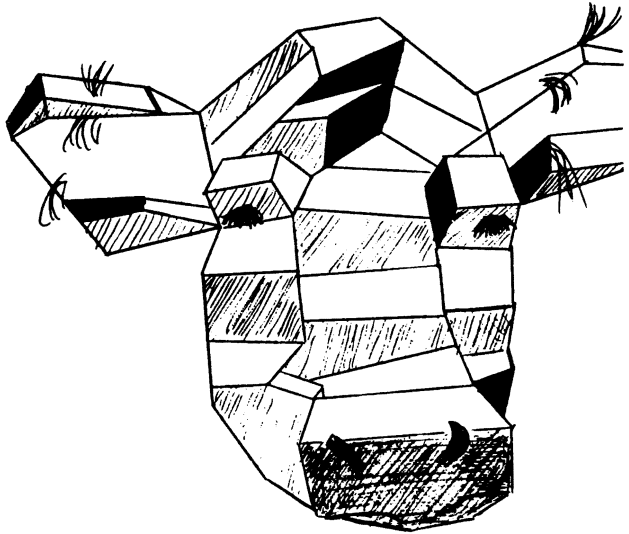


1979-80



LIVESTOCK RESEARCH REPORT

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Virginia Polytechnic Institute

and State University

Blacksburg, Virginia 24061

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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

June 2, 1980

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

The faculty and graduate students of the Animal Science Department are pleased to offer the following 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 conducted with beef cattle, swine, sheep and horses. 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 pleased to hear from you.

Sincerely yours,

A handwritten signature in cursive script that reads "Thomas N. Meacham".

Thomas N. Meacham, Acting Head
Animal Science Department

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EFFECTS OF WINTER ENERGY INTAKE AND COW SIZE ON COW AND CALF PERFORMANCE AND MILK YIELD AND COMPOSITION¹

W. D. Lamm and T. N. Meacham

Introduction

Breeding females divergent in mature frame size and milking ability are available to beef producers. The response of these types of females to recommend energy levels has been studied extensively on range, or at feed levels simulating range conditions (Kropp *et al.*, 1973; Holloway *et al.*, 1975; Wyatt *et al.*, 1977). Cattle may respond differently to nutritional regimens in the eastern United States (U.S.) since environmental conditions are different than in the western U.S.

Since many beef producers in the eastern U.S. sell calves at weaning, heavy calf weaning weights are desirable. The introduction of genes from dairy animals can result in increased milk yield, growth rate and mature size of beef animals (Cundiff, 1970). Increased milk production and perhaps restricted nutrient intake could affect cow reproductive performance and calf performance.

The purpose of this three year study was to determine the response of beef cows of different mature sizes and milking abilities to two energy intake levels during the winter. The parameters evaluated were weight change, reproductive efficiency, milk yield and composition and calf performance.

Experimental Procedure

Initially, 47 2-year-old Angus and 51 Angus x Holstein (Cross-bred) pregnant heifers which grazed permanent pastures consisting primarily of bluegrass (*Poa pratensis*), fescue (*Festuca arundinacea*), white clover (*Trifolium repens*) and orchardgrass (*Dactylis glomerata*) from approximately May 1 to November 30 were used in the study. On December 1 the heifers were blocked by weight within breed and randomly allotted to two wintering treatments. Heifers of each breed were placed into 2 paddocks which were outdoor lots that provided no grazing.

Ration treatments consisted of either 80 or 100% of NRC (1976) recommended levels for energy. Protein was fed at recommended (NRC, 1976) levels. Total digestible nutrient (TDN) requirements for gestation were based upon heifer weights obtained December 1 and were determined by averaging the requirement for pregnant heifers during the last 3 to 4 mo of pregnancy and the requirement of dry pregnant mature cows in the last third of pregnancy since the heifers were coming 3-year-olds. After one half of the cows fed an energy level calved, all cows on that energy level were fed a lactation ration.

¹

The authors express appreciation to Henry Dickerson, Dave Gibson and Alan Lee for care of the experimental animals and to Dr. David Notter for assistance in the statistical analysis of the data.

Angus cows were fed to meet requirements of cows with average milking ability nursing calves the first 3 to 4 mo postpartum while Crossbred cows were fed to meet requirements of cows with superior milking ability. Estimated TDN levels fed are presented in table 1. The cows and calves remained in the paddocks until returned to pasture April 21.

The diets of corn silage (IRN 3-08-153) and soybean meal (IRN 5-04-604) were fed once daily in fence line feed bunks at levels calculated to supply the required energy and protein. Ingredients were sampled weekly, frozen and composited every 4 weeks for analysis. A mineral mixture of equal parts of trace mineralized salt, defluorinated phosphate (IRN 6-01-780) and magnesium oxide was available throughout the year.

All cows were weighed immediately after parturition. Calves were ear tagged and weighed at birth. Male calves were left intact. Calves were not fed a creep diet and were weaned October 18. At weaning, cows and calves were weighed and calf weights were adjusted to a 205-day and bull-equivalent basis. No adjustment was made for age of dam. Pregnancy status of all cows was determined by rectal palpation at weaning. Only cows weaning calves are included in data analyses.

The protocol for the study in the second and third years was similar to that described for the first year with the following exceptions. In the second and third years cow breed groups fed the same energy level were separated during the wintering period. Immediately prior to start of the calving season, all cows receiving the same energy level were comingled but still fed appropriate feed levels. After calving, cows and calves were moved to adjacent paddocks where they were fed their appropriate lactation diets. Gestation requirements for Angus cows were obtained from NRC (1976) and for Crossbred cows they were calculated by averaging values presented in NRC (1971). Lactation requirements for Angus cows were based upon NRC (1976) for average milking ability. Requirements for Crossbred cows were calculated by averaging requirements for average milking ability (NRC, 1976) and requirements for maintenance and 13.6 kg milk containing 4% butterfat (NRC, 1971). All requirements were based upon average weights of the 4 cow breed-energy level subgroups obtained the first day of the winter feeding period. The second and third years urea replaced soybean meal as the supplemental nitrogen source.

Calves the first year were sired by Angus bulls, while the second year they were sired by Angus, Polled Hereford or Simmental bulls and the third year by Simmental or Charolais bulls. Breeding seasons began approximately June 1 and lasted 65 days. The second and third years cows were evaluated for condition (1 = very thin, 5 = very fat) at weaning.

Twelve hour milk yield and composition estimates were made with 37 and 71 cow-calf pairs the second and third years, respectively. After a 12-hr separation of cows and calves, several milliliters of initial milk was manually removed from the left rear quarter of each cow's udder and discarded. Additional milk was placed into two plastic

whirl paks to obtain two samples of milk for laboratory analysis. One sample was retained for butterfat content analyzed with a Milko-Tester¹. The second sample was immediately chilled in ice and transported to a laboratory for determination of total solids (Stone *et al.*, 1964). Solids-not-fat was calculated as the difference between the butterfat and total solids determinations. Crude protein was determined by the dye-binding procedure of the Foss Pro-milk instrument (Kroger, 1973; McGann and O'Connell, 1971). Milk yield was determined by the calf weigh-suckle-weigh technique. Estimates were obtained on days 36, 66, 92, 124 and 184 of lactation the second year and days 49, 91, 142 and 179 the third year.

Statistical Analysis. The data were first analyzed by least squares procedures using the Statistical Analysis System (1979). A model was developed within year which included the main effects of cow breed, winter energy level, calf sex, calf sire breed and all two factor interactions. Least-squares means were then pooled across years and analyzed by least squares procedures. Year effects were not significant when the data were analyzed in this manner. Reproductive performance was evaluated by developing two-way frequency tables and testing for homogeneity by chi-square procedures (Snedecor and Cochran, 1967).

Results and Discussion

Cow and Calf Performance. Least-squares means of cow and calf performance by winter energy level are presented in table 2. Since cow breed x winter energy level interactions were not significant ($P < .05$), only the main effects are shown. Initial weights of cows entering each winter were similar. Weights obtained immediately postpartum indicated cows fed the low energy diet lost an average of 30.8 kg and cows fed the high energy diet lost 8.0 kg from the beginning of each winter until immediately after parturition. At weaning, cows fed the low energy diets during the winter and early spring gained 7 kg and cows fed the high energy diet lost 7.6 kg from parturition to weaning. Cows wintered at the high energy level were evaluated higher in condition ($P < .05$) at weaning than cows fed the low energy diet. Although not statistically different, conception rates were 95.0 and 88.7% for cows fed the low and high energy diets, respectively. Davis *et al.* (1977) reported cows losing less weight in winter and gaining more in summer rebred more efficiently.

Winter energy level had no effect on calf birth weight, adjusted weaning weight, the percent calves born that were weaned or the kilograms of calf weaned per pregnant cow entering the preceding wintering period. Work by others (Bellows and Short, 1978; Davis *et al.*, 1977; Laster, 1974) can be influenced by pre-calving feeding levels. In the first year of the present study the average length of the pre-calving feeding period was 65 days, and the second two years the average was 120 days. This should have been sufficient time for energy level to influence calf birth weights or cow reproductive performance.

The percent calves born that were weaned averaged 65% the first year and 95% the last two years of the study. Heifers calved for the

¹Foss Milko-Tester, Foss America, Inc. Fishkill, NY 12524.

first time as 3-year-olds and were in a high state of body condition entering the first winter feeding period. This high degree of fatness has been shown to increase dystocia and calf mortality (Arnett et al., 1971) which was evident the first year. When percent calves weaned was multiplied by the respective adjusted weaning weight, the cows fed the low and high energy diets weaned 193.2 and 194.1 kg of calf per pregnant cow, respectively.

The performance of the Angus and Crossbred cows and their calves is presented in table 3. Cow weight changes observed at parturition and weaning indicated little difference between the cow types. Angus cows were evaluated in higher condition at weaning ($P < .01$) and had a conception rate of 89.2 compared to 94.5% for the Crossbred cows. Deutscher and Whiteman (1971) observed first calf Angus x Holstein cows did not rebreed as efficiently as first calf Angus cows. In the present study, time of first estrus postpartum was not observed but conception rates during 65 day breeding seasons were similar among breeds. Kropp et al. (1973) reported 100% conception rates on range in Hereford and Hereford x Holstein 2-year-old cows in a 90-day breeding season. In a drylot phase, all Herefords rebred but 20% of the crossbred cows fed a moderate level of supplemental feed failed to conceive.

Calf birth weights were similar among cow breeds in the present study although there were sire breed effects ($P < .01$) which were accounted for in the model. There were no cow breed x sire breed interactions ($P > .05$). Age and sex adjusted weaning weights were higher ($P < .05$) for calves from Crossbred cows (243.1 vs 216.0 kg). Numerous studies support this observation (Deutscher and Whiteman, 1971; Holloway et al., 1975; Kropp et al., 1973). Since Crossbred cows weaned 87.9% of their calves compared to 80.9% for the Angus cows, the Crossbred cows weaned 213.7 kg of calf per pregnant cow and the Angus cows weaned 174.7 kg of calf.

Milk Yield and Composition. Winter energy level had no effect on 12-hr milk yield or composition determinations made the second and third years (table 4). Similar observations were made by Falk et al. (1974) when energy intake was restricted to beef cows prepartum and by Ray et al. (1974) when energy levels were varied postpartum. Milk yield estimates were higher than those reported by Notter et al. (1978) and Ray et al. (1974) but were similar to those reported by Kropp et al. (1973) for 12-hr milk yield. Milk composition was not affected by level of energy intake. The result is in contrast to work by Kropp et al. (1973) in which Hereford x Holstein cows had higher butterfat levels than Herefords. Rutledge et al. (1971) indicated percent protein, percent solids-not-fat and percent fat had little effect on weaning weight. Apparently milk quantity was more important than milk quality in influencing weaning weights.

Milk yield and composition was not affected by cow breed although the difference in milk yield approached significance ($P < .07$). Crossbred cows produced an average of 5.9 kg compared to 4.4 kg for Angus cows at all sampling times. Deutscher and Whiteman (1971) observed that 2-year-old Angus x Holstein cows produced more milk than Angus cows through 12 wk of lactation.

Summary

The data suggest that under the conditions of this study feeding Angus and Crossbred cows during late gestation and early lactation at levels of 80% of NRC (1976) recommended levels for energy had no detrimental effect on calf survival, adjusted weaning weights or cow reproductive performance. Milk yield and composition was not affected by energy level. State of body condition of cows beginning the winter feeding period probably influenced their subsequent performance.

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TABLE 1. ESTIMATED TOTAL DIGESTIBLE NUTRIENTS FED DAILY

Year	Stage of production	Energy level and cow breed			
		80% NRC ^a		100% NRC ^a	
		Angus	Angus x Holstein	Angus	Angus x Holstein
1 ^b	Gestation		3.8		4.8
	Lactation		4.6		5.7
2	Gestation	3.3	3.4	4.2	4.3
	Lactation	4.0	5.2	5.0	6.4
3	Gestation	3.0	3.3	3.9	4.2
	Lactation	5.2	6.6	5.3	6.7

^aNRC (1976).

^bBreed groups within energy level were fed together the first year.

TABLE 2. LEAST SQUARES MEANS OF PERFORMANCE OF COWS FED TWO WINTER ENERGY LEVELS, 3 YEAR AVERAGES

Item	Energy level		SEM
	80% NRC	100% NRC	
No. of pregnant cows	45	43	
<u>Cow performance</u>			
Initial weight, kg	475.0	476.6	6.6
Average calving date	March 16	March 16	
Weight after parturition, kg	444.2 ^a	468.0 ^b	4.7
Weight at weaning, kg	451.3	460.4	4.8
Condition score at weaning ^c	2.2 ^d	2.5 ^e	.02
Conception rate, %	95.0	88.7	1.6
<u>Calf performance</u>			
Birth weight, kg	37.0	36.2	.7
Adj. weaning weight, kg	230.6	228.4	4.1
Calves weaned, %	83.8	85.0	4.3
Calf weaned/pregnant cow, kg	193.2	194.1	12.0

^{ab} Means in the same row with different superscripts differ ($P < .10$).

^c 1 = very thin, 5 = very fat.

^{de} Means in the same row with different superscripts differ ($P < .05$).

TABLE 3. LEAST-SQUARES MEANS OF PERFORMANCE OF ANGUS AND ANGUS X HOLSTEIN COWS AND THEIR CALVES, 3 YEAR AVERAGE

Item	Cow breed		SEM
	Angus	Angus x Holstein	
No. of pregnant cows	42	46	
<u>Cow performance</u>			
Initial weight, kg	470.9	480.7	6.6
Average calving date	March 16	March 16	4.7
Weight after parturition, kg	454.3	458.0	4.7
Weight at weaning, kg	456.5 ^b	455.2	4.8
Condition score at weaning ^a	2.9 ^b	1.8 ^c	.02
Conception rate, %	89.2	94.5	1.6
<u>Calf performance</u>			
Birth weight, kg	35.6 ^d	37.8 ^e	.7
Adj. weaning weight, kg	216.0 ^d	243.1 ^e	4.1
Calves weaned, %	80.9	87.9	4.3
Calf weaned/pregnant cow, kg	174.7	213.7	12.0

^a1 = very thin, 5 = very fat.

^{b,c}Means in the same row with different superscripts differ (P<.01).

^{d,e}Means in the same row with different superscripts differ (P<.05).

TABLE 4. LEAST-SQUARES MEANS OF MILK YIELD AND COMPOSITION OF COWS FED
TWO WINTER ENERGY LEVELS, 2 YEAR AVERAGES

Item	Energy level		SEM
	80% NRC	100% NRC	
No. of cows	28	26	
12-hr milk yield, kg	5.0	5.3	.12
Total solids, %	9.8	9.6	.08
Butterfat, %	1.3	1.2	.03
Solids-not-fat, %	8.4	8.4	.08
Crude protein, %	3.2	3.3	.04

TABLE 5. LEAST-SQUARES MEANS OF MILK YIELD AND COMPOSITION OF ANGUS
AND ANGUS X HOLSTEIN COWS, 2 YEAR AVERAGES

Item	Cow breed		SEM
	Angus	Angus x Holstein	
No. of cows	26	28	
12-hr milk yield, kg	4.4	5.9	.12
Total solids, %	9.9	9.6	.08
Butterfat, %	1.2	1.4	.03
Solids-not-fat, %	8.7	8.2	.08
Crude protein, %	3.3	3.2	.04

Influence of Crossbred Sires and a Growth Stimulant
on Preweaning Performance of Calves ¹

J. S. Copenhaver, M. B. Wise, T. J. Marlowe and W. D. Lamm

In 1977, forty-two Shorthorn and forty-eight 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 allotted by breed, sex and age to four groups (1,2,3,4) with group 1 as control (no ralgro); groups 3 and 4 received 36 mg of ralgro at birth; group 2 was implanted with 36 mg of ralgro at 4 months and group 4 received a second 36 mg implant at 4 months. This test was repeated in 1978 with 26 Shorthorn cows and 44 Crossbred cows.

Cows were separated into breeding groups on similar pastures and placed with proper sires on May 5, 1977 and May 3, 1978 and were allowed a breeding season of approximately 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 occurred on October 17, 1978 and October 16, 1979. Results are shown in Table 1.

Table 1: Calf Performance 1978-79

	Number Calves	Birth Wt. Lbs.	Weaning Wt. Lbs.	ADG.
Shorthorn Dams (68)	63	77	494	1.95
Crossbred Dams (92)	88	77	533	2.08
Hereford Sires	73	75	508	1.99
Simmental x Hereford Sires	78	79	539	2.08
Implant Group:				
1	38	78	516	2.01
2	38	76	517	2.06
3	36	78	508	1.95
4	39	77	532	2.10

1. The authors wish to express their appreciation to Agricultural Processing Corporation of Salem, Virginia, for furnishing vitamins for the research and teaching programs.

Data was obtained from 151 calves; 83 in 1978 and 68 in 1979. Considering only weaning weights, calves from Crossbred cows were 8% (39#) heavier than those from Shorthorn cows; and calves sired by the Crossbred sires were 6% (31#) heavier than those by Hereford sires. Differences among the four calgro treatments were not statistically significant but calves receiving two Implant; were 4% (20#) heavier than those receiving only one. Additive performance response to the combined breeding management programs was approximately 18% (86#).

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

H. R. Thomas and E. T. Kornegay¹

Double and triple decking is an effective means by which nursery density can be increased. Thus, building and operating costs can be reduced. Research at Virginia Tech (1978 and 1979 Livestock Research Reports) found that 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. Thomas and Kornegay (1979 Livestock Research Report) reported that daily gain, daily feed and feed efficiency were not different among pigs housed in triple deck cages with galvanized expanded metal, galvanized woven wire and oil tempered wire cloth floors. However, foot pad scores were higher; indicating more cuts, cracks and abrasions for pigs housed in cages with the wire cloth compared to pigs housed in cages with expanded metal or woven wire.

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 flat expanded metal and plastic coated expanded metal 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 1.0 in openings plastic coated expanded metal² were located in a Latin square pattern on each side of the nursery. Two trials were conducted using 288 pigs averaging 16.4 lb initially. Eight pigs were housed per cage (2 ft² per pig).

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 initially and weekly thereafter. Pigs were on test for either 35, 42 or 49 days.

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

²Tenderfoot is the trade name. Supplied by ADA Enterprises, Inc., Box 151, Freeborn, MN 56032.

Temperature for the first two weeks was kept about 85° with about 2 F degrees drop each week thereafter, if possible. The relative humidity ranged from 70 to 90% with a ventilation rate ranging from a minimum of 4 to a maximum of 25 CFM per pig.

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

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 and middle decks ate more feed and grew faster than pigs housed on the 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 plastic coated expanded metal, woven wire and expanded metal. However, pad scores were lower ($P<.05$), indicating fewer cuts, cracks and abrasions for pigs housed in cages with plastic coated expanded metal as compared to pigs housed in cages with woven wire and expanded metal. The response was similar between trials. The deck times floor type interaction was non-significant ($P>.10$).

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 plastic coated expanded metal had lower pad scores, indicating fewer 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. Daily Gain, Daily Feed, Feed per Gain Ratio and Foot Pad Score of Weaned Pigs Housed in Triple Deck Cages with Three Types of Floors. Trials 1 and 2.

Items	Deck			Floor Type		
	Bottom	Middle	Top	Expanded	Woven	Coated
Initial wt, lb						
Trial 1	17.2	17.3	17.2	17.3	17.2	17.2
Trial 2	15.6	15.6	15.6	15.5	15.6	15.6
Combined ^b	16.4	16.4	16.4	16.4	16.4	16.4
Final wt, lb ^b						
Trial 1	52.1	52.0	50.4	50.9	52.3	51.3
Trial 2	51.8	51.5	51.0	51.2	50.8	52.4
Combined	52.0	51.8	50.7	51.1	51.5	51.9
Daily gain, lb						
Trial 1	.85	.84	.81	.82	.86	.83
Trial 2	.80	.80	.79	.79	.78	.82
Combined	.83	.82	.80	.80	.82	.82
Daily feed, lb						
Trial 1	1.72	1.68	1.60	1.63	1.73	1.63
Trial 2	1.58	1.58	1.51	1.55	1.53	1.61
Combined	1.66	1.63	1.56	1.59	1.63	1.62
Feed per gain						
Trial 1	2.02	2.00	1.98	2.00	2.03	1.97
Trial 2	1.97	1.97	1.92	1.95	1.96	1.96
Combined	2.00	1.99	1.95	1.97	1.99	1.97
Foot pad score ^c						
Trial 1	2.8	3.0	2.7	3.4 ^d	3.2 ^d	1.9 ^e
Trial 2	2.7	3.5	2.9	3.9 ^d	3.4 ^d	1.7 ^e
Combined	2.9	3.3	2.6	3.6 ^d	3.3 ^d	1.8 ^e

^aExpanded = 9 gauge, 1.9 x 3.8 cm (.75 x 1.5 in) galvanized flat expanded metal; Woven = 5 gauge, 1.0 x 3.8 cm (.38 x 1.5 in) galvanized woven wire, Plastic = 9 gauge plastic coated 1.3 x 2.5 cm (.5 x 1.0 in) openings expanded metal.

^bAverage of 40 days on test in trial 1: two replicate pens (of 8 pigs) per treatment for 35 days and four replicate pens (of 8 pigs) per treatment for 42 days. Average of 43 days on test in trial 2: 5 replicate pens (of 8 pigs) per treatment for 42 days and 1 replicate pen per treatment for 49 days.

^cScored 1 to 5 with 1 given to good pads and 5 given to pads with severe cuts, cracks and abrasions.

^{d,e}Means on the same line within main treatment are significantly different (P<.05).

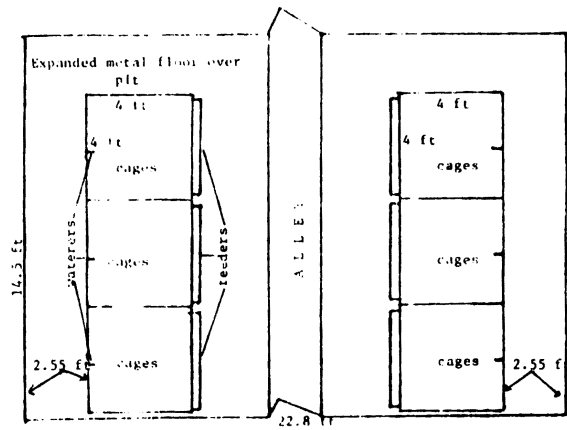


Figure 1. Plan view of triple deck nursery.

SUPPLEMENTAL BIOTIN FOR SWINE. II. FOOT LESIONS FOR
DEVELOPING GILTS

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

Feet and leg problems continue to cause economic distress for swine producers and the incidence of these problems continue to rise. The general condition of structural unsoundness, is a complex one involving many factors. Nutrition, unfavorable confinement facilities, diseases, and genetics (selection) are all suggested to cause unsoundness.

Biotin, a naturally occurring water-soluble B-complex vitamin, has been implicated as a factor in lameness due to its role in maintaining normal skin and foot pads. Biotin deficiency symptoms include decreased performance, alopecia, dry scaly skin, a white film and transverse grooves on the tongue, and finally erosion of the soft heel followed by cracking of the sole and horn (Cunha et al., 1946 and Glattli, 1975).

During the past 12 years claw defects and skin lesions comparable to these mentioned above have been reported in the United States (Cunha et al., 1968) and Europe (Tagwerker, 1974; Brooks et al., 1977). Biotin treatments in these studies were reported to give beneficial results.

This study was conducted to evaluate the need for supplemental biotin in swine diets. Three trials were conducted to evaluate the effects of biotin supplementation for developing gilts. Feedlot performance, hair scores and structural soundness scores from trials 1 and 2 were presented in the 1979 Livestock Research Report (Bryant et al., 1979). Biotin supplementation of the corn-soybean meal diets did not improve performance, and hair and soundness scores were not different. Similar results were found for gilts in trial 3. Combined over all trials, daily gain, daily feed intake, feed per gain, hair scores and structural soundness scores were not affected by supplementing 220 ug/kg biotin to a corn-soybean meal diet. This report will present the data on the effects of supplemental biotin on foot lesions.

Experimental Procedures

In three separate trials, 80 crossbred gilts were allotted 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.

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 National Research Council (1979) requirements. Rovimix (220 mg D-biotin/kg) provided the source of supplemental biotin for the 220 ug diet.

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 house where each pen of ten gilts was split by outcome groups into two pens of five

gilts. They remained there until completion of the test. Body weight gains, feed consumption, and feed per gain ratios were determined every 14 days.

All feet on each gilt were evaluated initially, at 45 kg body weight and at the completion of the test. Foot lesions were noted as to location and severity by a modification of the system outlined by Brooks *et al.* (1977). Based on visual observation each lesion was given a severity score of 1 to 5 with 1 being very small and 5 very large. A severity value for each lesion was obtained by adding the severity scores from each of the eight claws on each gilt. The incidence values (table 3 in parenthesis) are expressed as the percentage of animals in that group having one or more lesions. Figure 1 gives a detailed account of the foot lesions.

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.

Results and Discussion

The severity and incidence of foot lesions for gilts fed corn-soybean meal diets with and without supplemental biotin in trials 1, 2 and 3 are presented in Table 2. Toe cracks, heel-toe junction cracks and side wall cracks (Figure 1) were seldom observed in all three trials. Their occurrence was not related to level of supplemental biotin and will be omitted from the following discussion.

Trial 1. Severity and incidence of foot lesions were very low initially. Heel and toe erosion and heel cracks were the most notable lesions. As the gilts grew, the incidence and severity of the foot lesions increased. When the gilts reach 45 kg, approximately 90% suffered heel and toe erosion while approximately 77% had one or more heel cracks. The heel and toe erosion continued to increase and at the final observation point, 100% of the gilts exhibited moderate heel and toe erosion. The incidence of heel cracks dropped slightly; however, the severity increased from 45 kg to the final observation period. Even though many changes were noted in the incidence and severity of foot lesions in trial 1, no change could be related to the level of supplemental biotin.

Trial 2. The results of the foot lesions in trial 2 followed trends very similar to trial 1. However, the incidence and severity of foot lesions were both lower in trial 2 as compared to trial 1. Dietary biotin supplementation did not significantly ($P < .10$) affect the incidence or severity of foot lesions in trial 2.

Trial 3. The overall severity and incidence of foot lesions were higher ($P < .01$) in trial 3 compared to trials 1 and 2. An explanation for this difference cannot be given; however, the change was very dramatic at the 45 kg and final observation periods. The gilts were housed in the same buildings on the same flooring material for all three trials. The severity and incidence of heel cracks at the final period were less ($P < .01$) for biotin supplemented gilts. Biotin supplemented gilts had a severity

score of 4 compared to a value of 7.15 for the unsupplemented gilts. The incidence of heel cracks was 98% for the unsupplemented gilts and 63% for the biotin supplemented gilts.

Trials 1-3 combined. The most common foot lesions observed during the three trials were heel and toe erosion and heel cracks (table 3). Heel bruises were noted less frequently. As the gilts grew, the incidence and severity of all foot lesions increased. Accompanying the increased severity of heel and toe erosion was a hardening of the soft tissue on the heel. For some gilts, this hardening of the soft tissue became so severe that the junction between the toe and heel was undetectable.

There was a significant ($P < .05$) trial effect for initial heel and toe erosion, heel bruising (at 45 kg) and all the final observations across biotin treatments. This effect reveals the inherent differences between individuals, as well as, groups of animals. Supplementing a corn-soybean meal diet with 220 ug/kg biotin had no affect ($P < .10$) on heel and toe erosion or heel bruising. However, biotin supplementation significantly reduced ($P < .05$) the severity of heel cracks. There was a trend ($P < .10$) for reduced incidence of heel cracks when biotin was supplemented to the corn-soybean meal diet.

This is the only controlled study reporting data on the effects of biotin supplementation on foot lesions in growing-finishing gilts. These results suggest that biotin supplementation (220 ug/kg) may reduce the incidence and severity of foot lesions, especially heel cracks, without improving feedlot performance.

Summary

Three trials using 80 crossbred gilts per trial were conducted to evaluate supplemental biotin (220 ug/kg) of a corn-soybean meal diet for growing-finishing gilts. Performance data, hair and structural soundness scores were not different between the control and the supplemental biotin diet. Biotin supplementation reduced ($P < .05$) the severity and incidence of heel cracks in one of the three trials. Other lesions were not different between dietary treatments. About half of the gilts on each treatment will be bred and continued on test for three reproductive cycles.

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TABLE 1. PERCENT COMPOSITION OF BASAL DIETS^a.

Ingredients, %	IRN	Feeding Period				
		4-7 kg	7-10 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
Biotin, ug/kg ^{e,f}		187	141	128	120	103

^aBiotin added at .10% to provide 220 ug biotin/kg diet. Generously supplied by Hoffmann-La Roche Company, Nutley, NJ.

^bContained (%): 20 Zn, 10 Fe, 5.5 Mn, 1.1 Cu and .15 I.

^cSupplied (per kilogram of premix): 1.76 g riboflavin, 8.8 g pantothenic acid, 8.8 g niacin, 8.8 mg vitamin B₁₂, 176 g choline chloride, 1,760,000 IU vitamin A, 176,000 IU vitamin D₃, 4400 IU vitamin E, 440 mg menadione dimethylprimidinol bisulfite (MPB) and 40 mg Se.

^d4.5-20 kg: ASP-250; 20-100 kg: Virginiamycin.

^eDetermined by a microbiological assay.

^fBiotin levels for the 220 ug supplemented diets were: 399, 373, 316, 312, and 306 ug/kg for the 22, 20, 18, 16 and 14% crude protein diets, respectively.

Table 2. SEVERITY^a AND INCIDENCE^b OF FOOT LESIONS ON GILTS FED TWO LEVELS OF SUPPLEMENTAL BIOTIN (TRIALS 1, 2 AND 3).

Type Lesion	Trial 1		Trial 2		Trial 3	
	0 ^c	220	0	220	0	220
	<u>Initial</u>					
Heel and Toe Erosion ^d	.21 (12)	.20 (13)	.10 (7)	.10 (6)	.20 (10)	.23 (17)
Heel Bruising	.00 (0)	.00 (0)	.00 (0)	.00 (0)	.00 (0)	.05 (3)
Heel Cracks ^d	.24 (18)	.20 (12)	.20 (10)	.13 (8)	.05 (2)	.05 (3)
	<u>45 kg</u>					
Heel and Toe Erosion	8.59 (90)	8.84 (90)	7.48 (83)	8.15 (93)	14.73 (98)	12.85 (98)
Heel Bruising ^d	.05 (5)	.08 (8)	.00 (0)	.00 (0)	.03 (3)	.00 (0)
Heel Cracks	2.98 (79)	3.02 (75)	1.03 (33)	.70 (35)	1.43 (55)	1.60 (53)
	<u>Final</u>					
Heel and Toe Erosion ^d	16.01 (100)	15.71 (100)	13.28 (95)	12.15 (93)	21.03 (100)	22.23 (95)
Heel Bruising ^d	.11 (10)	.14 (10)	.25 (15)	.20 (12)	.05 (4)	.00 (0)
Heel Cracks ^{de}	3.28 (64)	3.63 (73)	2.38 (53)	2.47 (50)	7.15 (98)	4.00 (63)

^aSeverity = Sum of severity scores from each claw for each lesion.

^bIncidence expressed as percent of animals having one or more lesions and is in parenthesis.

^cSupplemental biotin, ug/kg diet.

^dSignificant trial effect (P < .05).

^eSignificant biotin x trial effect (P < .01).

TABLE 3. INCIDENCE AND SEVERITY OF FOOT LESIONS ON GILTS
FED TWO LEVELS OF SUPPLEMENTAL BIOTIN (TRIALS 1-3)^a.

Type Lesion	Supplemental Biotin, ug/kg	
	0	220
	<u>Initial</u>	
Heel and Toe Erosion ^b	.17 ± .05 (16)	.18 ± .04 (13)
Heel Bruising	.00 ± .00 (0)	.02 ± .00 (1)
Heel Cracks ^b	.16 ± .03 (14)	.13 ± .03 (14)
	<u>45 kg</u>	
Heel and Toe Erosion ^b	10.30 ± .41 (90)	10.57 ± .42 (93)
Heel Bruising	.03 ± .01 (9)	.03 ± .01 (6)
Heel Cracks ^d	1.81 ± .19 (56)	1.77 ± .19 (54)
	<u>Final</u>	
Heel and Toe Erosion ^b	16.79 ± .50 (98)	16.70 ± .48 (96)
Heel Bruising ^b	.14 ± .02 (16)	.12 ± .02 (13)
Heel Cracks ^{bc}	4.27 ± .28 ^d (71)	3.36 ± .28 ^e (62)

^aIncidence expressed as percent of animals having one or more lesions and is placed in parenthesis.

^bSignificant trial effect (P < .05).

^cSignificant biotin x trial effect (P < .01).

^{d,e}Values on the same line with different superscripts are significantly different (P < .05).

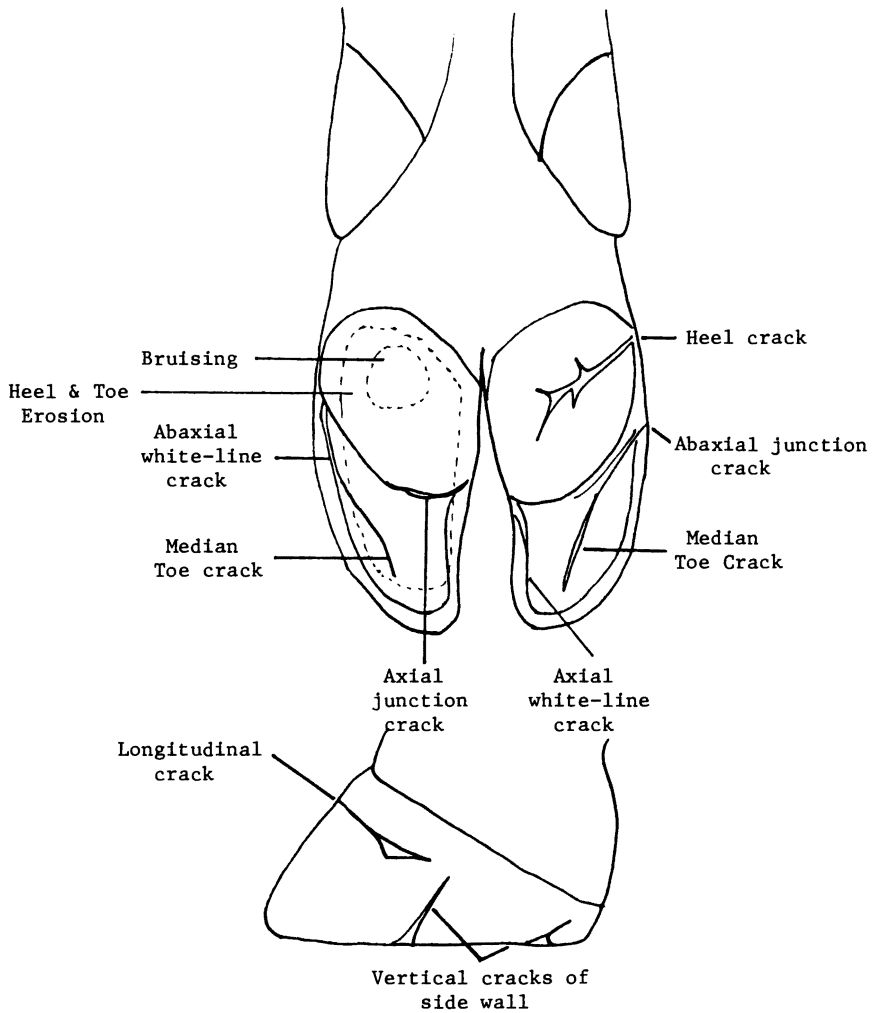


FIGURE 1. CLASSIFICATION OF FOOT LESIONS
(Adapted from Brooks et al., 1977)

CORN PLANT RESPONSE TO SOIL APPLICATION OF COPPER-ENRICHED SWINE MANURE¹

W. P. Miller, G. L. Mullins, D. C. Martens
E. T. Kornegay and L. W. Zelazny²

Dietary copper levels of 125 to 250 ppm act as a growth stimulant for swine, but higher levels are very toxic (Kornegay et al., 1977). The major portion of the copper, 80 to 95%, is excreted in the swine manure (Kornegay et al., 1977). Environmental concern exists for copper-enriched manure utilization in crop production. This long-term research was initiated to evaluate environmental aspects of copper-enriched swine manure utilization in corn (Zea mays L.) production. The initial phase of the research, discussed herein, was conducted to evaluate effects of two-annual applications of copper-enriched swine manure on copper concentration and yield of corn on three soils.

EXPERIMENTAL PROCEDURES

Field experiments were initiated on three soils in the spring of 1978 and continued in 1979. Properties of the three soils are shown in Table 1. Soil pH was measured in 1:1 soil-to-water suspensions after a one-hour equilibration period. Contents of soil organic matter were determined by a chromic acid oxidation procedure. Soil samples were leached with sodium acetate (pH 5.0) to remove calcium carbonate in preparation for cation exchange capacity (CEC) measurements. Calcium from calcium acetate (pH 7.0) was used as the saturating cation and magnesium from magnesium acetate (pH 7.0) was used as the displacing cation for the CEC measurement (Jackson, 1958).

Five treatments applied in quadruplicate to the three soils in the springs of 1978 and 1979 were 1) a control, 2) 33.6 metric tons of wet copper-enriched pig manure/ha, 3) copper as copper sulfate equivalent to treatment 2, 4) 67.2 metric tons of wet copper-enriched pig manure/ha, and 5) copper as copper sulfate equivalent to treatment 4. Manure was collected for the treatments from sows and gilts fed growth stimulating levels of copper as copper sulfate. All treatments received recommended levels of nitrogen, phosphorus, potassium, limestone and micronutrients for high corn yields. The manure and fertilizer amendments were worked into the soils by plowing and disking. Corn 'Pioneer 3369A' was grown at recommended populations on the three soils, and was harvested at plant maturity. Corn-grain yields were corrected to 15.5% moisture content.

¹This research was supported in part by the International Copper Research Association, Inc.

²Graduate Research Assistants, Professor of Agronomy, Professor of Animal Science and Associate Professor of Agronomy, respectively.

Swine feed and manure were dried at 105°C for 16 hours and ground to pass a 20-mesh screen in preparation for copper analyses. Dry matter contents of dried manure samples were determined gravimetrically. Corn earleaves, sampled at the early silk growth stage, and corn grain, sampled at maturity, were ground in the above manner for copper analyses after a 48-hour drying period at 70°C. Copper concentrations in the feed, manure and plant tissue samples were determined by atomic absorption spectrophotometry after one-gram subsamples of these materials were dry ashed at 450°C and dissolved in acidic solution.

Yield and nutrient concentration data were evaluated by analyses of variance and by Duncan's Multiple Range Tests. These analyses were performed on an IBM 370 computer utilizing the SAS programs.

RESULTS AND DISCUSSION

Field experiments were conducted on three soils to study corn response to application of copper-enriched swine manure. The soils under study were selected to vary in both texture and CEC in order to provide wide applicability of the experimental results. This was achieved in that the Ap horizons of the three soils had clay loam, fine sandy loam and silt loam textures, and had CEC values ranging from 5.0 to 12.3 meq/100 g (Table 1). The Ap horizon of each soil was slightly acid and contained moderate amounts of organic matter.

Addition of the copper sulfate increased the copper concentrations in swine feed to 260.8 ppm in 1978 and to 178.1 ppm in 1979. Three batches of swine manure produced for the field experiments ranged from 1313 to 1398 ppm copper in 1978 and from 899 to 1273 ppm in 1979 on a dry weight basis (Table 2). The higher levels of copper in 1978, than in 1979, reflect the higher copper concentration in swine feed in 1978.

From 22.4 to 33.6 metric tons/ha of wet swine manure are commonly applied to agricultural soils annually for corn production (Donohue and McCart, 1977). The 33.6 metric ton/ha level of pig manure was selected as the low rate of application for use in the three field experiments (Table 3). A higher level of 67.2 metric tons/ha was included in the field experiments to simulate an abnormally high rate of swine manure application. The dry matter contents of the swine manure (Table 2) were higher than the average value of 18% reported by Donohue and McCart (1977). Thus, our lower rate of 33.6 metric tons/ha of manure supplied a slightly higher amount of solids than is commonly applied to soils annually for corn production.

Corn-grain yields were relatively high in field experiments on the fine sandy loam soil at Holland and on the silt loam soil at Blacksburg (Table 3). Lack of rainfall limited corn-grain yields on the clay loam soil at Orange. Application of copper as either copper-enriched swine manure or copper sulfate did not affect corn-grain yield on the clay loam and fine sandy loam soils. Corn-grain yields were higher on the copper-enriched manure treatments than on the control for the silt loam soil.

The normal range for copper concentrations in corn grain is from 1 to 5 ppm (Jones and Eck, 1973). Copper concentrations in corn grain from all treatments of the field experiments were below this range (Table 3). The copper concentrations in corn grain were not increased by applications of either copper-enriched swine manure or copper sulfate to the clay loam, fine sandy loam, or silt loam soils. In agreement, Kornegay et al. (1977) reported no increase in copper concentration of corn grain on a Groseclose silt loam that received five-annual applications of copper-enriched swine manure.

Copper added to soils as either copper-enriched swine manure or copper sulfate in both 1978 and 1979 increased the copper concentration in corn ear leaves at the early-silk growth stage on the fine sandy loam soil at Holland (Table 3). These values were in the normal range of copper concentrations of 3 to 15 ppm in corn ear leaves at the early-silk growth stage (Jones and Eck, 1973). Copper application as either copper-enriched swine manure or copper sulfate did not increase the copper concentrations in ear leaf tissue of plants on the clay loam soil at Orange or on the silt loam soil at Blacksburg (Table 3). Previously, Kornegay et al. (1977) reported that the copper concentration in corn ear leaf tissue increased an average of one ppm per year from a base level of 7ppm when copper-enriched swine manure was applied annually for five years to a Groseclose silt loam.

Research with municipal sewage sludge has shown that much higher levels of copper, than used herein, could be applied to soils without the development of environmental problems. That is, cumulative loading rates of 125, 250, and 500 kg copper/ha from municipal sewage sludge has not led to problems on soils with pH levels >6.5 and with CEC values of 0-5, 5-15 and >15 meq/100 g, respectively, (Sommers and Nelson, 1978).

SUMMARY

Copper concentrations were relatively high in manure from swine fed growth stimulating levels of copper. Two annual applications of the manure at twice the level recommended for corn production did not affect either corn-grain yields or copper concentrations in corn grain on three soils with diverse properties. Application of the manure increased copper concentrations in ear leaves sampled at the early silk stage on one of the three soils. However, copper concentrations in the ear leaves were within the normal range on all soils.

