm$ .00
Daily feed, kg[c]	1.71 $\pm$ .02	1.77 $\pm$ .02	1.47 $\pm$ .03	1.40 $\pm$ .03	1.59 $\pm$ .23	1.59 $\pm$ .23
Feed per gain[c]	2.88 $\pm$ .04	2.91 $\pm$ .04	2.64 $\pm$ .02	2.56 $\pm$ .02	2.76 $\pm$ .02	2.73 $\pm$ .02
Committee Scores[d]						
Hair, initial	1.00 $\pm$ .00	1.00 $\pm$ .00	1.00 $\pm$ .00	1.00 $\pm$ .00	1.00 $\pm$ .00	1.00 $\pm$ .00
Hair, final	1.54 $\pm$ .05	1.64 $\pm$ .04	1.65 $\pm$ .05	1.55 $\pm$ .05	1.60 $\pm$ .05	1.60 $\pm$ .05
Structural Soundness[e]	3.15 $\pm$ .04	3.24 $\pm$ .05	3.12 $\pm$ .03	2.93 $\pm$ .05	3.14 $\pm$ .04	3.09 $\pm$ .04

[a]All values, except No. of pigs, represents $\overline{X} \pm$ S.E.M.
[b]Expressed in µg of supplemental biotin per kg diet.
[c]Significant ($P < .05$) trial effect.
[d]Based on a visual evaluation by three committee members on a scale of 1-5 with 1 being very good and 5 very poor.
[e]Significant ($P < .05$) trial effect.

Phosphorus and Protein Requirement of Developing Boars

E. T. Kornegay and H. R. Thomas[1]

Higher than National Research Council (NRC) suggested levels of calcium and phosphorus are being recommended for growing and developing boars by a number of swine specialist. Further, it has been suggested that the phosphorus requirement is increased when higher levels of protein are fed as is being currently recommended for growing and developing boars. The National Swine Improvement Federation recommends 18% crude protein, .9% Ca and .7% P for growing and developing boars. Some swine specialist, producers and nutritionist believe that structural soundness can, to some degree, be improved by feeding higher than NRC suggested calcium and phosphorus levels. It is further believed by the above people that the faster growing, more efficient boar requires a higher level of minerals to provide stronger, denser bones because of the direct relationship between mineral intake (calcium and phosphorus) and bone density.

Experimental data to support these views are not available. In an experiment (1977 Livestock Research Report) with boars and gilts, it appeared that 25% higher than NRC suggested levels of calcium and phosphorus provided a small increase in overall feedlot performance. However, there appeared to be no influence of dietary calcium and phosphorus on structural soundness scores.

The objective of these trials was to evaluate higher than NRC suggested levels of calcium and phosphorus when fed in combination with higher levels of crude protein for growing and developing boars.

Experimental Procedures

Two trials using 192 crossbred boars with an average initial body weight of 47 lb were conducted to evaluate the following dietary treatment combinations of calcium and phosphorus and protein.

	Dietary Combination					
	1	2	3	4	5	6
Initially to 100 lb						
Calcium, %	.98	.81	.65	.98	.81	.65
Phosphorus, %	.75	.68	.50	.75	.63	.50
Protein, %	18	18	18	16	16	16
100 lb to termination						
Calcium, %	.75	.60	.50	.75	.60	.50
Phosphorus, %	.60	.50	.40	.60	.50	.40
Protein, %	16	16	16	14	14	14

[1]Appreciation is expressed to Charlie Babb, Carl Eure and Paul Boone for caring for the animals, to Helen Bartlett for bone and mineral analysis, to C. C. Brooks, L. B. Allen and J. H. Carter for committee scores of soundness, to Borden Chemical Co., Inc. for supplying phosphorus and to Virginia Pork Industry Commission for partial support.

The proportion of corn and soybean meal was varied to provide the proper crude protein level. Limestone and defluorinated phosphate were varied to obtain desired calcium and phosphorus levels. Combinations 1 and 4 contained 150% of the NRC suggested calcium and phosphorus levels for market hogs with combinations 2 and 5 containing 125% of NRC suggested levels. Combinations 1, 2 and 3 contained two percentage units more protein than suggested by NRC for market hogs.

Boars were randomly assigned from outcome groups based on weight to the above treatments. There were five pens (4 boars/per) in trial 1 and three pens (4 boars/pen) in trial 2 per treatment. Boars were housed in partially slotted floor pens in an enclosed building. Feed was available ad libitum and pigs had free access to water. Body weight and feed consumption were determined biweekly. Feed per gain ratio were calculated.

Blood samples were taken at the end of the test for calcium and phosphorus determinations. The pads of the feet were subjectively scored initially and at the end of the test. Structural soundness was subjectively evaluated by a committee at 70 lb in trial 1 and 140 lb in trial 2 and at the termination of both trials. At the termination of both trials, the right foot was removed at the carpal joint and frozen. The foot was later examined carefully and given an overall score by a committee. Also, all individual leisons were located and scored. A metacarpal bone was removed for breaking strength and bone ash.

The data were statistically analyzed first by trials using the analysis of variance. The data appeared compatible and was combined for this report.

Results

Calcium and Phosphorus Levels.

In phase 1, there was a trend for improved average daily gains when the diet contained 25% higher than NRC calcium and phosphorus levels as compared to diets containing NRC or 50% higher than NRC calcium and phosphorus levels. However, during phase 2 and overall there was no difference in average daily gain between pigs fed the various levels of calcium and phosphorus. Feed per gain was less ($P < .01$) during phase 1 for pigs fed 25% higher calcium and phosphorus, but was not different for levels of calcium and phosphorus during phase 2 or overall. There were no differences in daily feed intake between pigs fed the various levels of calcium and phosphorus.

The final pad scores were highest ($P < .05$) for pigs fed the diet containing 25% higher calcium and phosphorus levels as compared to NRC or 50% higher levels. However, foot scores taken on the right foot were not statistically different between the levels of calcium and phosphorus. The average number of leisons on the inside toe appeared greater ($P < .10$) for pigs fed the diet containing 25% higher calcium and phosphorus levels. There were no differences between calcium and phosphorus levels for the leisons on the outside toe. Soundness score one taken when pigs weighed approximately 70 and 140 lb (trials 1 and 2, respectively) favored ($P < .05$) pigs fed the diets containing 50% and 25% higher calcium and phosphorus levels. Soundness score two taken at the end of the test was not different between pigs fed the three calcium and phosphorus levels.

Serum phosphorus levels were elevated ($P < .001$) for pigs fed the lower level (NRC) of calcium and phosphorus. Normally the opposite response is observed and no explanation is offered for the response obtained. Serum calcium level were not different between pigs fed diets containing the various calcium and phosphorus levels.

Bone ash and breaking strength decreased ($P < .001$ and P .01, respectively) as the dietary level of calcium and phosphorus decreased.

Protein levels.

There was a trend for average daily gain to be greater ($P < .10$) during phase 1 and overall for pigs fed the higher protein level. Feed per gain ratios were lower during phase 1 and overall ($P < .05$ and $P < .10$, respectively) for pigs fed the higher protein level.

Final pad scores were higher ($P < .05$) for pigs fed the higher protein level. There were no differences between protein levels for soundness scores one and two, feet score, inside and outside toe leisons, serum calcium and serum phosphorus.

Bone ash was greater ($P < .05$) although the magnitude of the difference was small (.5%) for the pigs fed the lower protein level. There was no effect of protein level on bone breaking strength.

Summary

Two trials using 192 crossbred boars averaging 47 lb were conducted to evaluate diets containing NRC, 25% higher and 50% higher calcium and phosphorus levels. These calcium and phosphorus levels were fed incombination with NRC and two percentage units higher than NRC protein levels. Average daily gain appeared to be improved initially and feed per gain was lowered when pigs were fed the diet containing 25% higher calcium and phosphorus as compared to pigs fed the diets containing NRC and 50% higher than NRC calcium and phosphorus levels. However, during phase 2 and overall there were no differences between the various levels of calcium and phosphorus. The effect of dietary calcium and phosphorus levels on pad, feet and soundness scores and toe leisons was not consistent and probably suggest little if any effect on these parameters. There was a trend toward higher final pad scores, feet scores and leisons on the inside toe for pigs fed the 25% higher calcium and phosphorus level as compared to pigs fed the NRC and 50% higher than NRC calcium and phosphorus levels. There was no effect of the various dietary calcium and phosphorus levels on final committee scores. Bone ash and breaking strength were increased as dietary calcium and phosphorus increased.

Average daily gain and feed per gain favored pigs fed the higher protein level during phase 1, but not phase 2. Final pad scores and bone ash were greater for pigs fed the higher protein level. There appeared to be no effect of protein level on soundness and feet scores, toe leisons and bone breaking strength.

These results provide little support to the suggestion that growing and developing boars require higher calcium and phosphorus and protein levels than NRC currently suggest for market hogs.

Table 1. Average Daily Gain, Feed Intake and Efficiency, Pad, Committee and Feet Scores, Toe Leisons, Metacarpal Ash and Breaking Strength and Serum Calcium and Phosphorus for Boars Fed Three Dietary Calcium and Phosphorus Leves and Two Protein Levels

	Ca and P Level			Protein Level		Sig Level	
Criteria	50% Ca&P	25% Ca&P	NRC Ca&P	2% Unit NRC	NRC	Ca&P	Protein
Phase I							
Avg daily gain, lb	1.27[a]	1.38	1.31	1.35	1.28	T	T
Avg daily feed, lb	3.16	3.21	3.23	3.22	3.18	NS	NS
Feed per gain	2.53	2.34	2.54	2.40	2.54	**	*
Phase II							
Avg daily gain, lb	1.52	1.52	1.54	1.55	1.51	NS	NS
Avg daily feed, lb	5.23	5.04	5.16	5.16	5.14	NS	NS
Feed per gain	3.50	3.37	3.48	3.45	3.45	NS	NS
Phases I & II							
Avg daily gain, lb	1.43	1.46	1.45	1.47	1.42	NS	T
Avg daily feed, lb	4.38	4.32	4.37	4.34	4.37	NS	NS
Feed per gain	3.13	3.04	3.14	3.07	3.15	NS	T
Final pad score[b]	2.8	3.3	3.0	3.2	2.9	*	*
Avg com score 1[b]	3.1	3.3	3.2	3.2	3.1	*	NS
Avg com score 2[b]	3.4	3.4	3.3	3.4	3.3	NS	NS
Avg feet score[b]	2.6	2.7	2.5	2.6	2.5	NS	NS
Avg toe lesion I	.18	.26	.21	.20	.23	T	NS
Avg toe lesion O	.50	.50	.53	.51	.57	NS	NS
Bone ash	60.7	60.3	59.6	60.1	60.4	***	*
Breaking strength	285	264	250	270	263	**	NS
Serum phosphorus	7.34	7.69	8.01	7.67	7.69	***	NS
Serum calcium	12.96	12.92	13.02	12.88	13.05	NS	NS

NS = nonsignificant (P>.10), T = (P< .10), *(P< .05), **(P< .01), ***(P< .001).

[a] Least square means. Sixteen pens (4 pigs per pen per treatment) per mean (ten pens per mean in trial 1 and 6 pens per mean in trial 2) for calcium and phosphorus levels and 24 pens per mean for protein levels. Individual values were used as the experimental unit for average gain and pen means for daily feed intake and feed per gain.

[b] Based on a visual scoring system with a scale of 1 to 5 with 1 being good and 5 very poor.

Comparison of Three Flooring Materials for Weaned Pigs Housed in a Triple Deck Nursery

H. R. Thomas and E. T. Kornegay[1]

Preliminary research at Virginia Tech (1978 Livestock Research Report) indicated that double and triple decking is an effective means by which nursery density can be increased. Thus, building and operating costs can be reduced. In two series of three trials each, performance was similar for three-to four-week weaned pigs housed in a single and a double deck nursery and in a triple deck nursery. There was no apparent ill effect on health, appearance and behavior. If properly designed and operated, decking can provide a means of improving management during the critical postweaning period.

The objective of this research was to evaluate the performance and pads of weaned pigs housed in triple deck cages in which three types of floors, galvanized woven wire, galvanized expanded metal and oil tempered wire cloth, were used.

Experimental Procedures

Eighteen 2 x 4 x 4 ft metal cages, stacked in three decks, were located in an environmentally controlled 7.5 x 14.5 x 22.8 ft nursery (figure 1). A 1 x 4 ft plywood sheet was used adjacent to the feeder. Three types of floors, .38 x 1.5 in galvanized woven wire, .75 x 1.50 in galvanized flat expanded metal and .5 x .5 in oil tempered wire cloth (quarry wire) were located in a Latin square pattern on each side of the nursery. Three trials were conducted using 312 pigs averaging 15.5 lb initially. Eight pigs were housed per cage (2 ft^2 per pig). There were 5 stacks of 3 cages each in trial 1 (summer), 6 stacks of 3 cages each in trial 2 (fall) and 2 stacks of 3 cages each in trial 3 (winter).

Crossbred pigs were randomly assigned to a stack of three cages from outcome groups based on sex and weight. A 22% crude protein corn-soybean meal diet containing 10% dried whole whey was fed until the average weight of pigs in a cage was 15 lb; then a 20% protein diet containing 10% whey was fed to 25 lb; and 18% protein diet without whey was fed afterwards. Pigs were weighed weekly and total feed consumption was recorded. Feed per unit of gain was calculated. The general appearance and behavior of pigs were observed and recorded. Pads of the feet were examined for cuts, cracks and abrasions and scored at the end of each trial. The trials were continued for either 42 or 49 days with an average of 44.3 days.

Temperature for the first two weeks was kept about 85°F with about 2 degrees drop each week thereafter if possible. In trial 1, conducted during the summer, temperatures in the nursery increased above the 85°F

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[1]Appreciation is expressed to Mr. Charlie Babb and Mr. Carl Eure for caring for pigs; to Dr. E. R. Collins, Jr. for advise; to Dr. Jim Steele for engineering help and to the Virginia Pork Industry Commission for final support.

during the day. The relative humidity ranged from 70 to 90% in trial 1 with a ventilation rate ranging from a minimum of 4 to a maximum of 25 CFM per pig. The humidity was lower during trials 2 and 3 (60 to 75%) with the ventilation rate ranging from 3 to 10 CFM per pig.

The data were analyzed by least squares analysis for statistical significance with pen means being used as the experimental unit.

Results

Average daily gain, feed intake, feed per gain and pad scores were not different ($P>.10$) between pigs housed on the bottom, middle and top decks (table 1). Although not statistically significant, pigs housed on the bottom deck ate more feed and grew faster than pigs housed on the middle and top deck.

There were no differences ($P>.10$) in average daily gain, feed intake and feed per unit of gain between pigs housed in cages with quarry wire, woven wire and expanded metal. However, pad scores were higher ($P< .05$), indicating more cuts, cracks and abrasions, for pigs housed in cages with quarry wire as compared to pigs housed in cages with woven wire and expanded metal.

Summary

Weaned pigs housed on the bottom, middle and top decks performed equally well with no apparent effects on their health and behavior. Although, pigs housed in cages with quarry wire had higher pad scores, indicating a greater number of cuts and abrasions, than pigs housed in cages with woven wire and expanded metal, performance of pigs was not affected by the types of flooring materials.

Table 1. Performance and Pad Scores of Weaned Pigs Housed in Triple Deck Cages with Three Types of Floors.

	By Decks			
Criteria	Bottom	Middle	Top	S.E.[a]
Avg daily gain, lb	.84	.76	.75	.03
Avg daily feed, lb	1.70	1.58	1.51	.09
Feed per gain	2.01	2.06	2.01	.04
Pad scores[c]	3.08	3.00	3.03	.25
	By Floor Types			
	Quarry	Woven	Expanded	S.E.
Avg daily gain, lb	.78	.81	.76	.03
Avg daily feed, lb	1.64	1.63]	1.52	.09
Feed per gain	2.08	2.01	2.00	.04
Pad scores[d]	3.64	2.61	2.86	.22

[a]Standard error of the mean (n=13) with pen mean used as the experimental unit.
[b]Mean of 13 pens (8 pigs per pen) with an initial weight of 15.5 lb and a final weight of 48.8 pounds.
[c]At the end of the trial, pads were scored from 1 to 5 with 1 given for pads with no cracks, cuts or abrasions and 5 given for pads with numerous cracks, cuts or abrasions.
[d]Higher (P< .05) scores for pigs housed on quarry wire as compared to pigs housed on woven wire and expanded metal.

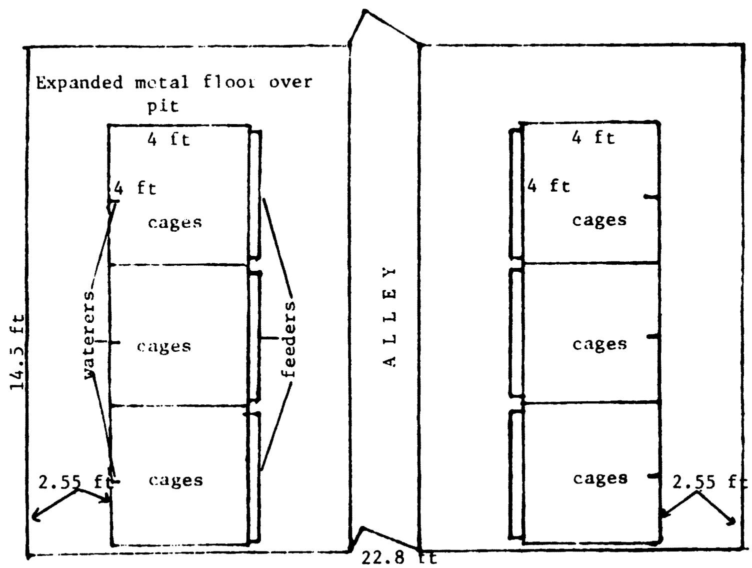

Figure 1. Plan view of triple deck nursery.