ACKNOWLEDGEMENT

Appreciation is expressed to Mr. Ken Bryant for supervising the collection of the swine manure.

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TABLE 1

PROPERTIES OF THE Ap HORIZON OF THREE SOILS PRIOR TO INITIATION OF FIELD EXPERIMENTS IN 1978.

Field experiment location	Soil series	Soil texture	Soil pH	Organic matter, %	CEC, meq/100g
Blacksburg	Landisburg-Greendale complex	silt loam	5.7	1.8	10.4
Holland	Bertie	fine sandy loam	6.2	1.7	5.0
Orange	Starr-Dyke complex	clay loam	5.9	1.4	12.3

TABLE 2

COPPER CONCENTRATION AND DRY MATTER OF SWINE MANURE USED FOR THREE FIELD EXPERIMENTS IN 1978 AND 1979.

Field experiment location	Copper concentration, ppm		Dry matter, %	
	1978	1979	1978	1979
Blacksburg	1,398	899	25.2	25.7
Holland	1,396	1,273	26.7	25.9
Orange	1,313	1,125	26.7	24.7

TABLE 3
EFFECT OF TWO-ANNUAL APPLICATIONS OF COPPER AS EITHER COPPER SULFATE OR SWINE MANURE ON COPPER CONCENTRATIONS IN CORN TISSUES AND ON CORN-GRAIN YIELDS ON THREE SOILS.¹

Copper treatment		Copper Conc., ppm		Corn grain
kg Cu/ha	Source	Grain	Ear leaves	yield, kg/ha
<u>Blacksburg Location</u>				
0.0	Control	0.24a	11.3a	9,350b
19.6	33.6 metric ton swine manure/ha	0.32a	11.7a	10,240a
19.6	CuSO ₄	0.51a	11.4a	9,650ab
39.2	67.2 metric ton swine manure/ha	0.40a	11.5a	10,350a
39.2	CuSO ₄	0.38a	12.0a	9,960ab
<u>Holland location</u>				
0.0	Control	0.46a	6.1c	8,860a
23.6	33.6 metric ton swine manure/ha	0.41a	9.6ab	8,680a
23.6	CuSO ₄	0.46a	8.5b	9,190a
47.2	67.2 metric ton swine manure/ha	0.43a	9.8a	8,570a
47.2	CuSO ₄	0.44a	10.1a	9,010a
<u>Orange location</u>				
0.0	Control	0.47a	10.5a	6,370a
21.1	33.6 metric ton swine manure/ha	0.38a	11.0a	6,770a
21.1	CuSO ₄	0.42a	11.2a	6,920a
42.2	67.2 metric ton swine manure/ha	0.29a	11.2a	6,870a
42.2	CuSO ₄	0.52a	10.6a	6,670a

¹Column means for each location followed by different letters are significantly different at the 0.05 probability level.

INFLUENCE OF RESTRICTED ENERGY AND ELEVATED CALCIUM AND PHOSPHORUS
ON SELECTED RADIOGRAPHIC BONE MEASUREMENTS IN DEVELOPING BOARS¹

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

An understanding of the etiological factors causing leg weakness in swine could provide useful guidelines for decreasing the incidence and severity of the problem. While specific interrelationships are poorly understood, it is obvious that the problem entails various nutritional, physiological, genetic, environmental and conformational factors. Thus, research efforts that combine various aspects of the above questioned areas should provide the greatest insight into an understanding of the abnormality.

It has been demonstrated that a rapid growth rate is highly correlated with the incidence and severity of the leg weakness syndrome and, more specifically, the non-infectious, non-inflammatory degeneration of bone and cartilage termed osteochondrosis. The knee and elbow joints are the areas of highest incidence of osteochondrosis in boars.

Since the growth pattern of these joints has not been fully characterized, it was the intention of this study to determine the morphological changes associated with the joints and the long bones throughout the growing period following various energy and mineral treatments.

Experimental Procedures

A total of 20 crossbred boars (5/treatment) were randomly assigned to one of four dietary treatment groups in a 2 x 2 factorial design. They were examined at eight 21-day intervals from 80 to 220 days of age. The treatments were as follows:

- Treatment 1 = ad libitum intake and National Research Council for calcium and phosphorus levels (NRC);
- Treatment 2 = restricted intake (75% of ad lib group) and NRC;
- Treatment 3 = ad libitum intake and 150% NRC;
- Treatment 4 = restricted intake (75% of ad lib) and 150% NRC.

This design facilitated the comparison of slow-growing animals with fast-growing animals and also allowed an evaluation of the effects of elevated calcium and phosphorus on bone formation. The diets were imposed following weaning at four weeks of age and maintained for the duration of the study.

Radiological examination consisted of x-raying the lumbar vertebrae (L₁) for both ventro-dorsal (VD) and lateral views (L), the radius ulna (R) for both the anterior-posterior (AP) and L views, and the fibula-

¹Appreciation is extended to the John Lee Pratt Animal Nutrition Program for financial support of this research.

tibia (T) for both the AP and L views. The measurements taken included the maximal length of the R and T, the maximal proximal width (PW) of the R and T for both L and AP views, the maximal distal width (DW) of the R and T for both L and AP views and the midshaft width (MW) of the T for both L and AP views.

Specific gravity of the synovial fluid was examined for four joints at necropsy (two corpal and two stifle).

Results and Discussion

Radiographic results (Table 1) revealed that full fed animals had a wider bone than did restrict fed animals. The radius-ulna showed no differences ($P > .05$) for either view. However, the tibia in the AP view showed a significantly greater ($P < .01$) midshaft width. Although it was not significant ($P > .05$), the lateral view of the tibia showed a greater proximal and midshaft width. The AP view of the T had a greater ($P < .01$) proximal width and a longer tibia.

Elevated calcium and phosphorus produced a significantly greater ($P < .05$) proximal width for the R when viewed L. The AP view of the R was greater ($P < .05$) for both distal and proximal widths. The L view of the T had a greater ($P < .01$) DW, PW and MW. The AP view of the T showed a wider ($P < .05$) MW for the elevated calcium and phosphorus levels.

The specific gravity of the synovial fluid was higher ($P < .05$) in the ad lib fed animals than in the restrict fed animals (Table 2). The boars receiving the NRC calcium and phosphorus levels had a higher ($P < .05$) specific gravity value than those fed the elevated levels.

The specific gravity increased ($P < .01$) with increasing age of the animal (Table 3). It was also noted that the specific gravity of the stifle synovial fluid was greater ($P < .01$) than that of the corpal joint (Table 3).

Summary

The use of restricted feed intake produced a smaller tibia. The synovial fluid specific gravity values were also lower in restrict fed vs full fed animals. The use of 150% NRC calcium and phosphorus levels produced a wider radius and tibia than did the NRC treatment. The elevated levels produced a lower specific gravity of the synovial fluid.

TABLE 1. A COMPARISON OF VARIOUS RADIOGRAPHIC MEASUREMENTS OBTAINED FROM BOARS FED TWO LEVELS OF ENERGY AND TWO LEVELS OF MINERALS^a

Bone, view and dimension	Energy		Mineral		S.E.
	Ad lib	fed Restricted	NRC	150% NRC	
No. of animals	10	10	10	10	
<u>Radius</u>					
Lateral view					
Length	118.6 ^{bc}	119.2	117.2	120.6	1.4
Distal width	32.4	31.4	31.3	32.5	.5
Proximal width	24.8	24.7	24.1	25.4*	.4
Anterior-posterior view					
Distal width	40.3	38.9	38.5	40.7*	.7
Proximal width	36.0	35.7	35.2	36.5*	.5
<u>Tibia</u>					
Lateral view					
Length	166.7	165.4	164.7	167.3	2.3
Distal width†	35.8	35.3	34.7	36.4**	.4
Proximal width	41.0	39.5 ^d	39.2	41.3**	.6
Midshaft width	17.2	16.6 ^d	16.4	17.4**	.2
Anterior-posterior view					
Distal width	43.0	42.2	42.7	42.5	.6
Proximal width	63.7	60.9 ^d	61.7	62.9	1.0
Midshaft width	26.3	24.8**	25.0	26.1*	.4

^aAll treatment comparisons made within energy level or within mineral level.

^bAll values represent least squares means adjusted over time based on the initial (day 80) and final (day 220) time points.

^cAll values expressed in millimeters.

^dTreatment means different ($P < .10$).

*Treatment means different ($P < .05$).

**Treatment means different ($P < .01$).

†Significant ($P < .05$) energy X mineral interaction.

TABLE 2. A COMPARISON OF THE SYNOVIAL FLUID SPECIFIC GRAVITY
VALUES IN THE CARPAL AND STIFLE JOINTS OF BOARS FED TWO
LEVELS OF ENERGY AND TWO LEVELS OF MINERALS^a

Joint ^b	Energy		Minerals		S.E.
	Ad lib fed	Restricted	NRC	150% NRC	
No. of animals	10	10	10	10	
Right carpal†	1.0170	1.0160	1.0172	1.0158*	.0004
Left carpal	1.0183	1.0163**	1.0183	1.0162**	.0005
Right stifle	1.0202	1.0192	1.0206	1.0187*	.0006
Left stifle	1.0205	1.0185*	1.0202	1.0188	.0007

^aAll treatment comparisons made within energy level or within mineral level.

^bSpecific gravity of stifle ($\bar{X}$ = 1.0196) significantly ($P < .01$) greater than that of carpal ($\bar{X}$ = 1.0169).

*Treatment means different ($P < .05$).

**Treatment means different ($P < .01$).

†Significant ($P < .05$) energy X mineral interaction.

TABLE 3. A COMPARISON OF THE SYNOVIAL FLUID SPECIFIC GRAVITY
IN THE CARPAL AND STIFLE JOINTS OF BOARS AT TWO AGES

	Carpal		Stifle	
	Right	Left	Right	Left
No. of animals	10	10	10	10
Early (days 80, 90 and 100)	1.0154 ^a	1.0144 ^a	1.0170 ^a	1.0150 ^a
Late (day 220)	1.0179 ^a	1.0182 ^b	1.0218 ^b	1.0219 ^b

^{ab}Means in same column (i.e., same joint and side) with different superscripts are significantly different ($P < .01$).

INFLUENCE OF RESTRICTED ENERGY AND ELEVATED CALCIUM AND
PHOSPHORUS ON BIOCHEMICAL CHANGES IN SWINE ARTICULAR CARTILAGE¹

G. A. Kesel, James W. Knight, H. P. Veit and E. T. Kornegay

Articular cartilage (AC) is composed of a rigid framework of protein termed collagen, which is enveloped by a gelatinous ground substance. The ground substance, or proteoglycan, is the component that supplies the nutrient transport and the elastic properties of the tissue. Therefore, any changes in the amount or biochemical composition of the collagen or proteoglycan moieties can lead to a disturbance in cartilage function.

Collagen consists of a unique sequence of amino acids containing hydroxyproline (HYP). Thus, the hydroxyproline values are directly related to the collagen content. The proteoglycan is composed of three primary units, the largest being chondroitin sulfate, followed by keratin sulfate, with the third and smallest component being hyaluronic acid. The three units are composed of disaccharides containing uronic acid (UA), except for keratin sulfate which contains galactose (GAL).

This report will explore the changes in HYP, UA and GAL as a result of restricted feed intake and elevated calcium and phosphorus levels in growing boars.

Materials and Methods

Eighty crossbred boars (20/treatment) were used in a 2 x 2 factorial experiment. Treatments were as follows:

- Treatment 1 = ad libitum intake and National Research Council (NRC) calcium and phosphorus
- Treatment 2 = restricted intake (75% of ad lib group) and NRC calcium and phosphorus
- Treatment 3 = ad libitum intake and 150% NRC calcium and phosphorus
- Treatment 4 = restricted intake (75% of ad lib group) and 150% NRC calcium and phosphorus

This design facilitated a comparison of AC between "slow growing" and "fast growing" boars. The influence of elevated calcium and phosphorus on cartilage composition was also explored to determine if dietary elevation provided a beneficial effect.

The 20 boars assigned to each treatment group were necropsied at 80-220 days of age (inclusive). For the purpose of this report, the data is reported by energy and by calcium and phosphorus levels.

¹Appreciation is expressed to the John Lee Pratt Animal Nutrition Program for financial support of this research, and to Helen Bartlett for laboratory assistance.

At necropsy, the total joint AC was removed from the distal end of the femur (F) and humerus (H) and the proximal end of the radius-ulna (R). All AC samples were acetone dried and lyophilized to obtain a fat free dried sample.

The AC was further prepared by digesting the cartilage with papain for 24 hours at 65 C. A 1 ml aliquot of the digest was then placed in a sealed culture tube with 1 ml of 6.0 N HCl and autoclaved for 24 hours. Hydroxyproline was measured by the method of Kivirikke *et al* (1967). Another 1 ml aliquot was removed from the digest and the proteoglycan precipitated using the procedure of Breen *et al*. (1976). Uronic acid was measured by the procedure of Bitter and Muir (1962) and GAL by Trevelyan and Harrison (1952).

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

Results and Discussion

Analysis of the AC for percent dry weight (Table 1) indicated no significant differences ($P > .10$) due to treatment for any of the three sampling sites. There was a higher ($P < .10$) HYP content in the F for the ad libitum fed boars than in the restricted fed group (Table 2). Although the HYP values for the H and R were not significantly different, the ad libitum fed boars had higher values than restricted fed animals. No differences in HYP was found in any AC due to 150% NRC levels.

Uronic acid was found to be higher, although not significant, in all AC from the restrict fed animals. No differences were found in UA content of AC due to 150% NRC levels. Levels of GAL were not different due to treatment in any AC samples.

Examination of the age effect on the AC showed that there was a significant ($P < .01$) decrease in percent fat free dry weight in the AC from the humerus. No age effects were seen in the percent fat free dry weight of the AC from the femur or radius-ulna (Table 3).

The HYP, although not significant, was found to increase in the older animals in all bones (Table 4). The UA and the GAL levels were all decreased ($P < .01$) with age.

Summary

The use of restricted energy intake led to a decrease in HYP content of the AC. Because AC has been shown to increase in HYP content with age, it can be suggested that the restrict fed animals had AC which was less mature. Uronic acid was elevated in the restrict fed animals, although they were not significantly different ($P < .10$). The UA levels decreased with age ($P < .01$) also suggesting that the AC of the restrict fed boars was less mature. The GAL levels remained unchanged in the restrict fed animals although there was a significant ($P < .01$) decrease in GAL in older boars.

The use of elevated calcium and phosphorus had no effect on the AC components.

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TABLE 1. LEAST SQUARES MEANS AND STANDARD ERRORS OF PERCENT FAT FREE DRY WEIGHT OF ARTICULAR CARTILAGE FROM BOARS FED TWO ENERGY LEVELS AND TWO CALCIUM AND PHOSPHORUS LEVELS^a

Bone	Energy		Calcium and phosphorus	
	Ad lib fed	Restricted	NRC	150% NRC
No. of animals	20	20	20	20
Femur	39.00 ± .85 ^b	40.15 ± .83	39.28 ± .76	39.88 ± .74
Humerus	39.99 ± 1.16	40.27 ± 1.14	40.17 ± 1.02	40.09 ± 1.03
Radius-ulna	49.56 ± 2.18	49.09 ± 2.15	49.16 ± 1.95	49.49 ± 1.93

^aAll treatment comparisons made within energy level or within calcium and phosphorus level.

^bAll values represent percent of wet weight.

TABLE 2. LEAST SQUARES MEANS AND STANDARD ERRORS OF CHEMICAL COMPONENTS OF ARTICULAR CARTILAGE FROM BOARS FED TWO ENERGY LEVELS AND TWO CALCIUM AND PHOSPHORUS LEVELS^a

Bone and analysis	Energy		Calcium and phosphorus	
	Ad lib fed	Restricted	NRC	150% NRC
No. of animals	20	20	20	20
<u>Femur</u>				
Hydroxyproline	76.9 ± 1.8 ^b	72.2 ± 1.8*	73.8 ± 1.6	75.4 ± 1.6
Uronic acid	61.8 ± 3.2	66.9 ± 3.2	65.5 ± 2.9	63.2 ± 2.8
Galactose	25.2 ± 1.7	22.4 ± 1.7	23.0 ± 1.5	24.6 ± 1.5
<u>Humerus</u>				
Hydroxyproline	76.9 ± 2.0	71.9 ± 2.0	74.2 ± 1.8	74.6 ± 1.8
Uronic acid	62.7 ± 3.5	68.8 ± 3.5	66.3 ± 3.2	65.2 ± 3.1
Galactose	25.2 ± 1.6	23.1 ± 1.6	23.8 ± 1.5	24.5 ± 1.4
<u>Radius ulna</u>				
Hydroxyproline	76.3 ± 1.8	72.6 ± 1.9	74.3 ± 1.7	74.6 ± 1.7
Uronic acid	55.9 ± 3.3	64.0 ± 3.3	60.6 ± 3.0	59.3 ± 2.9
Galactose	22.8 ± 1.6	20.9 ± 1.7	20.7 ± 1.5	22.9 ± 1.5

^aAll treatment comparisons made within energy level or within calcium and phosphorus level.

^bAll values represent mg/gm fat free dry cartilage.

*Treatment means different (P < .10).

TABLE 3. LEAST SQUARES MEANS AND STANDARD ERRORS OF PERCENT FAT FREE DRY WEIGHT OF ARTICULAR CARTILAGE FROM BOARS AT TWO AGE GROUPS^a

Bone	Young boars (≤ 100 days of age)	Older boars (≥ 200 days of age)
No. of animals	12	28
Femur	38.69 ± 1.13	39.83 ± .80
Humerus	44.55 ± 1.26	37.55 ± .87*
Radius ulna	49.40 ± 2.33	45.03 ± 1.65

^aAll values represent percent of wet weight.

*Treatment means differ (P < .01).

TABLE 4. LEAST SQUARES MEANS AND STANDARD ERRORS OF CHEMICAL COMPONENTS OF ARTICULAR CARTILAGE FROM BOARS AT TWO AGE GROUPS

Bone and analysis	Young boars ($\leq$ 100 days of age)	Older boars ($>$ 200 days of age)
No. of animals	12	28
<u>Femur</u>		
Hydroxyproline	71.8 $\pm$ 3.3 ^a	78.1 $\pm$ 2.1
Uronic acid	83.2 $\pm$ 5.3	56.8 $\pm$ 3.4*
Galactose	33.9 $\pm$ 2.7	20.8 $\pm$ 1.7*
<u>Humerus</u>		
Hydroxyproline	72.3 $\pm$ 3.8	76.8 $\pm$ 2.4
Uronic acid	80.0 $\pm$ 5.9	59.4 $\pm$ 3.6*
Galactose	34.5 $\pm$ 2.5	21.2 $\pm$ 1.6*
<u>Radius ulna</u>		
Hydroxyproline	71.7 $\pm$ 3.9	77.0 $\pm$ 2.4
Uronic acid	72.7 $\pm$ 5.5	52.6 $\pm$ 3.3
Galactose	31.0 $\pm$ 2.4	17.9 $\pm$ 1.5

^a All values represent mg/gm fat free dry cartilage.

*Significant difference within rows (P < .01).

DETERMINATION OF RESPIRATORY QUOTIENTS IN EQUINE

S. A. Rich, T. N. Meacham, K. E. Webb, Jr. and J. P. Fontenot

This study was undertaken to more precisely define the metabolism of fats as energy sources for horses. Equipment was needed to measure the respiratory quotients (RQ's) and heat increments of saturated and unsaturated fats.

To determine the RQ of an animal, the ratio of the volume of carbon dioxide (CO_2) produced to the volume of oxygen (O_2) consumed must be known. The numerical value of this quotient is dependent upon the chemical nature of the substrate being oxidized within the body. Typical RQ's for carbohydrate utilization are approximately 1.0, for protein .8 and for fat .7.

In order to obtain samples of the gases to calculate RQ's, it was necessary to develop a system to measure the expired gases. The design implemented at our research facility was based on the indirect open circuit method of calorimetry. The animal inhales atmospheric air and the volume of expired gases is measured and sampled. A face mask (figure 1) made of light plexiglass adopted from the design of Burke and Albert (1978) fits over the muzzle of the animal and is secured to the horse in much the same manner as a feed bag. Located around the perimeter of the mask are one-way inhalation valves which allow atmospheric air into a chamber at the bottom of the mask. A removable hose is attached to the bottom of the mask which pulls the expired air, by means of a vacuum pump from the mask (figure 2). The expired air is pumped into a large flow meter that measures the volume. Thermometers record the temperature of the gases and a barometer measures the barometric pressure. All gas volumes are corrected to standard temperature and pressure. A sample of the expired air is obtained continuously via a small polystaltic pump and stored in 6 liter gas storage containers. Samples of both atmospheric air and expired air are obtained and analyzed for O_2 and CO_2 content using a Fisher Hamilton gas partitioner and automatic recorder. A mixture of gases (O_2 , CO_2 , N_2 and CH_4) of known concentrations was analyzed and served as standards.

Respiratory gases were collected from two ponies in a series of preliminary trials to perfect the sampling apparatus and standardize the procedures. Preliminary results obtained from animals fed an alfalfa hay diet are shown in table 1. The initial data indicate RQ values of $1.0 \pm .06$ from this feedstuff. Slight alterations of procedure and fine adjustment of equipment are still being made to improve the repeatability and accuracy of the determinations.

TABLE 1. PRELIMINARY RESPIRATORY QUOTIENTS OF PONIES FED AN
ALFALFA HAY DIET

Trial No.	Pony No.	Sampling time, min.	O ₂ consumed L/min	CO ₂ produced L/min	RQ value
1	29	47	.101	.107	.943
2	29	37	.766	.759	.990
3	29	37	.780	.810	1.03
4	29	40	.71	.74	1.04
	30	40	.70	.68	.971

RESPIRATION MASK

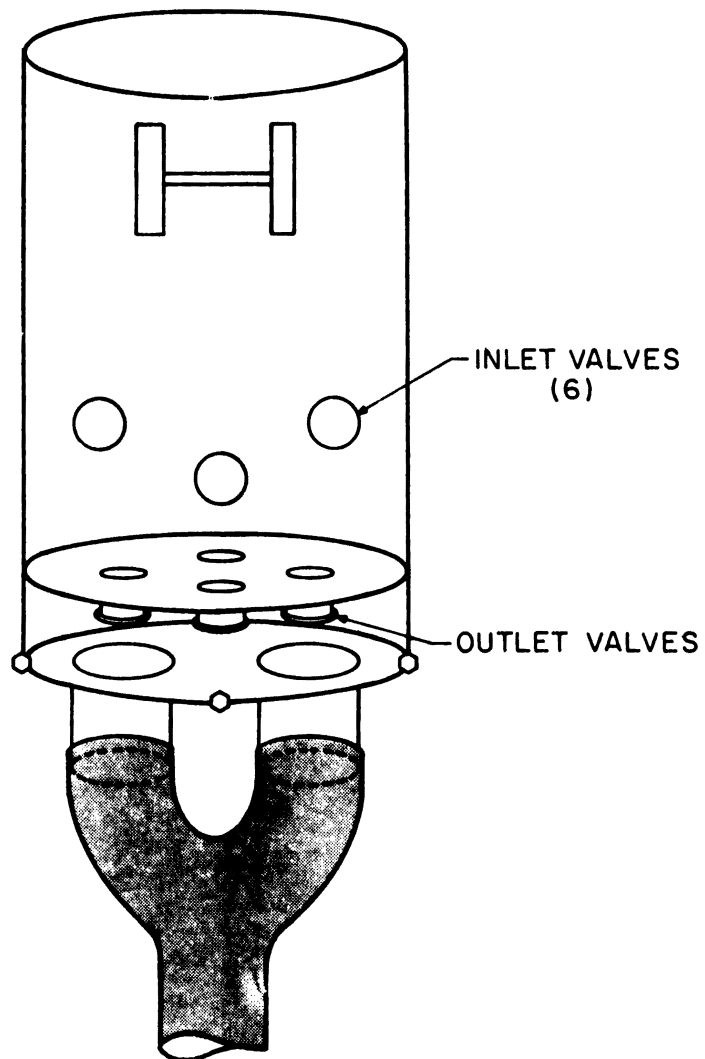


Figure 1.

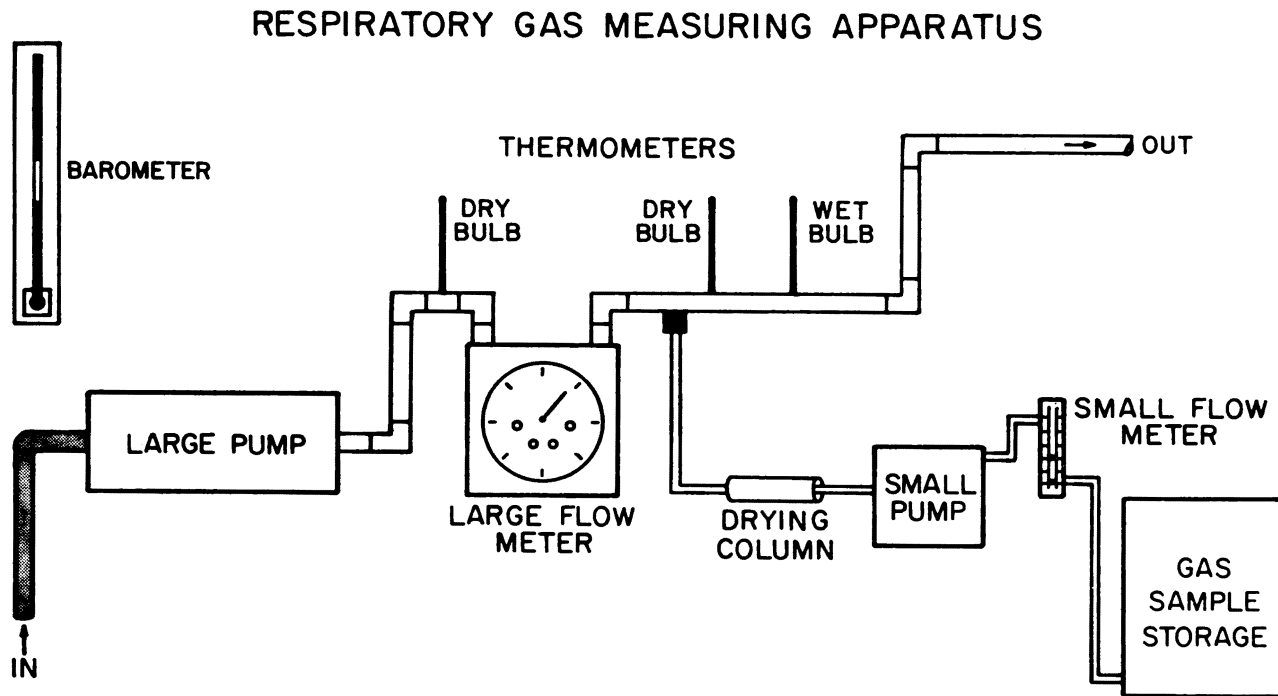


Figure 2.

A BIOCHEMICAL ASSAY FOR DETERMINING THE ACROSIN
RELEASE FROM EXTENDED BOAR SPERMATOZOA

C. R. Underwood, T. M. Tamblyn and James W. Knight

Mammalian fertilization requires that a spermatozoa penetrate the ovum investments. Acrosin, a proteolytic enzyme located in the acrosome of mammalian spermatozoa, is essential for penetration of the zona pellucida of the ovum. Since acrosin is intimately involved in fertilization, its potential as a parameter to estimate the fertilizing capacity of spermatozoa appears great.

This study was conducted to validate the acrosin assay and to determine the effects of freezing and storage time on acrosin activity. This study was preliminary to further studies involving the development of extenders and extender systems to maximize the long-term storage of boar semen.

Experimental Procedures

The sperm-rich fraction of a boar's ejaculate was collected and extended, at 37 C, in either Beltsville L2 (Pursel *et al.*, 1973) or Purdue extender (Pursel *et al.*, 1974). Each sample of extended semen was packed in an ice jacket and then sonicated for 30 seconds to rupture the acrosomal membranes. Samples were then centrifuged for ten minutes, at 10,000 G to remove cellular debris. The supernatant was decanted and approximately 1.5 ml of a 1 mg/ml solution of bovine serum albumin was added to minimize autolysis of acrosin. Samples were adjusted to pH 3.0 with 1.0 M HCl to dissociate the acrosin-acrosin inhibitor complex (Polakoski *et al.*, 1971). Following the pH adjustment, samples were incubated in a 37 C water bath for at least ten minutes.

Each sample was mixed and divided into four aliquots. One aliquot was placed in an ice jacket for immediate analysis, the remaining aliquots were sealed and placed in a freezer for future analysis.

The acrosin assay was conducted, using a Gilford Spectrophotometer, according to the procedures of Parrish and Polakoski (1978). Duplicates of each sample were assayed fresh, and equal aliquots were frozen at -20 C and assayed during subsequent weeks.

Results

Table 1 shows the amount of acrosin activity, expressed as the change in optical density, initially and in stored samples. The raw data is presented for duplicates of each sample. Freezing and storage time does not appear to greatly affect the amount of acrosin activity present.

Summary

We conclude that the acrosin assay described in this study is valid and that samples can be frozen and stored for at least 32 days without a significant loss of activity. These techniques will be used to relate the amount of acrosin released into the extenders during long-term storage to various morphological changes observed in boar sperm as they age.

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TABLE 1. ACROSIN ACTIVITY OF INITIAL AND FROZEN SAMPLES OF EXTENDED BOAR SPERMATOZOA^a

Assay Date	Extenders			
	Beltsville L2		Purdue Extender	
	Replicate 1	Replicate 2	Replicate 1	Replicate 2
November 13, 1979	.17	.17	.30	.30
November 30, 1979	.11	.15	.25	.27
December 7, 1979	.18	.16	.30	.31
December 14, 1979	.18	.15	.27	.28

^aSamples (.05 ml) were prepared and assayed initially on November 13, 1979. Sample aliquots, frozen since November 13, 1979, were thawed and assayed on subsequent dates.

^bValues expressed as the change in optical density per minute.

EFFECTS OF SUPPLEMENTAL PROGESTERONE/ESTRONE DURING
DISCRETE PERIODS OF EARLY GESTATION ON CONCEPTUS DEVELOPMENT IN SWINE¹

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Reproductive inefficiency is one of the most costly and production-limiting problems facing the livestock industry. The major component of this inefficiency is poor litter size. Ovulation rate and fertilization failure (see review by Wrathall, 1971) can be discounted as practical factors limiting litter size. Prenatal mortality has been reported to account for a 30-50% loss of potential offspring (see reviews by Hanly, 1961; Boyd, 1965; and Wrathall, 1971).

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. The ultimate objective of this line of research is to determine the factors responsible for prenatal death loss and seek means to reduce it.

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 cross-breds 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. Following breeding, each gilt was assigned at random to one of the treatment groups shown below.

The experiment was conducted by trials. Within each trial, there were three treatment groups. Two of the treatment groups in each of the three trials represented days (inclusive) at which P/E was administered. The other gilts in each trial served as controls and received injections of corn oil only during the entire treatment period under examination. Thus, within each trial there was a control group to which the hormone supplemented groups were compared. The ultimate destiny of the gilts in each trial was to be either (1) hysterectomized at day 50 of gestation

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so that numerous specific measures of conceptus development could be taken, or (2) allowed to go to term, farrow and reproductive performance assessed. As summarized below, there were a total of nine treatment groups over the three trials, with both hysterectomized and farrowed gilts receiving each treatment. This report will be limited to the data obtained from the gilts hysterectomized at day 50.

Experimental Design

Trial no.	1			2			3		
Treatment no.	1	2	3	4	5	6	7	8	9
Days of administration ^a	4-20	20-30	4-30	4-12	12-20	4-20	20-25	25-30	20-30
Hormones administered ^b	P/E	P/E	CO	P/E	P/E	CO	P/E	P/E	CO

^aRepresents days of gestation (inclusive) at which the hormones were administered. All dosages administered once daily subcutaneously in neck.

^bP/E = combination of progesterone (P) and estrone (E). CO = corn oil. P dosage = .55 mg/kg. E dosage = .275 µg/kg (2000:1). This is equivalent to 25 mg P and 12.5 µg E/100 lbs body wt. CO vol = 2 ml.

In all trials, at least six gilts per treatment were assigned to be hysterectomized at day 50 of gestation. Day 50 was chosen as the time for hysterectomy since placental growth has essentially ended by that time (Knight *et al.*, 1977).

The rationale for the periods of P/E administration was as follows. In trial 1, days 4-20 were examined based upon the fact that the first 20 days of gestation represent the period of time during which the greatest percentage of embryonic mortality occurs. Days 20-30 represent a crucial time for early placental expansion, probably due to an increase in allantoic fluid volume during this period. Since the initial 4-20 day period encompassed two major critical events, this period was subdivided for further analysis in trial 2. Days 4-12 represent the time during which uterine specific proteins are stimulated to begin secretion. Days 12-20 include the period of trophoblast expansion, early placentation (implantation) and the events crucial to maternal recognition of pregnancy and corpora lutea maintenance. Based upon the beneficial effects found with the P/E 20-30 treatment in trial 1, this period was subdivided in trial 3 to try to determine the minimum effective time.

All gilts were fed, housed and subjected to routine management procedures in an identical manner. The various parameters obtained following either hysterectomy at day 50 are indicated in the tables.

All gilts hysterectomized at day 50 of gestation (day of mating = day 0) 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 ovarian weights determined. 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 graduate cylinder. The allantoic and amniotic fluid samples obtained were labelled and frozen at -20 C 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 placentae 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. Placental surface area was determined by spreading each

placenta out on heavy paper and then cutting around the edge of the placenta with scissors. The surface area of the paper was measured with a planimeter, and this value used to represent placental surface area.

Each placenta was then divided into five sections of approximately equal size. One section was taken over the location previously occupied by the fetus and was designated as the middle section. Two sections represented the interior and two sections represented the outer or polar pieces of the placenta. In each of the five sections, the total number of areolae were counted in two different areas measuring 2.54 x 7.62 cm each. In each area the diameter of ten randomly selected areolae was measured. Counting of the areolae and measurement of their diameter was done under a dissecting microscope with an eye-piece micrometer. Knowing total placental area, an estimate was then made of total number of areolae. Total number of areolae was multiplied by the estimated surface area of each areolae to obtain an estimate of total areolae surface area. Areolae surface area was divided by placental surface area to determine the percentage of the placenta occupied by the areolae.

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. The space occupied by each fetus was measured directly. 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 concentrations in these samples were determined by radio-immunoassay procedures. Hematocrits were determined on all blood samples. Protein concentrations were determined by the method of Lowry et al. (1951).

Least squares analysis of variance procedures were used to analyze the data (Barr and Goodnight, 1972). Differences in least squares means were analyzed by the procedure of Duncan (1960). Data obtained following hysterectomy were analyzed in terms of "gilt data" and "fetal data". Gilt data analysis involved (1) those variables which applied to the entire litter (e.g., total CL number, uterine weight, uterine surface area, etc); and (2) the sum of various fetal responses for the litter (e.g., total placental weight, total fetal weight, etc.). Fetal data analysis involved those parameters which were obtained on each individual fetus (e.g., fetal weight, crown-rump length, placental length, allantoic fluid volume, etc.). All values reported represent least squares means $\pm$ standard errors of the mean.

Results and Discussion

Trial 1

There were no overall treatment effects on potential number of fetuses (CL), live fetuses, dead fetuses or percent survival (Table 1). Gilts receiving P/E 20-30 had the greatest uterine weight, uterine length, uterine width, uterine surface area and average space per fetus of the three treatments. However, only in the case of uterine surface area was this significantly ($P < .05$) greater than controls (Table 1).

In the P/E 4-20 group, ovarian weight was significantly ($P < .05$) depressed compared with CO 4-30 (Table 1). This suggests that initiation of exogenous progesterone administration as early as day 4 had a negative effect on CL development and function. This was further reflected in a higher incidence of abortions and/or non-conceptions in this treatment group compared with the others. Apparently by administering progesterone at high levels prior to the establishment of endogenous competence for progesterone secretion, such development is inhibited with the result being a higher than normal incidence of abortions following withdrawal of the exogenous source of progesterone (i.e., cessation of daily injections).

The most dramatic effects were reflected in the placental measurements (Table 2). Gilts receiving P/E 20-30 had litters with longer and heavier ($P < .01$) placentas compared with both control gilts receiving CO 4-30 of gestation and gilts receiving P/E 4-20. Average placental length was approximately 12.5 cm greater and average placental weight approximately 25 g heavier in the P/E 20-30 gilts compared with controls. Placental surface area was likewise greater ($P < .05$) in P/E 20-30 vs CO 4-30. The total number of areolae/placenta (non-significant) and the areolae mass/placenta ($P < .05$) was greater in the P/E 4-20 treatment group.

Both P/E 20-30 (132.89 ± 9.0 ml) and P/E 4-20 (128.37 ± 9.26 ml) treated gilts had larger ($P < .05$) allantoic fluid volumes compared with controls (102.34 ± 8.85 ml). Amniotic fluid volume was elevated ($P < .01$) in P/E 20-30 vs the other two treatment groups (Table 2).

Analysis of the fetal parameters in trial 1 gilts indicated that P/E 20-30 supplemented gilts also had a greater crown-rump length ($P < .01$) and greater wet ($P < .001$) and dry ($P < .01$) fetal weight (Table 2).

There were no treatment differences in progesterone concentration in any of the three maternal pools samples. In all three treatments, however, there was a positive uterine artery-uterine vein difference, suggesting a uterine/conceptus uptake and utilization of progesterone. These data are shown in Table 3. There were no treatment differences in allantoic fluid progesterone concentrations, while progesterone levels were greater ($P < .05$) in the amniotic fluid of both steroid supplemented groups vs controls (Table 3).

Analysis of protein concentrations in various fluid pools samples indicated no treatment differences in anterior vena cava, uterine vein or allantoic fluid. There were lower ($P < .05$) concentrations in the uterine artery of P/E 20-30 gilts and depressed ($P < .01$) levels in the amniotic fluid of both supplemented groups vs controls (Table 4).

Trial 2

There were no treatment effects on CL number or total number of live or dead fetuses (Table 5). CO 4-20 did have a greater number of dead fetuses than did either hormone supplemented group, although these differences were not significant. Based upon the results seen in trial 1, a surprising finding was the higher ($P < .05$) fetal survival in P/E 4-12 supplemented gilts.

Values for uterine weight, width, length, surface area and space per fetus are shown in Table 15. There were no overall treatment differences. Once again, early administration of progesterone (P/E 4-12) resulted in a decreased ovarian weight (Table 5).

Placental length was greater ($P < .01$) in gilts receiving P/E 12-20 (67.33 ± 1.78 cm) vs CO 4-20 (58.65 ± 1.66 cm) and also longer (non-significant) than that in P/E 4-12 gilts (61.80 ± 1.40 cm). Placental surface area was reduced ($P < .05$) in P/E 4-12 gilts (353.0 ± 14.5 cm²) compared with P/E 12-20 (443.0 ± 17.9 cm²) and CO 4-20 (408.4 ± 17.3 cm²). Likewise, total areolae number and areolae mass was reduced in the P/E 4-12 gilts. Placental measurements are summarized in Table 6.

Both P/E 4-12 and P/E 12-20 treated gilts had a larger ($P < .05$) allantoic fluid volume than did control gilts. Amniotic volumes were not different (Table 6). All fetal parameters of measurement were similar in trial 2 (Table 6). There was a sex of fetus effect observed in trial 2 results, with male fetuses having a greater ($P < .05$) crown-rump length and wet and dry weight.

Progesterone concentrations were not significantly different due to treatment in any of the fluid pools sampled (Table 7). Once again, a positive uterine artery-uterine vein progesterone difference was seen for all treatments.

While protein concentrations were not different in any maternal blood pool, there was a greater ($P < .01$) protein concentration in the allantoic fluid for P/E 12-20 supplemented gilts. In the amniotic fluid, protein concentrations were reduced ($P < .01$) in P/E 4-12 gilts (Table 8).

Trial 3

In contrast to the previous two trials, P/E 20-25 gilts had a greater ($P < .001$) number of CL and thus more potential offspring than did their contemporaries. Likewise, they had a greater ($P < .01$) number of live fetuses (Table 9).

Owing no doubt to the larger number of fetuses, uterine length ($P < .10$) and uterine surface area ($P < .05$) was elevated in P/E 20-25 gilts. Ovarian weights were not different among treatments (Table 9).

A marked difference in the various placental measurements were seen in P/E 25-30 supplemented gilts compared with the other two treatments. Placental length, placental weight, placental surface area and number of areolae per placenta were all elevated ($P < .01$) in the P/E 25-30 treated gilts compared with either P/E 20-25 or CO 20-30 gilts (Table 10).

Fluid volumes were not different among treatments (Table 10). Allantoic fluid volumes in all three trial 3 groups tended to be larger than that seen in trials 1 and 2.

Crown-rump length was not affected by treatment. Fetal wet weight was lower in P/E 20-25 gilts vs P/E 25-30 or CO 20-30. P/E 25-30 gilts had a higher ($P < .001$) percent fetal moisture (Table 10).

Progesterone concentrations were not significantly affected by treatment in any of the five fluid pools measured (Table 11). There was an unexplained negative uterine artery minus uterine vein difference in P/E 25-30 and CO 20-30 gilts. This finding was at variance with that seen in the other seven treatments. Especially surprising was the large (-3.64 ± 2.89 ng/ml) difference in the CO 20-30 gilts.

Protein concentrations were not different in the maternal blood pools or in amniotic fluid. They were, however, greater ($P < .05$) in P/E 20-25 gilts vs the other two treatments (Table 12).

Summary

Supplementation with exogenous P/E during discrete time intervals early in gestation does measurably influence conceptus development. The period of time during which supplementation had the greatest positive effect in this study was the period from day 20 to day 30 of gestation. This period of time had been targeted by previous research (Knight *et al.*, 1977) as one of dynamic importance to placental expansion. Future studies are planned to examine the effects of supplementing with P/E implants with a constant release rate during these periods. Future studies will examine more directly the uptake, metabolism and utilization of the steroid hormones by the conceptus.

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TABLE 1. LEAST SQUARES MEANS AND STANDARD ERRORS FOR GILT PARAMETERS OBTAINED FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION (TRIAL 1)

Parameters	Treatment ^{ab}					
	P/E 4-20		P/E 20-30		CO 4-30	
Corpora lutea, total	12.2	± .9	12.8	± .9	13.3	± .9
Live fetuses, total	9.8	± 1.1	10.7	± 1.1	10.8	± 1.1
Dead fetuses, total	1.3	± .5	.5	± .5	1.0	± .5
Fetal survival, %	78.3	± .1	83.8	± .1	81.2	± .1
Ovarian weight, total, g	13.50	± 1.17 ^c	16.17	± 1.17 ^{cd}	18.88	± 1.86 ^d
Ovulation sites unaccounted for	1.17	± .59	1.67	± .59	1.40	± .65
Uterine weight, g	1618.52	± 143.36	2026.53	± 143.36	1721.37	± 143.36
Uterine length, total, cm	464.83	± 26.85	471.83	± 26.85	417.83	± 26.85
Uterine width, total, cm ₂	22.63	± 1.34	24.47	± 1.34	20.88	± 1.34
Uterine surface area, cm ²	5296.90	± 463.09 ^c	5816.50	± 463.09 ^{cd}	4324.40	± 463.09 ^{ce}
Average space per fetus, cm	38.24	± 3.04	42.84	± 3.04	38.80	± 2.77

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bSix gilts per treatment.

^{cde}Means in same row with different superscripts differ significantly (P < .05).

TABLE 2. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PLACENTAL, FETAL, AND FETAL FLUID PARAMETERS OBTAINED FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION (TRIAL 1)

Parameters	Treatment ^{ab}					
	P/E 4-20		P/E 20-30		CO 4-30	
Placental length, cm	59.29	± 1.54 ^h	68.67	± 1.50 ⁱ	56.11	± 1.49 ^h
Placental weight, g	109.57	± 3.96 ^f	126.53	± 3.85 ^g	101.40	± 3.83 ^f
Placenta surface area, cm ²	423.1	± 19.0 ^c	450.7	± 19.9 ^{cd}	393.7	± 18.1 ^{ce}
Ave. total no. areolae/placenta	1717.9	± 98.5	1541.7	± 102.9	1490.4	± 93.8
Areolae mass, %/placenta	12.0	± .3 ^c	10.4	± .3 ^d	11.0	± .3 ^d
Allantoic volume, ml	128.37	± 9.26 ^c	132.89	± 9.00 ^c	102.34	± 8.85 ^d
Amniotic volume, ml	35.12	± 1.13 ^f	39.38	± 1.10 ^g	38.01	± 1.09 ^f
Crown-rump length, mm	85.67	± .66 ^f	88.83	± .64 ^g	87.94	± .64 ^f
Fetal wet weight, g	40.70	± .13 ^h	44.75	± .71 ⁱ	39.87	± .70 ^h
Fetal dry weight, g	4.00	± .08 ^c	4.69	± .08 ^d	4.28	± .08 ^e
Moisture, %	10.08	± .12 ^c	10.47	± .11 ^d	10.78	± .11 ^d

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bSix gilts per treatment.

^{cde}Means in same row with different superscripts differ significantly (P < .05).

^{fg}Means in same row with different superscripts differ significantly (P < .01).

^{hi}Means in same row with different superscripts differ significantly (P < .001).

TABLE 3. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PROGESTERONE CONCENTRATIONS (ng/ml) OBTAINED FROM MATERNAL BLOOD AND FETAL FLUID POOLS FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION (TRIAL 1)

Parameters	Treatment ^{ab}		
	P/E 4-20	P/E 20-30	CO 4-30
Anterior vena cava	9.05 ± 2.10	10.53 ± 2.10	11.28 ± 2.10
Uterine artery	8.51 ± 1.46	9.20 ± 1.46	10.96 ± 1.46
Uterine vein	6.00 ± 1.47	8.20 ± 1.47	9.91 ± 1.47
UA-UV difference	2.51 ± 2.89	1.00 ± 2.89	1.05 ± 2.89
Allantoic fluid	1.46 ± .32	1.89 ± .32	1.50 ± .30
Amniotic fluid	1.05 ± .12 ^c	1.18 ± .12 ^c	.94 ± .11 ^{cd}

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bSix gilts per treatment.

^{cd}Means in same row with different superscripts differ significantly (P < .05).

TABLE 4. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PROTEIN CONCENTRATIONS (mg/ml) IN THE MATERNAL BLOOD AND FETAL FLUID POOLS AT DAY 50 OF GESTATION (TRIAL 1)

Parameters	Treatment ^{ab}		
	P/E 4-20	P/E 20-30	CO 4-30
Anterior vena cava	93.13 ± 8.06	100.00 ± 8.06	94.72 ± 8.06
Uterine artery	111.95 ± 8.95	81.55 ± 8.94 ^d	108.15 ± 8.94 ^c
Uterine vein	101.22 ± 8.08	97.57 ± 8.08	97.37 ± 8.08
Allantoic fluid	4.99 ± .58	5.94 ± .61	6.05 ± .57
Amniotic fluid	1.89 ± .12 ^e	2.01 ± .12 ^e	2.55 ± .11 ^f

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bSix gilts per treatment.

^{cd}Means in same row with different superscripts differ significantly (P < .05).

^{ef}Means in same row with different superscripts differ significantly (P < .001).

TABLE 5. LEAST SQUARES MEANS AND STANDARD ERRORS FOR GILT PARAMETERS OBTAINED FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION (TRIAL 2)

Parameters	Treatment ^a		CO 4-20 ^c
	P/E 4-12 ^b	P/E 12-20 ^c	
Corpora lutea, total	11.25 + .02	12.00 + .94	11.50 + .94
Live fetuses, total	9.37 + .95	8.17 + 1.10	8.67 + 1.10
Dead fetuses, total	.25 + .43	.83 + .50	1.33 + .50
Fetal survival, %	84.07 + .04 ^d	70.48 + .04 ^e	73.30 + .04 ^{de}
Ovarian weight, total, g	12.74 + 1.20	17.39 + 1.34	15.14 + 1.33
Ovulation sites unaccounted for	1.62 + .69	3.00 + .80	1.50 + .80
Uterine weight, g	1591.67 + 94.81	1409.78 + 109.48	1589.07 + 109.47
Uterine length, total, cm	426.50 + 19.04	475.17 + 21.98	443.00 + 21.98
Uterine width, total, cm ²	24.57 + .74	23.24 + .82	23.24 + .82
Uterine surface area, cm ²	5205.57 + 377.59	5126.72 + 436.00	5196.48 + 436.00
Avg. space per fetus/cm	40.19 + 2.62	44.58 + 3.02	42.42 + 3.02

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bEight gilts per treatment.

^cSix gilts per treatment.

^{de}Means in same row with different superscripts differ significantly ($P < .05$).

TABLE 6. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PLACENTAL, FETAL AND FETAL FLUID PARAMETERS OBTAINED FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION (TRIAL 2)

Parameters	Treatment ^a		CO 4-20 ^c
	P/E 4-12 ^b	P/E 12-20 ^c	
Placental length, cm	61.80 + 1.40 ^d	67.33 + 1.78 ^e	58.65 + 1.66 ^d
Placental weight, g	118.80 + 3.74	117.90 + 4.72	111.00 + 4.41
Placental surface area, cm ²	353.0 + 14.5 ^d	443.0 + 17.9 ^e	408.4 + 17.3 ^e
Ave. total no. areolae/placenta	1075.5 + 71.6 ^d	1733.2 + 88.8 ^e	1747.9 + 83.4 ^e
Areolae mass, %/placenta	9.1 + .3 ^d	11.7 + .4 ^e	12.7 + .4 ^{ef}
Allantoic volume, ml	145.62 + 9.27 ^d	113.20 + 11.72 ^e	86.94 + 10.96 ^e
Amniotic volume, ml	39.37 + 1.09	39.84 + 1.38	38.05 + 1.29
Crown-rump length, mm	88.73 + .66	86.53 + .83	87.22 + .78
Fetal wet weight, g	42.37 + .70	43.44 + .88	41.97 + .82
Fetal dry weight, g	4.22 + .07	4.27 + .89	4.10 + .08
Moisture, %	10.02 + .09	9.79 + .12	9.80 + .11

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bEight gilts per treatment.

^cSix gilts per treatment.

^{def}Means in same row with different superscripts differ significantly ($P < .05$).

TABLE 7. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PROGESTERONE CONCENTRATIONS (ng/ml) OBTAINED FROM MATERNAL BLOOD AND FETAL FLUID POOLS FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION (TRIAL 2)

Parameters	Treatment ^a		
	P/E 4-12 ^b	P/E 12-20 ^c	CO 4-20 ^c
Anterior vena cava	9.04 ± 2.18	13.92 ± 2.52	12.07 ± 2.52
Uterine artery (UA)	11.62 ± 1.39	14.25 ± 1.61	10.64 ± 1.61
Uterine vein (UV)	8.73 ± 1.55	10.38 ± 1.78	7.72 ± 1.78
UA-UV difference	2.89 ± 2.50	3.87 ± 2.89	2.03 ± 2.89
Allantoic fluid	1.39 ± .24	1.53 ± .28	1.40 ± .28
Amniotic fluid	.84 ± .17	.78 ± .20	1.01 ± .20

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bEight gilts per treatment.

^cSix gilts per treatment.

TABLE 8. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PROTEIN CONCENTRATIONS (mg/ml) IN THE MATERNAL BLOOD AND FETAL FLUID POOLS AT DAY 50 OF GESTATION (TRIAL 2)

Parameters	Treatment ^a		
	P/E 4-12 ^b	P/E 12-20 ^c	CO 4-20 ^c
Anterior vena cava	94.54 ± 8.73	80.63 ± 10.08	88.30 ± 10.83
Uterine artery	91.56 ± 8.14	87.62 ± 9.40	92.27 ± 9.40
Uterine vein	96.88 ± 7.29	91.50 ± 8.42	76.72 ± 8.42
Allantoic fluid	2.50 ± .80 ^d	5.37 ± .92 ^e	3.88 ± .92 ^{de}
Amniotic fluid	.84 ± .48 ^f	1.78 ± .55 ^{fg}	2.97 ± .55 ^g

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bEight gilts per treatment.

^cSix gilts per treatment.

^dMeans in same row with different superscript differ significantly (P < .01).

^fMeans in same row with different superscript differ significantly (P < .001).

TABLE 9. LEAST SQUARES MEANS AND STANDARD ERRORS FOR GILT PARAMETERS
OBTAINED FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION (TRIAL 3)

Parameters	Treatment ^a					
	P/E 20-25 ^b		P/E 25-30 ^c		CO 20-30 ^c	
Corpora lutea, total	13.86 ±	.65 ^h	10.67 ±	.70 ⁱ	11.83 ±	.70 ⁱ
Live fetuses, total	12.71 ±	.69 ^f	9.00 ±	.74 ^g	10.50 ±	.74 ^f
Dead fetuses, total	.71 ±	.37	.67 ±	.40	.83 ±	.40
Fetal survival, %	92.14 ±	.04	84.99 ±	.04	88.17 ±	.04
Ovarian weight, total, g	15.14 ±	1.31	14.27 ±	1.42	13.46 ±	1.42
Ovulation sites unaccounted for	.43 ±	.57	1.67 ±	.67	1.00 ±	.62
Uterine weight, g	1825.21 ±	150.58	1882.18 ±	162.65	1544.78 ±	162.65
Uterine length, total, cm	532.57 ±	20.61	481.17 ±	22.26	469.50 ±	22.26
Uterine width, total, cm ₂	25.33 ±	.95	24.58 ±	1.03	22.85 ±	1.03
Uterine surface area, cm ²	6806.19 ±	541.09 ^d	4787.13 ±	584.45 ^e	5359.00 ±	584.45 ^{de}
Avg. space per fetus, cm	40.67 ±	2.33	44.50 ±	2.52	41.30 ±	2.52

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bSeven gilts per treatment.

^cSix gilts per treatment.

^{f,g}Means in same row with different superscripts differ significantly (P < .01).

^{h,i}Means in same row with different superscripts differ significantly (P < .001).

TABLE 10. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PLACENTAL, FETAL AND FETAL FLUID PARAMETERS OBTAINED FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION (TRIAL 3)

Parameters	Treatment ^a		
	P/E 20-25 ^b	P/E 25-30 ^c	CO 20-30
Placental length, cm	55.24 + 1.65 ^h	67.61 + 2.28 ⁱ	56.24 + 2.02 ^h
Placental weight, g	101.73 + 4.05 ^f	122.91 + 5.61 ^g	104.46 + 4.97 ^f
Placental surface area, cm ²	425.6 + 18.5 ^f	511.4 + 24.7 ^g	407.4 + 22.9 ^f
Avg. total no. areolae/placenta	1480.0 + 87.0 ^f	1931.3 + 116.3 ^g	1501.5 + 108.8 ^f
Areolae mass, %/placenta	10.3 + .3	11.1 + .4	11.1 + .4
Allantoic volume, ml	154.55 + 14.37	147.41 + 19.90	160.71 + 17.65
Amniotic volume, ml	36.12 + 1.14	38.61 + 1.58	36.59 + 1.40
Crown-rump length, mm	82.23 + .79	83.43 + 1.10	83.38 + .98
Fetal wet weight, g	40.26 + 1.02 ^f	43.49 + 1.42 ^{gh}	45.70 + 1.26 ^h
Fetal dry weight, g	4.32 + .25	5.07 + .35	4.75 + .31
Moisture, %	10.59 + .21 ^h	11.68 + .29 ⁱ	9.18 + .20 ^j

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bSeven gilts per treatment.

^cSix gilts per treatment.

^dMeans in same row with different superscripts differ significantly (P < .05).

^f^gMeans in same row with different superscripts differ significantly (P < .01).

^hⁱ^jMeans in same row with different superscripts differ significantly (P < .001).

TABLE 11. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PROGESTERONE CONCENTRATIONS (ng/ml) OBTAINED FROM MATERNAL BLOOD AND FETAL FLUIDS FOLLOWING HYSTERECTOMY AT DAY 50 OF GESTATION (TRIAL 3)

Parameters ^a	Treatment ^a		
	P/E 20-25 ^b	P/E 25-30 ^c	CO 20-30
Anterior vena cava	12.12 $\pm$ 1.94	9.91 $\pm$ 2.09	12.84 $\pm$ 2.09
Uterine artery (UA)	11.08 $\pm$ 2.58	15.83 $\pm$ 2.79	12.36 $\pm$ 2.79
Uterine vein (UV)	10.14 $\pm$ 4.87	17.15 $\pm$ 5.26	16.00 $\pm$ 5.26
UA-UV difference	1.08 $\pm$ 2.67	- 1.05 $\pm$ 2.89	- 3.64 $\pm$ 2.89
Allantoic fluid	2.73 $\pm$.67	2.72 $\pm$.73	2.10 $\pm$.73
Amniotic fluid	1.02 $\pm$.42	2.03 $\pm$.45	1.15 $\pm$.45

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bSeven gilts per treatment.

^cSix gilts per treatment.

TABLE 12. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PROTEIN CONCENTRATIONS (mg/ml) IN THE MATERNAL BLOOD AND FETAL FLUID POOLS AT DAY 50 OF GESTATION (TRIAL 3)

Parameters	Treatment ^a		
	P/E 20-25 ^b	P/E 25-30 ^c	CO 20-30 ^c
Anterior vena cava	85.04 $\pm$ 4.92	85.85 $\pm$ 5.32	94.08 $\pm$ 5.32
Uterine artery	89.33 $\pm$ 5.72	87.13 $\pm$ 6.18	85.00 $\pm$ 6.18
Uterine vein	90.37 $\pm$ 6.39	88.08 $\pm$ 6.90	83.15 $\pm$ 6.90
Allantoic fluid	6.14 $\pm$.62 ^d	3.65 $\pm$.67 ^e	4.66 $\pm$.67 ^{de}
Amniotic fluid	1.91 $\pm$.13	2.25 $\pm$.14	2.11 $\pm$.14

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bSeven gilts per treatment.

^cSix gilts per treatment.

^{de}Means in same row with different superscripts differ significantly (P < .05).

EFFECTS OF SUPPLEMENTAL PROGESTERONE/ESTRONE DURING DISCRETE PERIODS
OF EARLY GESTATION ON FARROWING PERFORMANCE IN SWINE¹

James W. Knight, D. Lee Dalton and K. L. Bryant

Despite tremendous improvement in numerous other areas, reproductive efficiency of swine has remained relatively unchanged during the past decade. The number of pigs marketed per litter has remained at about 7.2 and each sow farrows about 1.8 litters per year. Prenatal mortality represents the greatest percentage of the difference between potential number of offspring and the number marketed (Wrathall, 1971). Placental insufficiency has been identified as the major factor responsible for death losses during the latter portion of pregnancy (Knight et al., 1977). Marginal placental insufficiency has been suggested to be related to "runt" pigs, the death of which contributes to an additional loss of pigs following birth. The data reported herein represent the farrowing data obtained from gilts treated with exogenous progesterone and estrone (P/E) during various defined periods in early gestation, as described in the previous report. This report is part of a series of studies examining methods to increase litter size in swine.

Experimental Procedure

All swine utilized in this study were crossbred gilts of similar age, weight and genetic background. Daily heat checks were initiated at approximately six months of age. After the initial detection of estrus, all gilts were checked for estrus twice daily. All gilts were bred at either their second or third estrus period by artificial insemination with semen from at least two different boars. Gilts were inseminated 12, 24 and 36 hours following initial detection of heat. Following breeding, each gilt was assigned at random to one of the treatment groups shown below.

As described in the previous report, this study was conducted in three separate trials, with three treatments in each trial. In each trial, two of the treatments represented days (inclusive) at which P/E was given via daily injections. The other treatment represented a control injection of corn oil (vehicle) during the entire treatment period. This report will be limited to the results obtained from the gilts so treated and allowed to go to term and farrow.

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

The experimental design may be summarized as follows:

Trial no.	1			2			3		
Treatment no.	1	2	3	4	5	6	7	8	9
Days of ad- ministration ^a	4-20	20-30	4-30	4-12	12-20	4-20	20-25	25-30	20-30
Hormones ad- ministered ^b	P/E	P/E	CO	P/E	P/E	CO	P/E	P/E	CO

^aRepresents days of gestation (inclusive) at which the hormones were administered. All dosages administered once daily subcutaneously in neck.

^bP/E = combination of progesterone (P) and estrone (E). CO = corn oil. P dosage = .55 mg/kg. E dosage = .275 µg/kg (2000:1). This is equivalent to 25 mg P and 12.5 µg E/100 lbs body wt. CO vol. = 2 ml.

In trial 1, 12 gilts per treatment were allowed to go to term and farrow. To date either 4 or 5 gilts per treatment have farrowed in each trial 2 treatment and either 2 or 3 per treatment in trial 3. The specific number farrowed to date for each treatment is shown in the tables. A total of 6 gilts per treatment group have been assigned to farrow for each treatment in trials 2 and 3. The remainder of the gilts assigned for which data is not included are farrowing at the time of report preparation, but their data is not available for inclusion.

Results and Discussion

In trial 1 farrowed gilts (Table 1) total pigs born was not different among treatments, although live pigs born was lower ($P < .05$) in the P/E 4-20 vs V0 4-30 gilts. Although non-significant, number of stillbirths was higher in the P/E 4-20 group contributing to this difference. There was also a reduced ($P < .05$) number of pigs weaned and a reduced ($P < .01$) percent survival from birth to weaning in the P/E 4-20 treatment group. This suggests that the initiation of exogenous progesterone administration prior to corpora lutea formation and the establishment of endogenous progesterone secretion (day 4) is detrimental. Although total placental weight ($P < .01$) and total birth ($P < .01$) and weaning (N.S.) weights were reduced in P/E 4-20 (due to fewer pigs), the average weights of these parameters were not different.

Although the values were not statistically different, P/E 12-20 supplemented gilts had the largest number of live pigs born, total pigs born and pigs weaned. Both P/E treated groups had a larger (non significant) survival rate of pigs from birth to weaning than did controls. Total placental weight ($P < .05$), total birth weight and total weaning weight was greater in P/E 12-20 gilts, apparently due to a greater number of pigs. Table 2 summarizes the trial 2 farrowing results.

As previously stated, the farrowing data for trial 3 is not complete at the time of this report. Data are included for only 2 gilts in the P/E 20-25 group and 3 gilts in the P/E 25-30 and CO 20-30 groups. Preliminary results based upon those farrowed to date suggests a greater ($P < .05$) number of live pigs and total pigs born in the P/E 20-25 treated group. The reduction in farrowing performance of P/E 25-30 treated gilts appears due to the adverse influence of one gilt on a reduction ($P < .01$) in gestation length and an increase in stillbirths. Farrowing data obtained to date for trial 3 is shown in Table 3. Additional data must be obtained before any conclusions are drawn.

Summary

Results suggest beneficial effects of P/E during early gestation are reflected in reproductive performance at farrowing. Since these measurements are considerably less precise than the measurements which can be made following hysterectomy, a larger number of animals is needed before more definitive conclusions are drawn.

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- Wrathall, A. E. 1971. Prenatal survival in pigs. I. Ovulation rate and its influence on prenatal survival and litter size in pigs. The Gresham Press. Surry, England.

TABLE 1. LEAST SQUARES MEANS AND STANDARD ERRORS FOR
PARAMETERS OBTAINED FOLLOWING FARROWING (TRIAL 1)

Parameters	Treatment ^{ab}		
	P/E 4-20	P/E 20-30	CO 4-30
Gestation length	113.18 ± .63	113.50 ± .60	114.08 ± .60
Number live pigs	7.82 ± .75 ^c	9.08 ± .72 ^{cd}	10.00 ± .72 ^d
Number stillborn	1.27 ± .45	.75 ± .44	.75 ± .44
Number mummies	.36 ± .21	.42 ± .20	.17 ± .20
Total born	9.45 ± .76	10.25 ± .73	10.92 ± .73
Number live at weaning	5.45 ± .90 ^e	7.58 ± .86 ^{ef}	9.33 ± .86 ^f
% survival - birth to weaning	59.14 ± 8.32 ^c	75.83 ± 7.96 ^{cd}	86.52 ± 7.96 ^d
Total placental weight, kg	2.04 ± .17 ^c	2.13 ± .17 ^{cd}	2.57 ± .17 ^d
Average placental weight, g	240.0 ± 20.0	210.0 ± 20.0	230.0 ± 20.0
Total birth weight, kg	9.58 ± .93 ^c	11.46 ± .89 ^{cd}	12.88 ± .89 ^d
Average birth weight, kg	1.89 ± .34	1.29 ± .32	1.29 ± .32
Total weaning weight, kg	26.42 ± 3.82	30.23 ± 3.30	33.93 ± 3.30
Average weaning weight, kg	3.99 ± .20	3.82 ± .17	3.74 ± .17

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bTwelve gilts per treatment.

^{cd}Means in a row with different superscripts differ significantly (P < .05).

^{ef}Means in a row with different superscripts differ significantly (P < .01).

TABLE 2. LEAST SQUARES MEANS AND STANDARD ERRORS FOR PARAMETERS
OBTAINED FOLLOWING FARROWING (TRIAL 2)

Parameters	Treatment ^a		
	P/E 4-12 ^b	P/E 12-20 ^b	CO 4-30 ^c
Gestation length	114.00 ± 1.13	114.75 ± 1.13	114.33 ± .92
Number live pigs	8.00 ± 1.62	10.75 ± 1.62	8.67 ± 1.33
Number stillborn	.25 ± .43	1.00 ± .43	.33 ± .35
Number mummies	.50 ± .31	0.00 ± .31	.33 ± .26
Total born	8.50 ± 1.57	11.75 ± 1.57	9.33 ± 1.29
Number live at weaning	7.25 ± 1.65	9.50 ± 1.65	7.00 ± 1.35
% survival - birth to weaning	85.05 ± 11.02	81.95 ± 11.01	76.00 ± 8.99
Total placental weight, kg	2.03 ± .25 ^d	2.68 ± .25 ^{de}	2.16 ± .22 ^e
Average placental weight, g	280.0 ± 30.0	250.0 ± 30.0	180.0 ± 20.0
Total birth weight, kg	9.98 ± 1.77	13.37 ± 1.77	10.30 ± 1.45
Average birth weight, kg	1.30 ± .12	1.20 ± .12	1.17 ± .10
Total weaning weight, kg	25.80 ± 5.16	32.60 ± 5.16	24.38 ± 4.21
Average weaning weight, kg	3.83 ± .42	3.40 ± .42	3.82 ± .34

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bFour gilts per treatment.

^cFive gilts per treatment.

^{de}Means in same row with different superscripts differ significantly (P < .05).

TABLE 3. LEAST SQUARES MEANS AND STANDARD ERRORS FOR
PARAMETERS OBTAINED FOLLOWING FARROWING (TRIAL 3)

Parameters	Treatment ^a		
	P/E 20-25 ^b	P/E 25-30 ^c	CO 20-30 ^b
Gestation length	114.50 ± .38 ^f	111.33 ± .31 ^g	114.00 ± .38 ^f
Number live pigs	11.00 ± .76 ^d	7.67 ± .62 ^e	8.00 ± .76 ^e
Number stillborn	0.00 ± .00	1.33 ± .62	0.00 ± .00
Number mummies	0.00 ± .00	0.00 ± .00	0.00 ± .00
Total born	11.00 ± .71 ^d	9.00 ± .58 ^{de}	8.00 ± .71 ^e
Number live at weaning	11.00 ± 1.83	6.00 ± 1.83	8.00 ± 1.83
% survival - birth to weaning	100.00 ± 20.21	65.00 ± 20.21	100.00 ± 20.21
Total placental weight, kg	3.15 ± .35	2.27 ± .28	1.95 ± .35
Ave. placental weight, g	300.0 ± 60.0	270.0 ± 50.0	250.0 ± 60.0
Total birth weight, kg	16.95 ± 1.74	11.20 ± 1.42	11.15 ± 1.74
Ave. birth weight, kg	1.55 ± .12	1.35 ± .12	1.40 ± .12
Total weaning weight, kg	44.95 ± 6.21	20.80 ± 6.21	33.35 ± 6.21
Ave. weaning weight, kg	4.05 ± .34	3.60 ± .34	4.20 ± .34

^aProgesterone/estrone (P/E) and corn oil (CO) administered during the days of gestation (inclusive) indicated.

^bTwo gilts per treatment.

^cThree gilts per treatment.

^{de}Means in a row with different superscripts differ significantly (P < .05).

^fMeans in a row with different superscripts differ significantly (P < .01).

EFFECT OF DIETARY ENERGY LEVELS IN MARES DURING GESTATION AND LACTATION

L. E. Goater and T. N. Meacham

The nutrient recommendations suggested by the NRC for horses, particularly the gestating mare, are not substantiated by experimental evidence but are based on theoretical calculations and interpolations from research with ruminants or from research with draft horses.

Nutritional management of the brood mare is of special concern. The average conception rate for mares is approximately 60% and the abortion rate about 11%. The interaction of nutrition and reproductive demand on the mare with regards to energy and protein is crucial during the last 90 days of gestation. During this time, the fetus grows at a rate greater than .5 kg per day; the mare is also preparing for lactation and rebreeding.

The current study is evaluating the effects of two levels of dietary energy fed during late gestation on foal birth weights, on milk production and composition, on peripheral plasma levels of progesterone, luteinizing hormone (LH) and estradiol and on subsequent rebreeding performance of the mare.

Experimental Procedure

Ten mares were paired for reproductive experience and randomly allotted to groups receiving either 100% or 120% of NRC digestible energy (DE) in a 60:40, orchardgrass hay:grain mixture daily on a body weight basis. The experimental period begins 90 days prior to the expected foaling date (based on 336 days from the last breeding date) and extends through 30 days of lactation. Intake is adjusted weekly to weight change. Average daily gain for the last 90 days is based on data from the beginning of the experimental ration to the last weigh date prepartum. During the first 30 days of lactation, the mares receive a diet according to NRC recommendations based on their immediate postpartum weight. They continue to be weighed at weekly intervals.

Jugular venous blood (20 ml) is collected at 5 day intervals; sampling will continue through the first month of lactation. Samples are to be analyzed for plasma concentrations of progesterone, LH and estradiol.

Foals are weighed at birth and every 7 days subsequently during lactation in order to calculate average daily gain. The birth weight is also expressed as a percent of the mare's body weight immediately postpartum. Foals receive only mare's milk. The weight of the placenta and the amnion is also recorded at birth.

Milk samples are collected on days 1, 2, 3 and 7 days postpartum and weekly throughout the first month of lactation. They will be analyzed for butterfat, total solids and crude protein; solids-not-fat will be calculated.

All mares receive 100ug gonadotrophin releasing hormone (GnRH) at 4 days postpartum. Jugular venous blood is taken at 0, 5, 10, 15, 30, 45, 60, 90, 120, 180 min., 4, 6, 8, 12, 24, 48 hr and at daily intervals for the next 7 days. The samples will be analyzed for plasma levels of progesterone, LH, estradiol and follicle-stimulating hormone (FSH). The mares are teased daily to determine the occurrence and duration of behavioral estrus.

Results

Analysis of the blood and milk samples has not yet been performed. Seven of the ten mares, three receiving 100% and four receiving 120% DE, have foaled to date. Current data is presented in table 1.

Ration	Horse	Average Intake of DE	Energy % of requirement	Length of Gestation	Average Daily Gain of mare (last 90 days)	Foal Birthweight	Foal % Birthweight	Weight of Placenta plus Amnion	Average Daily Gain of the Foal	Average Daily Gain of the Lactating Mare
	number	Mcal/day	%	days	kg/day (days)	kg	% of mare's postpartum weight	kg	kg/day (days)	kg/day (days)
100% DE	32	20.57	99.07	350	.24 (98)	47.6	9.4	5.390	1.15 (21)	-1.36 (21)
	34	14.89	97.96	345	.09 (91)	34.0	9.8	4.675	.88 (30)	.045 (30)
	35	15.33	99.23	329	0 (49)	36.3	10.0	4.829	1.21 (30)	- .76 (30)
Average		*NA	98.75	341	.11	39.3	9.7	4.965	1.09	- .692
120% DE	37	19.61	118.40	335	.03 (84)	37.7	9.9	4.842	1.15 (21)	.15 (21)
	L	23.93	109.41	332	.39 (84)	48.1	9.3	4.304	1.91 (14)	.49 (14)
	33	22.26	109.08	341	.47 (91)	41.7	8.2	7.332	**	**
	31	17.13	90.00	336	.22 (84)	47.6	10.8	5.759	**	**
Average		*NA	106.72	336	.28	43.8	9.6	5.559	1.53	.32

*NA = not applicable.

** = no data available.

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 of 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. Figures 1 and 2 are representative examples of mares in control and progesterone treated groups. 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 Treatment	
		Progesterone	Luteinizing hormone	Progesterone	Luteinizing hormone
		ng/ml	ng/ml	ng/ml	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	48.0	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

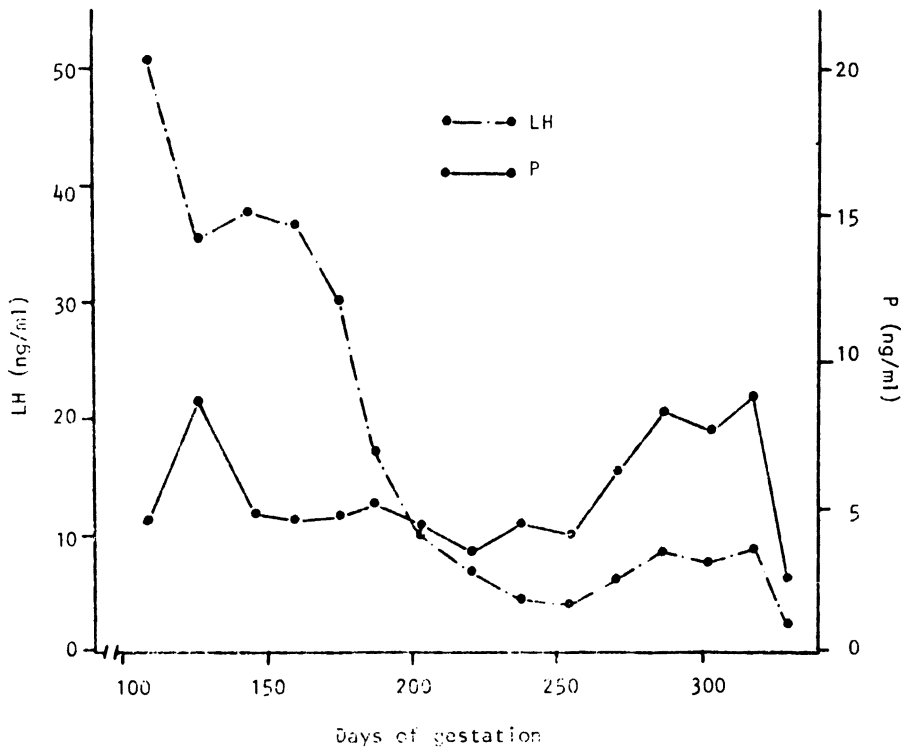


Figure 1. Plasma progesterone and LH concentrations in mare #4 (control).

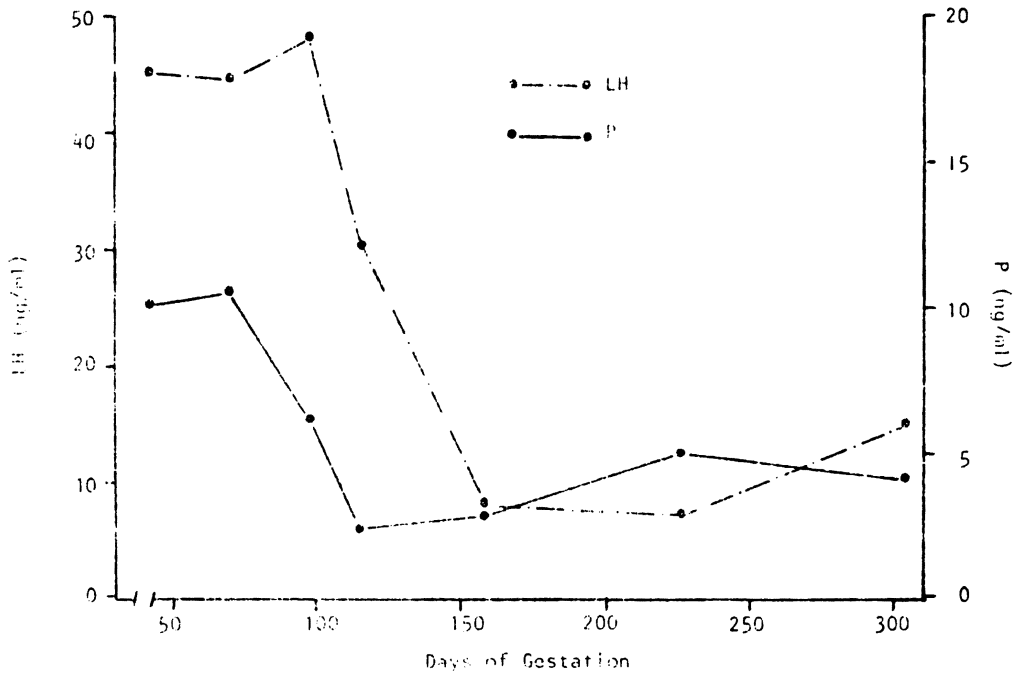


Figure 2. Plasma progesterone and LH concentrations in mare #1 (progesterone treated).

SIRE BREED EVALUATION AT SOUTHAMPTON: POSTWEANING PERFORMANCE

Thomas J. Marlowe and Elizabeth T. Barnes

The data for this report came from a cooperative cattle breeding research project with the Southampton Correctional Farm, Capron, Virginia - part of a larger cooperative project with the Virginia Department of Corrections at five locations. Objective 1 was to evaluate the several sire breeds used in crossbreeding programs for beef production when mated to Angus or Hereford cows. Progress reports on fertility, calf survival, and performance to weaning have been published in earlier Livestock Research Reports; those references are given at the end of this report for the Southampton herd.

The purpose of this report is to compare postweaning performance of steers and heifers from the six calf crops of the sire breed evaluation phase.

Data

The yearling cattle belonged to the 1970-75 calf crops. A description of mating scheme and management of the cattle can be found in the 1975 Livestock Research Report along with their preweaning performance. There were 223 steers and 207 heifers sired by 12 Angus, 12 Charolais and 12 Holstein bulls over the six calf crops. All dams were Angus. Calves were born August-September and weaned in May.

After weaning the heifers and steers were managed differently. The heifers were turned immediately on fescue pasture and supplemented with approximately 1% of their body weight of a concentrate consisting of three parts corn and one part soybean oil meal until the end of the grazing season around November 1. Throughout the winter months they were fed corn silage plus the supplement.

The steers were separated into two groups. A random 1/2 of each breed type was put on fescue pasture without supplementation until the end of the grazing season. The other group was put in a 2-acre dry lot and fed corn silage ad lib plus 1% of their body weight of a concentrate, a 3:1 corn soybean oil meal mixture. On or about November 1 of each year, the two steer groups were combined and fed corn silage ad lib plus approximately 1% of the body weight of the concentrate in dry lot until slaughtered.

The measurement traits included in the analyses were average daily gain and weight per day of age from birth to 12 and 18 months, yearling weight at 12 and 18 months, and conformation grades and condition scores for each period. The heifers averaged 386 and 580 days and the steers averaged 384 and 588 days at the 12 and 18 months weighings, respectively. The authors express their appreciation to Mr. Grizzard, Mr. Burgess and Mr. Purvis of the Southampton Correctional Farm for their cooperation and support in carrying out this research; also to Mrs. Ellie Stephens for typing the manuscript.

The scoring system used for conformation and condition at each weighing (weaning, 12 months and 18 months) was a numerical scale ranging from 3 to 17, representing the grades of common through fancy. The actual weaning weight of each calf was used as the starting weight for calculating average daily gain between weaning and 12 or 18 months of age.

Statistical Analyses

The general linear models procedure of SAS was used for statistical analyses. The statistical model for the steer data included as sources of variation: year, breed of sire, management practice, year x breed and year x management practice interactions, dam's age (both linear and quadratic) and age of animal. Omitted from the model for the heifer data were the management practice and year x management interaction since all heifers were treated alike.

Results and Discussion

Since the preweaning performance of these cattle was presented in the 1977 Livestock Research Report, only the postweaning performance will be included in this report. However, weaning weights adjusted for year and age effects are shown in tables 1 and 2.

The least squares means for the several performance traits are shown in table 1 for heifers and in table 2 for steers.

The crossbred heifers and steers were heavier at all ages than the straightbred Angus controls. The crossbred steers outgained the Angus controls by approximately 1/4 pound per day and the heifers from weaning to 12 months by about .17 lb/day but slightly less from birth to 18 months. Holstein X steers grew slightly faster than the Charolais X steers to 12 months, but there was no difference between the two groups from weaning to 18 months. This trend is also reflected in the 12 and 18 months weights.

The breed of sire effect was highly significant for all measurement traits. The Charolais X steers were 12.1% heavier and the Holstein X steers 9.2% heavier than the Angus controls at 18 months.

The management of the steers immediately following weaning had a highly significant effect on average daily gain and later weights. Steers in the dry lot gained .66 pound per day faster, weighed 139 pounds more at 12 months, but only 59 pounds more at 18 months. They also graded one grade point higher at 12 months and were 1.4 points higher on condition score. However, much of this difference had disappeared by 18 months, after six months of dry lot feeding. At 18 months, the difference in the average daily gain from weaning was only .09 pounds, in conformation score, .6 points, and in condition score, .1 point. Steers grazed during the summer prior to being placed in the dry lot were more variable in all measurement traits at 18 months than steers that were in dry lot during the entire period.

The statistical model was effective in removing the environmental sources of variation in both the steer and heifer data. The R^2 values, a measure of the total variation accounted for by the model, ranged from

TABLE 1. LS MEANS OF POSTWEANING TRAITS FOR HEIFERS IN SOUTHAMPTON HERD BY SIRE BREED

Sire breed	Wean* wt (lbs)	ADG (lb)		WDA (lb)		Weight (lb)		Grade (pt)		Cond (pt)	
		12	18	12	18	12	18	12	18	12	18
Angus	412	0.87	0.98	1.44	1.33	560	776	11.7	11.6	7.5	9.0
Holstein	442	1.02	1.11	1.57	1.45	609	845	11.2	10.5	6.8	8.0
Charolais	460	1.02	1.15	1.64	1.51	634	884	12.8	12.5	7.8	9.1
R ² values		.62	.46	.58	.52	.62	.54	.48	.40	.50	.60

*Not adjusted for age of cow or sex.

All cows were Angus.

Number observations: 207 and 197 at 12 and 18 months, respectively.

Average ages were: 386 and 580 days at 12 and 18 months, respectively.

TABLE 2. LS MEANS OF POSTWEANING TRAITS FOR STEERS IN SOUTHAMPTON HERD BY SIRE BREED

Sire breed	Wean* wt (lbs)	ADG (lb)		WDA (lb)		Weight (lb)		Grade (pt)		Cond (pt)	
		12	18	12	18	12	18	12	18	12	18
Angus	447	1.05	1.39	1.60	1.64	619	964	11.8	12.0	8.0	10.8
Holstein	452	1.29	1.61	1.74	1.79	673	1053	10.3	11.1	6.9	10.1
Charolais	491	1.23	1.60	1.82	1.84	701	1081	13.0	13.0	8.0	10.7
R ² values		.75	.40	.76	.55	.77	.53	.68	.53	.71	.53

*Not adjusted for age of cow or sex.

All cows were Angus.

Number observations: 223 and 213 at 12 and 18 months, respectively.

Average ages were: 384 and 588 days at 12 and 18 months, respectively.

.68 to .77 at 12 months and from .40 to .55 at 18 months for the steers. Corresponding values for the heifers were .48 to .62 at 12 months and .40 to .60 at 18 months.

Summary

Angus, Hereford and Charolais sire breeds crossed to Angus cows were evaluated over six calf crops (223 steers and 207 heifers) for postweaning performance of their progeny to 12 and 18 months of age. All crossbreds outperformed the straightbred controls. Measurement traits included average daily gain and weight per day of age from birth to 12 and 18 months and yearling weight, conformation and condition scores at both ages. Both Charolais and Holstein crossbred steers outgrew the straight Angus steers by about 1/4 pound per day and were 82 and 54 pounds heavier at 12 months and 117 and 89 pounds heavier at 18 months, respectively. Differences between the two crossbred types were small, being only 28 pounds at both ages in favor of the Charolais X steers.

Differences among the heifer groups were about .17 pound per day in ADG and WDA in favor of the crossbred heifers. Yearling weights also favored the crossbred heifers by 49 and 74 pounds at 12 months and 69 and 108 pounds at 18 months for the Holstein X and Charolais X, respectively.

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SIRE BREED EVALUATION AT BEAUMONT: POSTWEANING PERFORMANCE

Thomas J. Marlowe and Elizabeth T. Barnes

The data for this study came from a cooperative cattle breeding research project with the Beaumont School for Boys, Beaumont, Virginia, one of five locations within the large cooperative project with the Virginia Department of Corrections. The purpose of the project was to evaluate Charolais, Holstein and Shorthorn sire breeds, mated to Hereford cows. Progress reports on fertility, calf survival and performance to weaning have been published in earlier livestock research reports. Those references are given at the end of this report.

The purpose of this report is to give results of the comparison of the postweaning performance of steers and heifers from three calf crops in this herd.

Data and Statistical Analyses

These yearling cattle were from the 1970-72 calf crops. A description of the mating scheme and management of the cattle can be found in the 1976 Livestock Research Report, along with their preweaning performance. Briefly, there were 77 heifers and 84 steers sired by 6 Charolais, 6 Holstein and 6 Shorthorn bulls during the three calf crops. All dams were Hereford. Cows were wintered on low quality Johnson grass and fescue hay without supplementation. During the summer they were pastured on unimproved river bottoms, consisting of fescue and Johnson grass, and some upland areas of local native grasses. Generally, calves were born in January and February and weaned in September. Calves were not creep fed. Following weaning, calves were placed on pasture until the end of the grazing season, usually in November, and were fed only roughage during the winter. Consequently, they made very slow gains - in fact, several of them actually lost weight during the winter period. In April, they were returned to pasture, where they remained until the 18 months weights were obtained.

The measurement traits included in the analyses were average daily gain and weight per day of age from birth to 12 and 18 months, yearling weights at 12 and 18 months, and conformation grades and condition scores for each period. The heifers averaged 375 and 607 days and the steers averaged 374 and 603 days at the 12 and 18 months weigh periods, respectively. The actual weaning weight of each calf was used as the starting point for calculating average daily gain for both the 12 and 18 months periods. The scoring system used for conformation and condition at each weighing (weaning, 12 months and 18 months) was a numerical scale ranging from 3 to 17, representing the grades of common through fancy.