Floor Space Requirement of Weaned Pigs Housed in a Triple Deck Nursery

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The trend toward more confinement swine operations continues. Intensive use of confinement facilities is necessary to minimize housing costs per pig. Decking offers the potential of increasing nursery density, thus, further minimizing housing costs for weaned pigs. Research at Virginia Tech and limited research at Ohio State University and Purdue University has shown that performance is similar for pigs raised in single, double and triple deck nurseries.

The ideal number of three-to four-week weaned pigs per cage (square feet required per pig) has not yet been resolved. The current recommendation for pigs weighing from 22 to 40 lb housed on slatted floors is 3 sq ft of floor area per pig. However, there has been limited research concerning the floor space requirements of weaned pigs weighing 10 to 15 pounds. The proper pig density (floor space requirement) per cage must be determined in order to best utilize decked housing of weaned pigs.

This experiment was designed to evaluate the performance of pigs housed at a density of 2.7, 2.0 and 1.6 sq ft of floor area per pig in triple deck nursery. Daily gain, daily feed intake and feed per gain were the criteria used to measure performance.

Materials and Methods

Three series of trials were conducted with six, eight or ten pigs per 4 x 4 ft cage (2.7, 2.0 and 1.6 sq ft of floor space per pigs, respectively). Eighteen galvanized wire cages (4 x 4 x 2 ft) were stacked (three stacks of three cages each on each side of the room) in an environmentally controlled 18 x 12 x 7.5 ft nursery (figure 1). A vertically suspended, 6 ft section of 6 in duct pipe containing a 65 CFM blower fan was hung from the ceiling in the center of the nursery, to help equalize the temperatures at the top, middle and bottom decks. Heat was provided by a 4800 watt heater which sat on the floor in the alley.

The cages had expanded metal or woven wire floors which allowed feces, urine and water to fall through to the pit below. There was one nipple waterer per cage. The feed trough ran across the front of the cage on the middle and top decks and was partitioned so that six pigs could eat at any one time. Trough space per pig was 8, 6 and 4.8 in for six, eight and ten pigs per cage, respectively. Thirty-six inch self-feeders were used on the bottom decks.

All pigs were started on a 22% crude protein corn-soybean meal diet containing 10% dried whole whey and fortified with mineral, vitamin and antibiotic. At an average pen weight of 15 lb, the diet was changed to a 20% protein

[1]Appreciation is expressed to Virginia Pork Industry Commission for partial support.

diet containing 10% whey. At an average pen weight of 25 lb, the diet was changed to 18% protein with no whey. All diets met NRC requirements, including .1 ppm selenium and recommended levels of chlorotetracycline, penicillin and sulfamethiazine. The 22% diet was reground to prevent the smaller pigs from sifting throught and picking out the corn.

Pigs were initially fed small amounts to ensure that they had fresh feed. Any soiled or old feed which accumulated in the feeders was replaced. Later, feed was supplied in greater amounts to ensure that pigs always had feed available.

Pigs were weighed, feed consumption measured and feed efficiency calculated weekly. Fecal consistency, dunging patterns, and cleanliness of all pigs were observed. At the end of the test, each pigs' pads were checked for cuts, cracks and abrasions and were scored from 1 to 5, with 1 being the best and 5 being the worst.

Humidity, temperature and fan speed were measured each morning and afternoon. The humidity ranged from 60-90% and the ventilation rate was 5 to 12 CFM per pig over the seven week trials. The temperature ranged from 78 to 85° F, with the bottom deck approximately 2 to 4°F lower than the top deck.

Crossbred pigs were weaned at three to four weeks of age ($\bar{X}$ = 22.7 days). The pigs were randomly assigned from outcome groups based on sex and weight to treatments.

Data was analyzed using least squares analysis with the Duncan Multiple Range test identifying the treatment differences. These trials were conducted at Blacksburg in the fall and winter, 1977-78.

Results

Pigs housed in the middle deck had greater ($P < .05$) overall average daily gains (.74 lb) than did those in either the top (.70 lb) or the bottom (.66 lb) decks (table 1 and figure 2). During 29 to 35 days, pigs housed in the middle deck showed the greatest ($P < .05$) average daily gains followed by pigs in the bottom deck with the lowest gain attained by pigs housed in the top deck. During the last period (43-49 days), average daily gains continued to be greater for pigs housed in the middle deck, but pigs housed in the bottom deck had the lowest gains. Daily gains of the top deck pigs were intermediate. During 36-42 and 43-49 days, pigs housed in the middle and top decks had similar average daily feed intake. Overall daily feed intake was not different among decks. Feed per unit of gain was lower ($P < .05$) for pigs housed in the middle deck as compared to pigs housed in the bottom deck during 8 to 14, 22 to 28, 29 to 35 and 0 to 49 days with intermediate values for pigs housed in the top deck.

Pad scores were not different among pigs housed on the various decks (table 2). Pigs housed on the top deck had lower cleanliness scores at 3, 5 and 7 weeks with the highest scores for pigs housed in the bottom deck.

In general, average daily gains were lowest for ten pigs housed per cage with little differences for eight and six pigs per cage (table 1 and figure 2). Differences were significant ($P < .05$) during 22 to 28, 29 to 35 and 0 to 49 days.

Average daily feed intake increased as number of pigs per cage decreased after 14 days with a significant difference after 28 days. The greatest difference occured between eight and ten pigs per cage.

Feed per unit of gain, in general, was similar for six, eight or ten pigs per cage with only a small but overall significantly larger ($P < .05$) feed per unit of gain for six pigs per cage as compared to eight or ten per cage. The reduced feed consumption which resulted in reduced daily gains ten pigs per cage could have been due to inadequate trough space per pig, not enough floor space per pig and too much stress caused by crowding. The differences became greater as the trials progressed (and the pigs grew larger).

Summary

Three trials were conducted in an environmentally controlled, triple deck nursery with six, eight or ten pigs per 4 x 4 ft cage (2.7, 2.0 and 1.6 sq ft of floor space per pig, respectively).

In general, pigs housed in the middle deck consumed more feed, grew faster and were slightly more efficient than pigs housed in the bottom deck, with performance intermediate for pigs housed in the top deck. After three weeks, pigs housed ten per cage consumed less feed and grew slower than pigs housed six per cage. Feed per unit of gain was similar, although overall, six pigs per cage required slightly more feed per unit of gain. Pigs housed on the upper decks were cleaner with no differences in cleanliness scores among pigs housed ten, eight or six pigs per cage.

Table 1. Weekly Average Daily Gain, Feed Intake and Feed Per Gain of Pigs Housed in Triple Deck Nursery with Six, Eight or Ten Pigs Per Cage.

	Main Effects					
Postweaning	Decks			Pigs Per Cage		
period, days	Top	Middle	Bottom	10	8	6
Avg daily gain, lb^{a,b}						
0- 7	.12^{c}	.10	.08	.11	.10	.09
8-14	.40	.40	.39	.36	.41	.42
15-21	.56	.57	.60	.54	.61	.59
22-28*	.82	.80	.80	.81de	.79^{e}	.82^{d}
29-35*	.93^{f}	1.07^{d}	.97^{e}	.90^{e}	1.03^{d}	1.04^{d}
36-42	1.04	1.09	.98	.98	1.04	1.10
43-49	1.06^{de}	1.17^{d}	.83^{e}	.95	1.05	1.06
Overall	.70de	.74^{d}	.66^{e}	.66^{e}	.72^{d}	.73^{d}
Avg daily feed intake, lb^{c}						
0- 7	.24	.25	.23	.26	.23	.23
8-14	.64	.56	.64	.61	.60	.62
15-21	1.06	1.00	1.00	.95	1.03	1.08
22-28	1.32	1.21	1.42	1.23	1.32	1.40
29-35	1.89	1.89	1.93	1.76^{e}	1.94^{d}	2.01^{d}
36-42*	2.04^{de}	2.15^{d}	1.95^{e}	1.94^{e}	2.06^{de}	2.14^{d}
43-49	2.30^{d}	2.42^{d}	2.03^{e}	2.08^{e}	2.23^{de}	2.43^{d}
Overall	1.35	1.35	1.32	1.26^{e}	1.34^{de}	1.42^{d}
Feed per unit of gain^{c}						
0- 7	2.00	2.50	2.81	2.36	2.30	2.56
8-14	1.64^{de}	1.44^{e}	1.75^{d}	1.77	1.52	1.54
15-21	1.98	1.81	1.71	1.81	1.76	1.92
22-28*	1.65^{de}	1.54^{e}	1.82^{d}	1.58	1.70	1.73
29-35*	2.09^{d}	1.77^{e}	1.99^{d}	2.00	1.89	1.95
36-42	1.98	2.05	2.02	2.03	2.04	1.99
43-49	2.26	2.12	2.54	2.28	2.26	2.37
Overall	1.93^{e}	1.83^{f}	1.99^{d}	1.91^{e}	1.89^{e}	1.96^{d}

[a] Avg initial weight was 13.0.
[b] Avg final weights were 46.8, 48.7, 44.8, 44.9, 47.3, 48.1, for top, middle, and bottom decks and ten, eight and six pigs per cage, respectively.
[c] Means were adjusted for average initial weight and age.
[def] Means on same line and within the same main effect with different superscripts are significantly ($P < .05$) different.
* Significant ($P < .05$) interaction between decks and number of pigs per cage.

Table 2. Pad Scores and Weekly Cleanliness Scores for Pigs Housed In Triple Deck Nurseries with Six, Eight and Ten Pigs Per Cage.

	Main Effects					
	Decks			Pigs Per Cage		
Item	Top	Middle	Bottom	10	8	6
Pad score[a]	2.8	3.6	3.3	3.3	3.2	3.3
Cleanliness score[b]						
Week 3	0.0	.3	.3	.2	.2	.2
Week 5	.7[d]	1.0[cd]	1.4[c]	1.0	1.1	1.0
Week 7	1.3[d]	2.3[cd]	2.9[c]	2.2	2.0	2.3

[a]At the end of the trial, pads were scored from 1 to 5 with 1 given for pads with no cracks, cuts or abrasions and 5 given for pads with numerous cracks, cuts or abrasions.
[b]Scored subjectively, 1-3 with 1 being the cleanest.
[cd]Means on the same line within the same main effect with different superscript letters are different ($P < .05$).

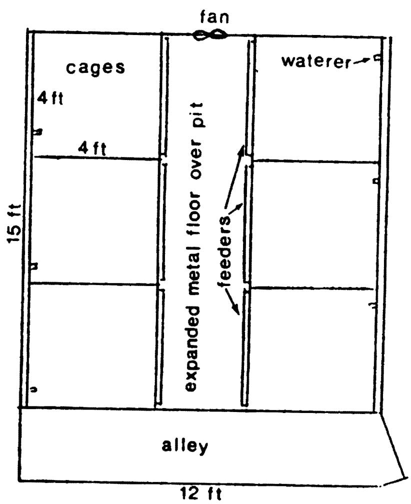

Figure 1. Plan view of Triple Deck Nursery.

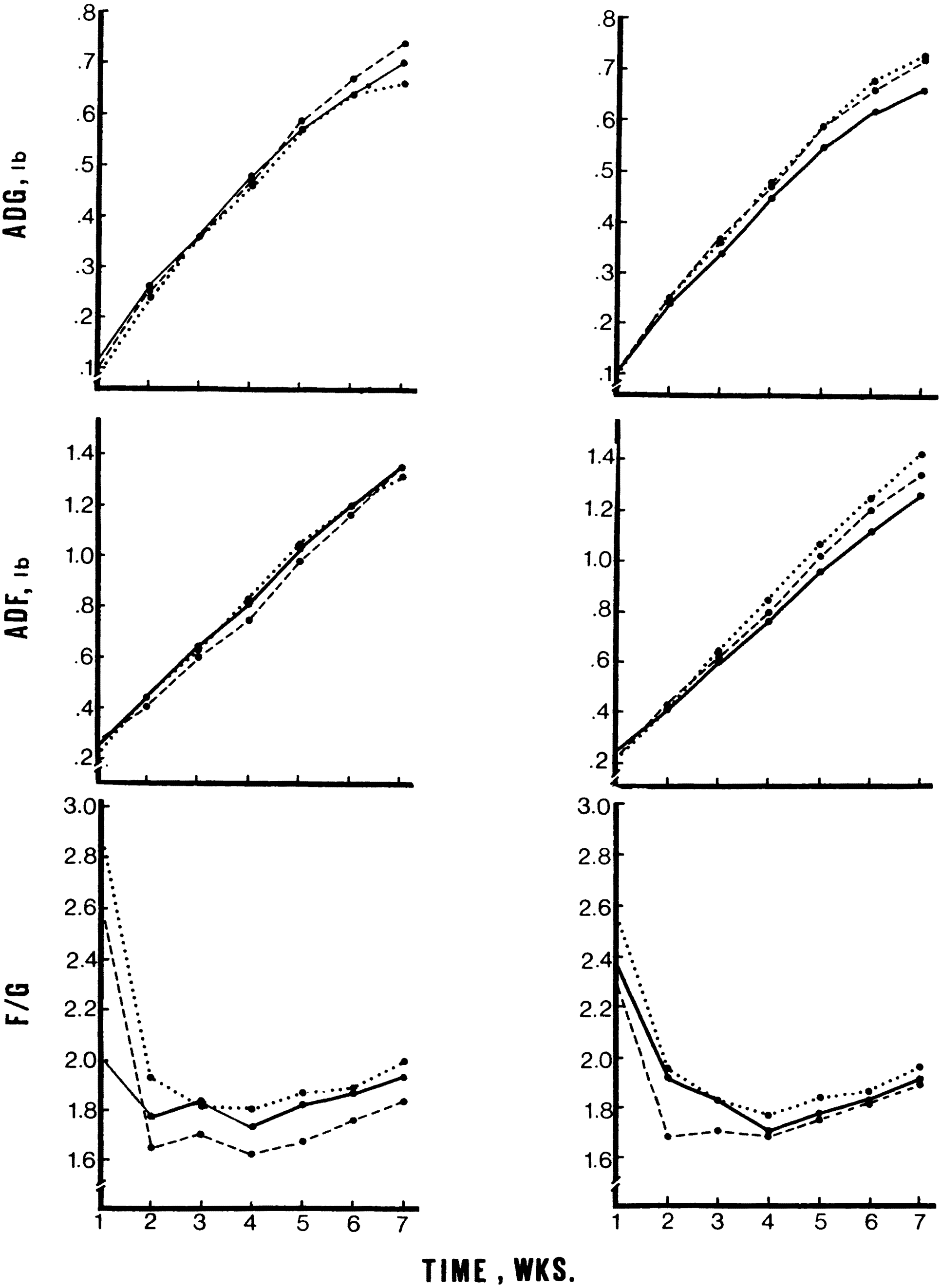

Figure 2. Accumulative average daily gain (ADG), average daily feed intake (ADF) and feed per gain (F/G) of pigs housed in a triple deck nursery (top ——, middle ----, bottom ····) with six (····), eight (----) or ten (——) pigs per cage.

INFLUENCE OF CROSSBRED SIRES AND A GROWTH STIMULANT ON PREWEANING PERFORMANCE OF CALVES.

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Forty-two Shorthorn and 48 Crossbred (Angus-Hereford-Shorthorn) cows were divided by weight, age and breed into two equal groups. One group was mated to Hereford bulls and the other group to Simmental x Hereford bulls. The resulting calves were alloted by breed, sex and age to four groups (1,2,3,4) with group 1 as controls (no ralgro); group 2 and 4 received 36 mg of ralgro at birth; group 3 was implanted with 36 mg of ralgro at 4 months and group 4 received a second 36 mg implant at 4 months.

Cows were separated into breeding groups on similar pastures and placed with the proper sires on May 5, 1977 and were allowed a breeding season of 90 days. Following the breeding season herds were combined (August 1). During the grazing season all cows were allowed access to pastures containing Orchard Grass-Bluegrass-White Clover with free choice minerals and running water. Winter feed consisted of mixed hay prior to calving and a combination of mixed hay and corn silage thereafter. No protein or energy supplement was fed. Calves were dehorned, males castrated, innoculated according to proper herd health procedures and received treatments for internal parasites and cattle grubs. Calves remained with their dams from birth to weaning which occured on October 17, 1978. Results are shown in Table 1.

TABLE 1. CALF PERFORMANCE

	Number Calves	Birth Wt.lbs.	Weaning Wt.lbs.	ADG.
Shorthorn Dams (42)	37	79	511	1.97
Crossbred Dams (48)	46	78	547	2.07
Hereford Sires	38	75	513	1.96
Simm x Her. Sires	45	81	545	2.10
Implant Group				
1	21	79	520	2.01
2	19	77	532	2.06
3	20	78	513	1.94
4	23	80	551	2.13

There were 4 or 5 calves in group 3 that didn't gain as rapidly as the other calves in this treatment group. Calves from crossbred cows gained 5% more than those from Shorthorn cows. Simmental x Hereford sired calves gained 7% more than those by Hereford bulls. Calves implanted at birth gained 2% more than non-implanted calves, while implants at 4 months prodiced a 9% increase in gains. Additive performance response to the combined breeding-management programs was approximately 20%.

PRE- AND POSTWEANING MANAGEMENT OF BEEF CALVES

W. D. Lamm, T. L. Bibb, G. R. Dana, F. S. McClaugherty,
W. H. McClure, J. S. Copenhaver and J. P. Fontenot

Virginia has traditionally been a feeder calf producing state with calves primarily shipped north or to the Corn Belt states at weaning. There is considerable stress associated with weaning and subsequent shipment, often enhancing the chances of respiratory problems and consequently poor performance.

In recent years there has been considerable interest in preventing these problems by certain management practices both pre- and postweaning. In fact, some states conduct feeder calf sales in which certification of these management practices is given. "Preconditioning" can include many aspects but usually includes 1) castration and dehorning, 2) immunization and 3) weaning and feeding.

Experimental Procedure

In the fall of 1978, preconditioning studies involving 191 calves were conducted at four Virginia Tech farms. The calves used were born from February 1 to May 12, 1978. Each farm will be discussed independently.

The following treatments were applied to all calves two to three weeks preweaning:

1) immunized with IBR, PI_3, BVD and a 7 strain Clostridium vaccine
2) wormed with thiabendazole
3) grubicide
4) castration and dehorning

All calves were weaned in mid-October and transported by truck to their final destination within 24 hours of weaning. Glade Spring and Steeles Tavern are located approximately 100 miles from Blacksburg. Smithfield and the Hoge farm are located at Blacksburg. The calves used at Catawba were raised on the farm there. Calves were weaned directly off their dams and were not creep fed.

Glade Spring

Upon arrival calves were placed in an open barn and fed grass hay for three days. They were then moved to fescue pasture where they remained without supplemental grain or protein for 24 days. After one week on pasture, all calves were injected with a broad-spectrum antibiotic.

Smithfield

Calves were fed grass hay the first day after arrival. Thereafter, they were fed hay free-choice and a ground ration (shown below) fed in 1 lb increments until heavier calves were fed 10 lb daily and lighter calves 12 lb daily. An antibiotic containing chlortetracycline and sulfamethazine was fed at the rate of .17 lb per head daily throughout the 29 day trial.

Ingredient	Percent, wet basis
Grass hay	50.0
Corn grain	40.2
Soybean meal	3.5
Liquid molasses	5.0
Trace mineral salt	.5
Vitamin A premix	.5
Limestone	.3
	100.0

Steeles Tavern

Calves were fed Ration A (below) for three days after arrival. For the next 11 days they received a full feed of Ration B (below). At this time corn silage was introduced at the rate of 10 lb per head until they were consuming 20 lb per head by day 28. As silage intake increased, Ration B was decreased until the calves were only fed corn silage by the end of the trial.

The intake of Ration B during the 25-day period averaged 6.25 lb per head daily. Corn silage intake averaged 15 lb during the 14 days it was fed. An antibiotic containing chlortetracycline and sulfamethazine was fed at the rate of .17 lb per head daily.

	Ration A		Ration B	
Ingredients	lb	%	lb	%
Mixed hay	600	42.86	300	20.00
Shelled corn	300	21.43	500	33.33
Barley	300	21.43	500	33.33
Soybean meal	100	7.14	100	6.67
Molasses	100	7.14	100	6.67
	1400	100.00	1500	100.00

Catawba

Calves were weaned and placed directly into a confinement unit and fed grass-legume hay free choice the first day. Beginning the 2nd day corn silage was fed at the rate of 10 lb per head daily with no supplemental grain or protein. The corn silage was increased to 15 lb on day 3 and 20 lb on day 4. This level was fed until day 12 at which time the silage was increased to 25 lb and 2 lb of coarsely cracked high-moisture corn and 1 lb of soybean meal was fed.

Silage intake reached a maximum of 30 lb on days 14-15 and gradually declined to 10 lb by day 25. Corn grain was increased to 4 lb on day 19 and was up to 10 lb by day 28. Soybean meal remained constant at 1 lb throughout the study. No antibiotic was fed.

Results

Glade Spring

The performance of these calves is presented in table 1. When weaning weights were used as the base from which to compare performance, calf weight loss averaged 6.2 lbs after 27 days. However, if arrival weight was used, calf gain was 42.8 lbs. Shrink incurred between weaning and arrival was 49 lbs, which indicates calves had not recovered their original weaning weights while grazing fescue pastures with no supplemental feed for 27 days.

The only sickness encountered was after one week on pasture, a few calves were coughing and all calves were subsequently treated once.

Smithfield

The performance of these calves is shown in tables 2 and 3. Interestingly, the calves requiring the shortest haul incurred the greatest shrink (39 lbs., table 2). The daily gain of the calves fed a dry, ground ration was approximately .8 lb faster than calves grazing fescue pasture at the Glade Spring unit.

No sickness was detected in any calves and none were treated.

Steeles Tavern

Results at this unit are shown in table 4. The shrink observed between arrival and weaning was similar to that observed between the Hoge farm and Smithfield (35.5 vs 39 lbs), although travel distance was considerably different. These calves gained at a slower rate than those fed a dry, ground ration at Smithfield or grazing pasture at Glade Spring.

No sickness problems were encountered and no calves were treated.

Catawba

Calf performance is given in table 5. Bull calves gained twice as fast as heifers during the 28-day study. However, overall performance of both sexes was considerably lower than that observed at the other units.

Sickness was not a problem and no calves were treated.

Summary

The performance of calves in this study indicates that to recover weaning weights postweaning, calves should be confined and fed at least a 50% concentrate ration. It appears grazing pasture or feeding corn silage will not support performance similar to calves fed a dry, ground ration.

Immunizing, castrating and dehorning calves at least two weeks prior to weaning certainly contributed to the low incidence of stress and sickness observed in this study as compared to that normally associated with weaning and immediately transporting calves.

TABLE 1. PERFORMANCE OF CALVES AT GLADE SPRING

Origin	Hoge Farm
Sex	Steers
No. of animals	24
Weaning wt. (10/17/78)	585.0
Arrival wt. (10/18/78)	536.0
Arrival wt. - weaning wt.	49.0
Interim wt. (10/24/78)	536.2
Interim wt. (10/31/78)	550.8
Final wt. (11/14/78)	578.8
Final wt. - weaning wt.	- 6.2
Final wt. - arrival wt. (27 days)	42.8
Daily gain (27 days)	1.58

TABLE 2. PERFORMANCE OF CALVES BY ORIGIN AT SMITHFIELD

Origin	Glade Spring			Steeles Tavern			Hoge Farm
Sex	Heifers	Steers	Total	Heifers	Steers	Total	Steers
No. of animals	4	3	7	19	12	31	9
Weaning wt. (10/16/78)	385.5	426.0	402.8	319.2	362.1	335.8	432.8
Arrival wt. at S'field (10/18/78)	372.2	406.7	387.0	302.5	342.2	317.9	393.8
Difference	13.3	19.3	15.8	16.7	19.9	17.9	39.0
Final wt. (11/16/78)	436.2	473.3	452.1	373.3	414.8	389.4	462.8
Final wt. - weaning wt.	50.7	47.3	49.3	54.1	52.7	53.6	30.0
Daily gain (31 days)	1.64	1.52	1.59	1.74	1.70	1.73	.97
Final wt. - arrival wt.	64.0	66.6	65.1	70.8	72.6	71.5	69.0
Daily gain (29 days)	2.21	2.30	2.24	2.44	2.50	2.46	2.38

TABLE 3. OVERALL PERFORMANCE OF CALVES AT SMITHFIELD

	Heifers	Steers	All Cattle
No. of animals	23	23	47
Weaning wt., lbs. (10/16/78)	330.7	396.6	364.4
Arrival wt. at Smithfield (10/18/78)	314.6	369.6	342.7
Difference	16.1	27.0	21.7
Final wt., lbs. (11/16/78)	384.3	440.1	412.8
Final wt. - weaning wt.	53.6	43.5	48.4
Daily gain (31 days)	1.73	1.40	1.56
Final wt. - arrival wt.	69.7	70.5	70.1
Daily gain (29 days)	2.40	2.43	2.42

TABLE 4. PERFORMANCE OF CALVES AT STEELES TAVERN

Origin	Hoge Farm
Sex	Heifers
No. of animals	41
Weaning wt. (10/16/78)	526.6
Arrival wt. (17/17/78)	491.1
Difference	35.5
Interim wt. (10/31/78)	517.2
Final wt. (11/15/78)	533.4
Final wt. - weaning wt.	6.8
Daily gain (30 days)	.23
Final wt. - arrival wt.	42.3
Daily gain (29 days)	1.46

TABLE 5. PERFORMANCE OF CALVES AT CATAWBA

Origin	Catawba		
Sex	Heifers	Bulls	Total
No. of animals	38	41	79
Weaning wt. (10/23/78)	520.5	527.6	524.2
Final wt. (11/20/78)	525.1	538.3	532.0
Difference	4.6	10.7	7.8
Daily gain (28 days)	.16	.38	.28

PERFORMANCE OF ANGUS AND ANGUS X HOLSTEIN COWS AND THEIR CALVES FED TWO WINTER ENERGY LEVELS[1]

W. D. Lamm and T. N. Meacham

With increased emphasis on larger, growthier calves, the use of beef-dairy crossbred females as brood cows appears promising. This type of female produces more milk and has been shown to wean heavier calves than conventional beef cows. The physiological stress of the increased milk production of these dairy-cross cows may cause a delay in the return to estrus after calving. The influence of greater body size of the crossbred cow on the nutrient requirements for production may also be involved when feed supplies are relatively limited.

Experimental Procedure

As reported in VPI & SU Research Division Reports 172 and 174, 47 Angus (A) and 51 Angus x Holstein (AH) 2-year-old heifers were initially pasture bred by registered Angus bulls from April 12 to June 25, 1976. After a summer grazing period, they were confined to drylots where they were wintered on corn silage and soybean meal at either 80 or 100% of N.R.C. energy (TDN) requirements from December 1, 1976, to April 21, 1977. At this time the cows and their calves were returned to pasture. Subsequently, the cows have been wintered using corn silage and urea. They are returned to pasture when grazing is available.

1978 Calf Crop

Research Division Report 174 reported calf performance at birth. On September 20 all calves were immunized with IBR, PI_3, BVD and 7 strains of Clostridia and treated for internal and external parasites. The calves were returned to pasture with their dams and weaned October 23.

Cow Wintering Study (1978-79)

After weaning October 23, 1978, the cows grazed corn crop residues and fall pasture until scored for condition, wither heighth measured and placed into drylots on November 30. The cows were assigned to the same wintering treatment they received the previous two wintering periods. Rations consist of corn silage fed once daily to provide either 80 or 100% of N.R.C. recommended levels of energy (TDN). Pregnant Angus and crossbred cows fed the 100% N.R.C. level were fed 28.53 and 30.44 lbs., respectively, of corn silage daily and A and AH cows fed the 80%N.R.C.level received 21.89 and 24.36 lbs., respectively, of corn silage daily. Urea was used to supply nitrogen as needed.

After calving, the cows will be fed 38.80 and 49.09 lbs. corn silage to the 100% A and AH cows, respectively, and 30.11 and 38.34 lbs. to the 80% A and AH cows, respectively. Cows began calving March 12, 1979. When grass is available for grazing, the cows and their calves will be turned out. A mineral mixture composed of 100 lbs. trace mineral salt, 80 lbs. of defluorinated phosphate and 80 lbs. of magnesium oxide is available free-choice at all times of the year.

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[1]Appreciation is expressed to Henry Dickerson, Dave Gibson and Alan Lee for care of the experimental animals.

Results

1978 Calf Crop

These data are presented in table 1. Bull calf birth weights were 11 lbs. heavier for crossbred versus Angus cows, while heifer calves from Angus dams were 4 lbs. heavier than those from crossbred dams. Calves from dams fed the 80% winter energy level were 5 lbs. heavier than calves from dams fed the 100% level. There appeared to be no differences in calf mortality related to cow winter treatment. However, bull calves from the crossbred cows and heifer calves from the Angus cows had higher mortality rates than their counterparts.

At weaning, bull and heifer calves from crossbred cows had 205-day adjusted weaning weights 76 and 24 lbs. heavier, respectively, than those from Angus cows. Calves from cows fed the 80% winter energy level were 5 lbs. heavier at weaning than calves from cows fed the 100% energy level. Possibly this is the result of better milk production by cows fed the 80% energy due to less udder fat.

Cow Wintering Study (1978-79)

Some pertinent data from the previous two years and preliminary data from this year are presented in table 2. Angus x Holstein cows weaned 12.7% more calves than did Angus cows when number of calves weaned is related to cows exposed to breeding the previous year.

Based upon results of rectal palpation for pregnancy, 1 Angus x Holstein and 3 Angus cows have been culled due to not weaning a calf two years in a row. Four 100% energy crossbred cows, 2 of the 80% Angus cows and 1 of the 80% crossbred cows were open following a 66-day breeding season which began June 17, 1978.

The 100% Angus cows had the highest degree of condition entering the wintering period, while the 80% crossbred cows exhibited the lowest degree of condition. Angus cows were considerably fatter than crossbred cows.

After 83 days on the wintering ration, the cows fed the 80% energy level had lost approximately 30 lbs. while cows receiving the 100% energy level maintained their initial weights.

Subsequent cow and calf performance will be reported at a later date.

TABLE 1 . PERFORMANCE OF SUCKLING BULL AND HEIFER CALVES (1978 CALF CROP)

	Cow Wintering Treatments							
	100% N.R.C.				80% N.R.C.			
	Angus[a]		Angus x Holstein[a]		Angus		Angus x Holstein	
Item	B[b]	H[c]	B	H	B	H	B	H
No. of calves born	10	10	11	10	10	10	13	12
No. of calves weaned, 10/23/78	10	9	10	10	10	8	11	12
Average birth date	4/12	3/21	3/28	4/6	4/5	3/23	4/2	3/31
Birth weight, lb.	85.7	84.2	96.3	80.9	87.1	92.6	98.0	88.2
No. of calves by sire								
Angus	2	2	-	2	6	1	1	-
Polled Hereford	6	6	5	6	1	3	7	8
Simmental	2	2	6	2	3	6	5	4
205-day adjusted weaning wt., 10/23/78, lb.	496.2	488.6	577.4	509.4	501.7	495.8	572.2	522.6

[a]Breed of cow.

[b]Bull calves.

[c]Heifer calves.

TABLE 2. PERFORMANCE OF ANGUS AND ANGUS X HOLSTEIN COWS (1978-79)

	Cow Wintering Treatments			
	100% N.R.C.		80% N.R.C.	
Item	Angus[a]	Angus x Holstein[a]	Angus	Angus x Holstein
No. of cows pregnant (12/1/76)	24	26	23	25
Initial weight (12/1/76)	1006.2	1108.3	1009.1	1107.8
No. of cows pregnant (11/30/77)	20	21[b]	20	25
Cow weight[c] (11/30/77)	1042.0	942.4	1001.8	1043.0
No. of calves weaned (10/23/78)	19	20	18	23
Calves weaned as % of cows exposed	79.2	90.9	78.3	92.0
No. of cows sold (10/24/78)	1	0	2	1
No. of cows pregnant (11/30/78)	21	18	20	24
No. of cows open (11/30/78)	0	4	2	1
Cow weight[c] (11/30/78)	1117.4	1080.8	1063.0	1081.2
Cow condition score[d] (11/30/78)	3.6	2.6	3.0	2.4
Cow weight[c] (2/21/79), 83 days	1106.0	1098.3	1037.2	1040.0
Lbs. feed consumed per cow, as fed (11/30/78 to 2/21/79), 83 days				
Corn silage[e]	2368.0	2526.5	1816.9	2021.9
Urea	-	9.5	5.9	15.1

[a]Breed of cow.

[b]Four cows died of causes unrelated to winter treatment.

[c]Does not include cows not pregnant.

[d]1 = very thin, 5 = extremely fat.

[e]45% dry matter and 7% crude protein (dry basis).

EFFECT OF IMPLANTING ZERANOL IN SUCKLING CALVES

W. H. McClure and J. P. Fontenot

It was shown by Virginia and other researchers that implanting suckling calves increased rate of gain and weaning weight. A trial was conducted during the summer and fall of 1978 at the Shenandoah Valley Research Station to study further implanting calves from cows which calved in late spring.

Experimental Procedure

Twenty seven suckling steers and heifer calves from cows which are used to study the effect of feeding broiler litter during the winter feeding period were used for this study. The cows were on native bluegrass-clover pastures during the trial. The calves were born in April and May. On July 5 the calves were paired on the basis of sex and weight, and one of the calves in each pair was allotted at random to be implanted with 36 mg zeranol (trade name: Ralgro).

The calves were weighed, initially on October 26, November 30 and December 21 (end of test).

Results

Rate of gain of the calves was lower than desirable, but fairly good considering they were started on test July 5, after which pasture was lower in quality than in early spring. Overall, the zeranol implant increased rate of gain by 19% (1.24 vs. 1.47 lb/day). A consistent response was noted during each period, regardless of the rate of gain of the control calves. The implant increased the gain up to weaning by 34 lb per calf.