The authors express their sincere appreciation to the late Dr. A. L. Grizzard and Mr. B. T. Mann for their cooperation and support of this research and to Mrs. Ellie Stephens for typing the manuscript.

The general linear models procedure of SAS was used for statistical analyses. The statistical model included as sources of variation: year, breed of sire, year x breed interaction, age of dam (both linear and quadratic) and age of animal.

Results and Discussion

Since the preweaning performance of these cattle was presented in the 1977 Livestock Research Report, only the postweaning performance will be presented here. However, weaning weights, adjusted for year and age of dam effects, are shown in the tables as reference points.

The least squares means for the postweaning performance traits are shown in table 1 for heifers and in table 2 for steers.

A probable result of the poor performance of these cattle was that the statistical model was not very effective in removing the environmental sources of variation, except for average daily gain of the heifers and grade and condition at 18 months of age for both heifers and steers. The R^2 values ranged from .14 for grade to .75 for average daily gain to 12 months of age, and from .39 for weight-per-day of age to .71 for grade at 18 months of age for the heifers. R^2 values were even lower for the steers ranging from .32 for weight-per-day of age to .50 for grade at 12 months, and from .28 for weight-per-day of age to .73 for condition at 18 months.

Effect of sire breed was significant only for grade and condition among the heifers, but approached significance (.09) for average daily gain to 12 months. Among the steers, sire breed effect was significant for average daily gain from birth to 12 months of age and highly significant for grade and condition scores at both 12 and 18 months of age. It was not significant for average daily gain from birth to 18 months, weight-per-day of age, or yearling weight at either period.

However, the year x sire breed interaction was significant for all heifer traits at one or both weigh periods. Among the steers, it was highly significant for weight-per-day of age to 12 months, 12 months yearling weight, and 18 months grade and condition scores.

Although not different statistically, sire breeds for steers ranked (H to L): Charolais, Holstein and Shorthorn at both 12 and 18 months of age. All three kinds of heifers had the same weight at 12 months of age, but sire breed ranked (H to L) as Holstein, Charolais and Shorthorn at 18 months of age.

Summary

Charolais, Holstein and Shorthorn sire breeds were evaluated over three calf crops (77 heifers and 84 steers), bred to Hereford cows, on the postweaning performance of their progeny to 12 and 18 months of age. Since there were no straightbred controls, there was no comparison between straightbred and crossbred progeny. Measurement traits included average daily gain and weight-per-day of age from birth to 12 and 18 months and weight, conformation and condition scores at both ages. There was no sire breed effect on yearling weight for either steers or heifers

TABLE 1. LS MEANS OF POSTWEANING PERFORMANCE TRAITS OF HEIFERS IN THE BEAUMONT HERD BY SIRE BREED

Sire breed	Wean* wt (lbs)	ADG (lb)		WDA (lb)		Weight (lb)		Grade (pt)		Cond (pt)	
		12	18	12	18	12	18	12	18	12	18
Charolais	421	.30	.70	1.24	1.11	468	677	12.1	12.9	7.5	8.1
Holstein	437	.42	.71	1.24	1.14	468	695	10.9	10.2	6.2	7.2
Shorthorn	399	.38	.71	1.24	1.10	468	669	11.7	12.4	7.3	7.7
R ² values		.75	.55	.45	.39	.52	.47	.14	.71	.64	.69

*Adjusted for year and age of dam effects.

Number observations: 77 and 73 at 12 and 18 months, respectively.

Average ages were: 375 and 607 days.

TABLE 2. LS MEANS OF POSTWEANING PERFORMANCE TRAITS FOR STEERS IN THE BEAUMONT HERD BY SIRE BREED

Sire breed	Wean* wt (lbs)	ADG (lb)		WDA (lb)		Weight (lb)		Grade (pt)		Cond (pt)	
		12	18	12	18	12	18	12	18	12	18
Charolais	449	.33	.80	1.33	1.24	500	750	11.7	12.4	7.2	8.0
Holstein	446	.36	.77	1.29	1.21	482	735	9.4	9.6	6.4	7.3
Shorthorn	411	.46	.80	1.26	1.17	474	711	11.8	12.3	7.7	8.3
R ² values		.49	.57	.32	.28	.40	.31	.50	.64	.43	.73

*Adjusted for year and age of dam effects.

Number observations: 84 and 72 at 12 and 18 months, respectively.

Average ages were: 374 and 603 days.

at either 12 or 18 months. The differences due to sire breed effect in average daily gain from birth to 12 months were significant for the steers and approached significance for the heifers. The sire breed effect was highly significant for grade and condition scores of both sexes.

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SIRE BREED EVALUATION AT STATE FARM: POSTWEANING PERFORMANCE

Thomas J. Marlowe and Elizabeth T. Barnes

The data for this study came from a cooperative cattle breeding research project with the Virginia State Farm located along the James River about 25 miles west of Richmond. It was part of a large cooperative cattle breeding research project with the Virginia Department of Corrections at five locations. The objective of this research was to evaluate the Angus, Brown Swiss, Charolais, Hereford, Holstein, Shorthorn and Simmental breeds as sire breeds when mated to Hereford cows. Comparisons on fertility, calf survival and performance to weaning have been published in earlier livestock research reports. Those references are listed at the end of this report.

The purpose of this report is to present results of the comparisons for the postweaning performance of heifers and steers sired by the several sire breeds during the years 1972-75 produced from an average of 370 cows annually.

Data and Statistical Analyses

These cattle were sired by 6 Angus, 6 Brown Swiss, 9 Charolais, 11 Hereford, 8 Holstein, 8 Shorthorn and 11 Simmental bulls. All dams were Hereford. Cows were randomized to the breeding groups within ages of 3, 4, 5, 6-10, and over 10 years. Sire breeds were then randomized to the cow groups annually. Bulls were placed with the cows on or about February 15 for a 75-day breeding season. Each year, calves were weaned in late July or early August and grazed until November. During their first winter, the cattle were fed a low quality corn or grass silage, supplemented with urea or a small amount of other protein source. The following summer they were placed on pasture. All progeny were weighed, graded and scored for condition at weaning, 12 and 18 months of age. These cattle made very low gains during the winter following weaning. In fact, some of these cattle actually lost weight during the winter period.

Postweaning measurement traits included average daily gain and weight-per-day of age from birth to 12 and 18 months, yearling weights at 12 and 18 months, and conformation grades and condition scores for each period. There were 541 observations at 12 months and 478 at 18 months for the heifers, whose ages averaged 400 and 588 days, respectively, for the two weigh periods. There were 512 steer observations at 12 months, but only 336 observations at 18 months because the 1974 steers were not weighed at 18 months. Average ages of the steers were 396 and 573 days, respectively.

The authors express their sincere appreciation to all personnel of the Virginia Department of Corrections who cooperated and supported this research and to Mrs. Ellie Stephens for typing the manuscript.

The actual weaning weight of each calf was used as the starting point for calculation of average daily gain for both the 12 and 18 month periods. The scoring system used for conformation and condition at each weighing (weaning, 12 months and 18 months) was a numerical scale ranging from 3 to 17, representing the grade range of common through fancy.

The general linear models procedure of SAS was used for the statistical analyses. The statistical model included as sources of variation: year, breed of sire, year x breed interaction, age of dam (linear and quadratic) and age of animal.

Results and Discussion

Since the preweaning performance of these cattle was presented in the 1977 Livestock Research Report, only the postweaning performance will be presented here. However, weaning weights adjusted for year and age of dam effects are shown in the tables as reference points. The least squares means for the postweaning performance traits are shown in table 1 for heifers and in table 2 for steers.

The statistical model was not very effective in removing environmental sources of variation, a situation probably due to the poor performance of these cattle which resulted from the poor feeding program at this location. The R^2 values are low, nevertheless, nearly all sources of variation in the model had a significant influence on each of the measurement traits. The exceptions were age of dam effect on ADG, 12 months condition score and 18 months weight of steers; also, on ADG to 12 months and 18 months condition score of heifers. The other exception was the effect of animal age on ADG of both sexes, WDA at 18 months for the steers and 18 months condition score for heifers.

The effect of breed of sire was highly significant on all measurement traits for both sexes.

Postweaning average daily gains were quite low for both sexes, ranging from .29 (Herefords) to .47 (Holstein steers and Brown Swiss heifers) at 12 months of age, and from .51 and .58 (Hereford steers and heifers) at 18 months of age to a high of .77 (Simmental heifers) and .75 (Holstein steers) at 18 months of age. Weight-per-day of age followed the same pattern with the straight Herefords being the lowest and the Holstein, Simmental and Shorthorn the highest. Based on 18 months weight, the order of rank of the heifers (H to L) was Simmental (672), Holstein (644), Brown Swiss and Charolais (608), Shorthorn (598), Angus (580) and Hereford (532). A similar ranking of the steers is Holstein (690), Shorthorn (660), Simmental (640), Charolais (622), Angus and Brown Swiss (584) and Hereford (559).

All crossbred heifers and steers gained more and were heavier at 12 and 18 months than the straightbred Hereford controls. The difference between the best crossbred type and the straightbred Hereford controls at 18 months was 140 pounds for the heifers and 131 pounds for the steers.

TABLE 1. LS MEANS OF POSTWEANING PERFORMANCE TRAITS FOR HEIFERS IN THE STATE FARM HERD BY SIRE BREED

Sire breed	Wean wt (lb)	ADG (lb)		WDA (lb)		Weight (lb)		Grade (pt)		Cond (pt)	
		12	18	12	18	12	18	12	18	12	18
Angus	368	.35	.56	1.07	.98	431	580	11.4	11.5	6.7	6.9
Brown Swiss	356	.47	.68	1.07	1.02	432	608	10.6	10.8	5.7	5.9
Charolais	382	.39	.67	1.08	1.03	435	608	11.9	12.1	6.2	6.6
Hereford	337	.29	.51	.92	.90	371	532	11.0	11.3	5.8	6.5
Holstein	398	.41	.70	1.15	1.09	464	644	11.2	11.3	5.9	6.1
Shorthorn	403	.35	.58	1.12	1.01	452	598	11.7	12.5	6.6	7.0
Simmental	396	.48	.77	1.15	1.13	465	672	12.4	12.8	6.6	7.2
R ² values		.46	.43	.40	.41	.47	.40	.37	.34	.36	.32

All dams were Hereford.

Number of observations: 541 and 478 at 12 and 18 months, respectively.

Average ages were: 400 and 588 days at 12 and 18 months, respectively.

TABLE 2. LS MEANS OF POSTWEANING PERFORMANCE TRAITS FOR STEERS IN THE STATE FARM HERD BY SIRE BREED

Sire breed	Wean wt (lb)	ADG (lb)		WDA (lb)		Weight (lb)		Grade (pt)		Cond (pt)	
		12	18	12	18	12	18	12	18	12	18
Angus	368	.37	.62	1.04	1.01	416	585	11.2	11.0	6.1	6.7
Brown Swiss	383	.36	.63	1.04	1.03	415	583	10.6	10.6	5.4	5.8
Charolais	400	.38	.64	1.06	1.07	419	622	12.3	12.3	6.0	6.8
Hereford	351	.29	.58	.95	.97	379	559	11.2	10.9	6.0	6.5
Holstein	423	.47	.75	1.21	1.19	482	690	11.6	11.7	6.2	6.7
Shorthorn	424	.36	.65	1.15	1.16	458	660	12.5	12.8	6.7	7.4
Simmental	403	.43	.74	1.06	1.11	421	640	12.3	12.7	6.0	6.7
R ² values		.54	.42	.45	.32	.48	.50	.26	.38	.45	.44

All cows were Hereford.

Number of observations: 512 and 336 at 12 and 18 months, respectively.

Average ages were: 396 and 573 days at 12 and 18 months, respectively.

Summary

Angus, Brown Swiss, Charolais, Hereford, Holstein, Shorthorn and Simmental sires were mated to Hereford dams for four calf crops. The postweaning performance of their progeny was compared in terms of average daily gain and weight-per-day of age to 12 and 18 months and 12 and 18 months yearling weights, grades and condition scores. The statistical model used included the effects of year, sire breed, year x sire breed interaction, age of dam (both linear and quadratic) and age of animal. Even though all R^2 values were relatively low for both the heifer and steer data, all sources of variation had a significant influence on every measurement trait at either 12 or 18 months (or both), except for the effect of dam's age on average daily gain of the steers and age of animal on average daily gain of the heifers. Sire breed had a significant influence on every measurement trait of both sexes at each age. All crossbred heifers and steers grew faster and were heavier at weaning, 12 months, and 18 months of age than the straightbred Hereford controls. The heaviest crossbred-type steers averaged 131 pounds (23.4%) heavier at 18 months and the crossbred-type heifers averaged 140 pounds (26.2%) heavier at 18 months than the straightbred control.

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EFFECT OF LENGTH OF ENSILING AND LEVELS OF CATTLE
WASTE TO RYE STRAW ON FERMENTATION AND
UTILIZATION BY RUMINANTS

A. W. Cornman, W. D. Lamm, K. E. Webb, Jr. and J. P. Fontenot

SUMMARY

A small laboratory silo study was conducted to determine optimum ensiling time and level of cattle waste ensiled with rye straw. Waste collected from cattle fed a high concentrate diet was ensiled with ground rye straw in the following proportions (wet basis), respectively: 30:70, 40:60, 50:50, 60:40 and 70:30.

Fermentation, as measured by pH and lactic acid content, reached maximum levels after 1 week of ensiling. No further reduction in soluble carbohydrate content or change in in vitro dry matter digestibility was noted after the first week of ensiling. All total and fecal coliforms and salmonella, shigella and proteus were destroyed in all the mixtures after one week of ensiling.

Lactic acid content indicated a more desirable fermentation had occurred in the silages containing higher waste levels although pH values were similar for all silages. Water soluble carbohydrate content increased with increasing levels of waste. In vitro dry matter digestibility increased only slightly with increasing levels of cattle waste.

The following diets were fed in a sheep metabolism trial: 1) 75% ground mixed hay, 15% ground corn, 9.7% soybean meal and .3% ground limestone (basal ration); 2) 50% ground rye straw ensiled at 37.3% dry matter and 50% basal (negative control); 3) 50% basal and 50% 40:60 cattle waste-rye straw silage; 4) 50% basal and 50% 50:50 cattle waste-rye straw silage; 5) 50% basal and 50% 60:40 cattle waste-rye straw silage; and 6) 50% basal and 50% 70:30 cattle waste-rye straw silage (proportions were on a dry basis). Dry matter digestibility was higher ($P < .05$) for the cattle waste-rye straw silage containing diets than the control diet but was lower ($P < .05$) than the basal diet.

Dry matter digestibilities of the waste silages, calculated by difference, were not different, but were higher ($P < .05$) than the ensiled rye straw alone. Nitrogen retention was negative for all sheep except those fed the basal diet.

INTRODUCTION

In recent years there has been interest in finding alternative sources of feed for ruminants. Two of the primary areas of interest are recycling animal waste and the use of crop residues as feed sources.

Ensiling cattle waste with a roughage, such as hay or straw, has been investigated in recent years as an economical and efficient way of processing cattle waste. Anthony (1966, 1967) and Bandel and Anthony (1969) ensiled a mixture of 57 parts cattle waste and 43 parts

grass hay (wet basis), and named the resulting mixture "wastelage." Steers fed diets containing this wastelage gained as well as steers fed a control ration.

Lamm et al. (1979) and Harpster et al. (1978) ensiled 60 parts cattle waste and 40 parts hay and fed it to steers.

McClure et al. (1973) were able to maintain the weight of two 363 kg steers with ensiled cattle manure from cattle which were bedded with straw. These workers also fermented manure from cattle bedded with corn stover.

Researchers have found that cattle waste containing silages undergo a rapid fermentation (Moore and Anthony, 1970; Knight et al., 1977; and Newton et al., 1977).

Ensiling has been effective in destroying potential pathogenic organisms in animal waste (Knight et al., 1977; Albert et al., 1976; Duque et al., 1978 and Berger, 1978). According to Fontenot and Webb (1975) there have been no reported cases of harmful effects on animals or humans due to the feeding of cattle waste.

The present study was conducted to determine the length of ensiling needed for maximum fermentation of cattle waste ensiled with rye straw at various proportions and the effect on pathogenic organisms present in the mixtures prior to ensiling. The nutritive value of these mixtures, when incorporated into the diets of sheep, was investigated.

MATERIALS AND METHODS

Small Silo Study

A small silo study was conducted to determine the optimum proportion of cattle waste to rye straw and the length of ensiling required for maximum fermentation. Cattle waste was ensiled with ground rye straw in the following proportions: 30:70, 40:60, 50:50, 60:40 and 70:30, wet basis. The cattle waste was primarily fecal material, however, it also contained hair, wasted feed, and urine which did not run off.

The cattle waste was collected from steers which were being fed a diet consisting of a full feed of dry, cracked corn grain, 4.55 kg of corn silage and .91 kg of soybean meal per head per day. The steers were confined in a feedlot with solid concrete floors in which the sides sloped into a gutter where excess water and urine could run off into a drain. The day prior to ensiling, the feedlot was cleaned. On the day of ensiling, the manure which collected on the sides was scraped into the gutter and mixed. Two fresh samples were taken for dry matter determination and other samples were taken and frozen for later analysis of lactic acid, pH and soluble carbohydrates. Also, two samples were placed in sterile jars for microbial analysis. The manure was then collected and thoroughly mixed in a horizontal mixer. The rye straw was ground through a 2.5 cm screen.

Each mixture was prepared by adding the ground rye straw to the cattle waste in a horizontal mixer and mixing for 15 minutes. Thirty, 3.8 liter laboratory silos containing 1.5 to 2 kg of mixture each were made for each mixture. The silos were made by firmly packing the

mixture into cardboard food containers triple lined with polyethylene bags. Air was expelled from the bags and each was individually sealed. All silos were stored in an open building during late summer.

Prior to ensiling, samples were taken from each mixture for dry matter determination. Other samples were frozen for later determination of pH, lactic acid, water soluble carbohydrates and in vitro digestibility. Initial samples for microbial analysis were taken aseptically, stored in sterilized jars and refrigerated until analyzed the next morning.

Five silos from each mixture were opened at weekly intervals for 6 weeks. Upon opening, observations were made for odor and appearance. The top 2.5 cm were discarded from each silo and two samples were aseptically removed and placed in autoclaved blender jars for immediate microbial analysis. Dry matter was determined on each silo. These dry matter samples were later ground through a 1 mm mesh screen, composited, subsampled and used for determination of in vitro dry matter digestibility by the method of Tilley and Terry (1963), as modified by Barnes (1969).

Water extracts of the initial and fermented mixtures were prepared by homogenizing 25 g wet sample with 225 ml of sterile distilled water in sterile blender jars at full speed. This homogenate was then filtered through four layers of sterile cheesecloth. These extracts were then immediately subjected to quantitative tests for total coliforms (Anonymous, 1967) and fecal coliforms (Millipore, 1973) and to qualitative tests for salmonella, shigella, and proteus (Lewis, 1964). The pH of the extracts was determined electrometrically and samples were frozen for later determination of lactic acid (Barker and Summerson, 1941, as modified by Pennington and Sutherland, 1956) and water-soluble carbohydrates (Dubois et al., 1956, as adapted to corn plants by Johnson et al., 1966).

Metabolism Trial

This study was conducted to determine the nutritive value of the waste silages evaluated in the small silo study. The 30:70 mixture was eliminated from the metabolism trial because of its bulkiness and poor handling qualities.

Large silos (208 liter) were made of the 40, 50, 60 and 70% waste-containing silages. A control silage of rye straw ensiled with water at 37.3% dry matter also prepared.

The cattle waste used in the large silos came from cattle which were fed the same diet as the ones which produced the manure for the small silo study. The rye straw came from the same source as that for the small silo study also.

The six rations evaluated were the 40:60, 50:50, 60:40 and 70:30 waste silages, a negative control (rye straw ensiled at 37.3% dry matter) and a basal ration composed of 75% ground mixed grass hay, 15% ground corn, 9.7% soybean meal and .3% limestone. The corn, soybean meal and limestone were mixed into a concentrate premix and 12,000 I.U. of vitamin A and 2,213 I.U. of vitamin D₃ were added per kilogram. All ensiled components were fed as 50% of the dry matter with the basal ration.

Thirty-six crossbred wethers were assigned to six blocks by weight and breed. Lambs within each block were randomly allotted to metabolism stalls and to the six rations giving a total of six lambs per treatment.

The lambs were treated for internal parasites immediately after being placed in the metabolism stalls which were similar to those described by Briggs and Gallup (1949). All lambs were initially fed 350 g dry matter of a ration consisting of 61.4% mixed grass hay, 26.4% corn, 9.6% soybean meal and 2.6% vitamin A supplement twice a day at 0630 and 1830 hours. Five grams of iodized salt was included at each feeding.

There was a 2-day adaptation period to the stalls, a 4-day transition period to the experimental diets during which the diets were introduced at a rate of 12.5% of the dry matter at each feeding, a 12-day preliminary period and a 10-day collection period. During the preliminary period the dry matter per feeding had to be reduced to 300 g to get total consumption of all the feed offered. The corn, soybean meal and limestone premix was mixed with the hay and silages at each feeding. Water was available ad libitum except during the two 1-hr feeding periods.

During the collection period, feces were collected each morning and dried in a forced draft oven at 60C until the next morning. They were then composited by animal in metal cans with loose fitting lids and allowed to air equilibrate. At the end of the study, the fecal composites were weighed, mixed and subsampled.

Urine was collected in plastic bottles which contained 15 ml of a 1:1 (w/w) solution of sulfuric acid and water and 500 ml of water. Each morning the bottles were changed at the same time the fecal samples were collected. The urines were diluted to a constant weight with water and a 2% sample was placed in a tightly capped plastic bottle and refrigerated. At the end of the trial the urine samples were subsampled and frozen for later nitrogen determination.

Samples of the dietary components were taken at each feeding starting 2 days prior to collection and ending 2 days prior to termination of the trial. The silage samples were frozen and the daily samples were composited for analysis at the end of the trial.

Duplicate 200 g samples of the ration components were dried in a forced draft oven at 100 C for 48 hr for dry matter determination. The air equilibrated feed and fecal samples were ground through a 1 mm mesh screen and analyzed for dry matter, crude fiber (Whitehouse et al., 1945), ether extract (A.O.A.C., 1970), neutral-detergent fiber (Van Soest and Wine, 1967), acid-detergent fiber (Van Soest, 1963) and lignin, cellulose and insoluble ash (Van Soest and Wine, 1968). Hemicellulose was determined by difference (neutral-detergent fiber minus acid-detergent fiber). Kjeldahl nitrogen determination (A.O.A.C., 1975) of feed ingredients was done on wet samples, and of fecal samples on the air equilibrated ground samples. Nitrogen content of the urine was determined on duplicate 10 ml samples.

On the last day of collection, rumen fluid samples were obtained via stomach tube 2 hr post feeding. The samples were strained through four layers of cheesecloth and the pH was determined electrometrically.

Ruminal ammonia nitrogen was also determined on the strained rumen fluid (Conway, 1958).

Blood samples were taken via jugular puncture 6 hr post feeding the same day the rumen samples were obtained and analyzed for blood urea nitrogen (Coulombe and Favreau, 1963).

All lambs were weighed as they were removed from the metabolism stalls.

The small silo study data were analyzed using analysis of variance by the general linear model (Barr *et al.*, 1976). These data were tested by linear and quadratic polynomials.

The metabolism trial data were analyzed by analysis of variance (Barr *et al.*, 1976). Means were tested using the multiple range test of Duncan (1955).

RESULTS AND DISCUSSION

Small Silo Study

Table 1 shows the proximate composition of the manure and straw used in the small silo study. Dry matter content of the cattle waste and rye straw was 18.0 and 88.3%, respectively. The crude protein content of the cattle waste was 26.9%, dry basis, which is similar to the crude protein of cattle waste reported by Albin and Sherrod (1975).

After ensiling for 1 week, the odor of all silage mixtures indicated that fermentation had occurred. The odor was similar to a good quality silage and remained so throughout the study. Knight *et al.* (1977) reported that approximately 37% moisture was required for good ensiling of rations containing 40 and 60% cattle waste (37.3 and 48.3% moisture, respectively).

Table 2 shows the effect of length of ensiling on pH, lactic acid, water soluble carbohydrates and *in vitro* dry matter digestibility in the small silo study. There did not appear to be any difference in pH after the first week of ensiling, which indicates that there was no net acid production after the first week of ensiling.

Due to a treatment x time interaction ($P < .05$) with respect to lactic acid production, it is difficult to ascertain the exact relationship. It is questionable whether there were any biologically significant changes in lactic acid content with length of ensiling. There was no change in water soluble carbohydrate content or *in vitro* dry matter digestibility after the first week of ensiling.

Table 3 is a summary of the effect of ensiling various levels of cattle waste to rye straw on the fermentation parameters and *in vitro* dry matter digestibility. There was no difference in pH between silages. Lactic acid and water soluble carbohydrate content increased ($P < .05$) with increasing waste levels.

The low pH's in the lower waste level silages seems to be in disagreement with the lower levels of water soluble carbohydrates available in the initial mixtures. These low pH's may result from a low buffering capacity of the rye straw due to the unavailability of

rations for neutralizing power (McCullough, 1978) and/or to increased levels of volatile fatty acids.

In vitro dry matter digestibility was below 36% for all the silages but increased linearly ($P<.05$) with increasing levels of cattle waste.

Total and fecal coliform counts were greater than 10^5 /g in all of the initial mixtures and proteus organisms were also detected before ensiling. After 1 week of ensiling there were no coliforms, salmonella, shigella or proteus detected. These results were observed throughout the study and support the work of other researchers (Knight et al., 1977; McCaskey and Anthony, 1975; Caswell et al., 1975).

Metabolism Trial

The ingredient composition of the diets fed in the lamb metabolism trial are presented in Table 4.

Table 5 shows the apparent dry matter digestibilities of the experimental diets. The basal diet was higher ($P<.05$) and the control diet was lower ($P<.05$) in digestible dry matter than the waste-containing diets. The digestibilities of the waste silage diets ranged from 50.17% for the 40:60 silage diet to 52.68% for the 70:30 silage diet, however, this difference was not significant ($P<.05$).

The apparent digestibility of the ensiled portions of the diets was determined by difference by the method of Crampton and Harris (1969). The digestibility of the ensiled rye straw (control) was lower ($P<.05$) than the waste-containing silages. There was no difference in digestibility between the waste silages.

Nitrogen intakes (table 6), expressed as grams per day, increased ($P<.05$) with increasing levels of cattle waste but was highest for those lambs fed the basal diet. Fecal nitrogen excretion was similar for the silage containing rations, however, it was lower ($P<.05$) for the basal diet than for the waste silage diets but not for the control diet. Both urinary and total nitrogen excretion increased ($P<.05$) with increasing levels of waste. All lambs fed a silage-containing diet were in a negative nitrogen balance, however, differences between ensiled treatments were not significant. This is a reflection of the poor retention of absorbed nitrogen. Nitrogen retention of the sheep receiving the basal diet was positive and higher ($P<.05$) than that of sheep receiving the silage-containing diets, which was due at least partly to a higher dietary nitrogen intake.

The lambs in the metabolism trial lost weight, however, this was not related to the dietary treatment. It was most likely due to the low dry matter intake (600 g/day) used to obtain total consumption of the diets by all lambs.

TABLE 1. COMPOSITION AND FERMENTATION PARAMETERS OF CATTLE
WASTE AND GROUND RYE STRAW, SMALL SILO STUDY

Item	Cattle Waste	Ground Rye Straw
Dry matter, % ^a	18.0	88.3
Composition of dry matter, % ^a		
Crude protein	26.9	4.8
Crude fiber	20.4	46.4
Ether extract	5.2	1.1
NFE	39.1	45.1
Ash	8.4	2.6

^aEach value represents the mean of two samples.

TABLE 2. SUMMARY OF EFFECT OF LENGTH OF ENSILING ON PH, LACTIC ACID, WATER SOLUBLE CARBOHYDRATES AND IN VITRO DRY MATTER DIGESTIBILITY, SMALL SILO STUDY

Item	Ensiling period, weeks ^a						SEM
	1	2	3	4	5	6	
pH ^b	4.62	4.66	4.62	4.58	4.61	4.63	.02
Lactic acid, ^c % dry matter	2.82	3.02	2.81	2.69	2.81	2.76	.08
Water soluble carbohydrates, % dry matter	0.95	0.96	1.13	0.93	0.97	1.06	.03
IVDMD	32.76	31.20	30.96	31.31	30.84	32.23	.44

^aEach value represents the mean of twenty-five silos.

^bWhen the replicates were accounted for, there was a linear increase with length of ensiling (P<.05).

^cThere was a treatment x time interaction (P<.05).

TABLE 3. SUMMARY OF THE EFFECT OF ENSILING VARIOUS LEVELS OF CATTLE WASTE TO RYE STRAW ON DRY MATTER, PH, LACTIC ACID PRODUCTION, WATER SOLUBLE CARBOHYDRATES AND IN VITRO DRY DIGESTIBILITY, SMALL SILO STUDY

Treatment ^c	Dry ^a Matter	pH ^a	Lactic ^{abd} acid	Water soluble ^{abd} carbohydrates	IVDMD ^{ae}
30:70	64.61	4.60	1.65	0.68	29.58
40:60	57.57	4.58	2.59	0.89	30.47
50:50	51.23	4.61	2.59	0.96	30.91
60:40	44.63	4.66	3.09	1.07	31.93
70:30	38.36	4.64	4.16	1.40	34.86
SEM	.31	.02	.08	.40	.03

^aEach value represents the mean value of thirty silos.

^bPercent of dry matter.

^cThe first value represents the percent cattle waste and the second number represents the percent rye straw on a w/w wet basis.

^dThere was a quadratic increase with higher levels of cattle waste.

^eIncreased linearly with increasing levels of cattle waste.

TABLE 4. EXPERIMENTAL DIETS IN SHEEP METABOLISM TRIAL, DRY BASIS

Item	Basal	50% basal + 50%(control) Silage	50% basal + 50% (40:60) Silage	50% basal + 50% (50:50) Silage	50% basal + 50% (60:40) Silage	50% basal + 50% (70:30) Silage
Ingredient composition, %						
Mixed grass hay, grnd Ref. no. 1-02-244	75	37.5	37.5	37.5	37.5	37.5
Corn, grnd, No. 2 yellow dent Ref no. 4-02-931	15	7.5	7.5	7.5	7.5	7.5
Soybean, seed, solv. - extra, grnd. Ref. no. 50-04-604	9.7	4.8	4.8	4.8	4.8	4.8
Limestone, grnd, mn 33% calcium Ref. no. 6-02-632	0.3	0.2	0.2	0.2	0.2	0.2
Ensiled rye straw 40% dry matter	-	50.0	-	-	-	-
Ensiled cattle waste: grnd. rye straw						
40:60 silage ^a	-	-	50.0	-	-	-
50:50 silage ^a	-	-	-	50.0	-	-
60:40 silage ^a	-	-	-	-	50.0	-
70:30 silage ^a	-	-	-	-	-	50.0
Vitamin A & D ^b	+	+	+	+	+	+
Iodized salt ^c	+	+	+	+	+	+

^aDiets were: basal, 50% basal + 50% control (rye straw ensiled at 40% dry matter), 50% basal + 50% 40:60 (40 parts cattle waste and 60 parts ground rye straw), 50% + 50% 50:50 (50 parts cattle waste and 50 parts ground rye straw), 50% basal + 50% 60:40 (60 parts cattle waste and 40 parts ground rye straw) and 50% basal + 50% 70:30 (70 parts cattle waste and 30 parts ground rye straw).

^bSupplied (per kg of concentrate): 12,000 I.U. of vitamin A and 2,213 I.U. of vitamin D₃.

^cAll animals received 10 g per head per day of iodized salt.

TABLE 5. APPARENT DRY MATTER DIGESTIBILITY OF TOTAL RATIONS AND ENSILED PORTIONS

Item	Basal	Diets ^{ab}					SEM
		50% basal + 50% control Silage	50% basal + 50% 40:60 ^c Silage	50% basal + 50% 50:50 Silage	50% basal + 50% 60:40 Silage	50% basal + 50% 70:30 Silage	
Total ration	67.55 ^d	46.95 ^e	50.17 ^f	51.25 ^f	51.87 ^f	52.68 ^f	.33
Ensiled portions ^c	-	26.35 ^d	32.79 ^e	34.96 ^e	36.19 ^e	37.81 ^e	.68

^aDiets were: basal, 50% basal + 50% control (rye straw ensiled at 40% dry matter), 50% basal + 50% 40:60 (40 parts cattle waste and 60 parts ground rye straw), 50% basal + 50% 50:50 (50 parts cattle waste and 50 parts ground rye straw), 50% basal + 50% 60:40 (60 parts cattle waste and 40 parts ground rye straw), and 50% basal + 50% 70:30 (70 parts cattle waste and 30 parts ground rye straw).

^bEach value represents the mean of six animals.

^cDetermined by difference by method of Crampton and Harris (1969).

^{defg}Means in the same row with different superscripts are different ($P < .05$).

TABLE 6. NITROGEN UTILIZATION OF EXPERIMENTAL DIETS BY SHEEP

Item	Basal	Diets ^{ab}					SEM
		50% basal + 50% control Silage	50% basal + 50% 40:60 Silage	50% basal + 50% 50:50 Silage	50% basal + 50% 60:40 Silage	50% basal 50% 70:30 Silage	
Nitrogen intake, g/day	13.68	9.36	10.32	11.04	11.28	12.24	0
Nitrogen excretion, g/day							
Fecal	3.73 ^c	3.97 ^{cd}	4.19 ^d	4.16 ^d	4.21 ^d	4.23 ^d	.03
Urinary	8.95 ^c	6.33 ^d	6.62 ^{de}	7.29 ^{ef}	7.29 ^{ef}	8.57 ^c	.10
Total	12.68 ^c	10.30 ^d	10.81 ^{de}	11.45 ^{ef}	11.72 ^f	12.80 ^c	.10
Nitrogen retention							
Grams per day	1.01 ^c	-0.93 ^d	-.048 ^d	-0.41 ^d	-0.43 ^d	-0.56 ^d	.10
Percent of intake	7.37 ^c	-0.98 ^d	-4.65 ^d	-3.73 ^d	-3.85 ^d	-4.55 ^d	.96
Percent of absorbed	10.16 ^c	-17.36 ^d	-7.87 ^d	-6.07 ^d	-6.14 ^d	-7.06 ^d	1.60

^aDiets were: basal, 50% basal + 50% control (rye straw ensiled at 40% dry matter), 50% basal + 50% 40:60 (40 parts cattle waste and 60 parts ground rye straw), 50% basal + 50% 50:50 (50 parts cattle waste and 50 parts ground rye straw), 50% basal + 50% 60:40 (60 parts cattle waste and 40 parts ground rye straw), and 50% basal + 50% 70:30 (70 parts cattle waste and 30 parts ground rye straw).

^bEach value represents the mean of six animals.

^{cdefgh}Means in the same row with different superscripts are different ($P < .05$).

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The Effect of Time of Feeding on Time of Lambing

J. S. Copenhaver and W. B. Williams

It has been reported by Canadian researchers (Yarney, et.al., 1979) that feeding cows in late evening or night will induce most of them to calve during the day. They also report some evidence that ewes fed in late evening or at night will lamb during the day. If this practice works it would bring about a big saving in labor cost and would increase calf and lamb percentages.

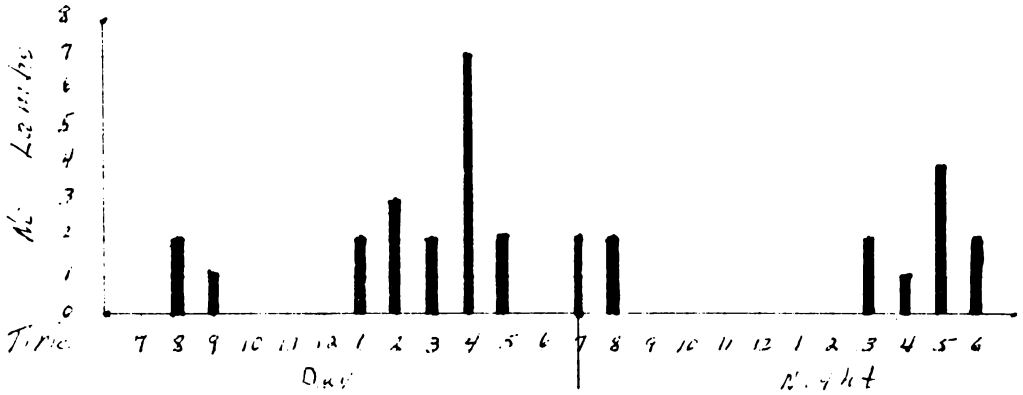
To test this theory two groups of ewes (14-Finn x Rambouillet and 23-Finn x Blackbelly x Rambouillet) were divided into two equal groups (1 and 2). These groups were confined in a barn thirty days prior to lambing. Group 1 was fed all of their daily feed at 8:30 a.m. and group 2 was fed at 4:30 p.m. Any feed left in feed troughs by the morning-fed group was removed at 4:30 p.m. and feed left by the afternoon-fed group was removed at 8:30 a.m. The ration consisted of mixed long hay and a 12% protein grain mixture plus minerals and water free choice. The results are shown in Table 1.

There were 18 ewes in the morning-fed group, 10 lambed during the day (7 a.m.-7 p.m.), 6 during the night and 2 failed to lamb. The average lambing time for this group was 11:36 a.m. The night-fed group consisted of 19 ewes. Eleven of these lambed during the day, 7 during the night and one ewe lambed prematurely during the night. The average lambing time for this group was 12:31 p.m., just 55 minutes later than the morning-fed group.

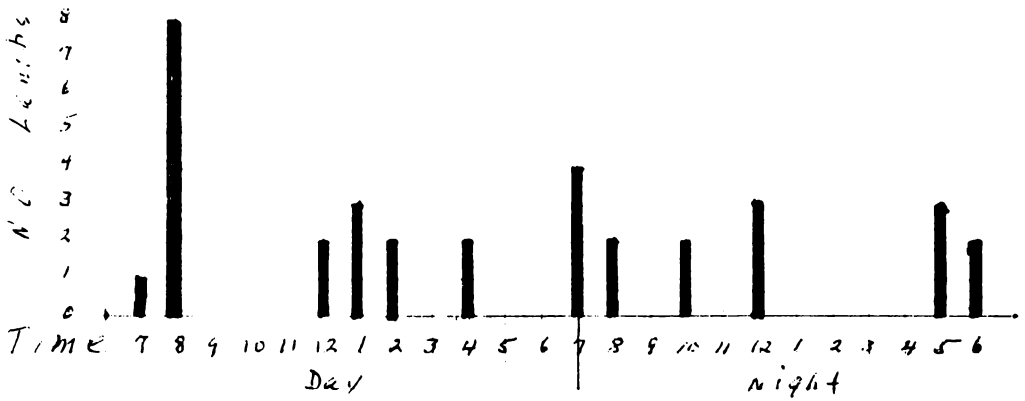
There was no difference in time of lambing due to the time of feeding. This work should be repeated with the night-fed group of ewes being fed around 8:00 p.m.

Table 1. Distribution of Time of Lambing

Morning Feel



Evening Feel



FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF BULLS AND HEIFERS FED DIFFERENT GRAIN LEVELS¹

W. D. Lamm, R. F. Kelly and J. P. Fontenot

The objective of this study was to compare the feedlot performance and carcass characteristics of weanling bull and heifer calves fed to slaughter weight on different dietary treatments. The efficacy of tylosin (trade name: Tylan) in promoting live weight gains during the finishing phase was also evaluated.

Experimental Procedure

Forty bull and 40 heifer calves were blocked by weight and breed within sex and randomly allotted within block to one of four dietary treatments, with two pens of five animals per treatment.

The calves, sired by Angus, Polled Hereford or Simmental bulls, were progeny of Angus or Angus x Holstein cows and were not creep-fed. At weaning (October 23) they were fed grass-legume hay and corn silage until start of the trial December 18. One week after weaning they were moved from open lots to a confinement feedlot where they remained until termination of the study.

The dietary treatments fed once daily were 1) corn silage fed ad libitum 2) corn silage fed ad libitum + whole high-moisture corn fed at 1% of body weight 3) corn silage fed ad libitum first 100 days; then, whole high-moisture corn fed ad libitum until slaughter and 4) same as treatment 3 except tylosin was fed at 90 mg per head daily during grain feeding phase. All calves were fed .68 kg of a 50% crude protein supplement containing 385 g monensin sodium per metric ton during the first 100 days and .68 kg of a 36% crude protein pelleted supplement containing 330 g monensin sodium per metric ton was fed daily from day 101 until slaughter. Water, salt and a vitamin-mineral mixture were available at all times. 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 adjacent pens in the east half. No heat suppressant was used for the heifers.

At slaughter, 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

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

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).

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 shearing device. 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 and heifers gained 1.20 and .94 kg daily, respectively, during the trial when data were pooled across dietary treatments. (Note: kg may be converted to lbs by multiplying by the factor 2.2). This was a 28% higher rate of gain for bulls than heifers. Bulls were 20% more efficient in the conversion of dietary dry matter to live weight gain than heifers (6.64 vs 7.98).

Bull carcasses were less fat than heifer carcasses as indicated by fat thickness, kidney, pelvic and heart fat percent and yield grade (table 2). However, they had higher dressing percents. Heifers had higher marbling scores and USDA quality grades. Longissimus muscle area was not different between bulls and heifers.

The physical separation of the 9-10-11 rib sections (table 3) indicated bulls had more lean and bone but less fat trim than heifers. Total cooking losses were not different between bulls and heifers. Taste panel members rated heifers more desirable for tenderness, juiciness and overall acceptability. There was no difference in flavor between the two sexes. Warner-Bratzler shear values were similar for both sexes.

The feedlot performance of bulls and heifers fed the four dietary treatments is presented in table 4. There were no sex x treatment interactions. Bulls fed the whole corn diets the last 96 days of the trial tended to gain slower than bulls fed the other dietary treatments. Bulls fed grain at 1% of body weight throughout the study consumed the most dry matter but also appeared to have the least desirable conversion of diet dry matter to live weight gain. Tylosin did not support increased

rate or efficiency of gain in bulls compared to the other diets.

Heifers fed only corn without tylosin the last 83 days of the study weighed significantly less at slaughter and had slower rates of gain, compared to heifers fed the other diets. Heifers fed the whole corn diets tended to have lower dry matter intakes and those fed the diet containing tylosin had the most desirable feed efficiency.

Carcass data of the bulls and heifers is shown in table 5. Bulls fed the diet containing 1% body weight corn had the highest dressing percent. None of the other carcass parameters measured were affected by dietary treatment. Heifers fed the corn diet with tylosin had significantly lower dressing percents but significantly higher quality grades. Dietary treatment had no effect on the other carcass parameters measured.

Results of the carcass evaluation tests are shown in table 6. Within sex, dietary treatment had no significant effect on lean, fat and bone percents, cooking losses, taste panel scores or Warner-Bratzler shear values.

Summary

Rate of gain and feed efficiencies were greater for bulls than heifers of similar breeding and age. Bulls had leaner carcasses with lower quality grades but more desirable yield grades than heifers. In this study it appeared both groups of cattle should have been fed longer to obtain a higher quality grade. Dietary treatment had no effect on feedlot performance although it appeared bulls fed the 1% body weight corn diet tended to be least efficient. Tylosin did not support increased rate of gain in either sex but did improve feed efficiency in heifers.