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[1]The implants were supplied by IMC Chemical Group, Terre Haute, Indiana.

TABLE 1. IMPLANTING ZERANOL IN SUCKLING CALVES

	Implant	
Item	None	Zeranol
No. of calves	13	14
Initial wt., lb.	207	198
Daily gain by period, lb.		
Days 0-113	1.46	1.67
Days 113-148	1.11	1.39
Days 148-159	0.24	0.43
Days 0-159	1.24	1.47
Weaning weight, lb.	395	420

ECONOMIC POTENTIALS FROM PERENNIAL FORAGE-CATTLE FINISHING SYSTEMS

F. S. McClaugherty, J. P. Fontenot, J. L. Hale, R. E. Blaser and K. E. Webb, Jr.

Forages are produced on more acres in Virginia than any agricultural crop. Grass and legume forages can be produced on land not suitable for crops requiring cultivation, and can be harvested by cattle. Using cattle to harvest improved forages in all four seasons of the year eliminates most of the harvesting, storing and feeding expenses of the conventional cattle feeder. Increased demand for cereal grains for human food keeps prices high and is strong competition for the cattle feeder. This competition has increased the value of high quality forage for fattening cattle. Fescue 31 and red clover can be stockpiled from early August to November to supply high quality winter feed. Adding red clover to the winter pasture improves the quality of the mixture, eliminating the need to provide a protein supplement. It also stimulates additional growth of the fescue and lowers the amount of nitrogen fertilizer required to produce an abundance of fescue forage.

Bluegrass and white clover have consistently produced excellent cattle gains from early April through June, but hot and dry weather in July, August and September emphasizes the need for a forage that will supplement the native bluegrass and clovers. Alfalfa grows well in the summer months and perhaps can be used to increase cattle gains in these months when cattle are not gaining satisfactorily.

Cattle on spring and summer pasture can be fattened to grade top good to low choice by feeding grain at the rate of 1% of bodyweight. With the use of limited grain feeding, perhaps cattle can be fattened to reach market at other time periods during the year. Cow-calf producers have been forced to market their calves in the fall regardless of the market price because they did not have feed and facilities to winter them. With improved forage systems the producer could retain his calves until the market improves or fatten them for market with about four choices of time to sell.

The main objectives of the research is to develop perennial forage-cattle management systems that provide forage of adequate nutritional value to produce sufficient gains for growing and fattening cattle with little or no additional grain and no protein supplement.

Experimental Procedures

Both yearling steers and steer calves have been incorporated in an effort to produce fat cattle in spring, summer, fall and winter. A description and summary of the seven systems being studied in this experiment are outlined in figure 1. Data have been collected on 24 steer calves and 18 yearling steers during each of 2 years at two locations. The experiment was conducted at the Southwest Virginia Research Station, Glade Spring, Va. and the Virginia Forage Research Station, Middleburg, Va. All animals were implanted with 36 mg of Ralgro in fall and spring. Results reported are from the work at Glade Spring.

Results

Results for the first year were given in last year's Research Report (V.P.I. & S.U. Res. Div. Rep. 174, p. 126). Results of the second year (1977-78) are given in tables 1, 2 and 3. The winter of 1977-78 was more severe than the first year of the experiment. Snow covered the ground for a period of 67 days from January 4 through March 12. Winter gains were about the same as the first year, less than desirable. Feeding grain improved rate of gain (table 1). Feeding grain at 0.5% of bodyweight increased daily gain about .32 lb. Daily gains in spring were very good, averaging over 2 lb. per day in calves and yearlings from late April until August 1. Feeding grain during this period did not increase rate of gain.

Carcass grade of the steers fed grain at 1% of bodyweight from November until slaughtered in mid-May averaged good (system 7). The grade for those fed grain at 0.5% until spring, then at 1% until August 1 was low good. The carcasses of the yearlings fed no grain graded only standard by August 1 (system 6). Performance was suboptimal during the winter for the cattle in these three systems, due at least partly to heavy snow accumulations.

The gains of the steers started as calves were poor from August until October except for those fed grain at 1% of bodyweight (system 4). Rate of gain during the spring and summer was quite good for the cattle fed no grain, averaging over 1.5 lb. per day (table 2). Feeding grain at 0.5% of bodyweight during that period did not improve gain (systems 1 vs. 2).

Live slaughter grades were low choice for the steers which had been fed grain (systems 2 and 4). However, carcass grades averaged low to average good. The carcass grades were average standard in October for the steers which had not been fed grain. After a 90-day feed on corn silage and supplement the carcasses of the other steers graded between average and high good.

A number of systems show potential for producing good grade cattle mainly on forage with minimum grain.

TABLE 1. FORAGE FINISHING OF STEERS IN SOUTHWEST VIRGINIA, NOVEMBER TO AUGUST, 1977-78

System no.	1	2	3	4	5	6	7
Kind of steers, initially	Weanling calves				Yearlings		
Type of grazing	Top		Whole		Whole	Top	Whole
Grain level, % of bodyweight	0	0.5	0	0.5[a]	0.5[a]	0	1.0
Number of steers	6	5[b]	6	6	6	6	6
Initial wt., 11/23/77, lb.	492	494	493	497	666	667	667
Spring wt., 4/28/78, lb.	585	682	609	619	826	800	878
Gain per head, winter, lb.	93	188	116	122	160	133	211
Daily gain, winter, lb.	0.60	1.20	0.74	0.78	1.02	0.85	1.35
Wt., August 1, 1978, lb.	804	884	832	804	1021	1022	884[c]
Gain per head, spring, lb.	219	202	223	185	195	222	6[c]
Daily gain, spring, lb.	2.31	2.13	2.35	1.95	2.05	2.34	0.35[c]
Gain/head, winter & spring, lb.	312	390	339	307	355	355	217[c]
Daily gain, winter & spring, lb.	1.24	1.55	1.35	1.22	1.41	1.41	1.25[c]
Slaughter grade[d]	7.5	10.8	8.0	9.2	12.2	8.5	10.8
Carcass grade[d]					8.8	7.3	9.7

[a] Increased to 1.0% of bodyweight in April.
[b] One steer died on Feb. 15, 1978. Cause was not related to treatment.
[c] Final weight was May 15, 1978.
[d] Code: 7.0=avg. standard; 10.0=avg. good; 13=avg. choice; etc.

TABLE 2. FORAGE FINISHING OF STEERS IN SOUTHWEST VIRGINIA AUGUST TO JANUARY, WEANLING CALVES, 1977-79

System no.	1	2	3	4
Type of grazing	Top		Whole	
Grain level, % of bodyweight	0	0.5	0	1.0
Weight, October 16, 1978	861	950	865	947
Gain per head, August to October	57	66	33	143
Daily gain, lb.	0.75	0.87	0.43	1.88
Gain per head, April to October, lb.	276	268	256	328
Daily gain, lb.	1.61	1.57	1.50	1.91
Slaugher grade[a], October	9.7	11.8	7.7	12.2
Carcass grade[a,b], October	6.7	10.5	7.3	8.9
Wt., January 16, 1979	1092		1049	
Gain in feedlot, lb.	207		196	
Daily gain, lb.	2.25		2.13	
Feed per head (feedlot)				
Corn silage, lb.	3720		3645	
Soybean meal	182		182	
Slaughter grade[a,c], January	12.0		11.0	
Carcass grade[a,c], January	10.7		10.3	

[a]Code: 7.0=avg. standard; 10.0=avg. good; 13.0=avg. choice; etc.
[b]Animals slaughtered in October.
[c]Animals slaughtered in January.

TABLE 3. FEED CONSUMED BY GRAZING STEERS. 1977-78

System no.	1	2	3	4	5	6	7
Kind of steers, initially	Weanling calves				Yearlings		
Type of grazing	Top		Whole		Whole	Top	Whole
Grain level, % of bodyweight	0	0.5	0	0.5[a]	0.5[a]	0	1.0
Feed per head, lb. 11/23/77-4/28/78							
Ground shelled corn		461		535	535		1189
Salt		102		136	136		133
Hay	1338	1051	1146	956	956	1338	961
Feed per head, lb., 4/28-8/1/78							
Ground shelled corn		438		817	817		163[b]
Salt		55		85	85		7[b]
Feed per head, lb., 11/23/77-8/1/78							
Ground shelled corn		899		1352	1352		1352[c]
Salt		157		221	221		140[c]
Hay	1338	1051	1146	956	956	1338	961[c]
Feed per head, lb., 8/1/78-10/16/78							
Ground shelled corn		390		785			
Salt		77		94			
Feed per head, lb., 11/23/77-10/16/78							
Ground shelled corn		1289		2137			
Salt		234		315			
Hay	1338	1051	1146	956			

[a]Increased to 1.0% of bodyweight in April.
[b]From April 28 to May 14, 1978.
[c]From November 23, 1977 to May 14, 1978.

PROGESTERONE AND LUTEINIZING HORMONE LEVELS IN PREGNANT MARES

B. B. Thomas, T. N. Meacham and F. C. Gwazdauskas

Introduction

The significance of progesterone and luteinizing hormone in maintaining pregnancy is well documented in many species but little is known concerning the concentrations throughout pregnancy in the mare. It is known that the average rate of abortion in mares is 10% between the third and fifth month. This may be due to peculiarities in the hormonal balance of the mare during pregnancy. Mares are endocrinologically susceptible to abortion due to hormonal deficiencies during the third, fourth and fifth months of pregnancy. This study was conducted to evaluate plasma progesterone and luteinizing hormone concentrations in problem mares treated with progesterone from day 36 to 310 of gestation.

Materials and Methods

This study was initiated in the winter of 1977 and continued through the spring of 1978. Five pregnant American Saddlebred mares were used in the study. The day of ovulation was detected by rectal palpation and considered to be day 0 or pregnancy.

Two problem mares with past histories of abortion were treated with an aqueous progesterone solution (500 mg, 2 times per week) 36 to 208 days post breeding. In order to determine plasma progesterone and luteinizing hormone concentrations, blood samples (15 ml) were collected from the mares by jugular venapuncture into heparinized tubes, daily for two-week periods at: 1) 36-50 days, 2) 62-76 days, 3) 91-105 days, 4) 111-125 days, 5) 151-165 days, 6) 220-234 days, 7) 294-308 days (see table 1). Plasma was stored at -4C until hormones were quantified by radioimmunoassay (RIA). Three non-treated normal mares were bled in a similar manner and served as controls. Two of the three controls were bled every fourth day throughout gestation.

Results and Discussion

All five mares gave birth to normal healthy foals. There were no complications during parturition or postpartum periods. The levels of plasma progesterone are summarized in table 1. Treatment and control groups have similar patterns which suggest that the treatment group was receiving adequate amounts of progesterone. The drop in progesterone in the fourth period for the treatment group to 2.2 ng/ml may indicate the degeneration of the secondary corpora lutea and a delay in the placenta becoming the sole source of progesterone. It has been reported that if the level of progesterone drops to a low level (<1 ng/ml) abortion is likely to occur. It is in these mares that progesterone therapy may prevent abortion.

In both groups of mares there is a high level of luteinizing hormone-like activity in the first half of pregnancy. It has been reported that there is a high degree of cross reactivity between pregnant mare serum gonadotropin (PMSG) and luteinizing hormone (LH). Thus, the activity in plasma from pregnant mares refers to combined PMSG and LH concentrations. PMSG appears to be produced by the feto-placental unit beginning during the second month of gestation and persisting into the fifth month. Thus it appears much of the LH activity during gestation is probably PMSG.

If the LH activity quantified were mainly PMSG, the concentrations of LH probably remained stable and near basal values during gestation.

Overall, there was little difference in the mean progesterone level between the two groups. The reduced level in the treated group during the fourth period suggests that the progesterone level could have dropped lower if progesterone wasn't administered.

TABLE 1. PROGESTERONE AND LUTEINIZING HORMONE CONCENTRATIONS

Periods		Control: Progesterone ng/ml	Control: Luteinizing hormone ng/ml	Progesterone Treatment: Progesterone ng/ml	Progesterone Treatment: Luteinizing hormone ng/ml
I	36-50	5.2	41.7	10.5	50.9
II	62-76	6.3	29.2	9.8	47.2
III	91-105	8.5	53.5	6.4	45.2
IV	111-125	10.9	47.0	2.2	25.2
V	151-165	4.6	32.7	4.3	14.9
VI	220-234	4.2	8.3	4.7	8.3
VII	294-308	8.7	2.7	4.1	15.9

SYNCHRONIZATION OF ESTRUS IN BEEF COWS

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Widespread application of artificial insemination in beef cattle awaits the development of an effective, simple means of synchronizing the heat periods of large groups of cows to minimize the problem of heat detection. Prostaglandin ($PGF_{2}\alpha$) holds considerable promise as a synchronizing agent. This naturally occurring hormone has been shown to be very effective in controlling the estrous cycle under experimental conditions. When two injections 11 days apart are given to cycling cows a high percentage of the cows will be in heat or estrus 2 to 3 days after the second injection, regardless of their cycle initially. The objectives of this study were to investigate the effectiveness of 1 vs 2 injections of $PGF_{2}\alpha$ in synchronizing the estrous cycles and determine the fertility of the controlled estrous period.

Experimental Procedures

Ninety-four cows, 47 Angus (A) and 47 Angus-Holstein (AH) which had been wintered on 80 or 100% of the recommended (N.R.C.) energy levels during the preceding winter were allotted by breed and feeding level to three treatment groups. Group 1 was controls, group 2 received a single 20 mg injection of $PGF_{2}\alpha$ and group 3 received two 20 mg injections 11 days apart. Cows in all groups were observed for estrus and artificially inseminated as they were detected in estrus for a period of 25 days post-injection. Clean-up bulls were placed with the cows after the artificial insemination period. Pregnancy rates were determined by rectal palpation approximately 70 days post-insemination and confirmed by a second palpation in the fall. The experimental groups were under identical management systems during the course of the study.

Results

The effect of one or two injections of $PGF_{2}\alpha$ on cows wintered on either 100 or 80% of the N.R.C. recommended energy level is shown in table 1. The degree of synchrony was essentially the same for the groups receiving one or two injections. The 100% cows displayed a greater degree of synchronization, 90% compared to 80% for the 80% level cows. It is possible that more cows on the 100% were cycling by the time the injections were made.

Conception to the AI service was also somewhat higher for the 100% level cows in the injection groups, but not in the control group. There were only slight differences between energy levels in the injection groups in fertility when AI and clean-up bull conceptions were combined. The low conception rate to AI for the 100% level control cows resulted in a 20% reduction in fertility for this group compared to the rest of the groups.

When the two breed groups are compared (Table 2) the Angus-Holstein cows had a higher % synchronization and somewhat higher AI conception rates. In the two injection groups the AH cows had a higher overall conception rate, while in the control group the Angus cows had a higher conception to the clean-up bulls resulting in a slightly higher final pregnancy rate. The final conception rate for the Angus cows was quite uniform across the three treatment groups, approximately 88%. The pregnancy rates were quite good, 100 and 93% for the AH cows receiving $PGF_2\alpha$ compared to the AH controls, 75%. The reason for the lowered conception in the control groups is not apparent.

Examining the results across breed and feed levels for all cows (Table 3) reveals again reduced AI and final conception rates in the control group, 52 and 81%. There was little difference between the two injection groups indicating that one injection of $PGF_2\alpha$ was as effective as two in synchronizing estrous cycles. Conception rates were essentially the same also. Based on these data, a single 20 mg injection of prostaglandin will effectively synchronize estrus. Fertility of the controlled estrus was good; 73% AI conception with a final conception of 93%.

TABLE 1. RESPONSE TO SYNCHRONIZATION TREATMENT BY FEED LEVEL.

	Treatment[a]					
	Control		1 Injection		2 Injections	
Feed level	100%	80%	100%	80%	100%	80%
No. animals	17	14	16	15	12	20
Cows synchronized, %	-	-	87	80	92	80
Conception						
AI, %	41	60	81	67	75	70
Bull, %	29	29	13	27	17	20
Combined, %	70	89	94	94	92	90

[a]20 mg $PGF_{2\alpha}$ per injection.

TABLE 2. RESPONSE TO SYNCHRONIZATION TREATMENT BY BREED GROUP.

	Treatment[a]					
	Control		1 Injection		2 Injections	
Breed group	A	AH	A	AH	A	AH
No. animals	15	16	15	16	17	15
Cows synchronized, %	-	-	80	87	82	87
Conception						
AI, %	47	56	67	81	71	73
Bull, %	40	19	20	19	18	20
Combined, %	87	75	87	100	89	93

[a]20 mg $PGF_{2\alpha}$ per injection.

TABLE 3. RESPONSE TO SYNCHRONIZATION TREATMENT - ALL COWS

	Treatment[a]		
	Control	1 Injection	2 Injections
No. cows	31	31	32
Cows synchronized, %	-	81	84
Conception			
AI, %	52	74	72
Bull, %	29	19	19
Combined, %	81	93	92

[a]20 mg $PGF_2\alpha$ per injection.