TABLE 1. FEEDLOT PERFORMANCE OF BULLS AND HEIFERS

Item	Sex	
	Bulls	Heifers
No. of animals	40	40
Days on feed	196	183
Age at slaughter, days	470	448
Initial weight, kg	270.8	258.8
Final weight, kg	506.6 ^a	429.8 ^b
Daily gain, kg	1.20 ^a	.94 ^b
DM per kg gain	6.64 ^a	7.98 ^b

^{ab} Means in the same row with different superscripts differ ($P < .01$).

TABLE 2. CARCASS DATA OF BULLS AND HEIFERS

Item	Sex	
	Bulls	Heifers
No. of carcasses	40	40
Age at slaughter, days	470	448
Slaughter weight, kg	506.6 ^a	429.8 ^b
Dressing %	61.7 ^a	60.0 ^b
Marbling score ^c	2.8 ^a	4.0 ^b
USDA quality grade ^d	9.4 ^a	11.2 ^b
Fat thickness at 12th rib, cm	.76 ^a	1.3 ^b
<u>Longissimus</u> muscle area, cm ²	78.8	74.8
Kidney, pelvic and heart fat, %	2.1 ^a	3.6 ^b
Yield grade	2.2 ^a	3.2 ^b

^{ab} Means in the same row with different superscripts differ (P<.01).

^c 1 = practically devoid, 9 = abundant.

^d 6 = standard minus, 17 = prime plus.

TABLE 3. CARCASS EVALUATION OF BULLS AND HEIFERS

Item	Sex	
	Bulls	Heifers
No. of carcasses	40	40
<u>Physical separation of 9-10-11 rib section, %</u>		
Lean	55.8 ^a	48.1 ^b
Fat	25.0 ^a	36.1 ^b
Bone	19.2 ^a	15.7 ^b
<u>Cooking losses, %</u>		
Evaporation	19.9	18.2
Drippings	5.1 ^a	6.5 ^b
Total	25.2	24.8
<u>Taste panel scores^e</u>		
Tenderness	16.2 ^c	13.5 ^d
Juiciness	17.0 ^a	14.4 ^b
Flavor	14.7	14.0
Overall acceptability	17.1 ^c	15.1 ^d
Warner-Bratzler shear, kg	3.6	3.6

^{ab} Means in the same row with different superscripts differ ($P < .01$).

^{cd} Means in the same row with different superscripts differ ($P < .05$).

^e 6 = most desirable, 30 = least desirable.

TABLE 4. FEEDLOT PERFORMANCE OF BULLS AND HEIFERS

Item	Internat'l Ref. No.	Sex, grain level and additive							
		Bulls				Heifers			
		None	1½ body weight	Full fed, last 96 days		None	1½ body weight	Full fed, last 83 days	
				None	Tylosin ^a			None	Tylosin ^a
No. of animals		10	10	10	10	10	10	10	10
Days on feed		196	196	196	196	183	183	183	183
Initial weight, kg		263.0	282.4	267.6	270.2	269.6	260.5	250.0	254.9
Final weight, kg		507.3	529.4	497.3	492.6	448.6 ^b	445.5 ^b	393.2 ^c	431.8 ^b
Daily gain, kg		1.25 ± .06	1.26 ± .06	1.17 ± .07	1.13 ± .06	.98 ± .06 ^b	1.01 ± .06 ^b	.78 ± .06 ^c	.97 ± .06 ^b
Daily DM consumed, kg									
Corn silage	3-08-153	7.2	5.1	3.6	3.3	7.0	4.8	3.4	3.8
Corn grain, cracked	4-02-915	-	3.5	3.7	3.2	-	3.0	2.9	2.4
Supplement		.6	.6	.6	.6	.6	.6	.6	.6
Total		7.8	9.2	7.9	7.1	7.6	8.4	6.9	6.8
DM per kg gain		6.24 ± .45	7.30 ± .45	6.75 ± .45	6.28 ± .45	7.76 ± .45 ^{bc}	8.32 ± .45 ^b	8.85 ± .45 ^b	7.01 ± .45 ^c

^aFed with grain at level of 90 mg per hd per day.^{bc}Means in the same row within sex with different superscripts differ (P<.05).

TABLE 5. CARCASS DATA OF BULLS AND HEIFERS

Item	Sex, grain level and additive							
	Bulls				Heifers			
	None	1% body weight	Full fed, last 96 days		None	1% body weight	Full fed, last 83 days	
			None	Tylosin ^a			None	Tylosin ^a
No. of carcasses	10	10	10	10	10	10	10	10
Age at slaughter, days	467	475	476	462	451	444	446	448
Slaughter weight, kg	507.3	529.4	497.3	492.6	448.6	445.5	393.2	431.8
Dressing %	61.4 ± .6 ^b	63.5 ± .6 ^c	61.0 ± .7 ^b	61.0 ± .6 ^b	60.8 ± .6 ^b	60.5 ± .6 ^b	59.5 ± .6 ^b	58.7 ± .6 ^c
Marbling score ^d	3.0 ± .3	3.0 ± .3	2.7 ± .3	2.6 ± .3	3.5 ± .3	4.1 ± .3	4.0 ± .3	4.2 ± .3
USDA quality grade ^e	9.9 ± .5	10.3 ± .6	8.6 ± .6	9.0 ± .5	10.3 ± .5 ^b	11.2 ± .5 ^b	11.2 ± .6 ^b	12.3 ± .6 ^c
Fat thickness at 12th rib, cm	.84 ± .1	.74 ± .2	.68 ± .1	.79 ± .1	1.3 ± .1	1.4 ± .1	1.3 ± .2	1.4 ± .2
Longissimus muscle area, cm ²	80.1 ± 3.5	80.4 ± 3.9	78.5 ± 3.8	76.0 ± 3.4	78.0 ± 3.7	75.0 ± 3.4	78.0 ± 4.2	68.2 ± 3.9
Kidney, pelvic and heart fat, %	2.2 ± .2	2.2 ± .2	1.8 ± .2	2.1 ± .2	3.4 ± .2	3.6 ± .2	3.6 ± .2	3.6 ± .2
Yield grade	2.2 ± .2	2.1 ± .2	2.1 ± .2	2.3 ± .2	3.0 ± .2	3.3 ± .2	3.2 ± .3	3.3 ± .2

^aFed with grain at level of 90 mg per hd per day.

^{b,c}Means in the same row within sex with different superscripts differ (P<.05).

^d1 = practically devoid, 9 = abundant.

^e6 = standard minus, 17 = prime plus.

TABLE 6. CARCASS EVALUATION OF BULLS AND HEIFERS

Item	Sex, grain level and additive							
	Bulls				Heifers			
	None	1% body weight	Full fed, last 96 days		None	1% body weight	Full fed, last 83 days	
			None	Tylosin ^a			None	Tylosin ^a
No. of carcasses	10	10	10	10	10	10	10	10
<u>Physical separation of 9-10-11 rib section, %</u>								
Lean	54.6 ± 1.7	55.0 ± 1.8	57.5 ± 1.8	56.2 ± 1.6	49.4 ± 1.7	47.5 ± 1.6	48.6 ± 2.0	47.0 ± 1.8
Fat	26.4 ± 1.8	26.0 ± 2.0	22.8 ± 1.9	24.7 ± 1.7	35.1 ± 1.8	37.1 ± 1.7	35.5 ± 2.1	36.6 ± 2.0
Bone	19.0 ± .6	19.0 ± .7	19.8 ± .7	19.1 ± .6	15.6 ± .6	15.5 ± .6	15.3 ± .8	16.5 ± .7
<u>Cooking losses, %</u>								
Evaporation	20.6 ± 1.4	20.3 ± 1.4	19.7 ± 1.4	18.9 ± 1.4	18.0 ± 1.4	19.9 ± 1.3	17.4 ± 1.4	17.7 ± 1.5
Drippings	4.1 ± .5 ^b	5.7 ± .5 ^c	5.4 ± .5 ^c	5.1 ± .5 ^c	6.0 ± .5	6.9 ± .5	6.8 ± .5	6.3 ± .5
Total	24.7 ± 1.9	25.0 ± 2.0	25.1 ± 1.9	24.0 ± 2.0	24.0 ± 1.9	26.8 ± 1.9	24.2 ± 2.0	24.0 ± 2.0
<u>Taste panel scores^d</u>								
Tenderness	14.8 ± 1.8	16.5 ± 1.8	16.6 ± 1.8	16.9 ± 1.8	14.3 ± 1.8	13.2 ± 1.7	13.0 ± 1.9	13.5 ± 1.8
Juiciness	16.0 ± 1.2	15.8 ± 1.2	18.9 ± 1.2	17.4 ± 1.2	14.0 ± 1.2	13.5 ± 1.1	16.0 ± 1.2	14.1 ± 1.2
Flavor	15.0 ± 1.1	14.7 ± 1.1	13.9 ± 1.1	15.4 ± 1.1	13.2 ± 1.1	14.2 ± 1.1	14.7 ± 1.2	13.8 ± 1.1
Overall acceptability	16.8 ± 1.4	16.0 ± 1.4	17.6 ± 1.3	18.1 ± 1.4	14.8 ± 1.4	14.3 ± 1.3	16.1 ± 1.4	15.1 ± 1.4
Warner-Bratzler shear, kg	3.63 ± .43	3.34 ± .43	3.66 ± .38	3.83 ± .44	3.44 ± .48	3.56 ± .41	3.35 ± .41	4.13 ± .46

^aFed with grain at level of 90 mg per hd per day.^{b,c}Means in the same row within sex with different superscripts differ (P<.05).^d6 = most desirable, 30 = least desirable.

LOW LEVEL, PERIPARTURIENT FECAL EGG COUNT CHANGES AND MILK PRODUCTION IN SPRING-CALVING BEEF COWS¹

Bruce Hammerberg² and W. D. Lamm³

Subclinical gastroenteric parasitism in cattle has begun to be investigated for its detrimental effects on dairy cow production, and role in the epidemiology of infections of spring pastures and dairy barn areas.

Yearling calves have been reported to demonstrate a low level "spring-rise" in nematode egg output, which can contribute to infection of spring pastures; and first pregnancy dairy heifers produced post-parturient rises in egg counts, which potentially contribute to infection of dairy barn areas. However, many older cows are also participants in this ecosystem and may play a role in maintaining gastrointestinal nematode infections on pastures and in barn areas, yet no studies of the peri-parturient fecal egg counts in mature cows of either beef or dairy breeds appear to have been done. The present study was therefore conducted to characterize low level egg output in apring-calving Angus and Angus-Holstein cows maintained at two nutritional levels during winter housing. Milk production and calf weaning weights were also monitored.

Experimental Procedure

A herd of 85, five-year-old, bred cows was removed from hillside pasture (grazed 3 months) on November 30, 1978, and placed in drylot paddocks for allocation into experimental groups. All cows had been wormed with Tramisol (8mg/Kg)⁴ and separated from their calves on October 23.

Experimental Grouping

Angus cows were randomly divided into groups of 22 and 19 to receive gestation and lactation diets containing either 80% or 100% of National Research Council recommended TDN, respectively. Angus-Holstein crosses (progeny of Holstein dams) were similarly divided into groups of 26 and 18 for 80% and 100% TDN, respectively. The controlled rations (composed of corn silage and urea) were fed once daily from December 1, 1978 until May 9, 1979, when all cows were turned out onto hillside pasture. Seven cows (two from each of the Angus nutritional groupings, two from the 100% TDN Angus-Holstein group and one from the 80% TDN Angus-Holstein group) did not calve and were reported in the results as open cows.

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Sampling and Treatment Regimen

Fecal samples were collected rectally on the following schedule: 20 random samples from cows were taken on November 30, 1978; all cows were sampled on February 21, 1979; each cow was sampled on the day of calving (March 13 to May 14); 28 cows calving before March 30 were sampled again on April 16, designated as early post-calving; 7 open cows were sampled between April 16 and May 14; all cows with calves were sampled on May 17; 20, 12 and 19 randomly selected cows were sampled on July 19, August 17 and October 20, respectively; all cows were sampled on September 20.

All cows were wormed with Tramisol (8mg/Kg body wt.) on October 23, 1978, thirty-eight days prior to removal from fall pastures. Approximately one-half of the cows in each of the four breed-nutrition groups were treated with TBZ paste (66 mg/Kg body wt.)⁵ at calving. Every other cow within a group in the sequence of calving was treated.

Parasite Ova Quantitation

The Wisconsin sugar flotation technique was used to quantitate numbers of strongylid-type eggs in individual cow fecal samples.

Differential Larval Quantitation

Fifty grams of feces, mixed with vermiculite to form a semi-moist paste, was incubated in a 150 ml jar at 23 C. After 6 days the jar was partially filled with tap water and inverted in a small petri dish. Infective stage larvae accumulated in water added to the petri dish and these were removed and identified after 24 hours. Criteria for differential larval identification were those previously described.

Milk Production

Twelve hour milk yield and composition estimates were made with 71 cow-calf pairs. After a 12-hr separation of cows and calves, several milliliters of initial milk was manually removed from the left rear quarter of each cow's udder and discarded. Additional milk was placed into two plastic whirl paks to obtain two samples of milk for laboratory analysis. One sample was retained for butterfat content analyzed with a Milko-Tester. The second sample was immediately chilled in ice and transported to a laboratory for determination of total solids. Solids-not-fat was calculated as the difference between the butterfat and total solids determinations. Crude protein was determined by the dye-binding procedure of the Foss Pro-milk instrument. Milk yield was determined by the calf weigh-suckle-weigh technique. Estimates were obtained on days 49, 91, 142 and 179 of lactation.

Results

Periparturient Changes in Egg Counts

The seasonal fluctuation in fecal egg counts determined for mature cows from November 30, 1978 to October 18, 1979 is represented in

⁵Merck and Co., Inc., Rahway, NJ.

Figure 1. A mean egg count per 5 grams of feces of 111 for 78 cows at the onset of lactation was markedly higher than that from open cows (Table 1), or from those determined at pre- and post-calving times (Tables 1, 3). The mean of the change (mean of the sum of differences) in egg counts from pre-calving to calving and from calving to post-calving was significantly different from zero ($P < .001$). Although cows calving earlier in the spring (March 13 to April 13) had higher counts at the onset of lactation (Figure 1) than later (April 14 to May 14) calving cows, the changes in counts from pre- to post-calving times were not statistically different ($P > .05$) from the mean change considering all calving cows (Table 1). Regression analysis demonstrated a mean decline of 1 egg per 5g sample per day from March 13 to May 14 in calving egg counts, but this was not statistically significant ($P > .05$). Post-calving egg counts in cows not wormed fell rapidly but not immediately after calving (Figure 1). This change was demonstrated in the mean difference between counts in early calving (March 13 to March 31) cows at parturition and at early (April 16) and late (May 17) post-calving times (Table 1); on April 16 (2 to 4 weeks after calving) the mean decline in eggs per 5g was 87, while on May 17 these same cows had reduced egg output by 135 compared to parturition samples.

Effect of Anthelmintic Treatment

Treatment of cows at calving produced statistically significant differences ($P < .002$) in egg counts at both early and late post-calving times (Table 4) between wormed and not wormed animals. Two of fourteen untreated cows calving before March 31 had counts exceeding 200 eggs/5g at 16 and 20 days after calving while none of the treated cows examined on April 16 ($N=16$) or on May 17 ($N=36$) exceeded 24 eggs/5g.

Breed and Nutritional Factors

Egg counts before calving and at calving were compared on the basis of breed and nutritional level and breed-nutritional level interaction. Angus and Angus-Holstein breeds were not statistically different ($P > .05$) in the number of eggs produced at calving, while cows fed 80% and 100% TDN had egg counts which were significantly different ($P < .03$) (Table 2). Combining the effects of breed and nutritional level enhanced the difference between breeds such that Angus cows had fewer eggs at 80% TDN than at 100% TDN while Angus-Holstein crosses produced many more eggs at 80% TDN than at 100%. This interaction of breed and nutritional level was highly significant ($P < .0009$). Although pre-calving counts were low at 14 eggs/5g, a similar breed-nutritional level interaction was suggested by these values which was not statistically significant (Table 3).

When changes in egg counts for individual animals from pre-calving to calving and from post-calving to calving were analyzed separately for the effects of breed or nutrition (Tables 5 and 6), then a statistically significant difference ($P < .02$) was found between all cows fed the 80% and 100% TDN rations (Table 6). This statistical difference was found only in the increase in egg numbers occurring from pre-calving to calving. More remarkable was the interaction of breed and nutritional level which showed that the changes in egg counts from pre-calving to

calving and from calving to post-calving in Angus-Holstein crosses were in some degree related to the nutritional level. Angus cows responded in an opposite manner from Angus-Holstein cows to the nutritional level fed in that perinatal changes in egg counts were much less at 80% TDN. The crossbred cows demonstrated the greatest rise in egg counts when fed 80% TDN and the least change of all groups at 100% TDN. The dependence of the nutritional level effect on breed was significant for changes in egg counts pre-calving ($P < .003$) and post-calving, ($P < .02$) (Table 7).

Larval Identification

Fecal cultures of 20 rectally collected samples from cows in September, 1979 produced from 60% to 50% Ostertagia larvae, 40% to 30% Cooperia larvae, and less than 10% Haemonchus and Trichostrongylus larvae. Similar results were observed in the calves grazed with these cows when 30 rectally collected samples were examined in September. The seventy-six calves had a mean egg count of 138 eggs per 5 grams at this time.

Milk Production and Calf Performance

Treating cows with TBZ at parturition had no significant effect on conception rate, milk yield and composition or adjusted calf weaning weights.

Discussion

The profile of fecal egg counts for mature beef cows calving between March 13 and May 14 exhibited mean values of 16 eggs/5 gm or less at times other than at calving. At calving and immediately following, egg counts were markedly higher and this rise and subsequent decline in egg numbers occurred in less than 3 months. A higher mean egg count for cows calving between March 13 and April 13 than for cows calving between April 14 and May 14 indicated a possible seasonal (spring rise) influence on the periparturient rise; however, this could not be confirmed as a statistically significant effect. Also the limited number of open cows, which were representative of both breed and nutritional level, demonstrated no detectable seasonal rise in egg counts on February 21 or between April 16 and May 17.

Even though the periparturient rise was short lived, anthelmintic treatment of cows at calving produced a significant reduction in post-parturient egg output. This difference between treated and untreated cows was due to sustained high level post-parturient egg output by a few of the untreated early-calving cows. The practical importance of the higher egg output of individual mature cows in relation to larval contamination of spring pastures was not evaluated and other factors such as overwintering of larvae on pastures and pasture rotation strategies have to be considered in this respect.

The periparturient egg rise described here for 5-year-old beef cows had been defined on the basis of both absolute parasite egg counts, as seen in Figure 1 and Table 2, and changes in egg counts for individual animals, as demonstrated in Table 1. Considering all calving cows,

regardless of breed or nutritional level, changes in egg output from pre-calving to calving and from calving to post-calving were highly significant. These changes by individual cows in egg output were examined for breed and nutritional influences because absolute egg counts suggested strong interactions between breed and nutritional level factors ($P < .0009$) (Table 2).

Breed and nutritional factors were analyzed for correlations with the degree of change in periparturient egg output. From this analysis the consideration of individual factors demonstrated an association of 80% TDN with a greater rise in egg counts which was statistically different from cows fed 100% TDN. Analysis of interaction of breed and nutritional level revealed opposing reactions of breeds to the nutritional levels. Angus cows fed 80% TDN demonstrated less of a change in egg counts perinatally than those fed 100% TDN while Angus-Holstein cows fed 80% TDN had the most dramatic rise and fall in perinatal egg counts and those fed 100% TDN produced the least change of all groups. Thus the breed-nutritional level interaction was significant ($P < .003$) for the pre-calving to calving egg rise and for the calving to post-calving egg decline ($P < .02$).

In an attempt to differentiate a periparturient rise from a "spring rise" seven non-pregnant cows kept with the herd in this study were sampled. There was no evidence of a rise in egg numbers in these animals, yet a seasonal influence on the rise associated with parturition cannot be ruled out in older cows. A small "spring rise" has been reported in yearling calves.

Most of the larvae found in fecal samples from both mature cows and their co-grazing calves were Ostertagia sp. and Cooperia sp.; these were nearly equally numerous. The cows and calves were grazing traditional fall pasture areas at the time that these fecal samples were taken. This was the same pasture area utilized each fall prior to moving cows into winter paddocks. Although no larval cultures were prepared from feces from mature cows in the spring and the presence of Haemonchus cannot be excluded, it may be speculated that both Ostertagia and Cooperia would be likely participants in the periparturient rise in egg counts because both have been reported to undergo arrested development.

The phenomenon of the periparturient rise in egg counts has been well reviewed and its occurrence in ruminants almost exclusively reported in sheep, even though arrested development and Type II ostertagiasis are commonly described in cattle. A recent report described the periparturient rise in egg output due primarily to Ostertagia and Cooperia in dairy heifers; however, no similar study has been conducted on older cows. A decreased ability of maintaining arrested Ostertagia larvae has been demonstrated in early lactational heifers when they were compared with age-matched open heifers. A similar decrease in resistance in older cows to resumed development by arrested Ostertagia or Cooperia larvae may explain the rise in egg counts reported here where levels of egg output approached those of co-grazing first year calves.

The low numbers of parasite ova detected in both adult cows and calves was reflected in the absence of clinical parasitism during this

study. This was expected because ample grazing area was available for rotation of the herd after 3 months on spring pasture and because all calves were moved to enclosed housing after weaning in October, leaving only old cows to return to spring pastures with their new calves. The limitations of the McMaster's technique and similar egg quantitation methods using dilution factors have been pointed out by other investigators who were examining low egg output in cattle. The Wisconsin sugar flotation technique has been shown to circumvent these limitations. The apparent low level of parasitism experienced by the adult cows did not preclude a distinct periparturient rise in egg output. This output might have been of a greater magnitude in the face of exposure to larger numbers of infective larvae during fall grazing. Indeed, the observed rise occurred even though cows were treated with an anthelmintic approximately one month before placement into drylot paddocks.

The results reported here suggest that peak egg output of gastrointestinal nematodes can occur at parturition in mature cows. Possibly any proposed effects of subclinical parasitism on cow performance are more likely to occur at this time, if indeed such effects are substantiated.

The role of even a low level periparturient rise or "spring rise" (as defined for yearling calves) in creating important levels of pasture infection has been investigated by others. Cows returning to pasture soon after calving might serve as a source of pasture infection, and yearling calves placed on spring pasture have produced pasture infections which resulted in fulminating infections in co-grazing young calves. The results reported here support the suggestion that the most appropriate time to treat beef cows is at parturition. However, no increase in milk production or calf weaning weights were observed in the present study.

Summary

A herd of mature Angus and Angus-Holstein cows calving between March and May were maintained at 80% and 100% of NRC recommended TDN levels during winter housing. Changes in fecal nematode egg counts of these cows, expressed as eggs/5g and quantitated by the Wisconsin sugar flotation technique, were detected perinatally and correlated with breed, nutritional level, and time of the year. A limited yet highly significant rise in egg output was found in cows sampled at calving. Anthelmintic treatment at calving produced post-calving egg counts which were statistically lower than those from untreated cows. When breed and nutritional level were considered independently there was less influence on egg counts than when the interaction of breed and nutritional level was examined. Angus-Holstein cows fed 80% TDN requirements had the greatest perinatal increase in egg output and those fed 100% TDN the smallest rise of all groups. Angus cows responded in an opposite manner to the nutritional level and had increases in egg counts intermediate to those of Angus-Holstein cows. This characterization of the periparturient egg output by mature cows will aid in evaluating the role of grazing cows in pasture infection.

TABLE 1. CHANGES IN EGGS/5g WITH RELATION TO CALVING

	Sample Dates Compared						
	Calving cows					Open Cows	
	Early calving ^a minus pre- calving ^c	All calving minus pre- calving ^c	Early calving ^a minus early post-calving ^d	Early calving ^a minus post- calving	All calving minus post- calving	Calving time ^b minus pre- calving time ^c	Calving time minus post- calving time
Mean differences in eggs/5g	111	97	87	135	92	-5	1
No. animals	50	78	14	12	38	7	7
Significantly different from zero at level	.001	.001	.001	.001	.001	n.s.	n.s.

^aEarly calving occurred between March 13 and April 13.

^bCalving time was between April 13 and May 14

^cPre-calving samples were those taken on February 21.

^dChange in fecal strongylid egg counts of fourteen untreated cows calving between March 13 and 31, and sampled early post-calving on April 16. Change in egg counts of these same cows sampled again post-calving on May 17.

^ePost-calving time was May 17 taken from untreated cows.

TABLE 2. EGG COUNTS/5g AT CALVING CONSIDERING BREED, NUTRITIONAL LEVEL AND BREED X NUTRITIONAL LEVEL INTERACTION

	Breed		Nutritional level		Breed x Nutritional level			
	A	AH	100%	80%	A 100%	A 80%	AH 100%	AH 80%
Mean eggs/5g	88	132	80	133	108 ^a	69 ^a	50 ^a	185 ^b
No. of animals	37	41	33	45	17	20	16	25
Significant difference at level	n.s.		.03		.0009			

^{ab} Means with different superscripts are different (P<.05).

TABLE 3. EGG COUNTS/5g PRE-CALVING CONSIDERING BREED, NUTRITIONAL LEVEL AND BREED X NUTRITIONAL LEVEL INTERACTION^a

	Breed		Nutritional level		Breed x Nutritional Level			
	A	AH	100%	80%	A 100%	A 80%	AH 100%	AH 80%
Mean eggs/5g	17	11	14	14	24	12	5	15
No. of animals	37	41	33	45	17	20	16	25
Significant difference at level	n.s.		n.s.		n.s.			

^aPre-calving was on February 21.

TABLE 4. CORRELATION OF WORMING WITH POST-CALVING EGGS/5g

	Sample Date			
	Early Post-Calving ^a		Late Post-Calving ^b	
	Wormed	Not wormed	Wormed	Not wormed
Mean eggs/5g	7	68	2	7
No. of animals	14	14	36	38
Significant difference between wormed and not wormed at level		.002		.002

^aEarly post-calving was on April 16.

^bLate post-calving was on May 17.

TABLE 5. CORRELATION OF BREED WITH PERIPARTURIENT CHANGES IN EGGS/5g

	Sample Dates Compared			
	Calving minus pre-calving ^a		Calving minus post-calving ^b	
	A	AH	A	AH
Mean differences in eggs/5g	69	121	83	100
No. animals	37	41	18	20
Significant difference between breeds at level	n.s.		n.s.	

^aPre-calving was on February 21.

^bPost-calving was on May 17 taken from untreated cows.

TABLE 6. CORRELATION OF NUTRITION WITH PERIPARTURIENT CHANGES IN EGGS/5g

	Sample Dates Compared			
	Calving minus pre-calving		Calving minus post-calving	
	100% TDN	80% TDN	100% TDN	80% TDN
Mean differences in eggs/5g	65	120	74	110
No. animals	33	45	19	19
Significant difference between nutritional groups at level	.02		n.s.	

^aPre-calving was on February 21.

^bPost-calving was on May 17 taken from untreated cows.

TABLE 7. CORRELATION OF BREED X NUTRITION INTERACTION WITH PERIPARTURIENT CHANGES IN EGGS/5g								
	Sample Dates Compared							
	Calving minus pre-calving ^a				Calving minus post-calving ^b			
	A		AH		A		AH	
	100% TDN	80% TDN	100% TDN	80% TDN	100% TDN	80% TDN	100% TDN	80% TDN
Mean differences in eggs/5g	84	56	45	170	104	58	40	148
No. animals	17	20	16	25	10	8	9	11
Interaction significant at level			.003				.02	

^aPre-calving was on February 21.

^bPost-calving was on May 17 taken from untreated cows.

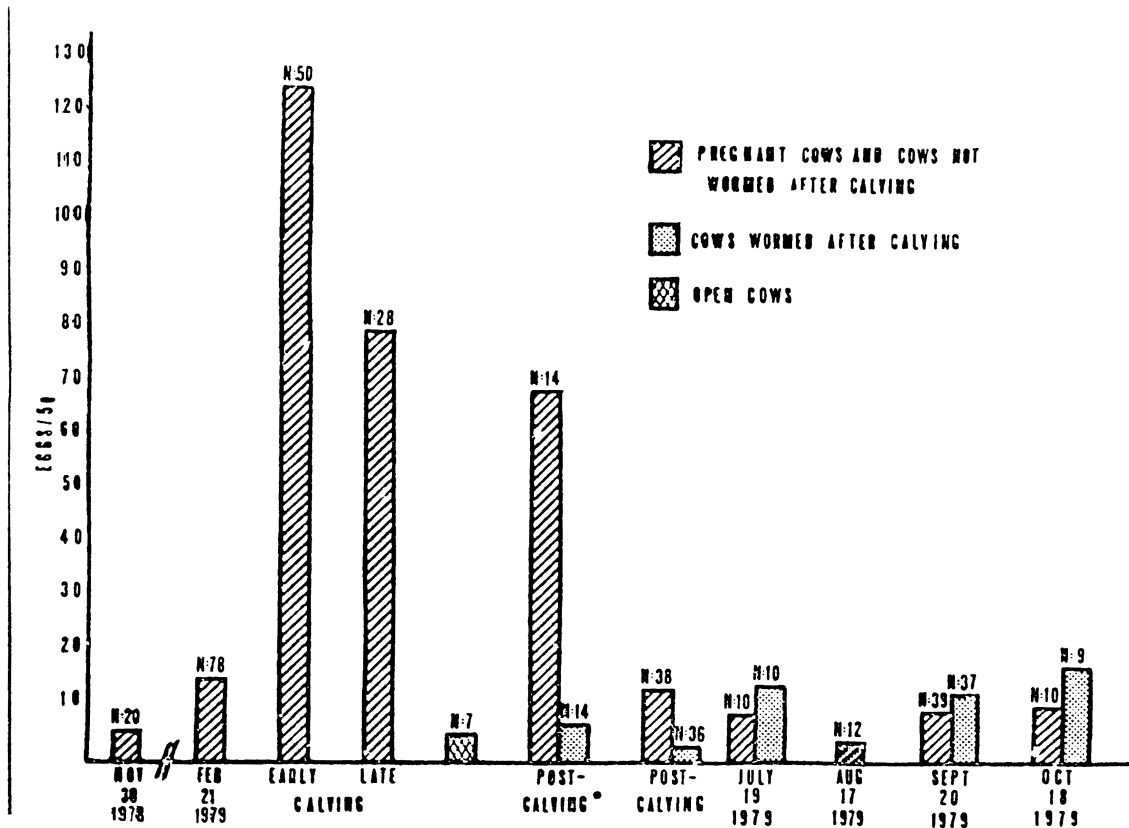
TABLE 8. EFFECT OF POSTPARTUM WORMING ON 12 HR MILK YIELD AND COMPOSITION AND COW AND CALF PERFORMANCE

Item	Cow worming treatment	
	Wormed ^a	Not wormed
No. of cows	37	34
Condition score at parturition ^b	2.1	2.0
Condition score at weaning ^b	1.9	2.0
Conception rate, %	94.6	92.1
<u>Milk yield and composition</u>		
12-hr milk yield, kg	4.9	4.4
Total solids, %	9.6	9.7
Butterfat, %	1.1	1.2
Solids-not-fat, %	8.4	8.5
Crude protein, %	3.4	3.5
<u>Calf performance</u>		
Adj. weaning weight, kg	236.9	231.6

^aWormed with thiabendazole (6.6g/100 kg body weight) at parturition.

^b1 = very thin, 5 = very fat.

Figure 1.



Seasonal variations in strongylid eggs/5g from spring calving cows. N=number of animals sampled. Early calving was from March 13 to April 13 and late calving was from April 14 to May 14. Twenty-eight early calving cows (between March 13 and March 31) were sampled post-calving on April 16(*) and all cows were sampled post-calving on May 17. Open cows were sampled between April 16 and May 14.

IMPLANTING DIFFERENT LEVELS OF ZERANOL IN SUCKLING CALVES

W. D. Lamm, J. P. Fontenot, W. H. McClure and H. Chester-Jones

Results of work in Virginia and other stations indicate that implanting suckling calves with 36 mg of zeranol increases rate of gain and weaning weight. Trials were conducted at the Shenandoah Valley Research Station and Blacksburg to study the effect of different levels of zeranol implants in spring-born calves.

Experimental Procedure

A total of 95 steer and heifer calves were used. Calves were blocked at birth within location, sex and time of birth. The calves were allotted to the following implant levels: 0, 12, 24 or 36 mg zeranol (trade name: Ralgro). Thus, approximately equal numbers of steers and heifers received each treatment and average age was similar among treatments. The calves were implanted at birth. At birth, calves were weighed, identified, navels were dipped in iodine, and they were injected with vitamins A, D and E. They were also vaccinated with IBR-PI₃ intranasally. The calves were born in March, April and early May. At approximately 100 days of age, all previously implanted calves were reimplanted with 36 mg of zeranol. Male calves were castrated at 2-3 months of age.

During the grazing season, cows were on native bluegrass-clover and fescue pastures. Calves were not creep-fed and were weaned in late October.

Results

Data obtained at both locations are summarized in table 1. Calves implanted with 36 mg showed a daily gain response of .06 lb. at weaning compared to unimplanted calves. There was a consistent trend for calves implanted with 12 mg to have a slower rate of gain compared to unimplanted calves or calves implanted with 24 or 36 mg. There appeared to be more tailhead elevation and mammary development in implanted calves compared to control calves.

The results of this study are in contrast to previous work which has demonstrated a significant growth response when calves are implanted at birth. The male calves in the present study were not castrated at birth and other work has indicated no response when suckling bull calves are implanted with zeranol. Therefore, these data should be considered preliminary. Further work involving similar treatments with male calves castrated at birth is presently being conducted.

TABLE 1. IMPLANTING DIFFERENT LEVELS OF ZERANOL IN SUCKLING CALVES

Item	Level of implant, mg			
	0	12	24	36
No. of calves	23	22	24	26
Birth wt., lb.	70	72	71	69
100-day weight, lb.	264	254	261	255
Gain, lb.	194	182	190	186
Daily gain, lb.	1.72	1.61	1.69	1.75
Weaning weight, lb.	420	405	417	415
Gain, 100-day to weaning, lb.	156	151	156	160
Daily gain, lb.	1.71	1.66	1.71	1.75
Gain, birth to weaning, lb.	350	333	346	346
Daily gain, lb.	1.69	1.63	1.69	1.75
Tailhead score ^a				
100-day	.67	.98	1.00	1.01
Weaning	.39	.76	.71	.88
Mammary development ^b				
100-day	.32	.50	.60	.67
Weaning	.11	.30	.35	.51

^aCode: 0 - no elevation; 1 - elevation; 2 - marked elevation.

^bCode: 0 - no development; 1 - development; 2 - marked development.

PERFORMANCE AND LIVER COPPER LEVELS OF BEEF COWS FED BROILER LITTER¹

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 was 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 to 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, 1978 and 1979 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/head/day of long hay during 1977 and 1979 and 3 lb/head/day during 1978.

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

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

of each group will be terminated in the Spring of 1980 following the winter feeding period and the remaining animals will be terminated after the grazing season.

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 five 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.

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

Sampling date	Wintering ration		
	Hay	Litter +	Litter + corn
		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
4-12-79	127.3	547.6	784.3
12-12-79	43.2	284.7	271.6

^a Dry basis.

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(10)	14(10)
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
12-28-78 to 4-12-79 ^d	20.5	17.6	17.8
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 ^e	-1.24	-1.36	-1.12
12-18-75 to 4-16-76	-.08	-.11	.25
12-28-76 to 4-19-77 ^f	-.18	-.12	-.11
12-8-77 to 4-6-78 ^g	.61	.28	-.09
12-28-78 to 4-12-79 ^h	-.15	-.75	-.72
Calving performances ⁱ			
No. calves born	53	49	53
Birth wt. of calves, lb	72	72	72
Weaning wt. of calves, lb	359	352	384

^aNumbers in parentheses indicate number of cows remaining on experiment as of 4-24-80.

^bIncludes 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.

^cIncludes 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.

^dIncludes 2 lb of hay per head per day from 1-25-79 to 4-12-79 for the litter + corn and litter + corn + copper treatments.

^eIncludes loss of weight due to calving.

^fThree cows in the group fed hay and two cows in each of the other two groups had calved prior to 4-19-77.

^gTwo cows in the litter + corn + copper group calved prior to 4-6-78.

^hOne cow in the group fed hay and two cows fed litter + corn calved prior to 4-12-79.

ⁱData from 1975, 1976, 1977, 1978 and 1979 calf crops.

AMINO ACID UPTAKE AND RELEASE ACROSS THE HINDLIMBS OF
FED AND FASTED STEERS¹

M. E. McCormick, K. E. Webb, Jr. and J. P. Fontenot

Numerous studies have been conducted using plasma free amino acid concentrations to evaluate the protein and amino acid metabolism of many species. Differences in plasma free amino acids have been observed, but these may reflect only a portion of the changes occurring. Concentrations of free amino acids in erythrocytes have been shown to be greater than those of plasma free amino acids in the dog, chicken and man. More importantly, changes in erythrocyte amino acid concentrations were independent of plasma amino acid fluctuations for the dog, thereby suggesting a distinct role for erythrocytes. In addition, chickens deprived of dietary protein responded by depleting erythrocyte free amino acids and the pattern of depletion did not follow that of plasma free amino acids. The sheep erythrocyte has also been shown to function as a carrier of free amino nitrogen to and from peripheral tissue.

The nutritional significance of peptides in relation to protein metabolism remains unclear. Peptide uptake by the intestine has been demonstrated by several species and there is some suggestion that their presence may in some way counteract some of the ill-effects caused by an imbalance of amino acids.

Peripheral uptake and release of amino acids from plasma has been reported in sheep. The amino acid flux across the forearm of man has also been investigated by monitoring plasma and erythrocyte free amino acids. In view of the absence of data concerning basic amino acid metabolism in cattle, this study was designed to evaluate the roles of plasma, erythrocytes and plasma peptides in transporting amino acids to and from a muscle mass. Arteriovenous differences across the hindlimbs of growing Holstein steers were used to measure these parameters.

Experimental Procedure

Animals and Feeding. Five Holstein steer calves weighing an average of 150 kg were used in this study. The composition of the ration fed is listed in table 1. The animals were fed on an equal metabolic weight basis in order to produce daily gains of .9 kilograms. The animals were housed in confinement under constant light on slotted floors and fed 24 meals (hourly) per day with automatic feeders. This was done to maintain a near "steady state" condition of ruminal fermentation, rate of passage, protein hydrolysis, amino acid absorption and related phenomena. After animals were sampled during the "steady state" condition, they were fasted for 72 hr and resampled.

Surgical Preparation of Animals. To obtain arterial and venous samples across the hindlimbs, cannulae were surgically implanted in the abdominal aorta and caudal vena cava. Two cannulae were implanted in each the aorta and vena cava. The two sets of cannulae were passed into the aorta and

¹Supported in part by a grant from the John Lee Pratt Animal Nutrition Program.

vena cava through the femoral artery and vein and ilio-lumbar artery and vein. Care was taken to assure the placement of venous cannulae posterior to the entry of the renal vein. Two sets of cannulae were implanted to increase the patency of the preparation by avoiding loss of the animal due to cannula malfunction. All cannulae were passed under the skin from the point of entry into the artery or vein to the lumbar region of the calf. The arterial cannulae were composed of teflon within the artery and silastic under the skin. The venous cannulae were composed entirely of silastic. Cannulae were flushed twice daily with 5 ml heparinized .9% saline (40 units/ml). Rectal temperatures were monitored daily.

Sampling. At each of the four successive 15-min samplings, both heparinized and nonheparinized blood were taken from both the artery and vein. These four samples represented the 1-hr period between feedings.

Blood chemistries. The four samples obtained during a sampling period were individually assayed for serum total protein, albumin and blood glutathione. The four samples were composited for the analysis of amino acids. Plasma free amino acids were determined on the filtrate obtained following the precipitation of proteins from 4 ml of plasma with 1 ml of 20% sulfosalicylic acid. The erythrocyte free amino acids were determined by precipitating the proteins from 5 ml of whole blood with 5 ml of 10% sulfosalicylic acid. The resulting filtrate was freeze-dried and reconstituted with .01 N HCl prior to analysis. Whole blood values were corrected for plasma contributions based upon microhematocrits to obtain a measure of erythrocyte free amino acid concentrations. A fraction referred to as peptide amino acids was determined by subjecting the sulfosalicylic filtrate of plasma to hydrolysis with 4 N methanesulfonic acid to release the amino acids from peptides and small proteins. The values observed following hydrolysis were corrected for the contributions of the free amino acids present prior to hydrolysis. All amino acid values are reported on a whole blood basis.

Statistical analysis. Differences between arterial and venous values and between fed and fasted values within a blood pool were tested for significance using the paired t test.

Results and Discussion

The animals, in all cases responded well to the surgical implantation of cannulae. There was no interruption in feed intake and within 3 days post-surgery rectal temperatures were normal. Presented in table 2 are the arteriovenous differences in plasma free amino acids measured across the hindlimbs of fed and fasted calves. Generally the free amino acids in plasma in the fed animal were removed by the hindlimb. The arteriovenous difference was observed to be significant for more than half the amino acids. Glutamine ($P < .01$), cysteine and ornithine appeared in greater concentration in venous than in arterial plasma. The extent of removal by the hindlimbs varied widely among amino acids ranging from .03 to 1.99 $\mu\text{M}/\text{dl}$ of blood for serine and alanine, respectively.

The amino acids removed in greatest quantity were asparagine, glutamate, alanine, leucine and lysine. Other amino acids including aspartic, threonine, citrulline, valine, methionine and isoleucine were removed in modest but significant quantities. Differences observed in the other amino acids were small and nonsignificant.

In the fasted state only glutamate, citrulline and tyrosine were found in greater concentration in arterial than venous plasma. All other amino acids appeared in venous plasma in higher concentration than arterial plasma. In most cases the differences observed were significant. This release of amino acids may be indicative of muscle catabolism. Alanine was released in by far the greatest quantities. Glutamine was also released in large quantities. Both of these amino acids are important contributors in the gluconeogenic process. In ruminants glycine transports nitrogen from muscle and kidneys to the liver where large amounts are used for the hepatic detoxification of benzoic acid by way of the formation of hippuric acid. This may account for the substantial release of glycine observed in the fasted state.

The A-V differences in the fed state as compared to the fasted state were significant for approximately two-thirds of the amino acids. As a pool, plasma free amino acids contribute to the muscle metabolism in the normal state and are involved extensively in the transport of amino acids from muscle in the fasted state.

Arteriovenous differences in erythrocyte free amino acids measured across the hindlimb of fed and fasted calves are presented in table 3. In the fed state the only arteriovenous differences which varied significantly from zero were negative values for aspartic, glutamate and glycine and positive values for alanine and glycine. All other amino acids showed a non-significant response.

During the fasted state the erythrocyte appeared to be more involved in the transport of amino acids as indicated by significant arteriovenous differences of over half the amino acids observed and the significant difference in some amino acids between the fed and fasted states. All of the amino acids which showed a significant response were higher in the erythrocytes of venous than of arterial blood with the exception of ornithine indicating a substantial transport of these amino acids from the muscle mass of the hindlimb during the fasting state. Once again, alanine and glycine exhibited large negative arteriovenous differences consistent with the observations of the plasma in the fasted state. Conversely, aspartic acid and histidine were removed in noteable quantities by the erythrocyte while the plasma arteriovenous difference was essentially zero. The substantial removal of ornithine by the muscle mass of the hindlimb from the erythrocyte is of interest. Ornithine is a known precursor of glutamate and arginine and is involved in the urea cycle. However, the urea cycle does not occur in the muscle.

Arteriovenous differences of peptide amino acids measured across the hindlimbs of fed and fasted calves are listed in table 4. Variability among animals in arteriovenous values was generally greater in peptide amino acid values as compared to the two previous pools discussed. Even though in many instances the absolute values observed were substantially

higher than either plasma free or erythrocyte free pools, the variation encountered preclude statistically significant responses. Never-the-less, significant responses were recorded for several amino acids. The general trend was for a substantial uptake of peptide amino acids with the exception of the basic amino acids, lysine, histidine and arginine. In contrast to the other pools where there was a significant removal of lysine from the arterial blood, lysine appeared in significantly higher quantities in the venous peptide fraction in the fed state. The peptide fraction of plasma in fed calves appears to be an important source of aspartic acid, serine, glutamate, alanine and phenylalanine as indicated by significant arteriovenous differences.

When calves were subjected to a 72-hr fast, greater quantities of amino acids appeared in the peptide fraction of venous as compared to arterial plasma. The only amino acid that was removed ($P < .06$) from the peptide fraction by the muscle was arginine. More alanine ($P < .10$) was released by the muscle via the peptide fraction than any other amino acid. Also, the net change ($P < .05$) between the fed and fasted states was the greatest of all amino acids. While the magnitude of change was far greater, the direction was the same as observed in the plasma free and erythrocyte free pools. Aspartate and glycine were released in the next highest quantity and these two amino acids were also released in substantial quantities via the erythrocyte. Generally, amino acids were removed from the peptide fraction in fed animals and added to the peptide fraction as plasma traversed the hindlimbs in fasted animals.

Arteriovenous differences in serum total protein, serum albumin, blood glutathione and hematocrit were monitored in both the fed and fasted state and results are presented in table 5. The values observed for all parameters were quite constant in both arterial and venous samples. None of the small differences detected were significant.

Monitoring the plasma free amino acid pool has been the predominant choice of investigators in protein research. Frequently, results from similar experiments have not been comparable and often specific values and general patterns have been difficult to interpret. The results of the present study indicate that a high probability exists for numerous fractions to be involved in the transport of amino acids to and from tissues. Furthermore, the relative importance of a particular fraction as a transport medium may vary with amino acid and with nutritional status. Continued investigations are needed in this area to elucidate more fully the roles of the various transport media in the amino acid metabolism of tissues.

TABLE 1. INGREDIENT COMPOSITION OF EXPERIMENTAL DIET.

Item	Internat'l Ref. No.	Percent of diet ^a
Ingredient composition		
Corn, ground	4-02-931	50.00
Orchardgrass hay	1-03-438	30.00
Soybean meal	5-04-604	13.30
Molasses	4-04-696	5.00
Defluorinated rock phosphate	6-01-780	0.42
Limestone	6-02-632	0.78
Trace mineral salt		0.50
Vitamins A, D ^b		
Selenium, Vitamin E ^c		
Chemical composition		
Crude protein ^d		12.60

^aAs is basis.

^bAdministered intramuscularly: Vitamin A, 1.5 million IU;
Vitamin D 225,000 IU.

^cAdministered intramuscularly: Selenium, 10 mg; Vitamin
E 680 IU.

^dDry matter basis.

TABLE 2. ARTERIOVENOUS DIFFERENCES IN PLASMA FREE AMINO ACIDS MEASURED ACROSS THE HINDLIMBS OF FED AND FASTED CALVES

Amino Acids	Fed			Fasted		
	A-V ^a	SE ^b	P ^c	A-V ^a	SE ^b	P ^c
	um/dl blood ^d			um/dl blood ^d		
Aspartic Acid ^e	.16	.05	.05	-.01	.05	NS
Threonine ^f	.34	.18	.10	-.80	.39	.06
Serine ^g	.03	.46	NS	-.81	.36	.05
Asparagine ^f	1.18	.51	.05	-.14	.52	NS
Glutamate ^f	1.71	.60	.05	.72	.45	.10
Glutamine	-1.20	.27	.01	-1.74	.92	.08
Proline	.09	.15	NS	-.50	.13	.02
Glycine ^g	.40	.41	NS	-1.27	.55	.05
Alanine ^f	1.99	.36	.005	-4.21	2.50	.09
Citrulline	.40	.06	.004	.32	.16	.07
Valine ^e	.68	.27	.05	-.22	.13	.09
Cysteine	-.55	.49	NS	-.31	.11	.04
Methionine ^g	.14	.06	.05	-.30	.18	.10
Isoleucine ^g	.50	.22	.05	-.57	.23	.05
Leucine ^f	1.42	.59	.04	-.69	.47	.12
Tyrosine	.21	.21	NS	.01	.46	NS
Phenylalanine	.12	.08	NS	-.06	.49	NS
Ornithine ^g	-.09	.10	NS	-.60	.41	NS
Lysine ^e	1.14	.31	.002	-.19	.11	.10
Histidine	.36	.59	NS	-.09	.27	NS
Arginine ^e	.11	.28	NS	-.82	.35	.05

^a Values expressed are the difference between arterial and venous samples. Negative values indicate a greater concentration of amino acid in venous blood.

^b Standard error of the mean.

^c Probability that arteriovenous difference does not differ from zero (paired t test).

^d Arteriovenous values for all fractions expressed on a whole blood basis.

^e Fed and fasted means differ (P < .01).

^f Fed and fasted means differ (P < .05).

^g Fed and fasted means differ (P < .10).

TABLE 3. ARTERIOVENOUS DIFFERENCES IN ERYTHROCYTE FREE AMINO ACIDS MEASURED ACROSS THE HINDLIMBS OF FED AND FASTED CALVES

Amino Acid	Fed			Fasted		
	A-V ^a	SE ^b	P ^c	A-V ^a	SE ^b	P ^c
	um/dl blood ^d			um/dl blood ^d		
Aspartic Acid ^e	-1.30	.34	.03	-2.70	.34	.08
Threonine ^f	.24	.17	NS	-.12	.30	NS
Serine	-.05	.38	NS	-.08	.45	NS
Glutamate	-1.34	.45	.07	.13	.66	NS
Proline	-.01	.13	NS	-.46	.64	NS
Glycine	-.59	.33	.10	-2.14	1.61	.14
Alanine ^e	.86	.48	.08	-2.23	1.04	.06
Valine ^e	.31	.33	NS	-.85	.27	.03
Methionine	.02	.08	NS	-.16	.13	NS
Isoleucine ^f	.11	.22	NS	-.40	.12	.03
Leucine ^f	.27	.43	NS	-.41	.29	.12
Tyrosine	-.02	.09	NS	-.22	.20	NS
Phenylalanine	.09	.13	NS	-.19	.14	.12
Ornithine	.34	.82	NS	1.16	.75	.11
Lysine	1.00	.49	.06	-.24	.79	NS
Histidine	-.84	1.40	NS	-1.93	1.45	.15

^aValues expressed are the difference between arterial and venous samples. Negative values indicate a greater concentration of amino acid in venous blood.

^bStandard error of the mean.

^cProbability that arteriovenous difference does not differ from zero (paired t test).

^dArteriovenous values for all fractions expressed on a whole blood basis.

^eFed and fasted means differ (P < .05).

^fFed and fasted means differ (P < .10).

TABLE 4. ARTERIOVENOUS DIFFERENCES OF PEPTIDE AMINO ACIDS MEASURED ACROSS THE HINDLIMBS OF FED AND FASTED CALVES

Amino Acid	Fed			Fasted		
	A-V ^a	SE ^b	P ^c	A-V ^a	SE ^b	P ^c
	um/dl blood			um/dl blood		
Aspartic acid ^f	1.24	.91	.13	-4.12	2.90	.12
Threonine	.33	.75	NS	-1.07	1.30	NS
Serine ^f	1.76	.90	.08	-.41	1.17	NS
Glutamate ^f	7.09	5.28	.14	-1.76	1.30	.09
Proline	4.20	4.88	NS	-.63	6.80	NS
Glycine	.25	1.50	NS	-4.56	2.30	.07
Alanine ^e	3.66	1.35	.03	-6.31	3.86	.10
Valine	4.19	4.31	NS	-2.59	1.75	.11
Ileucine	2.72	2.80	NS	-.62	1.04	NS
Leucine	9.77	11.97	NS	-1.35	1.87	NS
Tyrosine	.01	1.30	NS	-1.12	1.19	NS
Phenylalanine	2.12	1.72	.15	-.82	.30	.02
Lysine	-1.70	.51	.03	-1.31	.96	.13
Histidine ^f	-.10	1.60	NS	-1.48	1.36	NS
Arginine	-.01	1.49	NS	2.32	1.06	.06

^aValues expressed are the difference between arterial and venous samples. Negative values indicate a greater concentration of amino acid in venous blood.

^bStandard error of the mean.

^cProbability that arteriovenous difference does not differ from zero (paired t test).

^dArteriovenous values for all fractions expressed on a whole blood basis.

^eFed and fasted means differ (P < .05).

^fFed and fasted means differ (P < .10).

TABLE 5. ARTERIOVENOUS DIFFERENCE OF BLOOD PARAMETERS
MEASURED ACROSS THE HINDLIMBS OF FED AND FASTED
CALVES

Item	Fed			Fasted		
	A-V	SE ^a	P ^b	A-V	SE ^a	P ^b
Serum total protein, g/dl	-.01	.03	NS	-.02	.03	NS
Serum albumin, g/dl	-.04	.02	NS	.04	.02	NS
Blood glutathione, mg/dl RBC	1.40	2.18	NS	-.69	1.98	NS
Hematocrit, %	.10	.20	NS	-.10	.10	NS

^aStandard error of the mean.

^bProbability that arteriovenous difference differs from zero (paired t test).

IMPREGNATION OF WHOLE CORN WITH UREA, CALCIUM, POTASSIUM
AND SULFUR FOR FEEDING LAMBS

L. L. Koeln,¹ 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.

Since preformed proteins are expensive and necessary for the feeding of nonruminants, researchers have turned to the use of nonprotein nitrogen (NPN) sources for feeding ruminants. Urea is the most widely used source of NPN in ruminant diets, yet it has not been successfully fed in 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 and improve urea utilization by slowing ammonia release rate and providing an available source of carbohydrate. Most of these products require heat treatment and extensive processing which adds substantially to the cost of the product.

It appears that several factors must be considered when feeding urea if animal performance equal to or approaching that of animals fed preformed protein is to be achieved. Considerations include: adequate supplementation of the diet with non-nitrogen nutrients, adaptation of animals to urea feeding if maximum utilization is to be realized, adequate amounts of a readily fermentable source of carbohydrate must be supplied and ammonia release rate must be controlled in the rumen to prevent loss of large amounts of nitrogen via absorption across the rumen wall.

With these factors in mind, the present study was conducted to develop a means of supplementing whole corn grain with urea, calcium, potassium and sulfur to meet the nutritional requirements of growing-finishing lambs and to evaluate the efficiency of utilization of this supplemented corn.

Experimental Procedure

Preliminary Experiment. Several compounds were considered as calcium, potassium or sulfur sources on the basis of their solubility, compatibility 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 requirements of growing-finishing lambs. Compounds with the greatest solubility in water (table 1) and which contained relatively high amounts of the element in question and were readily available were selected and mixed in all possible combinations. These compounds were mixed in a ratio,

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which along with corn grain, would provide a final product containing 12% crude protein, .37% calcium, .50% potassium and a 10:1 nitrogen from urea to sulfur ratio, dry basis. The combination that could be dissolved in the least water was selected.

Corn Impregnation. Impregnated corn was prepared using whole shelled corn containing 14% moisture. A solution was prepared containing 6.4% urea, 8.72% calcium chloride (CaCl_2), 2.71% potassium acetate ($\text{KC}_2\text{H}_3\text{O}_2$), and 1.12% sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) on a weight per volume basis. This solution (10.78 liters) was applied as a spray while the corn (114 kg) was mixing in a horizontal mixer. The corn was allowed to mix for 10 min after application. The impregnated corn was then transferred to a laboratory grain drying bin constructed from a large metal cylinder (90 cm x 58 cm) with a wire mesh false bottom. The corn was dried by passing ambient air through it via the false bottom for 48 hr at a rate to provide a face velocity of approximately 570 liters per minute.

After drying, 100 g samples of the impregnated corn and initial corn were washed with 250 ml of deionized water for 5 seconds. Washed and unwashed samples were analyzed for Kjeldahl nitrogen to determine if nitrogen from urea was absorbed into the corn kernels or was merely adhering to the surface.

Metabolism Study. Twenty-eight growing wether lambs with an average weight of 33.9 kg were used in a metabolism study to compare the following rations: 1) whole shelled corn alone, 2) whole shelled corn impregnated with urea, calcium as calcium chloride, potassium as potassium acetate and sulfur as sodium thiosulfate, 3) whole shelled corn fed with a dry supplement containing urea, calcium, potassium and sulfur and 4) whole shelled corn fed with a dry supplement containing soybean meal, calcium and potassium. All lambs were fed 700 g daily of their respective rations plus 70 g of long orchardgrass hay fed in equal parts at 12-hr intervals. Rations containing either urea or soybean meal fed as a dry supplement were prepared by combining the nitrogen, calcium, potassium and sulfur sources with ground corn so that each animal received 100 g of supplement and 600 g of whole corn daily. Corn fed alone was supplemented with 10 g per day of iodized salt. The chemical composition of the diets is described in table 2. Water was available ad libitum except during the 2-hr feeding periods.

Lambs were adapted to urea by feeding a ration (table 3) which provided approximately one-third of the dietary nitrogen as urea. Lambs were fed this diet for 40 days. The lambs were then blocked by weight and randomly assigned to the four diets. The lambs were placed in false-bottom metabolism stalls allowing separate collection of urine and feces. Lambs were adjusted to the experimental diets over a 5-day period by replacing 10% of the adaptation diet with 10% of the experimental diet per feeding. Following a 10-day preliminary period all urine and feces were collected during a 10-day collection period. Urine was collected in acid and diluted to a constant weight daily, and a 2% aliquot composited and refrigerated. Feces were collected daily and dried 24 hr in a 60 C forced air oven. Daily collections for each animal were composited in cans and allowed to air equilibrate. Composites were weighed and sampled for future analysis. All feed and fecal samples were ground through a 1 mm screen and mixed prior to analysis.

On the last day of the trial jugular blood was obtained at 0 and 6 hr postfeeding. Heparinized blood to be used for plasma free amino acid analysis was chilled in an ice bath. Protein free filtrates were prepared by adding 1 ml of 20% sulfosalicylic acid to 4 ml of plasma and filtering through a funnel with a glass wool plug in the stem. The filtrates were placed under an atmosphere of N_2 and frozen for later analysis of amino acids. Protein free filtrates were prepared from whole blood and frozen for later analysis of blood urea nitrogen (BUN). Serum was prepared and frozen for future analysis of serum total proteins and serum albumin.

On the following day, rumen samples were taken via stomach tube at 0, 1, 2, 3, 4, 5 and 6 hr postfeeding. The pH of the fluid was determined electrometrically. Rumen fluid was analyzed for ammonia and volatile fatty acids.

Results and Discussion

As a result of solubility trials, calcium chloride, potassium acetate and sodium thiosulfate were combined with urea in water solution. The low solubility of calcium when combined with other salts determined the minimum water volume or conversely the maximum mineral concentration. When the four compounds were combined into solution, impregnating 100 g of corn dry matter with 11 ml of this solution resulted in a product which meets the requirements of growing-finishing lambs.

The initial nitrogen content of corn prior to impregnation was 1.55 percent (dry basis). The impregnation procedure resulted in a product containing 1.85% nitrogen. This represents an addition of .30 percentage units of nitrogen. After the washing process, 1.67% nitrogen remained with the corn. This indicates that 40% of the added nitrogen from urea was absorbed into the corn kernels while 60% was merely adhering to the surface. Washing did not influence the nitrogen remaining in the initial corn. A greater amount of urea may be incorporated into the corn if the material had been mixed longer before drying.

Presented in table 4 are the nitrogen intake, excretion, absorption and retention data. Nitrogen intake for lambs fed the supplemented diets was similar while that of those fed the unsupplemented corn was lower ($P < .01$). Urinary nitrogen excretion was lowest for lambs receiving the unsupplemented corn diet but there were no differences among lambs fed the supplemented diets ($P < .01$). Fecal nitrogen tended to be less with the impregnated corn treatment than any of the other treatments, however, fecal nitrogen did not differ significantly among the three nitrogen supplemented treatments. Total nitrogen excretion was lowest for lambs fed unsupplemented corn but differences were not significant.

Nitrogen absorption, expressed as either grams per day or as a percent of intake was similar for the treatment groups receiving nitrogen supplementation. Absorption of nitrogen was least ($P < .01$) for lambs receiving the unsupplemented corn diet. Nitrogen retention, when expressed as g per day, was lowest ($P < .05$) for lambs fed the unsupplemented corn diet but no significant differences existed among the supplemental treatments. There was no significant treatment effect for nitrogen retention expressed as percent of intake or percent of absorbed nitrogen. Regardless of how it was expressed, nitrogen retention tended to be greatest for the lambs fed the impregnated corn.

Apparent digestibilities of the proximate components are presented in table 5. The unsupplemented corn treatment resulted in the lowest ($P < .05$) apparent digestibility of all the proximate components except ether extract, which was similar for all treatments. This is probably due to the lower nitrogen content of the unsupplemented corn diet which may have been inadequate to support optimum microbial activity. The impregnated corn diet tended to result in the highest apparent digestibilities for all proximate components. This may be due to a slower release of ammonia in the rumen from the impregnated corn or a lower absorption of ammonia across the rumen wall allowing for greater microbial protein synthesis and optimum microbial activity in the rumen. In all cases impregnated corn was superior or similar to soybean meal supplemented corn ($P < .05$).

Changes in ruminal pH which occurred during a 6-hr period postfeeding are illustrated in figure 1. There was a similar pattern of change in ruminal pH for all treatments. This change with time can best be described as a cubic effect ($P < .01$). Although there were no significant treatment differences observed, animals consuming the impregnated corn tended to have a lower ruminal pH throughout the 6-hr period. The lower ruminal pH for animals fed impregnated corn may have resulted in trapping of ammonia in the rumen for microbial protein synthesis and could explain the tendency for proximate component digestibilities and nitrogen retention to be higher.

Ruminal ammonia levels were not significantly different among treatments, however, a treatment x time interaction was observed ($P < .01$). Shown in figure 2 are the changes that occurred in ruminal ammonia nitrogen postfeeding. The best overall time effect is described by a cubic response ($P < .01$). Ruminal ammonia nitrogen peaked at 1 hr postfeeding in lambs fed both urea supplemented corns and declined thereafter. Soybean meal supplementation resulted in a more gradual increase throughout the entire period. There was little change observed for the unsupplemented corn treatment. Impregnation of whole corn grain was expected to result in lower ruminal ammonia levels than those encountered with other methods of urea supplementation. Although treatment differences were not significant, the impregnated corn diet tended to result in higher ruminal ammonia levels than did the dry urea supplemented corn. On the day rumen samples were taken from these animals, three of the six animals receiving whole corn supplemented with a dry urea-mineral mix did not consume all of the urea presented to them. This probably accounts for some of the differences observed in ruminal ammonia between the two urea supplemented groups but may not be indicative of what occurred during the earlier portions of the trial.

There were no significant differences in volatile fatty acid concentrations among treatments, however, differences did exist in molar proportions. The molar proportions of the volatile fatty acids are presented in table 6. Treatment differences existed for acetate and butyrate ($P < .05$). The urea supplemented lambs tended to have lower acetate and higher butyrate levels. This agrees with work by Orskov and Oltjen (1967) with cattle fed purified diets. There were no significant differences between treatments for propionate, isobutyrate, isovalerate or valerate. A treatment x time interaction occurred for acetate ($P < .10$) and propionate ($P <$

.01). The molar proportions of acetate for a 6-hr period after feeding are plotted in figure 3. The proportion of acetate in the ruminal fluid from lambs fed both urea supplemented corns tended to peak at a lower level and subsequently decline more rapidly than in lambs fed the soybean meal supplemented or unsupplemented corns. Molar proportions of propionate are presented in figure 4. The proportion of propionate in the ruminal fluid from lambs fed soybean meal supplemented corn tended to peak at a lower level and subsequently decline more rapidly than lambs fed the other diets. The proportion of propionate tended to remain highest in lambs fed impregnated corn.

Serum total protein, albumin and blood urea nitrogen concentrations are presented in table 7. There were no significant time differences or treatment x time interactions for serum total protein or albumin. Mean serum total protein levels were not significantly different among treatments.

Mean serum albumin levels were higher ($P < .10$) in lambs fed both urea supplemented diets. Similar values were observed for the unsupplemented corn and the soybean meal treatments. A similar pattern was noted for blood urea nitrogen. Blood urea nitrogen concentrations were not affected by time after feeding but a treatment x time interaction was apparent ($P < .05$). The interaction is probably explained by the increase in BUN from 0 to 6 hr in lambs fed both urea supplemented corns compared to a decline in BUN in the lambs fed the other diets. The tendency for lambs fed unsupplemented corn to have lower blood urea nitrogen values is probably due to the lower nitrogen intake by animals receiving this treatment.

Concentrations of most plasma free amino acids were not significantly different among treatments, however, differences ($P < .10$) were observed for asparagine, glutamate, tyrosine, ornithine and lysine (table 8). Feeding corn supplemented with urea tended to yield higher levels of these amino acids in lambs than the other two treatments.

Glutamate and ornithine concentrations were higher ($P < .10$) in plasma of lambs fed both urea treatments. These amino acids are involved in the urea cycle and may be elevated as a result of increased ammonia absorption. This may be supported by the higher ruminal ammonia and blood urea nitrogen levels, however, other amino acids of the urea cycle were not significantly affected by treatment.

There were no significant differences in essential, nonessential or total amino acid concentrations among treatment groups. Molar ratios of amino acids were not affected by treatment with the exception of asparagine which was highest ($P < .10$) in lambs fed the dry urea supplemented corn treatment but not different for the impregnated corn and soybean meal supplemented corn treatments.

The results of the present study indicate that impregnating whole corn with urea, calcium, potassium and sulfur appears to be a feasible approach to supplementing corn for lamb feeding. All parameters measured tended to indicate that the nutrients in impregnated corn were utilized at least as efficiently as those provided by either the soybean meal or dry urea supple-

ments. In addition, the problem of separation of the dry supplement from whole corn grain would be alleviated by the impregnation process. However, before this process is recommended for use in lamb feeding, additional research is needed to assure animal acceptability of the product and to investigate the impact on animal performance.

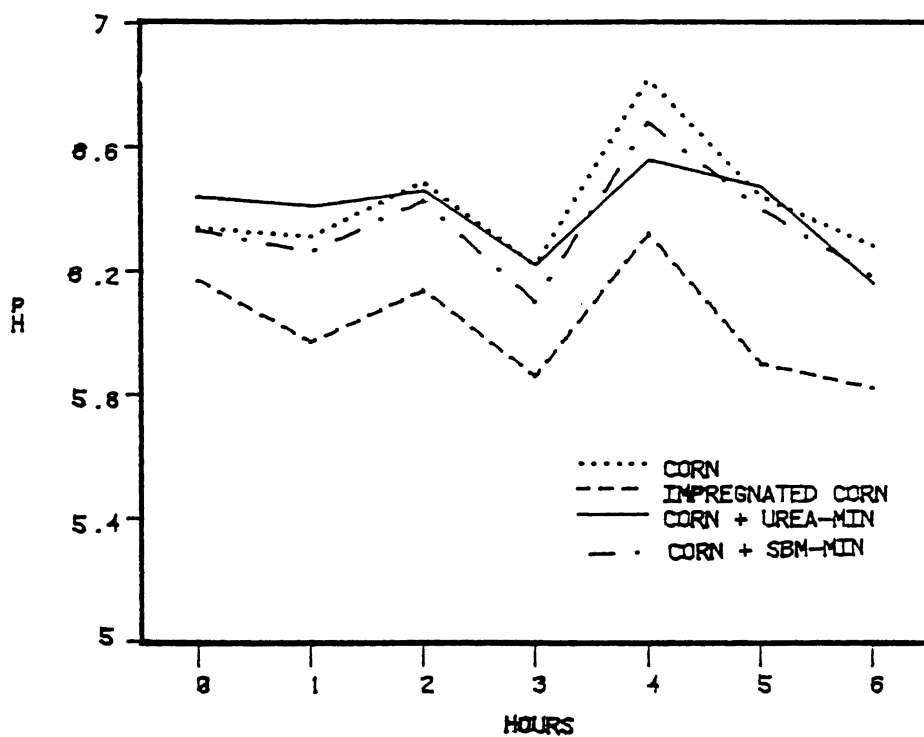


Figure 1. Ruminal pH changes of lambs during a 6-hr period postfeeding.

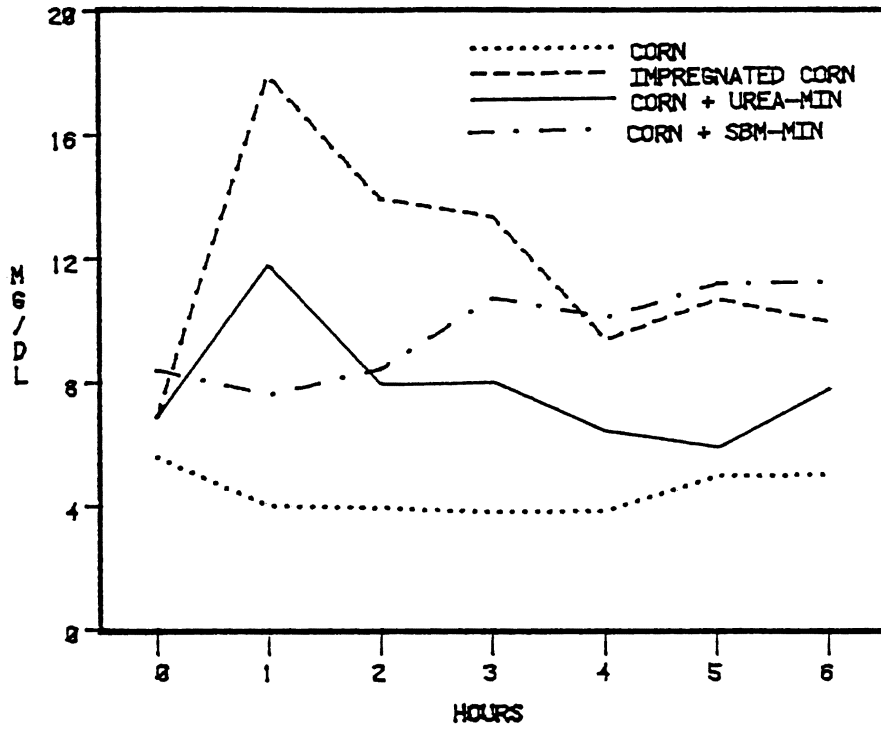


Figure 2. Ruminal ammonia nitrogen levels in lambs during a 6-hr period postfeeding.

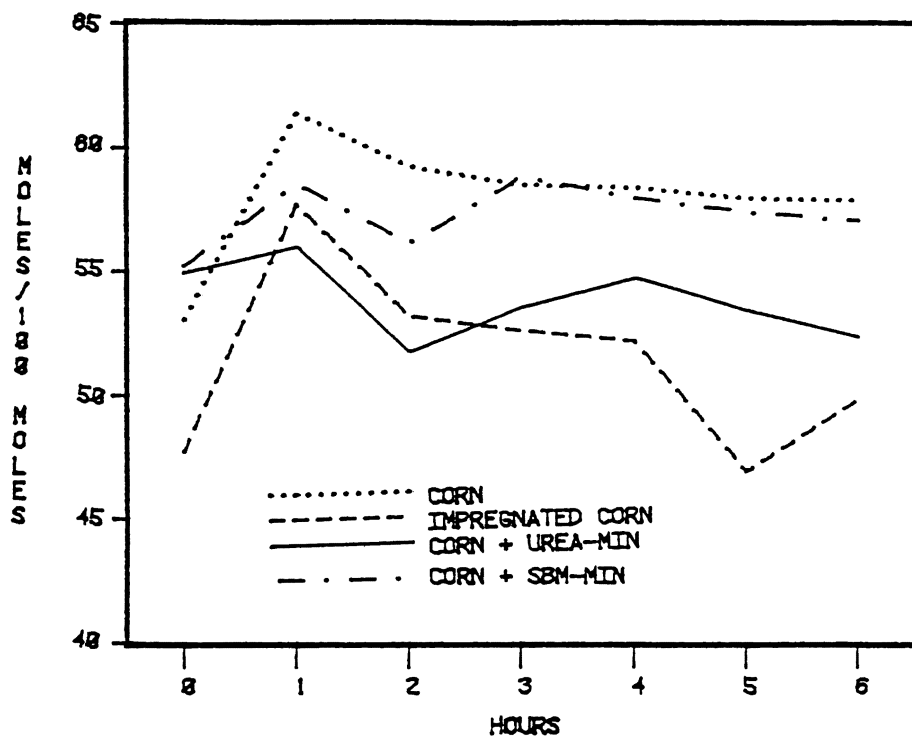


Figure 3. Molar proportions of acetate in lambs during a 6-hr period postfeeding.

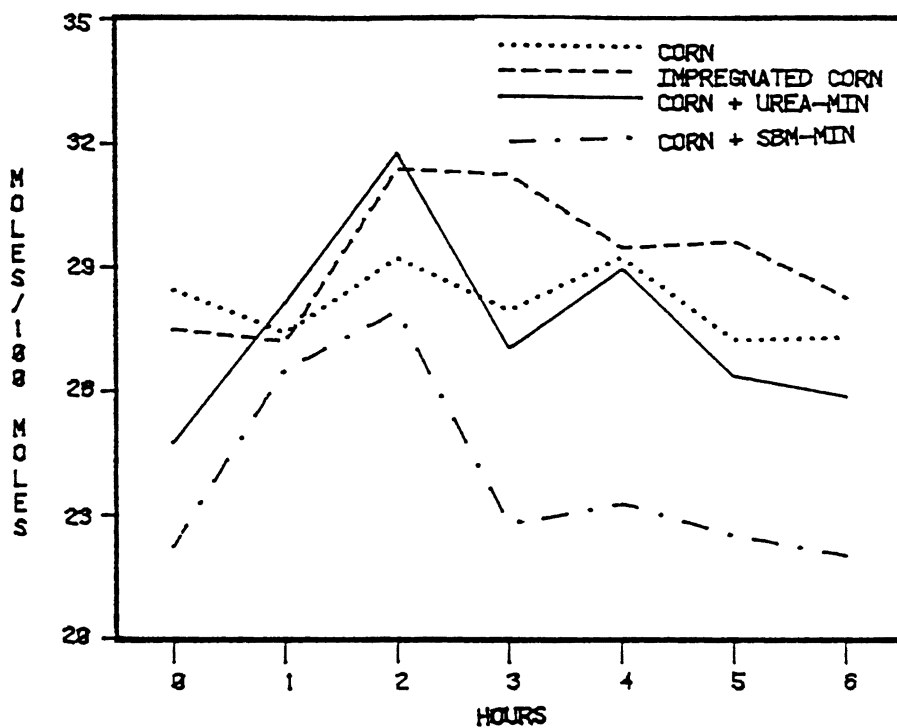


Figure 4. Molar proportions of propionate in lambs during a 6-hr period postfeeding.

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 RATIONS
USED IN METABOLISM STUDY (DRY BASIS)

Component	Rations			
	Corn	Impregnated corn	Corn + Urea-Minerals	Corn + SBM-Minerals
	%			
Dry matter	89.64	91.04	89.79	89.77
Crude protein	9.36	10.86	11.16	11.20
Nitrogen	1.50	1.74	1.78	1.79
Crude fiber	7.79	5.47	5.67	6.00
Ether extract	4.27	4.12	4.04	3.96
NFE	86.52	85.97	85.37	85.22
Organic matter	97.91	97.30	96.85	96.96
Ash	2.09	2.70	3.14	3.03
Calcium	.08	.32	.38	.37
Potassium	.65	.74	.74	.74

TABLE 3. COMPOSITION OF ADAPTATION RATION

Item	Internat'l Ref. No.	% of the diet ^a
Corn grain	4-02-931	77.92
Orchardgrass hay	1-03-438	15.00
Urea		1.05
Molasses	4-04-696	5.00
Limestone	6-02-632	.48
Sulfur, elemental ^b		.046
Iodized salt		.50
Vitamin A	7-05-143	+ ^c

^aAs is basis.

^bReagent grade, Fisher Scientific Company, Chemical Manufacturing Division, Fair Lawn, New Jersey 07410.

^c1,100 I.U. per kilogram of ration.

TABLE 4. NITROGEN INTAKE, EXCRETION
ABSORPTION AND RETENTION BY LAMBS

Item	Treatment			
	Corn	Impregnated corn	Corn + Urea-Minerals	Corn + SBM-Minerals
Total nitrogen intake, g/day	9.98 ^a	12.03 ^b	11.40 ^b	12.09 ^b
Nitrogen excretion, g/day				
Urinary	4.78 ^a	6.53 ^b	6.02 ^{a,b}	6.34 ^b
Fecal	4.24 ^a	3.22 ^b	3.44 ^{a,b}	3.64 ^{a,b}
Total	9.02	9.75	9.46	9.98
Nitrogen absorption				
Grams/day	5.74 ^a	8.81 ^b	7.96 ^b	8.36 ^b
Percent of intake	57.34 ^a	73.21 ^b	69.76 ^b	69.83 ^b
Nitrogen retention				
Grams/day	.96 ^c	2.27 ^d	1.95 ^d	2.11 ^d
Percent of intake	9.50	18.83	16.62	17.50
Percent of absorbed	15.36	25.72	23.68	25.42

^{a,b} Means in the same row with different superscripts are different (P<.01).

^{c,d} Means in the same row with different superscripts are different (P<.05).

TABLE 5. APPARENT DIGESTIBILITIES OF
PROXIMATE COMPONENTS BY LAMBS

Component, %	Treatment			
	Corn	Impregnated corn	Corn + Urea-Minerals	Corn + SBM-Minerals
Dry matter	82.75 ^a	88.17 ^c	85.66 ^{b,c}	86.19 ^b
Crude protein	57.34 ^a	73.21 ^b	69.76 ^b	69.83 ^b
Crude fiber	40.14 ^a	63.16 ^b	57.57 ^b	60.34 ^b
Ether extract	78.64	85.91	83.99	83.28
N. F. E.	87.19 ^a	91.35 ^c	89.22 ^b	89.60 ^{b,c}
Organic matter	83.73 ^d	89.22 ^e	86.81 ^f	87.22 ^{e,f}

^{a,b,c} Means in the same row with different superscripts are different ($P < .01$).

^{d,e,f} Means in the same row with different superscripts are different ($P < .05$).

TABLE 6. MOLAR PROPORTION OF VOLATILE FATTY ACIDS

VFA	Treatment			
	Corn	Impregnated corn	Corn + Urea-Minerals	Corn + SBM-Minerals
Acetate ^a	58.08 ^c	51.50 ^d	53.83 ^{d,e}	57.33 ^{c,e}
Propionate ^b	28.12	29.25	27.52	23.90
Isobutyrate	.88	.50	.81	.90
Butyrate	8.86 ^c	14.32 ^e	14.35 ^e	13.19 ^e
Isovalerate	3.01	2.47	2.80	3.42
Valerate	1.29	1.51	1.10	1.26

^a A treatment x time interaction was observed ($P < .10$).

^b A treatment x time interaction was observed ($P < .01$).

^{c,d,e} Means in the same rows with different superscripts are different ($P < .05$).

TABLE 7. CONCENTRATION OF SERUM PROTEIN,
BLOOD UREA NITROGEN AND SERUM ALBUMIN FOR LAMBS

Treatment	Hours post- feeding	Serum protein ^a	Serum albumin ^a	BUN ^b
		----- g/dl -----	----- g/dl -----	--- mg/dl ---
Corn	0	6.25	4.02	3.58
	6	6.40	4.02	2.97
	Mean	6.32	4.02 ^c	3.27 ^c
Impregnated corn	0	6.33	4.36	6.59
	6	6.33	4.32	8.06
	Mean	6.33	4.34 ^d	7.32 ^d
Corn + Urea-minerals	0	6.50	4.26	5.99
	6	6.69	4.29	6.63
	Mean	6.60	4.27 ^{c,d}	6.31 ^d
Corn + SBM-minerals	0	6.39	4.03	5.83
	6	6.47	4.08	5.08
	Mean	6.43	4.06 ^c	5.56 ^c

^a Neither time effects nor treatment x time interactions were observed (P<.05).

^b A time x treatment interaction was observed (P<.05).

^{c,d} Means in the same column with different superscripts are different (P<.10).

TABLE 8. CONCENTRATIONS OF PLASMA FREE AMINO ACIDS

Amino acid	Treatment			
	Corn	Impregnated corn	Corn + Urea-Minerals	Corn + SBM-Minerals
	----- $\mu\text{m}/\text{dl}$ plasma -----			
Phosphoserine	6.56	10.31	11.39	7.04
Phosphoethanolamine	0.00	.36	0.00	0.00
Taurine	0.00	.36	0.00	0.00
Aspartate	3.73	3.72	3.78	3.29
Threonine	16.04	13.27	16.30	12.01
Serine	12.24	13.45	15.68 ^b	11.81
Asparagine	6.12 ^a	8.02 ^{a,b}	8.97 ^b	6.36 ^a
Glutamate	15.06 ^{a,b}	16.25 ^b	15.90 ^b	14.00 ^a
Glutamine	33.66	34.62	33.10	29.06
Proline	19.27	18.74	20.71	19.74
Glycine	121.07	124.29	132.23	104.41
Alanine	32.60	36.76	34.56	32.02
Citrulline	10.39	13.16	12.84	12.55
Valine	22.47	18.71	21.97	19.50
Cystine	2.98	2.49	3.08	3.43
Methionine	4.64	4.22	4.66	3.93
Isoleucine	8.83	8.56	8.76	8.77
Leucine	20.39	16.48 ^b	19.23	16.61 ^b
Tyrosine	11.51 ^{a,b}	9.51 ^b	13.58 ^a	8.44 ^b
Phenylalanine	7.88	7.08 ^b	7.68 ^b	6.55
Ornithine	5.14 ^a	7.04 ^b	7.29 ^b	5.07 ^a
Lysine	5.04 ^a	7.33 ^b	6.64 ^{a,b}	5.77 ^{a,b}
Histidine	5.63	6.60	6.78	6.54
3-methyl histidine	6.72	11.65	9.54	9.89
Carnosine	.46	.72	.76	0.00
Arginine	7.87	10.80	11.01	10.62
Total essential	98.80	93.05	103.06	90.32
Total nonessential	292.38	320.33	332.68	274.51
Total	391.18	413.38	435.74	364.83

^{a,b} Means in the same row with different superscripts are different ($P < .10$).

GROWING CATTLE FED DIFFERING LEVELS OF ENSILED AND DEEP STACKED BROILER¹

LITTER

H. Chester-Jones, J. P. Fontenot, W. D. Lamm and K. E. Webb, Jr.

Broiler litter is a valuable source of protein, energy and minerals. When processed properly it is a valuable substitute for the more traditional protein supplements. Deep stacking broiler litter in a well aerated covered building results in pathogen elimination. In previous research it was shown that the optimum dry matter level for good ensiling and pathogen destruction is 60%.

An experiment was initiated to study the effect of feeding different levels of deep stacked and ensiled broiler litter in ground dry rations. The results of the first trial were reported in V.P.I. & S.U. Res. Div. Rep. 175. This is a report of the second trial, which was conducted in 1979-80.

Experimental Procedure

Seventy tons of wood shaving base broiler litter were obtained from two commercial broiler houses. Approximately one half of the litter was deep stacked to a depth of 54 in in a covered building open on all sides. The width of the stack was 10 ft and the length was 44 ft. Temperature fluctuations in the stack were measured by placing 12 thermistor probes at 4 ft intervals along the stack at alternating depths of 18 and 40 in. Temperatures were recorded daily for 14 days and on alternate days for a subsequent 32 days. Samples of the litter were taken when litter was obtained for feeding.

The other half of the litter was ensiled. The litter was adjusted to a moisture level of 40% by addition of water prior to ensiling, in an 8 mm plastic bag measuring 10 feet in diameter by 90 feet in length. Silopress² equipment was used for ensiling. The ensiled litter was sampled when it was removed from the plastic bag. A minimum of 6 weeks was allowed before feeding the litter from either of the processing methods.

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

²Midwest Silopress, Inc., Sergeant Bluff, Iowa.

Forty-two crossbred weanling steers were blocked by weight and breed into six blocks of seven animals per block. Animals were assigned to the following seven treatments; 1) Control (no 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 14.0% crude protein, 72% TDN, 0.54% calcium and 0.42% phosphorus, dry basis. The litter was substituted on a dry basis for the basal ration.

Results

The temperatures of the deep stacked litter presented in table 1 indicate a higher initial temperature than previously reported in similar experiments, indicating that some heating had already occurred prior to inserting the thermistor probes. Initial temperatures were 42°C and 34°C for the 18 in and 40% depth, respectively. A peak of 60°C was reached on the sixth day for the 18 in depth, while a peak temperature of 51°C for the 40 in depth was not reached until the sixteenth day. Temperatures at both depths decreased considerably for the remainder of the period.

The crude protein values of the respective processed litters were similar, as shown in table 2. The dry matter of the ensiled litter was less than 60%.

The results of the feeding trial ~~after~~ 112 days are summarized in table 3. Incorporation of 20 or 40% litter in the diet on a dry basis did not lower dry matter intake, compared to the control diet. In fact, the intakes were higher than for the control ration. The increases were especially large for the cattle fed the deep stacked litter.

Feeding 20% ensiled or deep stacked litter in the ration resulted in higher rates of gain in cattle than feeding the control diet. Values were 2.26 and 2.11 lb per day for deep stacked and ensiled litter, respectively, and 1.99 lb per day for the control cattle. Cattle fed 40% litter showed similar gains as the control diet, regardless of processing method. The marked reduction in dry matter intake at the 60% level was reflected in a decreased daily gain. Daily gains were 1.25 lb for the cattle fed ensiled litter and 0.84 lb for those fed the deep stacked litter. Differences in daily gain reflected differences in dry matter intake between the cattle fed rations with 60% litter.

Feed efficiencies were similar for cattle fed the control ration and 20% litter levels. Incorporation of 40 and 60% litter decreased feed efficiencies, especially at the higher level.

TABLE 1. TEMPERATURE OF THE DEEP STACKED BROILER LITTER

Day no.	Probe level ^a	
	18 in	40 in
	o C	o C
0	42	34
2	53	38
4	58	42
6	60	45
8	59	47
12	58	50
14	57	50
16	56	51
20	52	51
24	51	49
28	48	47
30	46	46
34	46	43
46	40	42

^aFrom top of stack.

TABLE 2. COMPOSITION OF FEEDS

Feed	Dry matter %	Crude protein ^a %
Control diet	90.1	12.5
Ensiled litter	55.7	30.1
Deep stacked litter	75.9	30.6

^aDry matter basis.

TABLE 3. PERFORMANCE OF WEANLING CALVES FED DIFFERENT LEVELS OF BROILER LITTER
112 DAYS

Item	Rations						
	Level of ensiled litter ^a				Level of deep stacked litter ^s		
	0 (basal)	20	40	60	20	40	60
Initial wt., lb	509	515	503	506	510	510	493
Final wt., lb	732	751	716	646	763	730	587
Daily gain, lb	1.99	2.11	1.91	1.25	2.26	1.97	.84
Dry matter intake per day, lb	16.0	16.7	16.6	14.3	18.0	17.5	12.7
Dry matter/lb gain, lb	8.0	7.9	8.7	11.4	8.0	8.9	15.1

^aDry basis.