AN EXAMINATION OF THE ALTERATIONS IN THE ENDOGENOUS CONCENTRATIONS OF TESTOSTERONE AND ANDROSTENEDIONE INDUCED BY THE ADMINISTRATION OF VARIOUS EXOGENOUS HORMONES IN BOARS OF DIFFERENT AGES

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There is a paucity of information concerning the testicular endocrine response of boars to a challenge of exogenous hormones. That which is available primarily demonstrates the augmented testicular secretion of C_{19} steroids in mature boars following the administration of human chorionic gonadotrophin (HCG) (Lindner, 1961; Raeside, 1965; Clark *et al.*, 1965; Andresen, 1975; Carlstrom *et al.*, 1975). Only the latter two of these reported investigations have measured HCG induced changes in peripheral plasma testosterone and 5α-androstenone in boars at frequent sampling intervals. Similarly, the effect of exogenously administered adrenocorticotrophin (ACTH) in boars has been reported only in regard to its causing a marked depression in urinary DHA levels (Raeside, 1965; Clark *et al.*, 1965) and indirectly lowering plasma levels of ICSH (Liptrap and Raeside, 1968).

In addition, the ability of the young boar to respond to a challenge of exogenous hormones at various ages (in effect, an indication of the maturation of the hypothalamo-hypophyseal-gonadal axis) has not been fully characterized. Therefore, the objective of this study was not only to provide basic information regarding the immediate endocrine (testosterone and androstenedione) response of boars to various exogenous hormones, but also to examine whether such response(s) varies in boars of different ages.

Experimental Procedure

Forty-four purebred Yorkshire boars, reared outdoors on concrete, were randomly assigned to one of three age groups (150 ± 7, 200 ± 7 or 250 ± 7 days of age) for the purpose of examining endogenous testosterone and androstenedione levels in response to one of four exogenously administered treatments.

Approximately five days prior to the appropriate age of sampling, boars were surgically fitted with indwelling anterior vena cannulae and tethered in individual stalls. The four treatments administered were as follows: 1) human chorionic gonadotrophin (HCG; 1,000 U.S.P. units administered intravenously), 2) testosterone propionate (TP; 25 mg administered intramuscularly), 3) andrenocorticotrophin (ACTH; 100 IU administered intravenously). Four boars in each of the three age groups were randomly assigned to receive one of the four treatments. However, due to cannula failure, only two boars in the youngest age group and three boars in each of the other two age groups were used as controls. Blood samples (10 ml) were collected from each boar at -120, -90, -60, -30 and 0 min pre-treatment administration and +15, +30, +45, +60, +75, +90, +105, +120, +150, +180, +210, +240, +270, +300, +330 and +360 min post-treatment administration. Plasma was obtained from all blood samples, frozen at -20 C and later assayed for testosterone and androstenedione concentrations by radioimmunoassay procedures.

Within treatment differences in peripheral plasma testosterone and androstenedione concentration, as measured over time, were analyzed statistically by least squares procedures (Harvey, 1977, for the control treatment due to an unequal number of boars across age groups; Barr and Goodnight, 1972, for the remaining treatments) for a mixed model. The model used was as follows:

$$Y_{ijk} = A_i + B\text{-}A_{ij} + T_k + (TA)_{ik} + e_{ijk}$$

where Y_{ijk} is the individual observation, A_i is the age group subclass, $B\text{-}A_{ij}$ is the boar within age group subclass, T_k is the time of sampling, $(TA)_{ik}$ is the time x age group interaction, and e_{ijk} is the residual. The effect of age on plasma testosterone and androstenedione concentration was tested using the $B\text{-}A_{ij}$ mean square. The remaining effects were tested using the residual mean square. Differences among least squares means were determined by the procedure of Duncan (1955).

Based on the combined age group results, a comparison of testosterone and androstenedione concentrations was made between each of the hormone treated groups of boars vs. controls at corresponding times of sampling. Inequality among treatment group residual variances was analyzed using an F-test at $P < .01$. Therefore, comparisons of treated vs. control hormone levels at similar times of sampling was performed using a modified Students t-test (t') for unequal residual variances as described by Snedecor and Cochran (1974). Tests of significance for t' were made according to the methods of Cochran (1964).

Results and Discussion

Peripheral plasma testosterone and androstenedione concentrations for boars prior to and following administration of 5.0 ml of physiological saline are shown in table 1. No differences ($P > .10$) were found among the three age groups of boars for overall mean testosterone or androstenedione concentration. Also, the age x time of sampling interaction was not significant ($P > .10$). Significant differences did exist in the levels of testosterone ($P < .01$) and androstenedione ($P < .05$) measured over time. However, these differences could not be partitioned. Since the concentrations for either hormone measured following administration of treatment were not markedly different from pre-treatment administration levels, it is suggested that the apparent differences in hormone level change over time were not a result of the 5.0 ml of saline given. These changes were more likely a reflection of the daily oscillations of testosterone and androstenedione which normally occur.

The overall mean concentrations of testosterone and androstenedione were not different ($P > .10$) among boars of 150 $\pm$ 7, 200 $\pm$ 7 and 250 $\pm$ 7 days of age which were given an intramuscular injection of 25 mg testosterone propionate. However, the three age groups of boars did differ ($P < .05$) in the manner in which peripheral plasma testosterone levels changed over sampling time. As illustrated in table 2, plasma testosterone concentrations in boars 150 $\pm$ 7 days of age increased rapidly and peaked within 2.5 hours following the exogenous administration of testosterone. In boars 200 $\pm$ 7 days of age, a similar increase in endogenous testosterone levels was not observed until 4.0 hours post-treatment administration. The oldest group of boars showed less of a treatment response as compared to the younger boars. Considering that the treatment dose was identical for all boars (i.e., unadjusted for body weight), the observed variation in response among age groups may have been caused by differences in the rate in which testosterone was absorbed into the circulation relative to the animal's body size. However, these differences could reflect age related changes in metabolic clearance or actual utilization of testosterone as well. Both hormones exhibited significant ($P < .01$) differences in concentration which occurred at similar times during the sampling period. Whether these hormone changes resulted from the treatment administered, or, merely reflect the normal secretory patterns occurring in peripheral plasma testosterone and androstenedione, is difficult to determine at this time.

The plasma testosterone and androstenedione values for boars treated with an intravenous injection of 1,000 U.S.P. units of chorionic gonadotrophin are presented in table 3. All boars, regardless of age group, responded in a similar fashion to the HCG treatment. Concentrations of both testosterone and androstenedione were greater ($P < .05$) within one hour after the time treatment was imposed as compared to pre-treatment levels (table 3). Approximately two hours post-treatment administration, both hormones appeared to reach a plateau in concentration which was maintained for the following two hours. At this time, corresponding to four hours post-treatment administration, testosterone and androstenedione levels began to increase once again. Significantly ($P < .05$) greater concentrations of both hormones were detected on the last sample taken (six hours post-treatment administration) as compared to the previous plateau levels. Since all three age groups of boars responded similarly to the HCG challenge, it may be assumed that the testicular steroidogenic capabilities of boar testes are fully functional by at least 150 days of age.

The peripheral plasma levels of testosterone and androstenedione in boars prior to and following an intravenous injection of 100 IU andrenocorticotrophin are shown in table 4. The three age groups of boars were not different ($P > .10$) in overall mean hormone concentration or in the manner in which they reacted to the administered treatment. However, there were significant ($P < .01$) differences for both hormones over the time of sampling when the results were averaged over age (table 4). Both hormones demonstrated a significant ($P < .05$) increase in concentration within 15 min after administration of ACTH. The peak level of each hormone, an approximate two-fold increase from the maximum pre-treatment value, was observed in samples taken 75 min following the ACTH injection. Following this peak period in concentration, testosterone and androstenedione levels steadily decreased for the remainder of the sampling period.

The reasons for the rapid increase in plasma testosterone and androstenedione levels in boars immediately following the administration of ACTH is unclear. A direct or indirect stimulation of androgen release by the testes could not have caused such a rapid increase in the hormones measured, as previously noted when boars were administered HCG. If the earlier report of Neher and Wettstein (1960) is indeed correct, production of adrenal androgens and estrogens is negligible in the boar. Thus, it would appear unlikely that the parallel increase in both hormones is a consequence of adrenal stimulation. However, this appears to be the most plausible speculation that can be suggested at the present time.

A comparison of plasma testosterone and androstenedione concentrations was made between the exogenous hormone treated and control treated boars at each sampling interval prior to and following administration of treatment (figure 1). Peripheral plasma levels of testosterone and androstenedione were similar among the four treatment groups of boars prior to the time the respective treatments were administered.

Boars treated with testosterone propionate were found to have greater ($P < .05$) concentrations of both testosterone and androstenedione five hours post-treatment administration. The increased levels of endogenous testosterone probably resulted from the additive effect of the exogenously administered and pre-existing endogenous sources of the hormone. However, no explanation can be given for the corresponding increase seen in the plasma levels of androstenedione.

Significantly ($P < .05$) greater concentrations of both hormones were detected in HCG treated boars vs. controls by 30 min post-treatment administration. The more rapid response detected here, in contrast to a within treatment examination, is attributed to the differences in hormone magnitude from which comparisons were made. The hormone concentrations of boars immediately following saline administration were lower than that of the pre-treatment concentrations of boars given HCG, from which the within treatment comparisons were made. Nevertheless, the augmented secretion of testosterone and androstenedione in boars following the administration of HCG is readily apparent (figure 1).

The immediate and heightened hormone response of boars following ACTH administration, as detected previously from the within treatment analysis, is substantiated upon comparing the response of ACTH treated boars with that of the controls by time of sampling. The ACTH treated boars had greater ($P < .05$) plasma concentrations of testosterone and androstenedione by 15 min post-treatment administration, which continued for an additional 90 min, as compared to the controls. Concentrations of both hormones measured for the remainder of the sampling period were not different ($P > .10$) between the ACTH and control treated boars.

A highly significant ($P < .01$) positive correlation was found between testosterone and androstenedione concentrations measured within saline ($r = .85$), testosterone ($r = .85$), HCG (.71) and ACTH ($r = .87$) treated boars. These relationships are consistent with those found in the previous boar studies and suggest that both steroids are stimulated by ICSH, as demonstrated by the similar results obtained following administration of chorionic gonadotrophin.

Summary

1. Boars 150 $\pm$ 7, 200 $\pm$ 7 and 250 $\pm$ 7 days of age were equally capable of responding to an exogenous challenge of HCG. This suggests that the androgen biosynthetic and secretory capabilities of the boar testes may be fully operational by five months of age.

2. Younger boars responded more quickly with an increase in endogenous testosterone concentration following the exogenous hormone treatment than did older boars.
3. Androgen changes following ACTH administration were not different among the three age groups. Results suggested that the adrenal gland may have been the source of a rapid increase in androgens.
4. Highly significant ($P < .01$) positive correlations were found between testosterone and androstenedione concentrations in all treated boars.

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TABLE 1. PLASMA TESTOSTERONE AND ANDROSTENEDIONE CONCENTRATIONS FOR BOARS SAMPLED PRIOR TO AND FOLLOWING ADMINISTRATION OF 0.9% NaCl[a]

Sampling Interval, min	Testosterone (ng/ml) Mean	Androstenedione (ng/ml) Mean
-120	2.8	10.7
- 90	2.3	10.0
- 60	1.5	8.0
- 30	1.1	6.4
0†	1.0	4.7
15	1.0	4.6
30	.9	5.5
45	1.0	5.2
60	1.2	5.0
75	1.1	4.9
90	1.3	5.1
105	1.2	4.6
120	1.2	6.5
150	1.6	6.8
180	2.1	10.3
210	2.8	12.4
240	2.8	13.6
270	2.1	8.6
300	1.8	8.1
330	1.7	7.5
360	1.6	6.4
SEM	.5	2.7

[a]Data presented as least squares means based on 8 observations, all ages combined.

†Treatment administered at time 0.

TABLE 2. PLASMA TESTOSTERONE AND ANDROSTENEDIONE CONCENTRATIONS FOR BOARS MEASURED PRIOR TO AND FOLLOWING INTRAMUSCULAR ADMINISTRATION OF TESTOSTERONE PROPRIONATE (25 mg)[a]

Sampling Interval, min	Testosterone (ng/ml) Mean	Testosterone (ng/ml) Mean Separation	Androstenedione (ng/ml) Mean	Androstenedione (ng/ml) Mean Separation
-120	3.0	c,d,e,f,g	12.9	b,c,d,e,f
- 90	2.2	f,g,h,i	11.8	b,c,d,e,f
- 60	1.8	g,h,i	9.4	b,c,d,e,f
- 30	1.7	h,i	7.9	e,f
0†	1.4	i	7.7	f
15	1.6	i	7.8	f
30	1.9	g,h,i	7.6	f
45	1.8	g,h,i	8.1	d,e,f
60	2.2	f,g,h,i	9.0	c,d,e,f
75	2.6	e,f,g,h,i	10.4	b,c,d,e,f
90	2.4	f,g,h,i	11.8	b,c,d,e,f
105	2.8	d,e,f,g,h	15.5	a,b,c,d,e
120	2.5	f,g,h,i	12.7	b,c,d,e,f
150	3.2	b,c,d,e,f	15.3	a,b,c,d,e
180	3.0	c,d,e,f,g	12.0	b,c,d,e,f
210	3.3	b,c,d,e,f	15.4	a,b,c,d,e
240	4.2	a,b	15.7	a,b,c,d
270	4.1	a,b,c	17.7	a,b
300	4.7	a	20.4	a
330	3.9	a,b,c,d	17.2	a,b
360	3.7	a,b,c,d,e	15.8	a,b,c
SEM	.4		2.3	

[a]Data presented as least squares means based on 12 observations, all ages combined.

[b]Means with different letters in the same column are different ($P < .05$).

†Treatment administered at time 0.

TABLE 3. PLASMA TESTOSTERONE AND ANDROSTENEDIONE CONCENTRATIONS FOR BOARS MEASURED PRIOR TO AND FOLLOWING INTRAVENOUS ADMINISTRATION OF CHORIONIC GONADOTROPHIN (1,000 U.S.P. units)[a]

Sampling Interval, min	Testosterone (ng/ml) Mean	Mean Separation[b]	Androstenedione (ng/ml) Mean	Mean Separation
-120	2.7	e	14.5	g
- 90	2.3	e	12.0	g
- 60	1.6	e	9.8	g
- 30	1.4	e	8.2	g
0†	1.1	e	7.6	g
15	2.6	e	11.4	g
30	4.7	e	19.0	g
45	6.5	d,e	26.6	f,g
60	10.2	d	47.7	e,f
75	19.5	c	55.5	d,e
90	21.8	a,b,c	58.4	d,e
105	21.0	b,c	73.2	c,d,e
120	19.8	c	70.5	d,e
150	18.7	c	64.2	d,e
180	18.6	c	68.3	d,e
210	18.8	c	75.7	c,d,e
240	22.1	a,b,c	79.5	c,d
270	21.4	a,b,c	99.7	b,c
300	23.2	a,b,c	121.6	a,b
330	26.1	a,b	124.5	a,b
360	27.0	a	138.3	a
SEM	1.8		8.9	

[a]Data presented as least squares means based on 12 observations, all ages combined.

[b]Means with different letters in the same column are different ($P < .05$).

†Treatment administered at time 0.

TABLE 4. PLASMA TESTOSTERONE AND ANDROSTENEDIONE CONCENTRATIONS FOR BOARS SAMPLES PRIOR TO AND FOLLOWING INTRAVENOUS ADMINISTRATION OF ADRENOCORTICOTROPHIN (100 I.U.)[a]

Sampling	Testosterone (ng/ml)		Androstenedione (ng/ml)	
Interval, min	Mean	Mean Separation[b]	Mean	Mean Separation[b]
-120	3.1	d,e,f	12.7	d,e,f
- 90	2.7	d,e,f	10.9	e,f,g,h
- 60	2.2	e,f	11.1	e,f,g
- 30	1.7	e.f	10.0	e,f,g,h,i
0†	1.6	e,f	7.4	f,g,h,i
15	5.5	a,b,c	14.0	c,d,e
30	7.0	a	19.6	a,b,c
45	7.5	a	20.4	a,b
60	7.3	a	21.2	a
75	7.5	a	23.3	a
90	6.0	a,b	19.4	a,b,c
105	4.6	b,c,d	17.9	a,b,c,d
120	3.5	c,d,e	14.5	b,c,d,e
150	2.5	d,e,f	9.6	e,f,g,h,i
180	1.3	e,f	8.2	e,f,g,h,i
210	1.3	e,f	6.4	f,g,h,i
240	1.2	e,f	6.7	f,g,h,i
270	.9	f	6.1	g,h,i
300	.8	f	4.6	h,i
330	.7	f	3.9	i
360	.8	f	3.8	i
SEM	.8		1.9	

[a]Data presented as least squares means based on 12 observations, all ages combined.

[b]Means with different letters in the same column are different ($P < .05$).

†Treatment administered at time 0.