EFFECT OF LENGTH OF GRAIN FEEDING PERIOD AND ZERANOL IMPLANTS IN
FINISHING HEIFERS FED BROILER LITTER DEEP STACKED OR ENSILED WITH
CORN FORAGE

W. H. McClure and J. P. Fontenot

Weanling calves have been successfully finished on a ration of high quality corn silage and broiler litter ensiled together, plus limited grain. Broiler litter contains about 30% crude protein, dry basis, and the nitrogen is efficiently utilized by ruminants. When the litter is ensiled with corn silage at a level of 30%, dry basis, the silage contains sufficient protein to remove the need for supplemental protein. Although it has been shown that broiler litter may successfully be ensiled with corn silage to provide a very palatable feed, less information is available concerning the possibility and practicality of mixing corn silage and deep stacked broiler litter together as it is fed.

Corn or corn and barley have been successfully fed at a 1% body-weight rate with high quality corn silage rations and supplemental protein to finish cattle, but efforts to finish cattle with corn silage and less than a 1% bodyweight level of grain for the entire feeding period have not been attempted in this particular series of cattle feeding studies at the Shenandoah Valley Research Station at Steeles Tavern, Virginia.

Implanting growing and finishing cattle with Zeranol (trade name Ralgro) has been shown in previous studies to result in an increased rate and efficiency of gain.

Experimental Procedure

Forty-eight straightbred and crossbred heifers were grouped according to breeding and weight and were allotted at random to eight pens of six head each. Four pens were fed a silage containing 70% corn forage and 30% broiler litter, dry basis, and four pens were fed corn silage with deep stacked broiler litter mixed into the silage at feeding time to constitute the same proportions of corn silage and broiler litter. No other supplemental protein was fed to any of the heifers.

Two pens of the heifers fed each silage-litter ration were fed grain at the rate of 1% bodyweight daily for the entire feeding period and the other two pens were fed grain at the 1% bodyweight per day level for the last half of the feeding period only. The heifers from one pen of each of the four treatments were implanted with a 36

¹Appreciation is expressed to IMC-Chemical Group, Terre Haute, Indiana for supplying the zeranol implants and to Rocco, Harrisonburg, Virginia for supplying the broiler litter.

mg implant of Zeranol at the beginning of the test. A summary of the treatments is shown in table 1. Supplemental Vitamin A was provided by an injection at the beginning and again at the middle of the feeding period.

The broiler litter contained 74.3% dry matter and the corn forage combined with it contained 45.6% dry matter. The proportions to give a level of 30% litter, dry basis, in the silage were 79.2% corn forage and 20.8% broiler litter. The ensiled 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 were weighed. The litter mixed with corn silage at feeding time had been deep stacked in an open shed and was weighed daily as it was fed.

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

The 191-day test was started on Nov. 15, 1978 and concluded on May 25, 1979.

Results

The corn forage-litter mixture ensiled well. 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 9.3%, dry basis. Substituting broiler litter for 30% of the dry matter of the corn forage increased the level of protein to 13.8%, dry basis.

The results of the 1978-79 test are shown in table 1. The comparison of the two methods of adding litter to the silage is shown in table 3, the effect of feeding grain for all or half of the feeding period in table 4 and the effect of implanting with zeranol in table 5.

The cattle receiving corn silage with broiler litter mixed in at feeding time gained slightly faster than those receiving the corn-litter silage, and were slightly more efficient (feed/pound of gain). Carcass data were similar for both groups. The cattle in both groups accepted the silage and litter rations readily, and there was no indication of a difference in palatability.

The cattle receiving grain for the entire period gained faster and had higher carcass grade and finish than those receiving grain for only the last half of the period. However, the cattle receiving grain for the last half of the trial finished to the top good grade.

The cattle implanted with Zeranol averaged over all treatments an additional .12 pound per day weight gain. The cattle fed grain at 1% bodyweight for the entire test responded more effectively to the implant.

In conclusion, it appears that beef cattle can be successfully fattened to slaughter weight with corn forage-broiler litter ensiled together, or with corn silage with deep stacked litter added to the silage at feeding time, plus grain supplementation. Feeding grain at the rate of 1% bodyweight per day for the last half of the feeding period reduced gain and final selling weight by 67 pounds. When the finished cattle prices and the corn costs for this particular feeding period are considered, there was very little or no economic gain realized from deleting grain at the 1% bodyweight level for the first half of the period only.

TABLE 1. COMBINED RESULTS OF THE 1978-79 FEEDING TRIAL

Grain feeding period Implant	Corn silage & deep stacked litter				Corn-litter silage			
	Entire		Last half		Entire		Last half	
	None	Zeranol	None	Zeranol	None	Zeranol	None	Zeranol
Initial wt., lb.	524	516	515	522	520	519	514	514
Final wt., lb.	981	1006	908	915	950	977	902	924
Daily gain, lb.	2.39	2.57	2.06	2.06	2.25	2.40	2.03	2.15
Feed/head/day, lb.								
Corn silage	19.3	21.8	21.9	21.9				
Stacked litter	5.0	5.4	5.5	5.5				
Corn litter silage					25.6	25.4	27.3	27.9
Grain	7.3	7.3	3.5	3.5	7.2	7.3	3.6	3.6
Feed/lb. gain, lb.								
Corn silage	8.1	8.5	10.7	10.7				
Stacked litter	2.1	2.1	2.7	2.7				
Corn-litter silage					11.4	10.6	13.5	13.0
Grain	3.1	2.9	1.7	1.7	3.2	3.1	1.8	1.7
Carcass quality grade ^a	12.0	11.8	11.0	10.7	13.1	11.9	11.4	10.9
Dressing %	.60	.58	.57	.59	.59	.59	.58	.59
Loineye muscle area, sq. in.	10.6	10.0	9.0	9.7	10.4	10.0	9.9	9.4
Backfat thickness, in.	.66	.45	.45	.43	.52	.60	.41	.50

^a

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

TABLE 2. COMPOSITION OF RATION INGREDIENTS

Ingredient	Dry matter, %	Composition of dry matter, %				
		Crude protein	Ether extract	Crude fiber	Ash	NFE
Corn	87.26	9.28	3.46	2.78	1.57	81.80
Litter	80.12	29.31	1.46	20.06	22.20	22.70
Corn silage	41.72	8.89	2.52	20.95	3.97	61.79
Litter silage	48.07	13.78	2.41	20.12	9.60	51.07

TABLE 3. EFFECT OF FEEDING CORN SILAGE AND STACKED LITTER OR CORN SILAGE LITTER

Item	Corn silage and deep stacked litter	Corn-litter silage
Initial wt., lb.	527	517
Final wt., lb.	953	938
Daily gain, lb.	2.27	2.21
Feed/head/day, lb.		
Silage & litter	26.6	26.6
Grain	5.4	5.4
Feed/lb. gain, lb.		
Silage & litter	11.8	12.1
Grain	2.3	2.5
Carcass quality grade ^a	11.4	11.8
Dressing %	.59	.59
Loineye muscle area, sq. in.	9.8	9.9
Backfat thickness, in.	.50	.51

^aCode: 11=high good; 12=low choice; 13=average choice, etc.

TABLE 4. EFFECT OF FEEDING GRAIN FOR ENTIRE OR LAST-HALF OF FEEDING PERIOD.

Item	Grain entire period	Grain last half
Initial wt., lb.	520	524
Final wt., lb.	979	912
Daily gain, lb.	2.40	2.08
Feed/head/day, lb.		
Silage & litter	25.6	27.5
Grain	7.3	3.6
Feed/lb gain, lb.		
Silage & litter	10.7	13.2
Grain	3.1	1.7
Carcass quality grade ^a	12.2	11.0
Dressing %	.59	.58
Loineye muscle area, sq. in.	10.3	9.5
Backfat thickness, in.	.56	.45

^a

Code: 11=high good; 12=low choice; 13=average choice, etc.

TABLE 5. EFFECT OF IMPLANTING ZERANOL TO FINISHING HEIFERS

Item	Implant	
	None	Zeranol
Initial wt., lb.	518	525
Final wt., lb.	935	956
Daily gain, lb.	2.18	2.30
Feed/head/day, lb.		
Silage & litter	26.2	27.0
Grain	5.4	5.4
Feed/lb. gain, lb.		
Silage & litter	12.1	11.8
Grain	2.5	2.3
Carcass quality grade ^a	11.9	11.3
Dressing %	.59	.59
Loineye muscle area, sq. in.	10.0	9.8
Backfat thickness, in.	.51	.50

^a

Code; 11=high good; 12=low choice; 13=average choice, etc.

PHYSIOLOGICAL PARAMETERS IN SHEEP FED HIGH LEVELS OF MAGNESIUM

H. Chester-Jones, J. P. Fontenot, H. P. Veit and K. E. Webb, Jr.

Introduction

Magnesium is an essential mineral involved in carbohydrate, lipid and protein metabolism, and cellular respiration. Hypomagnesemic tetany has been the impetus, in the past, for studies on the role of magnesium in ruminants. This disorder can be prevented by supplemental dietary magnesium. There is limited information on the effects in ruminants of over-supplementation of dietary magnesium. Previous research has indicated deleterious effects from feeding high levels of magnesium to both ruminants and non-ruminants, but physiological parameters have not been defined.

An experiment was initiated to determine the effects of high levels of magnesium on animal health, metabolism of nutrients and mineral residues in tissues.

Experimental Procedure

A palatability study was conducted with three diets to develop a diet which would be sufficiently palatable after addition of large amounts of magnesium oxide. The level of magnesium in the basal diet was .2% magnesium, which corresponds to the minimum dietary intake required by lactating beef cows. The basal diet (table 1), consisted of corn, 49%; corn cobs, 9.2%; alfalfa hay, 28%; sugarbeet pulp, 13%; T.M. salt, 5%; magnesium oxide, .05% and chromic oxide .25%. Chromic oxide was incorporated to calculate fecal output during periods when total feces were not collected.

Twenty-four wether lambs were fed the basal diet 10 days prior to a metabolism study. The lambs were grouped according to apparent breeding and weight and the lambs within each group of four were allotted at random to diets with .2, .6, 1.2, and 2.4% magnesium. The lambs were transferred to metabolism stalls and introduced to their respective diets during a 5-day transition period. Lambs were fed 500 g per feeding, twice daily. The first stage of the experiment was a 20 day metabolism study subdivided into four 5-day collection periods. Total feces were collected daily, weighed, and a 10% subsample composited for 5 days.

At the end of the first 20 days the lambs were transferred to stalls at Smithfield barn for 15 days. Grab fecal samples were taken once daily from each lamb and composited for two 10-day periods. During the last 5 days of fecal grab sampling period the lambs were

in the metabolism stalls to allow the lambs to readjust before a final 10 day period. Upon conclusion of 50 days on experimental rations, detailed necropsies were performed on all lambs. Histopathological studies were made on tissues from the abdominal and thoracic cavities. Samples of liver, kidney, muscle, bone and adipose tissue were obtained for mineral analysis.

Jugular blood samples were taken 3 hr and 10 hr post feeding prior to introduction of experimental diets and on days 1, 2, 5, 10, 15, 20, 30, 40, and 50. Total red and white blood cell counts and differential white blood cell counts were made. Blood serum, feed, feces and urine samples were analyzed for magnesium, calcium, phosphorus, potassium, sodium and nitrogen. Plasma and whole blood samples were analyzed for magnesium.

Results and Discussion

High dietary magnesium levels resulted in decreases in dry matter content of the feces (table 2). Severe diarrhea was observed in lambs fed the 2.4% magnesium level, with occasional signs of blood and tubular sections of mucosal tissue voided in the feces. Increasing dietary magnesium decreased dry matter digestibility linearly ($P < .01$) as shown in table 3. The differences in dry matter digestibility were similar for all periods, indicating no adaptation in this parameter with time.

During the initial 15 days magnesium absorption (g/day) was lowest for lambs fed 2.4% magnesium (Figure 1). After 15 days, magnesium absorption was directly related to dietary intake as exemplified in Figure 1. Generally, phosphorus, calcium and nitrogen absorption and retention decreased as magnesium level increased ($P < .01$).

Serum magnesium increased linearly ($P < .01$) with higher dietary magnesium (Figure 2). Values ranged from 2.2 mg/dl for sheep fed the diet containing .2% magnesium to 5.9 mg/dl for those fed the 2.4% magnesium level. Significant depressions ($P < .01$) of serum calcium (Figure 3) resulted from increasing dietary magnesium, especially at the 2.4% magnesium level. Values ranged from 12.2 mg/dl for sheep fed .2% magnesium to 7.8 mg/dl for those fed 2.4% magnesium. Serum sodium and phosphorus exhibited significant day x time and treatment x time interactions ($P < .01$) but values were within the normal ranges.

Magnesium urinary output decreased proportionately as fecal magnesium increased with high magnesium intake levels.

Red blood cell (table 4) and white blood cell (table 5) counts showed day x magnesium level interactions ($P < .01$). Hematocrit and hemoglobin did not show definite treatment trends but showed significant day x time interactions ($P < .01$). Segmented neutrophils (table 6) tended to be lower with higher magnesium levels and showed day x magnesium level interactions ($P < .01$).

There was no difference across treatments in cerebrospinal fluid levels of magnesium and calcium. Tissue sodium, phosphorus, potassium and calcium levels were not affected by treatments. However, a linear increase was recorded ($P < .01$) for magnesium levels in kidney liver, rib and femur bones as dietary magnesium increased (table 7).

TABLE 1. COMPOSITION OF THE BASAL DIET AS FED

Ingredient	Grams per day
Ground corn grain	490
Corn cob fraction	92
Alfalfa hay	280
Sugar beet pulp	130
T.M. salt	5
Magnesium oxide	.5
Chromic oxide	2.5
Vitamin A ^a	
Vitamin D ^b	

^a892 IU vitamin A per day.

^b194 IU vitamin D per day.

TABLE 2. FECAL DRY MATTER BY TREATMENT
AND COLLECTION PERIOD

Magnesium levels %	Fecal dry matter, by collection period						
	1 %	2 %	3 %	4 %	5 %	6 %	7 %
.2	39.0	39.3	40.0	36.6	39.3	41.2	40.0
.6	25.1	27.2	26.4	25.7	24.8	24.8	24.2
1.2	14.7	16.0	19.7	18.6	19.9	19.2	22.6
2.4	13.4	14.2	14.0	14.3	15.6	12.1	15.6

TABLE 3. DRY MATTER DIGESTIBILITY BY TREATMENT
AND COLLECTION PERIOD

Magnesium level %	Dry matter digestibility, by collection period				
	1 %	2 %	3 %	4 %	7 %
.2	77.5	77.7	77.5	76.6	77.9
.6	73.9	74.9	73.4	74.4	74.4
1.2	70.7	69.2	69.0	69.8	70.2
2.4	64.7	60.2	62.6	65.0	63.1

^aSignificant magnesium level X collection period interaction ($P < .05$).

^bSignificant linear effects as dietary magnesium increases ($P < .01$).

TABLE 4. RED BLOOD CELL COUNTS,^{a,b} BY TREATMENT
AND DAY OF SAMPLING (MILLIONS/MM³)

Day of sampling	Magnesium levels, %			
	.2	.6	1.2	2.4
Initial	8.4	8.6	9.2	8.3
1	8.3	8.6	9.5	8.3
5	7.7	7.9	8.5	7.2
20	6.6	7.1	7.2	6.4
50	7.5	7.5	8.2	6.9

^aSignificant day x magnesium level interaction ($P < .01$).

^bSignificant quadratic effects for increasing dietary magnesium ($P < .01$).

TABLE 5. WHITE BLOOD CELL COUNTS^{a,b} BY TREATMENT AND DAY OF SAMPLING (1000/MM³)

Day of sampling	Magnesium levels (%)			
	.2	.6	1.2	2.4
Initial	9.8	8.0	10.2	8.3
1	11.6	7.9	9.3	8.5
5	10.6	7.7	9.7	8.3
20	11.9	8.8	11.9	10.0
50	10.2	8.5	9.6	9.6

^a Significant day x magnesium level interaction ($P < .01$).

^b Significant quadratic effects for increasing dietary magnesium ($P < .01$).

TABLE 6. SEGMENTED NEUTROPHILS^a BY TREATMENT AND
DAY OF SAMPLING (PER MM³)

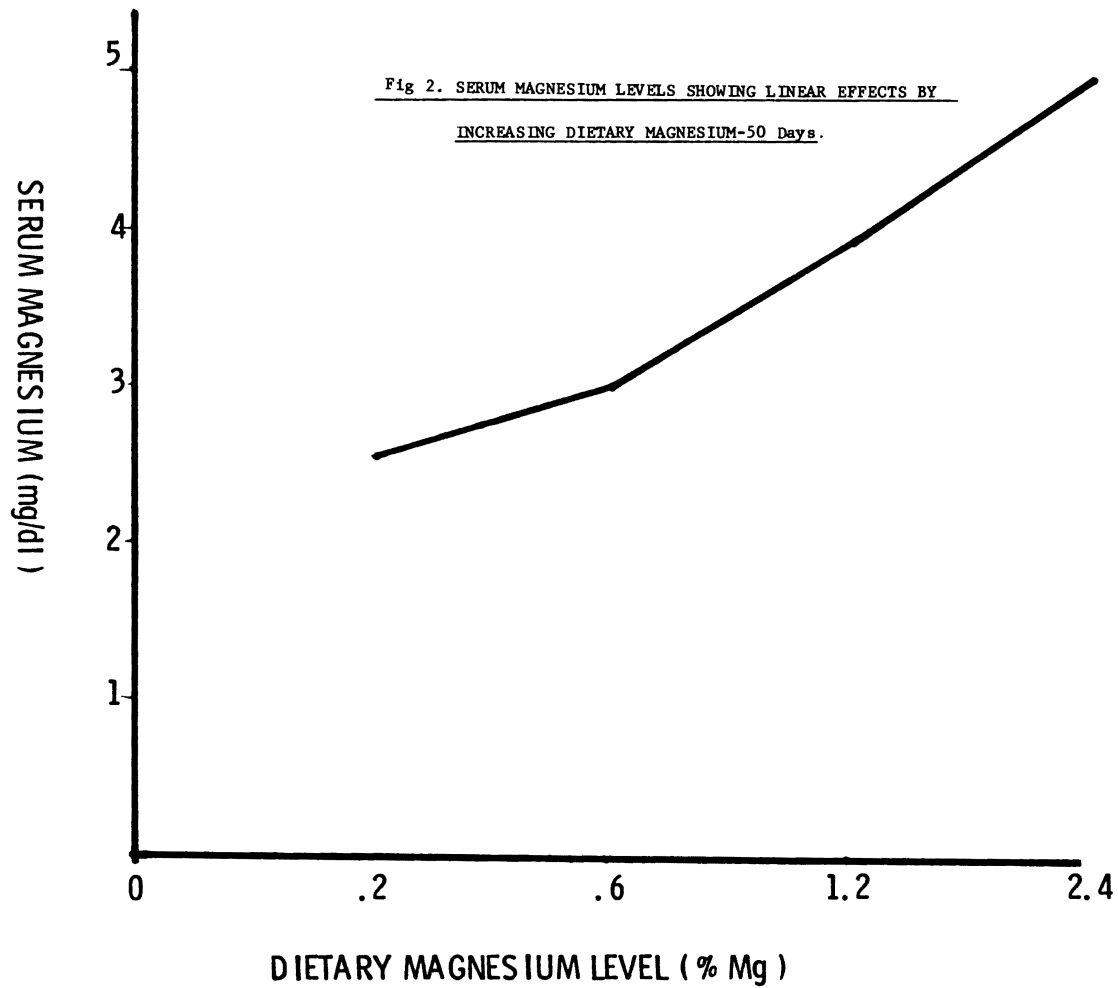
Day of sampling	Magnesium levels (%)			
	.2	.6	1.2	2.4
Initial	2040	2306	2534	2250
1	3287	2365	3274	2098
5	2553	2016	2462	1710
20	2648	2635	3880	2627
50	2804	1549	2284	1950

^aSignificant day X magnesium level interaction ($P < .01$).

TABLE 7. TISSUE MAGNESIUM LEVELS BY TREATMENT (PERCENT, DRY BASIS)

Magnesium levels %	Liver ^a	Kidney	Muscle	Rib bone ^a	Femur bone ^a
.2	.057	.052	2.12	.349	.438
.6	.056	.084	.904	.475	.455
1.2	.059	.093	.950	.503	.474
2.4	.066	.111	.820	.605	.517

^a Significant linear effects for increasing dietary magnesium ($P < .05$).



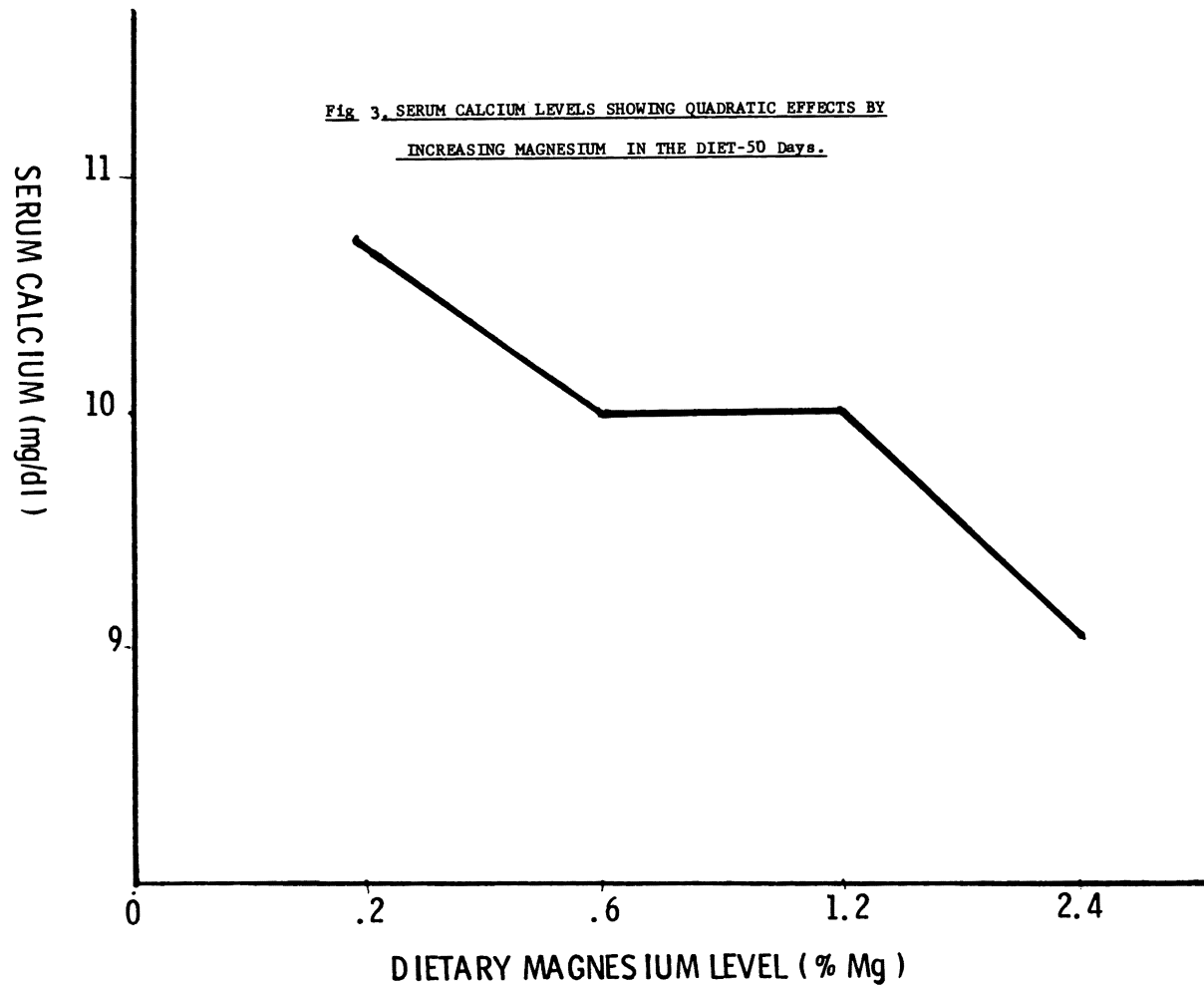
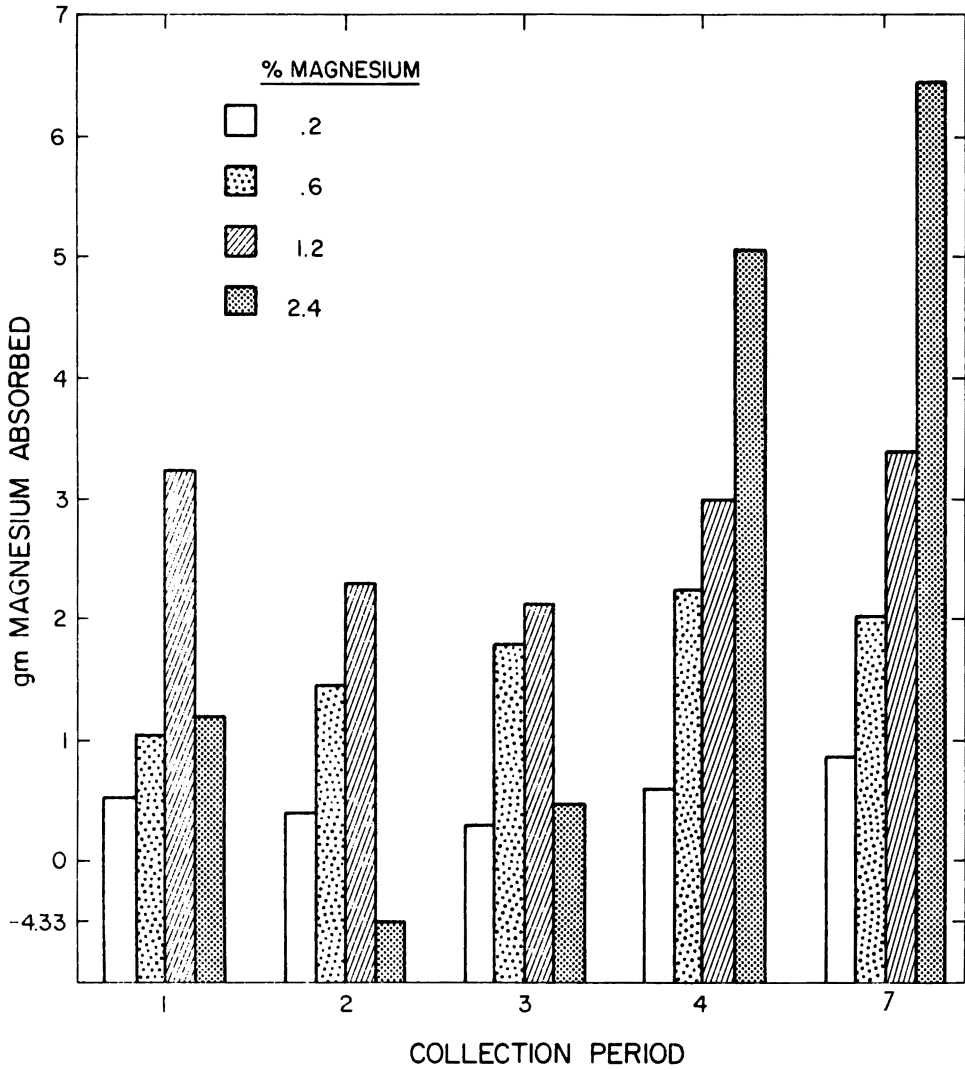


Fig 1. MAGNESIUM ABSORPTION BY COLLECTION PERIOD.



PERFORMANCE OF HEIFERS FED CORN SILAGE SUPPLEMENTED WITH DEEP
STACKED OR ENSILED BROILER LITTER¹

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

Broiler litter has been shown to be a valuable feedstuff for cattle. Some processing methods are effective for pathogen elimination and good storage characteristics. Previous work by Virginia Tech researchers 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.

Mixing corn forage and broiler litter at ensiling time may not be feasible for all producers. Another method of handling litter would be to deep stack it, then mix it with corn silage at 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%. The preliminary results were reported in the V.P.I. & S.U. Research Division Report 175.

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 in an 8 mil thickness plastic bag 10 feet in diameter and 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 equipped mixing wagon, prior to ensiling. Ensiling was with Silo-press equipment. The litter was fed after it had been deep stacked or ensiled for a minimum of 6 weeks.

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

²Midwest Silopress, Inc., Sergeant Bluff, Iowa.

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 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, deep stacked litter, ensiled litter and soybean meal supplement were weighed and mixed in the feed bunks at each feeding. All lots of cattle were full fed. Refusals were weighed and fresh rations were fed twice daily. Fresh water was 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.

Performance data of the heifers fed the three rations for the entire 153 day trial are given in table 2. Dry matter intake was highest for the cattle fed corn silage and deep stacked litter (19.0 lb/day) and lowest for those fed corn silage and soybean meal (16.3 lb/day). Average daily gains were similar for the cattle fed the three rations. The values ranged from 2.03 lb for the cattle fed the deep stacked litter to 1.98 lb for those fed ensiled litter and soybean meal.

The amount of corn grain per pound of gain was similar for the cattle fed the three rations. More corn silage was required per pound of gain for the cattle fed soybean meal. In the case of the cattle fed deep stacked litter, 2.7 lb of litter substituted for 0.67 lb soybean meal and 0.9 lb corn silage. Assuming values of \$200 per ton for soybean meal and \$20 per ton for corn silage, the litter was worth \$56.09 per ton. Dry matter intake per pound of gain was similar for heifers fed both the deep stacked litter and ensiled litter rations (9.37 and 9.04 lb, respectively). The value for heifers fed the control ration was 8.25 lb dry matter per pound of gain.

TABLE 1. COMPOSITION OF RATION INGREDIENTS

Item	Dry matter	Crude protein ^a
	%	%
Corn silage	38.2	8.2
Deep stacked litter	79.5	35.0
Ensiled litter	60.5	31.4
Soybean meal	89.0	48.7
Corn grain	89.0	-

^aDry basis.

TABLE 2. PERFORMANCE OF HEIFERS ON EXPERIMENTAL RATIONS^a

Item	Corn silage & deep stacked litter	Corn silage & ensiled litter	Corn silage & soybean meal
Initial wt., lb	450	449	462
Final wt., 153 days, lb	761	753	765
Daily gain, lb/day	2.03	1.99	1.98
Average daily intake lb/day ^b			
Corn silage	27.4	26.3	28.5
Soybean meal			1.3
Ensiled litter		6.5	
Deep stack litter	5.5		
Corn grain ^c	4.7	4.5	4.8
Dry matter intake, lb/day	19.0	18.0	16.3
Feed efficiency ^b , lb/lb gain			
Corn silage	13.5	13.2	14.4
Soybean meal			.67
Ensiled litter		3.27	
Deep stack litter	2.71		
Corn grain	2.32	2.26	2.47
Dry matter/lb. gain, lb	9.37	9.04	8.25

^a10 animals per ration (2 pens of 5 head).^bAs fed basis.^cFed only during last 67 days.

FERMENTATION CHARACTERISTICS OF CAGED LAYER WASTE ENSILED WITH SUGARCANE BAGASSE

W. A. Samuels, J. P. Fontenot, W. D. Lamm and K. E. Webb, Jr.

Disposal of caged layer waste has become a major problem with the advent of large systems of egg production. Traditionally, caged layer waste was spread on the land for its fertilizer value. Many layer operations, however, do not have sufficient land to efficiently dispose of the waste. Feeding offers a means of alleviating the waste disposal problem as well as a method of recovering some of the potentially valuable nutrients in the waste. Research has shown that caged layer waste has substantial nutritive value for cattle and sheep. In most of the previous research caged layer waste has been fed in the dried form, but drying may not be practical with the high costs of fuel. The process of ensiling has been used to preserve various crops and in some cases, enhance their acceptability to farm animals.

Bagasse, the fibrous residue of sugarcane stalks, which remains after the juice is pressed out, constitutes one of the principal by-products of the sugarcane industry. Presently bagasse is used primarily as a fuel source in sugar mills. Bagasse has been used as a roughage in beef and dairy cattle rations. It is deficient in protein, calcium and phosphorus, but is rich in water soluble carbohydrates, which are valuable for ensiling. Since caged layer waste is rich in protein and minerals, ensiling the caged layer waste as part of a mixture with bagasse could make a desirable and economical product.

The objective of this study was to investigate the feasibility of ensiling varying mixtures of caged layer waste and bagasse to be used as a feedstuff for ruminants.

Experimental Procedure

Caged layer waste which had accumulated for 24 hr was collected at 1-day intervals from hens housed on wire mesh. The waste was scraped and transferred to a 55 gal drum. Waste collected on a given day was mixed in a horizontal mixer until a homogenous mixture was obtained. The waste was mixed with bagasse that had been previously ground in a hammer mill through a 1 in screen in the following proportions of waste to bagasse (W/W) wet basis: 70:30, 60:40, 50:50, 40:60, 40:60 + water, 30:70 + water. The mixtures with added water were adjusted to a dry matter of 50%. The mixtures were ensiled for a minimum of 42 days in 1 gal laboratory silos double-lined with polyethylene bags. Samples were taken initially. Upon opening the silos the silages were analyzed for dry matter and were assayed for the presence of coliform organisms, Salmonella, Proteus and Shigella. Extracts were prepared for determination of pH then frozen for subsequent analyses for lactic acid and water soluble carbohydrate. Samples will be analyzed for protein nitrogen, ash and fiber.

Results and Discussion

Table 1 shows the results of the small silo study for pre-and post-ensiling parameters. After ensiling, the appearance and odor of all the mixtures except the 70:30 were altered. The 70:30 silage was only slightly less offensive than upon the day of ensiling; putrefaction was evident. The other ensiled mixtures had aromas similar to that of good quality haylage. Mold was present in three of the six silos containing the 30:70 mixture.

The pH of the initial mixtures ranged from 5.57 to 6.24 and water soluble carbohydrates were greater than 7.7%, dry basis. Lactic acid content was negligible (approached .14%) prior to ensiling. There was a drop in pH following ensiling. There was some variation in pH between treatments. The highest value was for the 70:30 mixture and the lowest value was for the 30:70 + water mixture. Water soluble carbohydrate levels decreased while lactic acid content in the mixtures increased to a high of 5.64% for the 40:60 mixture. Addition of water to the 40:60 mixture did not markedly affect pH, but addition of water to the 30:70 mixture resulted in a decrease in pH. Lactic acid was considerably higher for the 60:40, 50:50 and 40:60, compared to the 70:30 and 30:70 mixtures.

Pre- and post-ensiling microbial counts are given in table 2. Total and fecal coliforms were eliminated following ensiling in most of the mixtures. Proteus organisms were eliminated in all treatments except the 70:30 which had a pH of 5.93. No Salmonella and Shigella were detected before or after ensiling. These organisms were not present in the waste.

Summary

Ensiling caged layer waste with bagasse decreased water soluble carbohydrates and increased lactic acid. Lactic acid was highest for the ensiled 60:40, 50:50 and 40:60 mixtures of waste and bagasse. Addition of water to the 30:70 mixture lowered pH, but did not affect pH when added to the 60:40 mixture. Following ensiling Proteus organisms were eliminated in all mixtures except the 70:30 which had a pH of 5.93.

TABLE 1. EFFECT OF ENSILING VARYING MIXTURES OF CAGED LAYER WASTE WITH
BAGASSE

Ingredient or mixture	Dry matter, %		pH		Lactic acid ^a		Soluble carbohydrate ^a	
	Initial	Ensiled	Initial	Ensiled	Initial	Ensiled	Initial	Ensiled
70:30 ^b	49.8	49.3	6.2	5.93	.36	.65	7.83	1.07
60:40	55.5	55.3	5.97	5.58	.43	3.30	8.11	.97
50:50	60.1	61.1	5.75	5.39	.53	5.29	8.98	1.16
40:60	64.6	66.0	5.71	5.23	.18	5.64	9.71	.96
40:60+water	49.0	48.5	5.57	5.16	.30	2.42	9.74	.76
30:70	70.6	72.3	6.24	5.66	.14	2.72	9.79	2.12
30:70+water	48.2	47.5	5.67	4.78	.16	1.35	10.59	1.35
Waste	33.2				.24		3.31	
Bagasse	86.4				.00		12.74	

^aExpressed as percent, dry basis.

^bRatio of waste and bagasse, wet basis.

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

Ingredient or mixture	Total coliforms ^a		Fecal coliforms ^a		Proteus		Salmonella		Shigella	
	Pre ^b	Post ^b	Pre	Post	Pre	Post	Pre	Post	Pre	Post
70:30	16X10 ⁵	6.5X10 ²	93.5X10 ⁵	-	+++ ^d	+ ^e	-	-	-	-
60:40	21.5X10 ⁵	-	70.5X10 ⁵	-	+++	-	-	-	-	-
50:50	++	4.5X10 ²	++ ^c	3X10 ²	+++	-	-	-	-	-
40:60	++X10 ⁵	-	++	-	+++	-	-	-	-	-
40:60+H ₂ O	25.5X10 ⁵	-	++	-	+++	-	-	-	-	-
30:70	8.5X10 ⁵	-	72.5	-	+++	-	-	-	-	-
30:70+H ₂ O	29X10 ⁵	-	126.5	-	+++	-	-	-	-	-
Waste	++		++		+++		-		-	
Bagasse	-		-		-		-		-	

^a Bacteria/gm of silage.

^b Pre = pre-ensiled; post=post ensiled

^c ++>300/plate.

^d +++ Large numbers of Proteus colonies were found consistently.

^e + Proteus detected.

ZERANOL IMPLANTS IN GRAZING STEERS FED MONENSIN¹

J. P. Fontenot, W. D. Lamm and R. F. Kelly

Implanting zeranol (trade name - Ralgro) has been shown to increase rate of gain in grazing steers. Feeding monensin (trade name - Rumensin) to cattle fed high grain rations has not affected rate of gain, but increased feed efficiency about 10%. Feeding monensin to cattle fed high levels of roughage has increased both rate and efficiency of gain. Feeding monensin has generally increased rate of gain in grazing cattle.

An experiment was started to determine the effect of zeranol implants in grazing steers fed monensin.

Experimental Procedure

Sixty Angus and crossbred steers, owned by and kept on the Graves Bros. Farm, Syria, Va., were started on test on April 30, 1979. At that time the cattle were allotted at random according to breeding and weight to the following treatments: 1 - Control (no implant) and 2 - Zeranol implant (36 mg). The cattle were grazed together on a single pasture and were fed 2 lb per head per day of a supplement containing 100 mg monensin per pound². Thus, the cattle were fed 200 mg monensin per day. On August 14, 1979 the implanted steers were reimplanted with 36 mg zeranol.

On October 29, 1979 the steers were removed from pasture and placed in the feedlot. They were fed corn silage, corn and supplement in the feedlot. The implanted cattle were reimplanted at the beginning of the feedlot phase and on January 24, 1980 with 36 mg zeranol. On April 8, 1980, 35 of the steers were slaughtered. The remainder were slaughtered on April 30, 1980.

At the beginning of the experiment, at intervals during the experiment, and at the end of the test the steers were individually weighed and scored for feeder grade (old grades), tailhead elevation and mammary development. Slaughter grades were placed on the cattle at each of these times starting October 29, 1979. At slaughter carcass data were obtained.

¹Appreciation is expressed to Graves Bros. Farm, Syria, Va. for their cooperation, IMC - Chemical Group, Terre Haute, Indiana for supporting, in part, this study with a grant-in-aid, and Elanco, Greenfield, Indiana for supplying the monensin.

²Prepared by Culpeper Farmers Cooperative, Culpeper, Va.

Results

At the end of 122 days (August 14) rate of gain was very low for all steers, with no substantial difference between the unimplanted and those which had been implanted with 36 mg zeranol. During the rest of the summer the implanted steers gained 15% faster (2.83 vs. 2.46 lb/day). The advantage for the implanted steers during the summer grazing period was 28 lb per head. This response is similar to the response we have obtained previously from implanting zeranol in cattle not fed monensin.

Response to zeranol implants continued in the feedlot. The increase in gain during the feedlot was 32 lb. The total increase in gain for the pasture and feedlot phases was 56 lb per head, which represents over an 8% increase in gain.

No consistent differences were noted in feeder grade, slaughter grade, tailhead elevation or mammary development. Thus, repeated use of zeranol implants at regular intervals did not produce visible side effects. Carcass quality was similar for the control and implanted cattle.

TABLE 1. ZERANOL IMPLANTS IN STEERS FED MONENSIN

Item	Implant	
	None	Zeranol
No. of cattle	31	30
Weight and gain data, lb.		
Initial wt., Apr., 1979	462	463
Wt., Aug. 14, 1979	556	558
Gain, Apr. 30-Aug. 14	95	92
Daily gain	.89	.87
Wt., Oct. 29, 1979	748	776
Gain, Aug. 14-Oct. 29	189	218
Daily gain	2.46	2.83
Gain Apr. 30-Oct. 29	286	314
Daily gain	1.56	1.71
Wt., Jan. 24, 1980	968	998
Gain, Oct. 29, 1979-Jan. 24, 1980	220	225
Daily gain	2.52	2.58
Wt., Apr. 7, 1980	1130	1178
Gain, Jan. 24-Apr. 7	156	187
Daily gain	2.11	2.53
Gain, Oct. 29-Apr. 7	377	409
Daily gain	2.34	2.54
Gain Apr. 30, 1979-Apr. 7, 1980	665	721
Daily gain ^a	1.93	2.10
Feeder grade ^a		
April 30, 1979	11.11	11.03
August 14, 1979	10.83	11.00
October 30, 1979 ^b	11.61	11.20
Tailhead elevation ^b		
April 30, 1979	.58	.35
August 14, 1979	.65	.87
October 30, 1979	.23	.58
January 24, 1980	.32	.33
April 7, 1980	.18	.27
Mammary development ^c		
April 30, 1979	0	0
August 14, 1979	.07	.13
October 30, 1979	0	.07
January 24, 1980	0	0
April 7, 1980 ^d	.03	.05
Slaughter grade ^d		
October 30, 1979	8.05	7.98
January 24, 1980	10.4	11.2
April 7, 1980	11.9	12.2

^aCode: 10 - avg. good; 11 - high good; etc.

^bCode: 0 - no elevation; 1 - elevation; 2 - marked elevation

^cCode: 0 - no development; 1 - development; 2 - marked development

^dCode: 8 - high standard; 9 - low good; etc.

TABLE 2. CARCASS DATA OF CONTROL STEERS
AND STEERS IMPLANTED WITH ZERANOL

Item	Implant	
	None	Zeranol
Dressing percent	59.8	59.9
Marbling ^a	5.3	4.9
Quality grade ^b	13.2	12.9
Loin eye area, sq. in.	11.7	12.4
Backfat thickness, in.	0.56	0.62
Yeild grade	3.34	3.34
Estimated lean cuts, %	49.3	49.3

^aCode: 4 = small; 5 = modest; 6 = moderate; etc.

^bCode: 12 = low choice; 13 = avg. choice; etc.

EFFECT OF HIGH LEVELS OF POTASSIUM ON MAGNESIUM ABSORPTION IN RUMINANTS¹

L. W. Greene, J. P. Fontenot and K. E. Webb, Jr.

Grass tetany is most common in beef cows grazing spring pastures during early lactation. The disease is characterized by a low serum magnesium concentration which can result from 1) an increased requirement for magnesium during lactation, 2) a lowered magnesium content of forages during the early growing season, and 3) a decreased absorption of magnesium from the digestive tract.