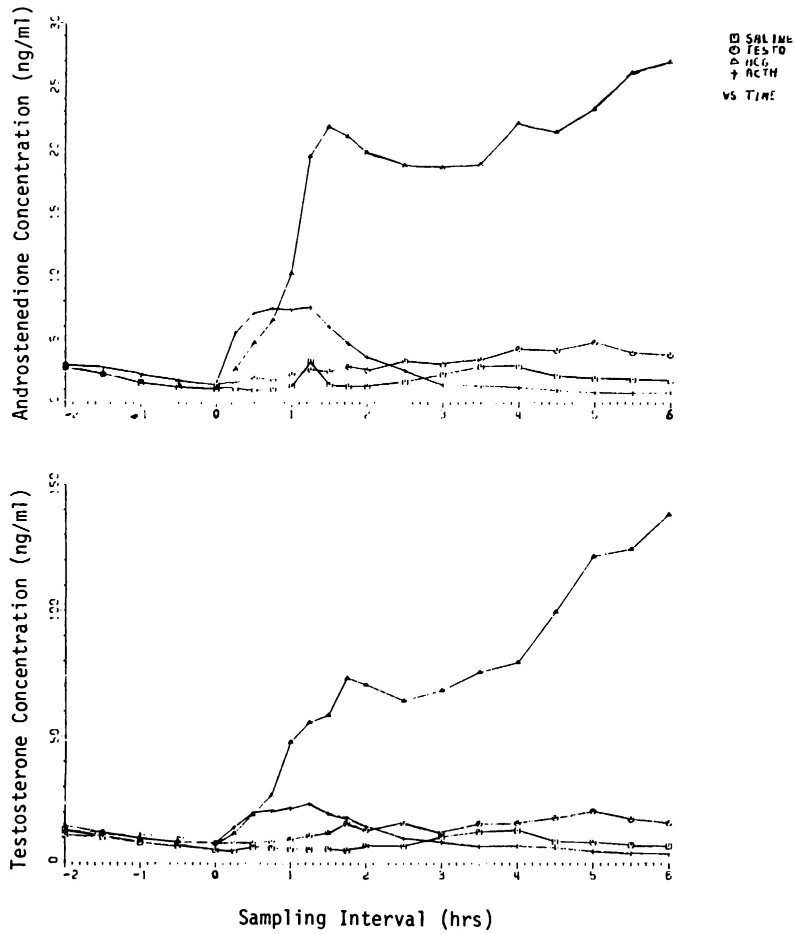

Figure 1. Plasma testosterone and androstenedione concentrations of boars of combined ages at various times prior to and following administration of various treatments (treatment administered at time 0).

AN EXAMINATION OF ENDOGENOUS CONCENTRATIONS OF TESTOSTERONE AND ANDROSTENEDIONE OVER A 24 HR PERIOD AND DEGREE OF SEXUAL BEHAVIOR OF BOARS AT VARIOUS AGES

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The daily variations in and interrelationship between circulating levels of testosterone and androstenedione in young boars have not been fully characterized. Previous studies in this area have yielded conflicting results (Ellendorf et al., 1975; Andresen, 1975; Brock and Wettemann, 1976; Claus and Gimenez, 1977). There are no studies reported which have examined the daily variation in testosterone and androstenedione concentration in boars at different ages. A previous study (Kattesh et al., 1977) suggested that changes in peripheral testosterone in boars may be related to age. However, those changes only represented differences in absolute hormone concentration and did not provide sufficient information to determine whether the temporal secretory pattern of testosterone or androstenedione changes as well.

The present study was conducted to provide this basic information, as well as to examine the relationship between daily testosterone and androstenedione secretory activity and the degree of sexual behavior of boars at various ages.

Experimental Procedure

A total of 18 purebred Yorkshire boars were randomly assigned in equal numbers to one of three age groups (150 $\pm$ 7, 200 $\pm$ 7 or 250 $\pm$ 7 days of age) for the purpose of examining endogenous testosterone and androstenedione concentrations measured over a 24 hr period. All boars were reared in their respective age groups outdoors on concrete.

Approximately five days prior to the appropriate age of sampling, boars were surgically fitted with indwelling anterior vena cava cannulae. Following surgery, boars were moved to a temperature controlled room, where temperature was maintained at approximately 23 C, and tethered in individual stalls constructed in a wooden crate. The design of the crate allowed for ease of blood sampling without subjecting the boars to stress which could possibly alter the levels of hormones in question. Blood samples (10 ml) were collected from each boar at consecutive 30 min intervals over a 24 hr period.

At weekly intervals beginning at approximately 140 days of age, boars were moved in their respective groups to a pen containing five to eight ovariectomized-estrogenized gilts. The administration of estrogen caused the gilts to be in constant heat. During a 15 min exposure to the females, boars were subjectively scored for libido using the following scoring code: 1 = no interest; 2 = interest; 3 = interest with mounting; 4 = mounting with erection; and 5 = mounting with erection and penetration.

Plasma was harvested from the blood samples collected, stored at -20 C and subsequently assayed for testosterone and androstenedione concentrations by radioimmunoassay procedures.

The 24 hr secretory patterns for peripherally measured plasma testosterone and androstenedione concentration of each boar were evaluated for overall mean hormone concentration, baseline mean concentration for determination of hormone secretory spikes, and the frequency and mean magnitude of hormone secretory spikes, by the method of Christian *et al.* (1978).

Least squares analysis of variance for a fixed effects model (Barr and Goodnight, 1972) was used to test treatment effects. The effect of age on the parameters used to evaluate daily variation in testosterone and androstenedione concentration, as well as on libido score (based on a boar's libido score for the week prior to sampling) and on the initial, middle and final hematocrit values, was tested against the residual (boar within age) mean square. Differences between least squares means were determined by the procedure of Duncan (1955).

Results and Discussion

Daily peripheral plasma testosterone and androstenedione secretory patterns for each boar sampled, corresponding to assigned age group, are illustrated in figure 1. This figure clearly shows the extreme variation which existed among and within boars in testosterone and androstenedione levels over a 24 hr period. Plasma testosterone and androstenedione levels measured in one boar (boar 1183) ranged from 1.43 ng/ml (1200 hr) to 6.10 ng/ml (0130 hr) and 2.60 ng/ml (1200 hr) to 18.07 ng/ml (1850 hr), respectively. In another boar (boar 1153) of the same age group, the range in testosterone (.16 ng/ml at 1600 hr to 1.88 ng/ml at 1900 hr) and androstenedione (1.01 ng/ml at 1500 hr to 5.22 ng/ml at 0330 hr) was found to be considerably less with the highest and lowest steroid values for each of these boars occurring at different times of the day. Similar daily variations occurring among boars for peripherally measured testosterone concentration have been reported (Brock and Wettemann, 1976). These findings emphasize the importance of taking frequent blood samples when examining plasma androgen differences among animals.

Since three of the six boars comprising an age group were offspring of gilts subjected to an applied stress during midgestation (Kattesh *et al.*, 1978), an analysis was performed on the hormonal time series evaluation results to determine if any alterations were incurred from the prenatal treatment. The results of this analysis indicated that boar offspring of stressed gilts were not different ($P > .05$) from boar offspring of control gilts for any of the parameters used to evaluate testosterone or androstenedione concentrations over a 24 hr period (tables 1 and 2, respectively). There was a tendency ($P < .10$) for boars of stressed gilts to have a greater overall mean frequency of androstenedione secretory spikes as compared to controls (3.6 vs. 2.0 spikes/24 hr for stressed vs. control boars, respectively). Other than this tendency, the results of the present study were in agreement with those reported earlier (Kattesh *et al.*, 1977) which suggested that boars were unaffected prenatally by certain physiological and endocrinological alterations in the maternal system resulting from an applied stress during midgestation.

Based on the combined boar results, no differences ($P > .10$) were found among the three age groups examined for overall mean testosterone concentration, baseline mean and frequency and mean magnitude of testosterone secretory spikes (table 1). Similarly, there were no differences ($P > .10$) in baseline mean androstenedione concentration, mean magnitude or frequency of androstenedione secretory spikes among the three age groups of boars (table 2). The mean androstenedione concentration for boars sampled at 150 $\pm$ 7 days of age tended ($P < .10$) to be greater than the mean concentration measured in boars at either 200 $\pm$ 7 or 250 $\pm$ 7 days of age. This tendency may reflect the development with age of the biosynthetic pathway for 16-unsaturated C_{19} steroids and may be related to the reversal in production of 5α-androsten-3α to 3β-ol. These data suggest that testosterone and androstenedione secretory patterns are established in boars by five months of age.

The overall mean number of testosterone and androstenedione secretory spikes detected in a boar over a 24 hr period was 2.9 $\pm$ .5 ($\bar{X} \pm$ SEM) and 2.8 $\pm$ .4, respectively. For both steroids measured, a detected spike existed for not more than .5 hr, however, in many cases a series of two to three spikes was observed to occur at consecutive hourly intervals.

The time of day at which testosterone and androstenedione secretory spikes occurred varied within and among the three age groups of boars studied (table 3). In the youngest group of boars, testosterone secretory spikes were most frequent during the afternoon and evening hours (1200 to 2330 hr). In the second oldest and oldest group of boars, a higher percentage of secretory spikes was evident during the morning and afternoon hours (0600 to 1730 hr) and the late evening and morning hours (2400 to 1130 hr), respectively. In comparison to these results, the greatest percentage of detected androstenedione secretory spikes for boars 150 $\pm$ 7 days of age occurred during the morning (0600 to 1130 hr) and evening (1800 to 2330 hr). The fewest number of spikes at this age occurred in the afternoon (1200 to 1730 hr), which corresponds to the period of greatest testosterone spike activity. Boars 200 $\pm$ 7 days of age demonstrated little change in androstenedione spike occurrence over the 24 hr sampling period. In the oldest group of boars, secretory spikes were more prevalent during the evening and early morning hours (1800 to 0530 hr), which appeared to precede the time of greatest testosterone apike activity. The frequency of secretory spikes for testosterone and androstenedione were unrelated.

It should be noted that each of the three groups of boars differed not only in regard to age, but also in the time of year they were sampled. Blood samples were collected in early July, late August and mid-October from the boars representing 150 $\pm$ 7, 200 $\pm$ 7 and 250 $\pm$ 7 days of age, respectively. Since this time span corresponds with decreasing daylight, a relationship may exist between this and the apparent shift in the time of day at which the greatest percentage of testosterone secretory spikes was observed among the three age groups of boars.

The mean peripheral plasma testosterone and androstenedione daily secretory patterns for each of the three age groups of boars, as well as for the three age groups combined, are illustrated in figure 2. The results obtained upon evaluation of each of these patterns are summarized in table 4. These results suggest that at certain times of the day, boars of a given age exhibit a common peak in hormone secretion. In most cases, however, the time of day at which this peak was observed did not correspond to the daily time period of greatest spike frequency.

The development with age in the occurrence of distinct oscillations in the daily secretion of testosterone and androstenedione is evident in figure 2. In the oldest group of boars examined, three distinct and equally spaced testosterone spikes were detected over the 24 hr period. These spikes were observed to occur in the morning (0930 hr), late afternoon (1830 hr) and at night (0130 hr). A single spike in androstenedione concentration was seen corresponding to that of testosterone in the late afternoon. Upon combining the results of the three age groups, no testosterone spikes and only one androstenedione spike was found to occur during the 24 hr period. It is suggested that in the process of merging hormone concentrations which are either increasing or decreasing coincidentally, a null change in hormone levels results.

Degree of sexual behavior was not different ($P > .10$) between boars due to treatment (prenatally stressed vs. control), age or treatment x age interaction. Boars of 150 ± 7, 200 ± 7 and 250 ± 7 days of age had a mean libido score of $3.3 \pm .6$ ($\bar{X} \pm$ SEM), $4.3 \pm .6$ and $4.0 \pm .6$, respectively. Also, no relationship was found between libido score and any of the parameters used to evaluate the daily secretory patterns of testosterone and androstenedione.

Summary

1. Boars of 150 ± 7, 200 ± 7 and 250 ± 7 days of age were not different ($P > .10$) in regards to overall mean concentration, frequency of secretory spikes and magnitude of secretory spikes for testosterone and androstenedione.
2. The daily occurrence of testosterone and androstenedione secretory spikes varied within and among the three age groups of boars.
3. A possible relationship between decreasing daylight and a shift in the time of day at which testosterone secretory spikes occurred was suggested.
4. There appeared to be a development with age in the occurrence of distinct oscillations in the daily secretion of both testosterone and androstenedione.
5. Degree of sexual behavior was not different ($P > .10$) over the three ages and was not related to testosterone or androstenedione levels.

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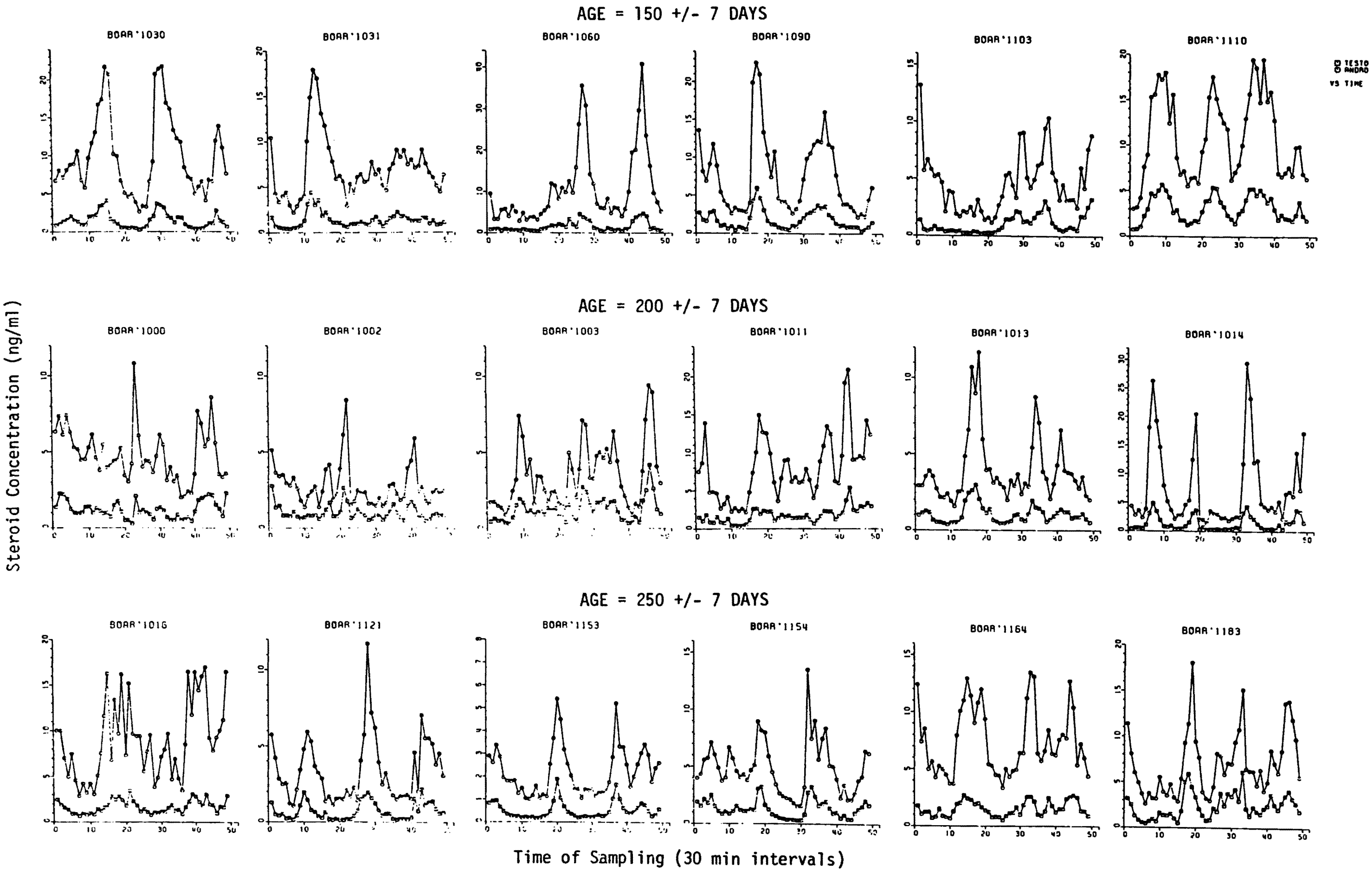

Figure 1. Temporal concentrations of plasma testosterone and androstenedione in boars of different ages over a 24 hr period of observation (0930 through 0930 hr).

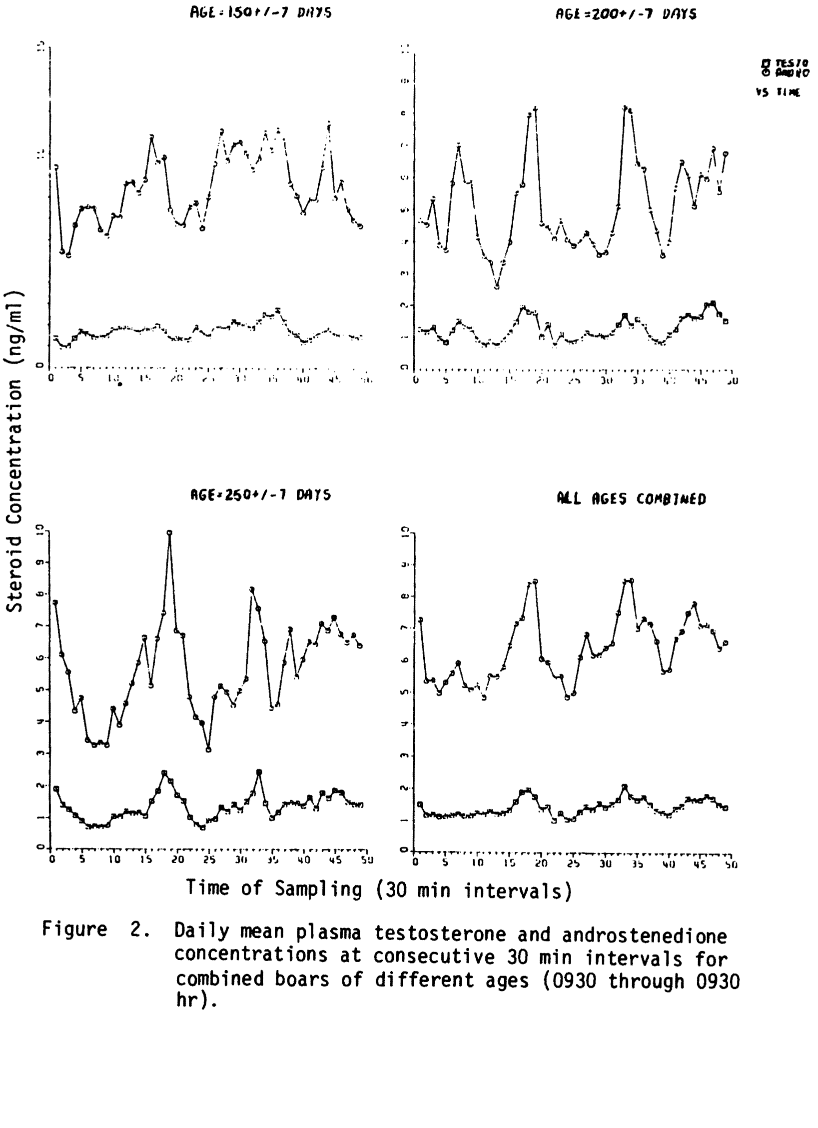

Figure 2. Daily mean plasma testosterone and androstenedione concentrations at consecutive 30 min intervals for combined boars of different ages (0930 through 0930 hr).

TABLE 1. EFFECT OF AGE AND PRENATAL TREATMENT ON OVERALL MEAN PLASMA TESTOSTERONE CONCENTRATIONS, BASELINE MEAN CONCENTRATIONS, FREQUENCIES AND MEAN MAGNATUDE OF HORMONE SECRETORY SPIKES FOR BOARS SAMPLED AT CONSECUTIVE 30 MIN INTERVALS OVER A 24 HR PERIOD [a]

Age, days	Prenatal Treatment	Boar	Overall Mean	Baseline Mean	Frequency of Spikes (per 24 hr)	Magnitude Mean
		1110[b]	3.0 ± .1	*	0	*
	Control	1031	1.4 ± .1	1.2 ± .1	3	3.1 ± .3
		1030	1.5 ± .1	1.2 ± .1	5	3.1 ± .2
150 ± 7		Mean[c]	1.9 ± .4	1.2 ± .4	2.7 ± 1.4	3.1 ± .9
		1090	1.8 ± .1	1.7 ± .1	1	4.1 ± .0
	Stressed	1060	1.6 ± .1	1.5 ± .1	1	4.0 ± .0
		1103	1.1 ± .1	.8 ± .1	6	2.1 ± .2
		Mean	1.5 ± .4	1.3 ± .3	2.7 ± 1.4	3.4 ± .7
		Overall[c]	1.7 ± .3	1.3 ± .2	2.7 ± 1.0	3.2 ± .6
		1002	1.0 ± .1	.9 ± .0	6	1.9 ± .2
	Control	1003	1.2 ± .1	1.1 ± .1	2	3.2 ± .6
		1000	1.2 ± .1	1.2 ± .1	2	2.5 ± .0
200 ± 7		Mean	1.1 ± .4	1.1 ± .3	3.3 ± 1.4	2.5 ± .7
		1013	1.1 ± .1	1.0 ± .1	2	2.1 ± .1
	Stressed	1014	1.4 ± .1	1.3 ± .1	2	3.6 ± .0
		1011	1.8 ± .1	1.7 ± .1	1	3.8 ± .0
		Mean	1.4 ± .4	1.3 ± .3	1.7 ± 1.4	3.2 ± .7
		Overall	1.3 ± .3	1.2 ± .2	2.5 ± 1.0	2.9 ± .5
		1153	.5 ± .0	.4 ± .0	6	1.0 ± .1
	Control	1183	2.3 ± .2	2.1 ± .1	2	5.6 ± .6
		1154	1.3 ± .1	1.2 ± .1	3	2.9 ± .2
250 ± 7		Mean	1.4 ± .4	1.3 ± .3	3.7 ± 1.4	3.2 ± .7
		1121	.7 ± .1	.5 ± .0	7	1.7 ± .1
	Stressed	1016	1.7 ± .1	1.6 ± .1	4	3.1 ± .1
		1164	1.5 ± .1	*	0	*
		Mean	1.3 ± .4	1.0 ± .4	3.7 ± 1.4	2.4 ± .9
		Overall	1.4 ± .3	1.1 ± .2	3.7 ± 1.0	2.8 ± .6

*No value.

[a]All values are concentrations of plasma testosterone (ng/ml).

[b]Individual boar estimates represent arithmatic mean ± SEM (N = 49).

[c]Treatment and overall means presented as least squares means ± SEM.

TABLE 2. EFFECT OF AGE AND PRENATAL TREATMENT ON OVERALL MEAN PLASMA ANDROSTENEDIONE CONCENTRATIONS, BASELINE MEAN CONCENTRATIONS, FREQUENCIES AND MEAN MAGNITUDE OF HORMONE SECRETORY SPIKES FOR BOARS SAMPLED AT CONSECUTIVE 30 MIN INTERVALS OVER A 24 HR PERIOD[a]

Age, days	Prenatal Treatment	Boar	Overall Mean	Baseline Mean	Frequency of spikes (per 24 hr)	Magnitude Mean
		1110[b]	10.8 ± .5	*	0	*
	Control	1031	7.1 ± .3	6.9 ± .3	1	14.7 ± 0
		1030	9.9 ± .5	9.2 ± .4	3	19.7 ± .7
150 ± 7		Mean[c]	9.3 ± 1.4	8.1 ± 1.6	1.3 ± .9	17.2 ± 4.1
		1090	7.6 ± .5	6.3 ± .3	7	14.3 ± 1.3
	Stressed	1060	10.7 ± .8	9.2 ± .6	2	28.0 ± .5
		1103	4.7 ± .3	4.0 ± .2	5	9.6 ± 1.0
		Mean	7.6 ± 1.4	6.5 ± 1.3	4.7 ± .9	17.3 ± 3.4
		Overall[c]	8.5 ± 1.0	7.3 ± 1.0	3.0 ± .6	17.2 ± 2.7
		1002	2.8 ± .2	2.7 ± .2	1	7.2 ± .0
	Control	1003	3.5 ± .2	3.5 ± .2	1	7.9 ± .0
		1000	4.8 ± .2	4.6 ± .2	2	9.5 ± 1.4
200 ± 7		Mean	3.7 ± 1.4	3.6 ± 1.3	1.3 ± .9	8.2 ± 3.4
		1013	3.9 ± .3	3.4 ± .1	4	8.6 ± 1.0
	Stressed	1014	7.7 ± .8	6.5 ± .6	3	21.5 ± 2.0
		1011	8.1 ± .4	7.7 ± .4	2	16.2 ± .4
		Mean	6.6 ± 1.4	5.9 ± 1.3	3.0 ± .9	15.4 ± 3.4
		Overall	5.1 ± 1.0	4.7 ± .9	2.2 ± .6	11.8 ± 2.4
		1153	2.2 ± .1	2.1 ± .1	3	4.4 ± .4
	Control	1183	7.0 ± .4	6.5 ± .3	3	14.4 ± 1.1
		1154	4.9 ± .3	4.4 ± .2	4	10.0 ± 1.3
250 ± 7		Mean	4.7 ± 1.4	4.3 ± 1.3	3.3 ± .9	9.6 ± 3.4
		1121	3.4 ± .3	2.9 ± .2	5	7.3 ± 1.0
	Stressed	1016	9.0 ± .5	8.5 ± .5	3	16.6 ± .2
		1164	7.4 ± .3	7.3 ± .3	1	12.7 ± .0
		Mean	6.6 ± 1.4	6.3 ± 1.3	3.0 ± .9	12.2 ± 3.4
		Overall	5.7 ± 1.0	5.3 ± .9	3.2 ± .6	10.9 ± 2.4

*No value.

[a]All values are concentrations of plasma androstenedione (ng/ml).

[b]Individual boar estimates represent arithmatic mean ± SEM (N = 49).

[c]Treatment and overall means presented as least squares means ± SEM.

TABLE 3. THE DAILY OCCURRENCE OF PERIPHERALLY MEASURED PLASMA TESTOSTERONE (T) AND ANDROSTENEDIONE (A) SECRETORY SPIKES FOR BOARS OF DIFFERENT AGES

		Time of Day (hr)							
		2400-0530		0600-1130		1200-1730		1800-2330	
Age, days	Boar	T	A	T	A	T	A	T	A
	1110	0	0	0	0	0	0	0	0
	1031	0	0	0	0	3	1	0	0
	1030	1	1	1	0	2	1	1	1
150 ± 7	1090	0	2	0	2	1	1	0	2
	1060	0	0	0	1	0	0	1	1
	1103	2	1	2	3	0	0	2	1
	Total	3	4	3	6	6	3	4	5
	Overall	.19	.22	.19	.33	.38	.17	.25	.28
	1002	2	0	2	0	1	0	1	1
	1003	0	0	1	0	0	1	1	0
	1000	0	0	1	1	0	0	1	1
200 ± 7	1013	0	2	0	0	2	1	0	1
	1014	1	1	0	1	1	1	0	0
	1011	0	0	1	2	0	0	0	0
	Total	3	3	5	4	4	3	3	3
	Overall	.20	.23	.33	.31	.27	.23	.20	.23
	1153	1	2	3	0	0	0	2	1
	1183	1	1	0	1	1	0	0	1
	1154	1	3	1	0	1	0	0	1
250 ± 7	1121	1	1	3	2	1	1	2	1
	1016	1	0	2	0	0	1	1	2
	1164	0	0	0	1	0	0	0	0
	Total	5	7	9	4	3	2	5	6
	Overall	.23	.37	.41	.21	.14	.11	.23	.32

TABLE 4. EFFECT OF AGE ON OVERALL MEAN PLASMA TESTOSTERONE AND ANDROSTENEDIONE CONCENTRATIONS, BASELINE MEAN CONCENTRATIONS, FREQUENCIES AND MEAN MAGNITUDE OF HORMONE SECRETORY SPIKES FOR THE COMBINED ESTIMATES OF BOARS SAMPLED AT CONSECUTIVE 30 MIN INTERVALS OVER A 24 HR PERIOD [a]

Steroid	Age, days	Overall Mean	Baseline Mean	Frequency of Spikes (per 24 hr)	Magnitude Mean
Testosterone	150 ± 7	1.7 ± .0	1.7 ± .0	1	2.3 ± .0
	200 ± 7	1.3 ± .0	*	0	*
	250 ± 7	1.4 ± .0	1.3 ± .0	3	2.2 ± .0
	Combined	1.4 ± .0	*	0	*
Androstenedione	150 ± 7	8.5 ± .2	*	0	*
	200 ± 7	5.1 ± .2	5.0 ± .1	2	8.0 ± .0
	250 ± 7	5.7 ± .2	5.6 ± .2	1	9.4 ± .0
	Combined	6.4 ± .1	6.4 ± .1	1	8.3 ± .0

*No value.

[a]Estimates represent arithmatic mean ± SEM (N = 49).

EFFECTS OF EXOGENOUS HORMONE SUPPLEMENTATION ON CONCEPTUS DEVELOPMENT AND LITTER SIZE IN SWINE[1]

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Ovulation rate and fertilization failure can be disregarded as practical factors limiting litter size in swine (see review by Wrathall, 1971). Embryonic (fetal) mortality in swine has been reported to account for a loss of 30 to 50% of potential offspring (see reviews by Hanly, 1961; Boyd, 1965; and Wrathall, 1971). Thus, we know that it is the death loss occurring between fertilization and parturition that limits litter size in swine. There is also data which suggests that a major portion of neonatal death loss, especially that occurring during the first postnatal day (which represents the time during which approximately half of the total postnatal death loss occurs) may be related to the same factors which affect prenatal death loss (Pomeroy, 1960). We know when, and to a very limited extent, why this prenatal death loss occurs. However, we do not know how to reduce its occurrence.

Wrathall (1971) reviewed the causes of embryonic mortality in swine and hypothesized that competition for uterine attachment area during the second and third weeks of gestation had far-reaching and important permanent influences on fetal development, litter size and ultimately even on postnatal survival. He suggested that embryos which obtain small areas of placental attachment in the early stages of gestation may have no further opportunity to increase their relative placental size and, therefore, remain at a disadvantage throughout gestation. These data were the basis for proposing that hormonal supplementation, as conducted in this study, may be a means of stimulating early placental development. Data of Knight et al. (1977) suggested that even a limited placental mass was capable of supporting the relatively limited fetal growth which occurred prior to day 35 of gestation. However, this placental insufficiency was reflected in a decreased rate of fetal growth and increased fetal mortality as gestation progressed.

Knight et al. (1977) reported that placental length and weight increased most rapidly between days 20 and 30 of gestation. Placental growth was found to essentially cease by midgestation. Thus, fetal growth in the latter stages of gestation, which is the period of maximum growth, is dependent upon the extent of placental development during early gestation.

A summary of the literature clearly indicates that the first month of gestation is probably the most critical since the extent of placental development which occurs during this period ultimately regulates fetal growth, fetal survival and perhaps even postnatal survival.

This research represents an attempt to find a means to reduce prenatal death loss and, thus, increase litter size in swine. This study involves a two-pronged approach to the problem. First of all, it attempts to supply some knowledte of the basic mechanisms involved with prenatal growth and development at

[1]Appreciation is expressed to the Virginia Agricultural Foundation for financial support of this research.

the level of the conceptus. The ultimate objective of this line of research is to determine and implement those procedures which are necessary to increase the number of live pigs born per litter. However, we must first determine via basic research what limitations exist and how they may be surmounted in order to achieve this long range goal. Secondly, it represents an applied approach to finding a means by which the producer could utilize this information on the farm.

This report is a preliminary one on this project. Additional parameters are being analyzed at present and further trials are in progress.

Experimental Procedures

Daily heat checks were initiated on all gilts used in this study when they were approximately six months of age. After the initial estrus had been detected, twice daily heat checks were conducted. Gilts were bred at either their second or third estrus period. All gilts were crossbreds of similar age, weight and genetic background. All gilts were artificially inseminated 12, 24 and 36 hours following initial detection of estrus. Semen from at least two different boars, selected at random, was used for the inseminations. The gilts were randomly assigned to one of the three treatment groups following breeding. The treatments for trials 1, 2 and 3 were identical. The 36 gilts in trials 1 and 2 were allowed to farrow (data reported on 33 gilts; 3 had not farrowed at the time of report preparation). The 18 gilts in trial 3 were hysterectomized at day 50 of gestation. The three treatment groups, to which an equal number of gilts were assigned, were as follows:

Trt. no.	Days of administration[1]	Hormone(s) administered[2]	Amount administered[3]
1	4-20	P/E	25 mg P/12.5 μgE/45.4 kg (100 lb) body wt.
2	20-30	P/E	25 mg P/12.5 μgE/45.4 kg (100 lb) body wt.
3 control	4-30	CO	2 ml

[1]Represents days of gestation (inclusive) at which the hormones were administered. All dosages administered once daily subcutaneously in the neck.
[2]P/E = combination of progesterone and estrone. CO = corn oil alone (control).
[3]The P/E administration represented a combination of the two steroids in a 2,000:1 ratio. All steroids were administered in corn oil.

In trials 1 and 2 all gilts were fed, housed and subjected to all routine management procedures in an identical manner. All gilts were allowed to go to term and farrow. At farrowing, the following parameters were measured and evaluated: gestation length, total number of pigs born, number of pigs born alive, number of mummified fetuses, number of stillborn pigs, total placental weight, pig birth weight, number of pigs weaned and pig weaning weight.

In trial 3, all gilts were hysterectomized at day 50 of gestation (day of mating = day 0). The gilts were not fed for 24 hours prior to surgery. At surgery initial anesthesia was induced with a 5 percent sodium thiopental solution injected into an ear vein. Anesthesia during surgery was maintained with halothane in a nitrous oxide and oxygen mixture. The reproductive tract was exposed by mid-ventral laparotomy and the ovaries, oviducts, uterine horns, uterine body and a portion of the cervix were removed.

The uterus was dissected free of the ovaries, oviducts and mesometrium. The number of corpora lutea (CL) on the ovaries was counted, and the number of CL was assumed to represent the ovulation rate and, therefore, the number of potential embryos. The uterus was carefully dissected open along the mesometrial border and each conceptus was removed intact and placed into a clean pan.

An uncontaminated 15 ml sample of allantoic fluid was obtained by puncturing the chorio-allantois with an 18 gauge needle attached to a 20 ml syringe. The chorio-allantois was then cut, the allantoic fluid collected in the pan and, finally, the allantoic fluid volume was measured directly in a graduated cylinder. A sample of amniotic fluid was obtained in the same manner, and the total volume was measured in a graduated cylinder. The allantoic and amniotic fluid samples obtained were labelled and frozen at -20° for future analysis for protein and hormone concentrations.

Each fetus was dissected free of the placental membranes and fetal crown-rump length measured directly in millimeters (mm) using a metric ruler. Care was taken to measure the crown-rump length while the fetus was in a normal fetal position. After the crown-rump length was determined, each fetus was placed in an individual piece of aluminum foil, the tare weight of which had previously been determined. The fetus was then weighed on an analytical balance, the tare weight subtracted from the total weight and the weight of each fetus, identified by its position in the litter, was recorded. Embryo dry weight was determined by drying each embryo to a constant dry weight, generally a minimum of 72 hours, at 100° C in a drying oven. Fetal wet weight was divided into fetal dry weight and that figure was multiplied by 100 to determine percent dry matter.

Placental length was determined by direct measurement using a metric ruler. The placenta was extended its full normal length for this measurement, but care was taken not to stretch the placenta. Only that portion of the placenta which was considered to be functional was included in the measurement, i.e., the necrotic tips of the chorion were not measured. Placentae from fetuses determined to be dead or dying were not included in the calculations of any of the placental parameters. Placental weight was determined by weighing each placenta directly on an analytical balance.

The placenta was then individually identified and placed in buffered formalin until they can be evaluated to determine placental surface area, number and distribution of areolae and total areolae surface area. These determinations have not been made at the time of this report.

After the contents of the uterus had been removed, width of each uterine horn was determined at five different randomly selected points. The average uterine width was then multiplied by the uterine length to estimate the total uterine endometrial surface area.

Empty uterine weight was determined by weighing the uterus on an analytical balance after the contents of the uterus had been removed.

Each fetus was examined and from this the number of live, dead and total fetuses were determined. Percent fetal survival was determined by dividing the number of corpora lutea into the number of live embryos and multiplying that figure by 100.

Immediately prior to hysterectomy, plasma samples were taken from the anterior vena cava, from a uterine vein and from a uterine artery. Progesterone and estrogen concentrations in these samples are being determined by radioimmunoassay procedures. Hematocrits were determined on all blood samples.

Results and Discussion

Tables 1 and 2 summarize the various measurements obtained following hysterectomy at day 50 of gestation. Gilts which received treatment 2 (P/E, days 20-30) had placentas which were significantly ($P < .01$) longer and heavier than those from gilts receiving the other two treatments. Those gilts receiving treatment 1 (P/E, days 4-20) had placentas which were longer and heavier than those from control gilts which had received no exogenous hormone supplementation. Placental lengths and placental weights ($\bar{X} \pm$ SEM), respectively, were 59.6 ± 1.7 cm, 68.9 ± 1.5 cm, 56.1 ± 1.5 cm and 112.5 ± 4.4 g, 126.4 ± 3.9 g, 101.8 ± 3.9 g for treatments 1, 2 and 3, respectively. It may be inferred from this data that exogenous hormone supplementation during the first 30 days of gestation had a stimulatory effect on placental development. The most favorable results were obtained when the supplementation occurred during the period of from day 20 to day 30 of gestation. Knight *et al.* (1977) have previously reported that days 20 to 30 of gestation represent time of a rapid increase in allantoic fluid volume. This increase in allantoic fluid volume, in turn, stimulates expansion of the placental membranes, which forces those membranes into apposition with the uterine glands, thus, determining the maximum number of areolae (sites of nutrient transport). Thus, it is postulated, the mechanism for obtaining larger placentas via exogenous P/E administration from days 20-30 of gestation may have been through a stimulatory effect on allantoic fluid accumulation.

Allantoic fluid volume fluctuates considerably and precipitously during gestation (Knight *et al.*, 1977); thus, the concentrations at day 50 do not necessarily indicate what the levels may have been earlier in gestation. However, allantoic fluid was significantly ($P < .01$) greater at day 50 of gestation in gilts which received exogenous hormones. Again, allantoic fluid volume was greatest in those gilts receiving P/E, days 20-30 (trt. 2) with an average volume of 132.9 ± 9.0 ml. This was not statistically different ($P > .10$) from the volume in treatment 1 gilts (P/E, days 4-20) which was 123.5 ± 10.2 ml. Both of these values, however, were significantly ($P < .01$) greater than the 102.8 ± 9.0 ml volume found in control (trt. 3) gilts.

There was no difference in crown-rump length of the fetuses seen at day 50. The fetal weight was significantly ($P < .01$) greater in gilts receiving the P/E, days 20-30 treatment compared to controls ($44.8 \pm .7$ g vs. $39.9 \pm .7$ g). This suggests that even at this relatively early stage of gestation, the larger placentas in those gilts which received exogenous hormones between days 20 and 30 of gestation were already contributing to the maximization of fetal growth.

At day 50, there were no treatment differences ($P > .10$) in regard to potential number of pigs (based on ovulation rate), number of live pigs, number of dead and reabsorbed fetuses, percent fetal survival, empty uterine weight, uterine length, or amniotic fluid volume. Uterine surface area was significantly ($P < .05$) less in the control gilts than in the two treatment groups receiving hormone supplementation.

There were highly significant ($P < .01$) overall correlation coefficients between numerous measures of conceptus development. These are presented in table 4.

Ovarian weight was less ($P < .05$) in the gilts which received P/E from days 4-20 than in the other two groups. This suggests that administering high levels of progesterone during the period of time of initial corpus luteum (CL) formation may have a detrimental effect on CL development and hence on its ability to produce adequate levels of endogenous progesterone following termination of exogenous supplementation. This suggestion may also explain why a poorer conception rate (i.e., increased number returning to estrus) was seen in this group than in the other two. Therefore, despite some beneficial results on conceptus development, due to a poorer conception rate (70% vs. 87.5% for treatments 2 and 3), administration of P/E at the levels used in this study from days 4-20 would not be recommended. It is further suggested that results seen may well be dose related and a dosage lower than 25 mg P/12.5 µgE/45.4 kg body weight may prove to be more effective.

Data obtained from trials 1 and 2 from gilts which were bred and allowed to farrow was not nearly as dramatic as that obtained in trial 3 following hysterectomy. Quite obviously, the number of parameters which could be measured at farrowing was less and the possibility of factors other than the treatments imposed influencing results was greater. Briefly stated, although some trends have appeared, no statistically significant differences ($P > .10$) among the three treatments were found in regard to gestation length, number of live pigs born, number of stillbirths, number of mummified fetuses, total number born, number of pigs weaned, total birth weight, average birth weight, total weaning weight, average weaning weight and total placental weight. Data relative to these parameters is given in table 3. One obvious reason for the lack of statistically significant differences is the relatively small number of observations involved (33). Farrowing data was obtained on 12 gilts in treatments 2 and 3, but only nine gilts in treatment 1. The remaining three gilts in treatment 1 had not farrowed at the time of report preparation.

A conclusion which can be drawn from our work to date is that the exogenous hormone supplementation does markedly influence and control conceptus development. Progress has been made in defining the period in which to administer exogenous hormones for best results (days 20-30). Much work still needs to be done to better define this period, to complete analysis of all parameters which may be affected, to examine the best dosage level to use and to investigate the easiest route of administration.

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TABLE 1. COMPARISON OF VARIOUS CONCEPTUS PARAMETERS OBTAINED BY DIRECT MEASUREMENT FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION[a]

Parameter[b]	Treatment 1 P/E 4-20	Treatment 2 P/E 20-30	Treatment 3 CO 4-30
Placental length, cm	59.6 ± 1.7[c]	68.9 ± 1.5[d]	56.1 ± 1.5[c]
Placental weight, g	112.5 ± 4.4[c]	126.4 ± 3.9[d]	101.8 ± 3.9[e]
Crown-rump length, mm	86.3 ± .7	88.7 ± .6	88.0 ± .6
Fetal wet weight, g	41.3 ± .8[c]	44.8 ± .7[d]	39.9 ± .7[c]
Fetal dry weight, g	4.4 ± .4	4.7 ± .1	4.3 ± .7
Fetal dry matter, %	10.7 ± .4	10.5 ± .4	10.3 ± .4
Allantoic fluid volume, ml	123.5 ± 10.2[c]	132.9 ± 9.0[c]	102.8 ± 9.0[d]
Amniotic fluid volume, ml	36.4 ± 1.2	39.4 ± 1.0	38.1 ± 1.2

[a]All values represent $\bar{X}$ ± SEM.
[b]Means on the same line with different superscripts are significantly (P <.01) different.

TABLE 2. COMPARISON OF VARIOUS GILT PARAMETERS OBTAINED BY DIRECT MEASUREMENT FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION[a]

Parameter[b]	Treatment 1 P/E 4-20	Treatment 2 P/E 20-30	Treatment 3 CO 4-30
Number of corpora lutea	12.2 ± 1.0	12.8 ± .9	13.3 ± .9
Number of live fetuses	9.8 ± 1.3	10.7 ± 1.2	10.8 ± 1.2
Number of dead fetuses	1.8 ± .6	0.5 ± .5	1.0 ± .5
Fetal survival, %	84.1 ± 9.2	95.1 ± 3.7	91.7 ± 2.9
Uterine weight, g	1704.5 ± 152.5	2026.5 ± 139.2	1721.4 ± 139.2
Uterine length, cm	454.0 ± 29.6	471.8 ± 27.1	417.7 ± 27.1
Uterine width, cm	22.2 ± 2.3	24.5 ± 2.1	17.8 ± 2.1
Uterine surface area, cm^2	5056.7 ± 501.0[c]	5816.5 ± 457.3[c]	4342.4 ± 457.3[d]
Ovarian weight, g	5.2 ± 1.0[c]	7.5 ± .9[d]	8.7 ± 1.5[d]
Anterior vena cava hematocrit, %	33.1 ± 2.8	33.6 ± 2.5	38.1 ± 2.7
Uterine vein hematocrit, %	34.0 ± 2.0	37.1 ± 1.8	35.7 ± 2.0
Uterine artery hematocrit, %	34.8 ± 1.9	37.2 ± 1.7	32.9 ± 1.9

[a]All values represent $\bar{X} \pm$ SEM.
[b]Means on the same line with different superscripts are significantly ($P < .05$) different.

TABLE 3. COMPARISON OF VARIOUS PARAMETERS OBTAINED AT FARROWING[a]

Parameter	Treatment 1 P/E 4-20	Treatment 2 P/E 20-30	Treatment 3 CO 4-30
Gestation length, days	114.1 ± .8	113.5 ± .6	114.1 ± .6
Number live pigs	8.6 ± .9	9.5 ± .7	10.0 ± .7
Number stillborn pigs	.3 ± .3	.4 ± .2	.8 ± .2
Number mummified fetuses	.3 ± .2	.3 ± .2	.2 ± .2
Total born	9.2 ± 1.0	10.1 ± .8	10.9 ± .8
Total birth weight, kg	11.1 ± 1.0	11.9 ± .8	12.9 ± .8
Average birth weight, kg	1.4 ± .1	1.3 ± .1	1.3 ± .1
Number weaned	7.3 ± .9	8.1 ± .7	9.3 ± .7
Average weaning weight, kg	4.1 ± .2	3.8 ± .2	3.7 ± .2
Survival to weaning, %	81.8 ± 7.0	81.2 ± 5.6	86.5 ± 5.3
Total placental weight, kg	2.1 ± .2	2.1 ± .2	2.6 ± .2

[a]All values represent $\bar{X} \pm$ SEM.

TABLE 4. SIMPLE CORRELATION COEFFICIENTS BETWEEN SELECTED PARAMETERS[a]

	PLWT	CRL	FWWT	ALVOL[b]
Placental length (PLL)	.70**	.32**	.45**	.30**
Placental weight (PLWT)		.31**	.55**	.30**
Crown-rump length (CRL)			.63**	.07
Fetal wet weight (FWWT)				.14

[a]Based on data obtained following hysterectomy at day 50 of gestation.
[b]ALVOL = Allantoic fluid volume.
**P < .01.

A SPECTROPHOTOMETRIC PROCEDURE FOR DETERMINING BOAR SPERMATOZOA CONCENTRATION

C. R. Underwood and J. W. Knight

Certain semen physiology studies require the determination of spermatozoa concentration in an ejaculate. Counting spermatozoa directly from a hemocytometer is one method of determining concentration. This method, when properly done, is highly accurate, but is also very tedious and time consuming. Another procedure for determining spermatozoa concentration entails the use of a calibrated photoelectric colorimeter. This procedure has been investigated for determination of spermatozoa concentration in bulls and shown to be accurate, rapid and relatively inexpensive and requires only small amounts of semen (Foote et al., 1978).

This study was conducted to investigate the applicability of photometric procedures to determine spermatozoa concentration in boars and to calibrate a photoelectric colorimeter for the determination of spermatozoa concentration in boar ejaculates. This determination was preliminary to further studies involving the development of extenders to maximize long-term storage of boar semen.

Experimental Procedures

A total of eighty-three ejaculates were collected from five boars, using a "dummy sow" and the gloved-hand technique. Each ejaculate was used to calibrate a Bausch and Lomb photoelectric colorimeter (Spectrophotometer 20), using the procedures outlined by Crabo (1978, personal communication).

Following collection, each ejaculate was strained through a double layer of cheesecloth to remove the gel portion of the ejaculate. Exactly 0.1 milliliters of the fresh ejaculate was pipetted into 4.9 milliliters of a 0.1 molar sodium citrate solution, to yield a 1 in 50 dilution of semen. The semen-sodium citrate dilution was thoroughly mixed and used to estimate the percentage of light transmittance using a colorimeter. The wavelength of the colorimeter was 525 nanometers.

The number of spermatozoa in the semen-sodium citrate dilution was determined by counting five diagonal squares (each containing sixteen squares) on both chambers of a hemacytometer. Counts from each chamber agreed within ten percent or a new sample was taken and recounted. The mean spermatozoa count was calculated by averaging the counts from both chambers of the hemacytometer. The mean was then multiplied by the dilution factor 2.5×10^6 to obtain the number of spermatozoa per milliliter.

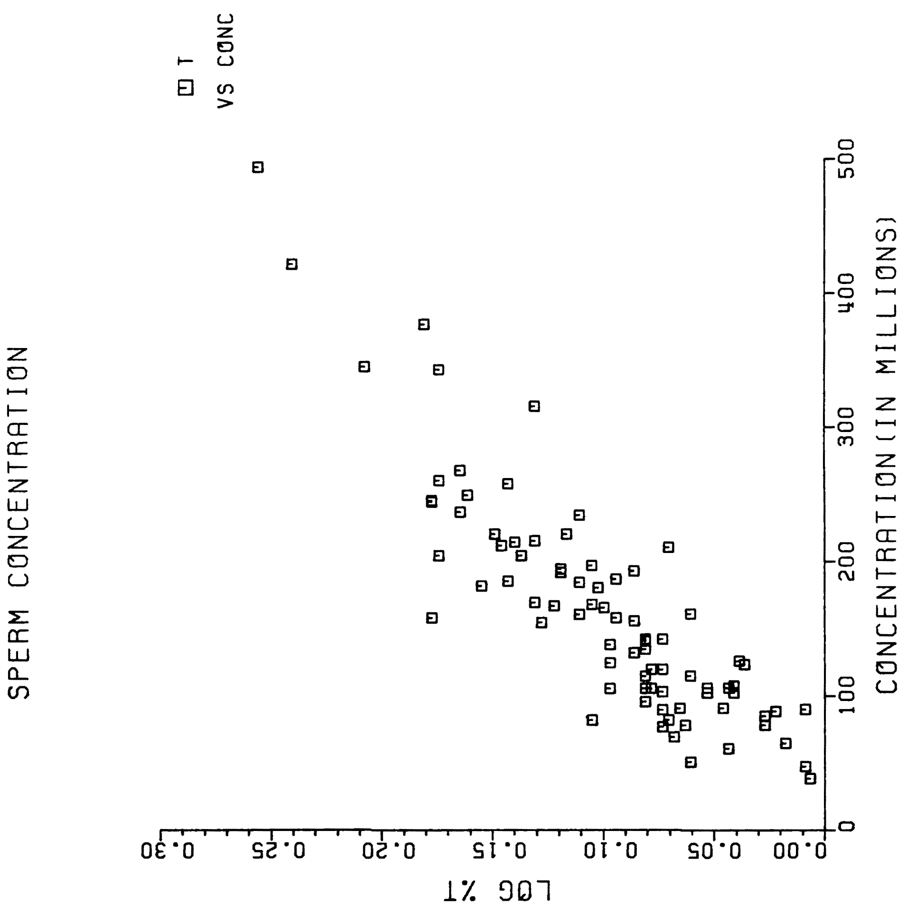
SPERM CONCENTRATION
T
VS CONC
LOG %T
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0
100
200
300
400
500
CONCENTRATION (IN MILLIONS)

FIGURE 1.

Results

The best model for predicting the spermatozoa concentration in boar ejaculates was found to be

$$C(X10^6) = \frac{1.9889 - \log T}{.000538}$$

where:

C = the predicted concentration; and
T = the observed percent transmittance

The R-square value for this model was .77. In other words, 77 percent of the error was accounted for by this model. Figure 1 shows the plot of log T vs. concentration.

Summary

We conclude that the use of a photoelectric colorimeter is an accurate, rapid, simple and very repeatable means by which to determine sperm concentration in a fresh sample of boar semen. This technique is being employed at present in ongoing research studies.

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