High potassium and nitrogen fertilization tends to increase the rate of growth and potassium content of the forage. The fertilization has been shown to increase the incidence of hypomagnesemia. A high dietary level of potassium results in higher fecal excretion and lower apparent absorption of magnesium. The minimum level of dietary potassium exerting this effect has not been determined. Two balance trials were conducted to study the effects of level of dietary potassium on the absorption of magnesium in ruminants.

Experimental Procedure

Two mineral balance trials were conducted with 24 wether lambs (average initial weight, 38.2 kg). Lambs were blocked according to weight and apparent breeding and randomly assigned to false bottom metabolism stalls designed for the total collection of urine and feces. Animals were fed rations containing two levels of magnesium (.1 and .2%) and four of potassium (.6, 1.2, 2.4 and 4.8%) in a 2 X 4 factorial arrangement. The animals were randomly assigned to the eight rations for trial 1 and reallocated to rations for trial 2 with the exception that no lamb would receive the same treatment during both trials.

The ingredient composition of the basal ration (.1% magnesium, .6% potassium) is given in table 1. The basal ration was formulated to contain the recommended level of calcium and crude protein. Supplemental levels of magnesium oxide and potassium bicarbonate for the eight rations are presented in table 2. The ingredients were mixed in a complete mix prior to feeding for trial 1. During trial 2, a supplemental mineral premix was prepared from corn, magnesium oxide and potassium bicarbonate and mixed with the basal ration at time of feeding. Lambs were fed the basal ration prior to starting their respective treatments. The treatments were gradually introduced during a 5-day transition period. Animals were fed 800 g per day, equal portions at 6:00 a.m. and 6:00 p.m. A 10-day preliminary period was followed by a 10-day collection period during which feces and urine were collected. Daily feed samples were obtained for 10 days beginning 2 days prior to the start of the collection period.

Blood samples were taken 3 hours after feeding by jugular puncture at the completion of the collection period.

¹Supported by John Lee Pratt Animal Nutrition Program.

Fecal and feed samples were wet-ashed prior to mineral analysis. Feces, feed, urine and blood serum were analyzed for calcium, magnesium, sodium and potassium. Serum, fecal and feed samples were analyzed for phosphorus.

Results and Discussion

Magnesium intake, excretion, absorption and retention data are presented in table 3. Lambs fed .2% magnesium excreted more magnesium in the feces and urine than lambs fed .1% magnesium. Apparent magnesium absorption and retention, expressed as grams per day, were higher ($P<.05$) for lambs fed the high magnesium level. Expressed as a percent of intake, there were no differences between levels of magnesium.

A linear increase ($P<.05$) was observed in fecal magnesium excretion in lambs fed increasing levels of dietary potassium. This resulted in a linear decrease ($P<.05$) in magnesium absorption, expressed as grams per day and percent of intake. The largest depression in absorption occurred when the potassium level was increased from 1.2 to 2.4%. A further large decrease in absorption resulted when the potassium level was increased to 4.8%. The magnesium absorption, averaged for the two magnesium levels, expressed as percent of intake, was 51.2, 49.8, 40.7 and 35.3% for the four respective potassium levels. Dietary potassium did not change urinary excretion and retention of magnesium in lambs.

Potassium balance data are presented in table 4. Potassium excretion, absorption and retention in lambs were not affected by dietary magnesium level. Increasing dietary potassium resulted in a linear increase ($P<.05$) in urinary, fecal and total potassium excretion. Apparent potassium absorption (grams per day or percent of intake) increased linearly ($P<.05$) with increasing dietary potassium. An increase ($P<.05$) in potassium retention expressed as grams per day, was observed when lambs were fed different dietary levels of potassium. No significant differences were recorded when expressed as percent of intake or absorbed.

Calcium balance data are presented in table 5. Calcium excretion, absorption and retention were not affected by dietary level of magnesium. Calcium absorption was not affected by level of dietary potassium. Generally, calcium excretion decreased with increasing levels of potassium.

As shown in table 6, increasing dietary potassium decreased ($P<.05$) fecal excretion of sodium and increased ($P<.05$) sodium absorption (percent of intake). More sodium (grams per day) was absorbed when lambs were fed the low (.1%) level of magnesium.

Phosphorus fecal excretion (table 7) was not affected by dietary level of magnesium or potassium. Phosphorus absorption appeared to decrease with increasing potassium levels.

Serum mineral levels of lambs are presented in table 8. Serum magnesium was higher ($P<.05$) for lambs fed .2% magnesium. Increasing dietary potassium depressed serum magnesium and increased serum potassium linearly ($P<.05$).

Intermediate levels of dietary potassium increased serum sodium levels in lambs. An interaction was observed in serum calcium between dietary magnesium and potassium levels.

In summary, lambs fed the high magnesium diet retained, absorbed and excreted more magnesium than those fed low magnesium levels. Magnesium absorption decreased when lambs were fed increasing levels of potassium. Excretion, absorption, or retention of potassium was not affected by dietary magnesium level. Serum magnesium was higher in lambs fed .2% magnesium, and decreased with increasing levels of potassium.

TABLE 1. COMPOSITION OF BASAL DIET^a
(0.1% Mg, 0.6% K)

Ingredient	g/day
Corn cob fraction	240
Ground corn grain	393
Corn gluten meal	81
Cerelose	72
TMS	4
Limestone	5
MgO	.4
KHCO ₃	4.0
Vit. A ^b	*
Vit. D ^c	*

^aAs fed basis.

^b486 IU Vit. A per/day.

^c111 IU Vit. D per/day.

TABLE 2. SUPPLEMENTAL LEVELS OF MAGNESIUM OXIDE
AND POTASSIUM BICARBONATE

Supplemental levels		Levels in ration ^a	
Magnesium oxide g/day	Potassium bicarbonate g/day	Magnesium %	Potassium %
.4	4.0	0.1	0.6
.4	15.0	0.1	1.2
.4	36.8	0.1	2.4
.4	78.6	0.1	4.8
1.5	4.0	0.2	0.6
1.5	15.0	0.2	1.2
1.5	36.8	0.2	2.4
1.5	78.6	0.2	4.8

^aCalculated, dry basis.

TABLE 3. MAGNESIUM INTAKE, EXCRETION, ABSORPTION AND RETENTION IN LAMBS
FED DIFFERENT LEVELS OF MAGNESIUM (Mg) AND POTASSIUM (K)

Item	.1% magnesium				.2% magnesium			
	.6% K	1.2% K	2.4% K	4.8% K	.6% K	1.2% K	2.4% K	4.8% K
Intake (g/day)	.96	.94	.94	.92	1.65	1.55	1.52	1.58
Excretion (g/day)								
Fecal ^{a,b}	.50	.45	.58	.63	.75	.79	.86	.95
Urinary ^a	.28	.24	.17	.19	.40	.50	.41	.23
Total ^a	.78	.70	.75	.82	1.15	1.29	1.28	1.18
Absorption								
Grams/day ^{a,c}	.46	.49	.36	.29	.90	.76	.65	.62
Percent of intake ^b	47.80	51.68	38.33	31.49	54.54	49.02	42.98	39.17
Retention								
Grams/day ^a	.18	.24	.19	.10	.50	.26	.24	.39
Percent of intake	18.18	25.32	19.36	11.68	30.41	16.81	15.86	24.45
Percent of absorbed	34.84	46.93	42.19	27.21	54.96	29.87	37.90	59.49

^aMagnesium levels differ significantly ($P < .05$).

^bPotassium levels differ linearly ($P < .05$).

^cPotassium levels differ quadratically ($P < .05$).

TABLE 4. POTASSIUM INTAKE, EXCRETION, ABSORPTION AND RETENTION IN LAMBS
FED DIFFERENT LEVELS OF MAGNESIUM (Mg) AND POTASSIUM (K)

Item	.1% magnesium				.2% magnesium			
	.6% K	1.2% K	2.4% K	4.8% K	.6% K	1.2% K	2.4% K	4.8% K
Intake (g/day)	4.61	9.34	18.56	36.44	4.77	9.42	17.02	36.27
Excretion (g/day)								
Fecal ^b	.38	.42	.51	.58	.35	.30	.37	.64
Urinary ^b	2.40	5.92	10.53	21.85	2.88	4.46	10.86	22.80
Total ^b	2.78	6.34	11.04	22.43	3.23	4.75	11.23	23.44
Absorption								
Grams/day ^a	4.23	8.91	18.05	35.86	4.42	9.12	16.65	35.62
Percent of intake ^b	91.74	95.46	97.25	98.40	92.71	96.79	97.84	98.22
Retention								
Grams/day ^a	1.83	2.99	7.52	14.01	1.53	4.67	5.79	12.82
Percent of intake	39.81	32.78	40.40	38.40	33.13	50.52	33.05	35.58
Percent of absorbed	43.16	34.36	41.52	39.01	35.81	52.32	33.85	36.24

^aPotassium levels differ linearly ($P < .05$).

^bPotassium levels differ quadratically ($P < .05$).

TABLE 5. CALCIUM INTAKE, EXCRETION, ABSORPTION AND RETENTION IN LAMBS
FED DIFFERENT LEVELS OF MAGNESIUM (Mg) AND POTASSIUM (K)

Item	.1% magnesium				.2% magnesium			
	.6% K	1.2% K	2.4% K	4.8% K	.6% K	1.2% K	2.4% K	4.8% K
Intake (g/day)	2.87	2.52	2.51	2.46	2.77	2.76	2.74	2.64
Excretion (g/day)								
Fecal ^a	1.83	1.85	1.76	1.65	1.87	1.86	1.76	1.76
Urinary ^b	.07	.04	.02	.02	.11	.03	.03	.02
Total ^b	1.89	1.90	1.78	1.67	1.98	1.89	1.79	1.79
Absorption								
Grams/day	1.04	.67	.74	.82	.89	.91	.97	.88
Percent of intake	34.95	26.23	28.80	31.17	31.50	31.59	35.12	31.46
Retention								
Grams/day	.98	.63	.73	.80	.78	.88	.95	.86
Percent of intake	32.68	24.56	28.11	30.34	27.27	30.37	33.98	30.62
Percent of absorbed ^a	93.35	90.87	96.98	95.37	79.90	93.60	96.50	96.35

^aPotassium levels differ linearly ($P < .05$).

^bPotassium levels differ quadratically ($P < .05$).

TABLE 6. SODIUM INTAKE, EXCRETION, ABSORPTION AND RETENTION IN LAMBS
FED DIFFERENT LEVELS OF MAGNESIUM (Mg) AND POTASSIUM (K)

Item	.1% Mg				.2% Mg			
	.6% K	1.2% K	2.4% K	4.8% K	.6% K	1.2% K	2.4% K	4.8% K
Intake (g/day)	2.14	2.06	2.03	2.02	1.98	1.81	1.91	1.77
Excretion (g/day)								
Fecal ^b	.25	.30	.24	.14	.42	.21	.19	.19
Urinary	1.28	1.25	1.14	1.38	1.00	1.04	1.30	1.22
Total	1.53	1.52	1.38	1.52	1.42	1.25	1.49	1.41
Absorption								
Grams/day ^a	1.89	1.76	1.79	1.88	1.56	1.59	1.72	1.58
Percent of intake ^b	87.99	85.15	87.97	92.99	78.38	88.17	90.30	89.52
Retention								
Grams/day	.61	.50	.65	.42	.55	.56	.38	.36
Percent of intake	25.18	21.18	28.95	16.05	26.31	30.90	17.86	18.65
Percent of absorbed	28.29	23.90	32.38	17.28	29.78	36.13	20.65	22.57

^a Magnesium levels differ significantly ($P < .05$).

^b Potassium levels differ linearly ($P < .05$).

TABLE 7. PHOSPHORUS INTAKE, EXCRETION AND ABSORPTION IN LAMBS
FED DIFFERENT LEVELS OF MAGNESIUM (Mg) AND POTASSIUM (K)

Item	.1% magnesium				.2% magnesium			
	.6% K	1.2% K	2.4% K	4.8% K	.6% K	1.2% K	2.4% K	4.8% K
Intake (g/day)	1.84	2.64	2.44	2.23	2.84	2.52	2.44	2.36
Excretion (g/day)								
Fecal	1.24	1.21	1.25	1.55	1.09	.93	1.30	1.25
Absorption								
Grams/day ^a	.28	1.43	1.18	.68	1.75	1.59	1.14	1.11
Percent of intake ^a	15.27	43.53	40.13	19.81	53.03	55.30	41.87	43.15

^a Potassium levels differ linearly ($P < .05$).

TABLE 8. SERUM MINERAL LEVELS (mg/dl) IN LAMBS
FED DIFFERENT LEVELS OF MAGNESIUM AND POTASSIUM

Item	.1% magnesium				.2% magnesium			
	.6% K	1.2% K	2.4% K	4.8% K	.6% K	1.2% K	2.4% K	4.8% K
Magnesium ^{a,b}	2.34	2.22	2.12	2.00	2.48	2.35	2.51	2.25
Potassium ^b	22.41	22.79	23.81	24.10	21.86	22.19	22.59	23.66
Sodium ^c	384	376	407	373	377	404	405	396
Calcium ^b	8.52	9.01	8.14	7.88	9.03	8.18	8.59	8.50
Phosphorus	9.46	8.25	11.44	10.63	8.10	9.19	8.72	8.55

^aMagnesium levels differ significantly ($P < .05$).

^bPotassium levels differ linearly ($P < .05$).

^cPotassium levels differ quadratically ($P < .05$).

THE EFFECT OF EARLY NUTRITION ON FEET AND LEG CHARACTERISTICS
AND REPRODUCTIVE PERFORMANCE IN FIRST PARITY SOWS

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The swine industry has been plagued in recent years with structural unsoundness which has accounted for approximately 30% of the breeding herd being culled each year and poor reproductive performance. These two problems have been magnified by high intensity confinement conditions, selection of rapidly growing, heavy muscled hogs and perhaps nutritional inadequacies. The complexity of these problems are increased because one or more of these factors may be involved.

It was the objective of this study to determine the effects of two energy levels and two calcium and phosphorus levels fed during the growing and developing period on subsequent feet and leg characteristics and reproductive performance. This report will only deal with the first parity of one-third of the sows. The study is being continued for three parities.

Experimental Procedure

In the original study, 96 crossbred gilts were assigned to one of four nutritional treatments at weaning:

- I. Ad libitum intake with NRC levels of Ca & P.
- II. Ad libitum intake with 150% NRC Ca & P.
- III. 75% Ad libitum intake with NRC levels of Ca & P.
- IV. 75% Ad libitum intake with 150% NRC Ca & P.

There were six replications per treatment and four pigs per pen for a total of 24 pigs per treatment. Animals were reared in confinement on slotted concrete floors with water available throughout the study. At 100 kg the gilts were taken off of the above treatments and fed a standard ration.

Measurements were taken and the feet were characterized following the first parity. The gilts were randomly assigned as right-left or left-right denoting which fore and hind limb would be measured and characterized. Four measurements were taken on each foot (figure 1) using an Omega caliper calibrated in millimeters. The pads and horns of each toe of each foot were scored from 0 to 3 according to the absence or presence of lesions. A score of 0 indicated an absence of lesions while a score of 3 denoted severe lesions. A total of four scores were placed on each foot.

Leg bones were measured using a tape measure calibrated in centimeters. The joints were palpated to determine the endpoints of the bone prior to its being measured. Bone measurements included the lengths of metacarpals, metatarsals, ulna and tibia. In addition, the circumference of the metacarpals and metatarsals were measured.

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

The gilts were visually scored from 1 to 15 by a panel of three individuals. A score of 1 denoted a normal movement while a score of 15 exemplified an abnormal gait.

The reproductive data were also collected for analysis. Factors considered included: days to breeding, age at 1st estrus, estrus at 1st mating, number of services, number of breedings, estrus length, gestation length, days weaning to estrus, days weaning to breeding, age at slaughter, weight at slaughter, total pigs born, number born live, number live at 7 days, number live at 14 days, number live at 21 days, number live at weaning, number stillborn, number mummies, average birth weight, average weight at 21 days, average weaning weight, age at weaning, average weight of stillborns, sow weight before farrowing, sow weight after farrowing, sow weight at weaning, days farrowing to weaning and days before farrowing that the sow was weighed.

Results and Discussion

Feet and bone measurements. Sows previously ad libitum-fed had wider ($P < .05$) hind inside toes than restricted-fed sows (table 1). The same trend was evident for the outside toe, but the difference was not significant. Width of the front toes did not differ between energy levels. Length (measurement 1) and height (measurement 3) of the front and hind toes were not affected by energy levels. The overall length (measurement 4) of the front outside toe and the rear inside toe was less for ad libitum-fed sows.

Mineral level did not affect any of the toe measurements. The energy times mineral interaction was significant ($P < .05$) for the height of the front inside toe and the overall length of the rear outside toe. The height and length were reduced when the high level of minerals was used in combination with ad libitum-fed sows, but were increased when used in combination with restricted-fed sows.

The length of the ulna was less for the restricted-fed sows compared to the ad libitum-fed sows with no effect on length of the metacarpal, metatarsal and tibia, and circumference of the metacarpal and metatarsal (table 2). The energy times mineral interaction was significant for the circumference of the metatarsal indicating an increased length when the high mineral level was used in combination with ad libitum-fed sows and a decreased when the high mineral level was used in combination with restricted-fed sows.

The front pad scores appeared to be higher ($P < .10$) for both inside and outside toes when the high energy level had previously been fed, but the front outside horn scores were lower when the higher energy level had been fed (table 3). Rear pad and horn scores for the inside and outside toes were not significantly influenced by energy levels. The energy times mineral interactions was significant for the hind inside and outside pad scores. For the inside toe, pad scores were increased when the high mineral level was fed with ad libitum intake and was decreased when fed with restricted energy intakes. The reverse was true for the hind outside pad scores.

Breeding and farrowing data. Age at first estrus, number of breedings and days to breeding after weaning were not different between energy or mineral levels (table 4). Gestation length was longer ($P < .01$) for the gilts which were previously ad libitum-fed compared to restricted-fed gilts. Length of gestation tended ($P < .10$) to be longer for gilts previously fed the high level of minerals.

Total pigs born and the number of pigs alive at birth 7, 14 and 21 days was greater for gilts previously ad libitum-fed compared to restricted-fed gilts (table 5). Gilts previously fed the higher mineral level had a smaller number of total pigs born, and the number of live pigs at birth 7, 14 and 21 days was less. A significant energy times mineral interaction showed a large decrease in total pigs and live pigs at birth 7, 14 and 21 days when the high mineral level was used in combination with the ad libitum-fed gilts, but the mineral level had no effect when gilts were restricted-fed.

Average birth weight was not different between energy levels, but pigs at birth were heavier when the higher mineral level was fed. This difference was probably due to those gilts having smaller litters. Average weaning weight favored ($P < .10$) the ad libitum-fed gilts, but these gilts also had much smaller litters.

Sow weight after farrowing and at weaning was less ($P < .05$) for the gilts which had previously been restricted-fed. Gilts fed the higher mineral level tended ($P < .10$) to be heavier at weaning (table 6).

Structural soundness scores were lower for gilts which had been fed the higher level of minerals during development compared to gilts fed NRC levels (table 5). Differences between energy levels were not significant.

Summary

Feet and leg characteristics and reproductive performance of gilts which had been fed two energy levels, ad libitum and 75%, and two mineral levels, 100 and 150% NRC Ca and P, during development were compared. Ad libitum-fed sows had wider toes on the hind foot than restricted-fed sows, but there was no difference between energy levels for the front toes. Mineral levels did not affect the size of the toes. Energy and mineral levels did not consistently affect pad and horn scores on the front and hind feet.

Age at first estrus, number of breeding and days from weaning to estrus were not different between energy or mineral levels. Total pigs born and the number of pigs alive at birth 7, 14 and 21 days were decreased when the 150% NRC Ca and P level was used in combination with ad libitum-fed sows, but mineral level had no effect when gilts were restricted-fed. Average birth weight was not different between energy levels previously fed to gilts during development. Pigs farrowed from sows previously fed the 150% Ca and P levels were heavier, however, this difference may be explained by slightly smaller litter sizes. Gilts which had previously been restricted-fed weighed less after farrowing and at weaning. These are only preliminary results and the study is continuing.

TABLE 1. MEASUREMENTS (MM) OF FRONT (F) AND HIND (H), INSIDE (I) AND OUTSIDE (O) TOES FOR GILTS FED TWO LEVELS OF ENERGY AND TWO LEVELS OF MINERALS DURING DEVELOPMENT. MAIN EFFECTS^a

Item ^b	Energy		Minerals	
	Ad lib	75% Ad lib	100%	150%
FI1	23.03	22.52	23.26	22.29
FO1	24.64	24.53	24.80	24.37
HI1	22.06	21.96	21.97	22.05
HO1	25.15	25.67	25.43	25.39
FI2	26.73	26.28	26.48	26.53
FO2	29.68	29.29	29.59	29.38
HI2	23.63 ^c	22.43	23.13	22.93
HO2	28.79	27.50	28.36	27.94
FI3 ^d	45.20	43.74	44.57	44.36
FO3	46.08	45.22	46.10	45.21
HI3	45.82	46.02	45.63	46.21
HO3	47.95	49.28	49.09	48.14
FI4	54.90	53.82	54.53	54.20
FO4	57.51 ^e	55.39	56.41	56.49
HI4	57.35 ^e	54.64	55.68	56.31
HO4	61.03	61.14	60.96	61.21

^aLeast square means adjusted for weight (57 observations).

^bSee figure 1 for location of measurements.

^cSignificant ($P < .01$) for energy effect.

^dInteraction ($P < .05$) for energy and minerals.

^eSignificant ($P < .05$) for energy effect.

TABLE 2. LENGTH OF METACARPAL (ME), ULNA (U), CIRCUMFERENCE OF FORE LIMB (CIRCF), CIRCUMFERENCE OF HIND LIMB (CIRCH), LENGTH OF TIBIA (T) AND METATARSALS (MT) FOR GILTS FED TWO LEVELS OF ENERGY AND TWO LEVELS OF MINERALS DURING DEVELOPMENT. MAIN EFFECTS.^a

Item	Energy		Minerals	
	Ad lib	75% Ad lib	100%	150%
MC, cm	10.44,	10.21	10.38	10.27
U, cm	25.38 ^b	24.68	24.81	25.25
CIRCF, cm	23.57	23.60	23.61	23.56
CIRCH, cm ^c	21.05	20.78	20.87	20.96
T, cm	22.90	23.53	23.31	23.10
MT, cm	11.69	11.66	11.62	11.73

^aLeast square means adjusted for weight (57 observations).

^bTrend ($P < .10$) for energy difference.

^cInteraction ($P < .05$) for energy and minerals.

TABLE 3. FRONT (F) AND HIND (H) FOOT, HORN (H) AND PAD (P) SCORES FOR INSIDE (I) AND OUTSIDE (O) TOES FOR GILTS FED TWO LEVELS OF ENERGY AND TWO LEVELS OF MINERALS DURING DEVELOPMENT. MAIN EFFECTS^a.

Item	Energy		Minerals	
	Ad 11b	75% Ad 11b	100%	150%
FPI ^b	.27	.64	.58	.33
FPO ^b	.51	.87	.60	.78
FHI ^b	.19	.17	.10	.25
FHO ^b	1.29 ^c	.73	.93	1.09
HPI ^b	.29	.42	.31	.40
HPO ^{bc}	.98	1.17	1.02	1.13
HHI ^b	.07	.24	.03	.28
HHO ^b	1.12	1.26	1.15	1.23

^aLeast square means adjusted for weight (64 observations).

^bScores were assigned on basis of 0 indicating no lesions and 3 indicating severe lesions.

^cInteraction ($P < .05$) for energy and minerals.

TABLE 4. DAYS TO BREEDING (DTB), AGE AT FIRST ESTRUS (A1E), NUMBER OF ESTRUS AT FIRST MATING (E1M), NUMBER OF SERVICES (NS), NUMBER OF BREEDINGS (NB), ESTRUS LENGTH (EL), GESTATION LENGTH (GL), DAYS WEANING TO ESTRUS (DWTE), DAYS WEANING TO BREEDING (DWTB), AGE AT SLAUGHTER (AS), SLAUGHTER WEIGHT (SW) FOR GILTS FED TWO LEVELS OF ENERGY AND TWO LEVELS OF MINERALS DURING DEVELOPMENT. MAIN EFFECTS^a.

Item	Energy		Mineral	
	Ad 11b	75% Ad 11b	100%	150%
DTB	249.1(33) ^b	249.4(32)	249.2(32)	249.3(33)
A1E	219.0(35)	215.2(36)	217.5(35)	216.7(36)
E1M	2.4(33)	2.4(32)	2.3(32)	2.4(33)
NS	2.0(33)	2.0(32)	2.0(32)	2.0(33)
NB	1.2(33)	1.2(32)	1.2(32)	1.2(33)
EL	24.6(25)	27.5(30)	25.5(28)	26.6(27)
GL	116.2(29)	114.9(29)	115.2(27)	115.9(31)
DWTE	10.4(28)	11.5(24)	10.2(23)	11.7(29)
DWTB	10.4(28)	11.5(24)	10.2(23)	11.7(29)
AS	450.0(19)	476.8(26)	455.8(20)	471.0(25)
SW	277.6(19)	280.2(26)	286.5(20)	271.4(25)

^aLeast square means

^bNumber of observations per treatment in parenthesis.

^cSignificant ($P < .01$) for energy effects.

TABLE 5. PIGS BORN (PN), NUMBER BORN LIVE (NL), NUMBER LIVE 7 DAYS (NL7), NUMBER LIVE 14 DAYS (NL14), NUMBER LIVE 21 DAYS (NL21), NUMBER LIVE AT WEANING (NLW), NUMBER STILLBORNS (NST), NUMBER MUMMIES (NM), BA SCORE (BA), JC SCORE (JC), CB SCORE (CB) OF 1ST PARITY GILTS FED TWO LEVELS OF ENERGY AND TWO LEVELS OF MINERALS DURING DEVELOPMENT. MAIN EFFECTS^a.

Item	Energy		Minerals	
	Ad 1lb	75% Ad 1lb	100%	150%
PN ^b	7.0 ^c	8.6	8.6 ^c	7.0
NL	6.1	7.6	7.7 ^c	6.1
NL7	5.5	6.9	7.0 ^c	5.3
NL14	5.3	6.6	6.8 ^c	5.2
NL21	5.2	6.5	6.7 ^c	5.0
NLW	5.1	6.2	6.4	4.9
NST	.56	.75	.64	.67
NM	.17	.25	.18	.25
BA	5.89	6.47	6.71	5.64
JC	5.91	6.30	6.72 ^c	5.50
CB	6.05	6.26	6.49	5.81

^aLeast square means (62 observations).

^bInteraction (P < .05) for energy and mineral levels.

^cSignificant (P < .05) for energy or mineral effects.

TABLE 6. AVERAGE PIG BIRTH WEIGHT EXCLUDING STILLBORNS (ABW), AVERAGE STILLBORN WT (AW), AVERAGE WEIGHT AT 21 DAYS (AW21), AVERAGE WEANING WEIGHT (AWW), AGE AT WEANING (AGW), SOW WEIGHT BEFORE FARROWING (SWBF), SOW WEIGHT AFTER FARROWING (SWAF), AND SOW WEANING WEIGHTS (SWW) FOR 1ST PARITY GILTS FED TWO LEVELS OF ENERGY AND TWO MINERAL LEVELS DURING THE GROWING PERIOD. MAIN EFFECTS^a.

Item	Energy		Mineral	
	Ad 1lb	75% Ad 1lb	100%	150%
ABW	3.1(29) ^c	3.1(32)	2.9 ^b (29)	3.2(32)
AW ^d	2.5 ^b (11)	3.4(12)	2.7(12)	3.1(11)
AW21	11.4(26)	10.8(31)	10.9(28)	11.3(29)
AWW	17.8(26)	16.0(29)	16.4(27)	17.3(28)
AGW	32.8(26)	33.2(29)	33.6(27)	32.5(28)
SWBF	336.6(30)	327.5(31)	333.5(28)	330.5(33)
SWAF	320.3 ^b (29)	300.0(32)	306.1(28)	314.2(33)
SWW	289.0 ^b (28)	268.2(31)	270.3(27)	286.9(32)

^aLeast square means (61 observations).

^bSignificant (P < .01) for energy or mineral effects.

^cNumber of observations per treatment in parenthesis.

^dInteraction (P < .001) for energy and mineral effects.

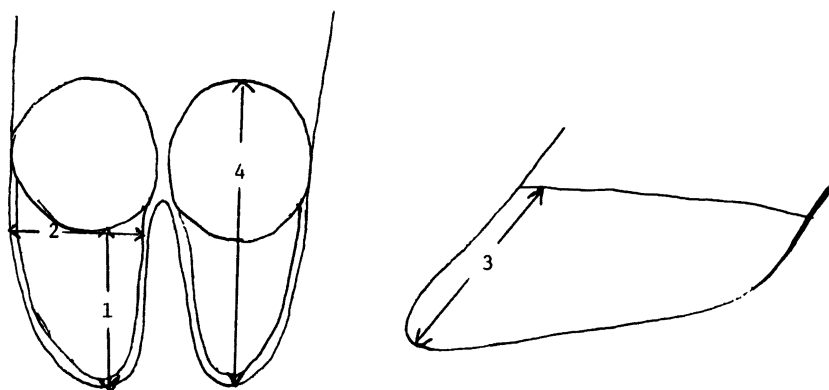


FIGURE 1. Measurements: (1) distance from distal periphery of the pad to the tip of the toe, (2) widest part of the toe along the distal periphery of the pad, (3) distance from the coronary band to the tip of the toe, and (4) distance from the proximal periphery of the pad to the tip of the toe.

METACARPAL AND METATARSAL CHARACTERISTICS OF SOWS AS INFLUENCED BY
RESTRICTED GROWTH RATE AND ELEVATED MINERAL LEVELS

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Structural unsoundness, leg weakness as sometimes called, remains an enigma to the swine industry. The demarcations of the causation of this leg weakness are poorly defined due to the complex interrelationships among various nutritional, structural, environmental, genetic and disease factors that may be involved.

Leg weakness appears to occur more frequently in breeding animals being selected by swine producers for fast growth and heavy muscling. Although these animals are probably being fed a balanced diet according to present NRC standards, they may, in actuality, have an increasing need for extra minerals and vitamins because of their rapid growth and heavier muscling.

A study was undertaken to determine the influence of increased calcium and phosphorus intake and reduced energy intake during growth and development on subsequent performance, bone development, structural soundness and reproductive performance of breeding sows. This report presents preliminary findings on bone characteristics of sows culled prior to completion of three parities. It includes gilts or sows that fail to display estrus, failed to conceive or became lame during the study.

Materials and Methods

Gilts in this study had previously been fed one of the four following dietary treatments from weaning to 100 kg:

- I. Ad libitum intake and NRC daily Ca and P.
- II. 75% of ad libitum intake and NRC daily Ca and P.
- III. Ad libitum intake and 150% NRC daily Ca and P.
- IV. 75% of Ad libitum intake and 150% NRC daily Ca and P.

After a body weight of 100 kg had been reached, all gilts were fed a common diet balanced for nutrients according to NRC standards. Initially three groups of 65 gilts each were selected for the reproductive study. The gilts were checked for estrus beginning at 150 ± 5 days of age and mated starting at 240 days of age. Animals remaining on the test are being studied for the remainder of three parities.

Gilts and sows that failed to display heat, conceive after three matings or became lame during the study were slaughtered. A complete necropsy was performed, and bones, joint sections and cultures were taken.

¹Appreciation is expressed to the John Lee Pratt Animal Nutrition Program for financial support; to Borden Chemical Co., Norfolk, VA and Calcium Carbonate Co., Quincy, IL for supplying ingredients; to Charlie Babb, Carl Eure and Paul Boone for caring for animals; and to Greg Kesel for his help in slaughtering and sampling.

This report will only present data on the middle metacarpal and metatarsal removed at slaughter. Once removed, the metacarpals and metatarsals were frozen at -20 C. The bones were then freed of all extraneous tissue and weighed. The following measurements were then taken on the bones using dial calipers: total bone length; narrow, perpendicular and wide dimension of the bone shaft; and the inside thickness of the bone shaft at the narrow, perpendicular, and wide dimension of the bone shaft. Bone breaking strength was determined and peak values were recorded using an Instron Universal Testing Machine. Stiffness, Young's modulus of elasticity and flexural modulus were calculated by procedures of Baker (1974)².

The bones were then bisected and the proximal half was crushed and dried for four days in a 70 C forced air oven. Percent ether extract and percent fat free ash were then determined.

The data were statistically analyzed by the least squares method adjusting for weight at slaughter. A comparison was made of metacarpal and metatarsal parameters.

Results and Discussion

Gilts ad libitum-fed during development had a wider ($P < .05$) metacarpal at the perpendicular dimension of the bone shaft compared to restricted-fed gilts, but other dimensions for the metacarpal and dimensions for the metatarsals were not different (table 1). Breaking strength, stiffness, Young's modulus of elasticity, flexural modulus, ether extract and ash values were not different between energy levels (table 2).

Increasing the mineral level to 150% of the NRC standards produced a metatarsal with thicker ($P < .05$) walls at the narrow and perpendicular dimension of the bone shaft (table 1) with a resultant greater ($P < .05$) breaking strength (table 2). Metacarpal differences were not as large and were non-significant ($P > .05$). Ether extract content of the metatarsal was lower ($P < .05$) for gilts fed 150% NRC minerals compared to those fed 100% NRC minerals, but the ash content was not different (table 2). Ether extract and ash content of metacarpals were not different between mineral levels.

A comparison of metacarpal and metatarsal parameters revealed that metatarsals were longer and heavier than the metacarpals, but the metacarpals were wider ($P < .05$) at the narrow and widest dimensions (table 1). Thickness at the narrow inside dimensions favored ($P < .10$) the metacarpals, but the thickness at the widest inside dimension was greater ($P < .05$) for the metatarsals. The energy times foot interaction approached significance ($P < .10$) for the narrow and perpendicular dimensions. Metacarpal dimensions were reduced more by reducing the energy level than were the metatarsals.

Breaking strength was greater ($P < .001$) for the metacarpals than for the metatarsals; however, stiffness, Young's modulus of elasticity and the flexural modulus were not different between metacarpals and the metatarsals.

²Stiffness measures the difficulty or ease of bending the bone. Young's modulus of elasticity indicates the bone's elasticity and flexural stress measures the bone's resistance to bending (Baker, J. L. 1974. Strength of Equine Bone and Tendon to Evaluate Diet and Anabolic Agent. Masters Thesis. Purdue University, Lafayette, IN).

The mineral times foot interaction was significant ($P < .01$) for breaking strength. Breaking strength of the metacarpals was not different between gilts fed 100 and 150% NRC minerals, but metatarsal breaking strength was increased when the diet containing 150% NRC minerals was fed. Ether extract and ash values were lower ($P < .01$) for metacarpals compared to metatarsals.

Summary

Preliminary findings on metacarpal and metatarsal characteristics of gilts fed two levels of energy and two levels of calcium and phosphorus showed that the feeding of elevated calcium and phosphorus (150% NRC) produced a stronger, thicker metatarsal containing less fat than that of gilts fed 100% NRC levels.

A comparison of metacarpal and metatarsal parameters revealed that metatarsals were longer and heavier than metacarpals, but metacarpals had a greater breaking strength.

TABLE 1. METACARPAL AND METATARSAL MEASUREMENTS FROM GILTS/SOWS FED TWO LEVELS OF ENERGY AND CALCIUM AND PHOSPHORUS DURING DEVELOPMENT. MAIN EFFECTS.^a

Variable	Energy		Mineral		SEM ^b
	Ad Lib	Restricted	NRC	150%	
No. of females	63	61	64	60	
Bone weight, g, F ^{c,d}	33.25	32.38	32.56 ^e	33.05	0.51
R ^c	34.04	33.66	33.39	34.32	0.54
Bone length, cm, F ^d	8.53	8.58	8.50	8.60	0.05
R	9.24 ^f	9.32	9.29	9.27	0.06
Narrow dimension, cm, F ^d	1.59 ^f	1.57	1.57	1.58	0.01
R	1.53	1.54	1.53	1.54	0.01
Perpendicular dimension, cm, F	1.86 ^{fg}	1.82	1.83	1.85	0.01
R	1.85	1.83	1.84	1.85	0.01
Widest dimension, cm, F ^d	2.11	2.10	2.10	2.11	0.02
R	1.99	1.95	1.94	1.99	0.02
Narrow inside, cm, F ^h	0.27	0.26	0.26	0.27	0.01
R	0.26	0.26	0.25 ⁱ	0.27	0.01
Perpendicular inside, cm, F	0.17	0.17	0.17 ^j	0.18	0.01
R	0.17	0.17	0.16 ⁱ	0.18	0.01
Widest inside, cm, F ^d	0.18	0.19	0.18	0.18	0.01
R	0.22	0.22	0.21	0.22	0.01

^aMeans adjusted for weight at slaughter (252 lb).

^bStandard error of the mean.

^cF = Front Foot; R = Rear Foot.

^dSignificant ($P < .01$) foot effect.

^eSignificant ($P < .05$) mineral x foot effect.

^fTrend ($P < .10$) for energy x foot effect.

^gSignificant ($P < .05$) energy effect.

^hTrend ($P < .10$) for foot difference.

ⁱSignificant ($P < .05$) mineral effect.

^jTrend ($P < .10$) for mineral difference.

TABLE 2. BREAKING STRENGTH, STIFFNESS, YOUNG'S MODULUS OF ELASTICITY, FLEXUAL MODULUS, ETHER EXTRACT AND ASH FROM GILTS/SOWS FED TWO LEVELS OF ENERGY AND CALCIUM AND PHOSPHORUS DURING DEVELOPMENT. MAIN EFFECTS.^a

Variable	Energy		Minerals		SEM ^b
	Ad Lib	Restricted	NRC	150%	
No. of females	63	61	64	60	
Breaking strength, lbs, F ^{c,d}	547.07	543.91	543.57 ^e	547.41	14.41
	467.81	466.79	447.31 ^f	487.29	12.03
Stiff, n/m, F ^g	65.39	63.51	62.92	65.97	1.81
	67.35	65.11	64.61 ^h	67.85	1.72
YME, Pa (x10 ⁶), F ⁱ	36.97	39.33	37.99	38.32	1.38
	39.24	38.54	38.52	39.26	1.34
FLEX, Nm ² (x10 ⁻²), F ^j	8.69	8.41	8.34	8.76	0.24
	8.93	8.62	8.56 ^h	8.99	0.23
Ether%, F ^d	24.43	23.83	24.88	23.38	0.93
	30.70	29.37	31.50 ^f	28.56	0.86
Ash%, F ^k	63.03	62.97	62.81 ^l	63.20	0.21
	63.41	63.62	63.42	63.62	0.18

^aMeans adjusted for weight at slaughter (252 lb).

^bStandard error of the mean.

^cF = Front Foot and R = Rear Foot.

^dSignificant (P < .001) foot effect.

^eSignificant (P < .05) mineral x foot effect.

^fSignificant (P < .05) energy or mineral effect.

^gStiff is defined as the slope of the force-deformation curve.

^hTrend (P < .10) for energy or mineral difference.

ⁱYME is Young's modulus of elasticity.

^jFLEX is the flexual modulus.

^kSignificant (P < .01) foot effect.

^lTrend (P < .10) for energy x mineral interaction.

OATS IN STARTER DIETS FOR WEANED PIGS

E. T. Kornegay¹ and K. L. Bryant

Pig starter diets are primarily based on corn and soybean meal with some dried whole whey recommended until the pig reaches about 25 pounds. Scouring has been reported by producers to be a major postweaning problem. Some recent research reports suggested that the addition of oats, a fibrous grain, to starter diets reduced the incidence of diarrhea and improved survival rate. It was reported in the 1979 Livestock Research Report that the addition of 10% soybean hulls, a by-product of the manufacture of de-hulled soybean meal which is high in fiber (32 to 35%), did not alter feed-lot performance. In this study there were no deaths and scouring was not a problem with any of the pigs.

The objective of the present study was to evaluate the use of ground whole oats in starter diets for weaned pigs housed in triple deck nurseries.

Experimental Procedures

Four trials, using 138 weaned pigs initially weighing 12 lb, were conducted to compare the performance of pigs fed a basal starter diet containing zero or 10% ground whole oats (table 1). There were six pigs per cage (3 ft x 4 ft or 4 ft x 4 ft) in trials 1, 3 and 4 and five pigs per 3 ft x 4 ft cage in trial 2. A 22% protein corn-soybean meal diet with 10% dried whole whey was fed until the average pen weight was 15 lb; then a 20% protein diet was fed to 25 lb; an 18% protein diet without the whey was fed for the remainder of the test. The 22% diet was reground using a hammermill with an 1.65 mm screen to prevent selective eating.

The cages were housed in an environmentally controlled triple deck nursery. A plywood mat or overlay was placed adjacent to the feeder in the front of each cage to encourage pigs to dung in the rear of the cage and to allow pigs a solid surface to lay on. Nipple waterer were located at the rear of the cage, which also encouraged pigs to develop a proper dunging pattern.

Pigs were weighed weekly. Cleanliness scores and dunging patterns were also noted on the weekly weigh day. Fecal firmness was scored each day. Daily gain, daily feed intake and feed per unit of gain were calculated. Trials 1, 2 and 3 lasted 6 weeks and trial 4 for 5 weeks. The data 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 and Summary

Daily gain, daily feed intake, feed per gain, cleanliness and fecal firmness scores were not different between pigs fed starter diets with zero or 10% ground whole oats during any weekly period and over the entire length

¹Appreciation is expressed to the VA Pork Industry Commission for partial financial support.

of the trial (table 2). Diarrhea was not a problem in these studies and no deaths occurred. In agreement several investigators from other universities (Arthur, 1979; Jesse, 1980; Rivera et al., 1978; Wahlstrom et al., 1977; Wahlstrom and Libal, 1979) found no benefit to the addition of oats to starter diets. However, to the contrary, other investigators (Moser, 1978; Real et al., 1977; Richards and Fraser, 1961) suggested that oats in the starter diet may have a protective effect against scours in early weaned pigs and may improve feedlot performance.

Wahlstrom and Libal (1979) reported a reduction in gain and feed efficiency when diets contained 30% or more oats. Sherry et al. (1978) reported increased deaths for pigs fed 15% oats compared to 5% oats. It was reported in last year's Livestock Research Report that the addition of 10% soybean hulls to a corn-soybean meal diet did not alter feedlot performance of pigs fed a basal corn-soybean meal diet.

In agreement with previously reported research at Virginia Tech, daily gain was similar for pigs housed on all decks; however, contrary to previous reports, feed intake and feed per gain was higher for pigs housed on the bottom deck compared to pigs housed on the top and middle decks. Cleanliness scores indicated that the pigs housed on the lower decks became more soiled as the study progressed and they became more crowded. The pigs dunged in the rear of the cages throughout the test, with no difference in fecal consistency between decks.

Results from these studies suggest that the addition of low levels of fiber to a corn-soybean meal diet was of no apparent benefit. Young pigs can tolerate low levels of fiber, but it is well known that high levels will result in decreased performance. A corn-soybean meal diet would contain 3 to 4% crude fiber.

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TABLE 1. COMPOSITION OF DIETS (%).

Item	Inter'l Ref. No.	Crude Protein, %					
		22 ^a		20 ^b		18 ^c	
		0% ^d	10% ^d	0%	10%	0%	10%
Ground corn	4-02-931	54.61	44.97	59.59	50.41	74.06	60.44
Soybean meal	5-04-612	32.71	32.35	27.73	27.73	23.37	22.99
Oats, whole	4-03-315	---	10.0	---	10.00	---	10.00
Limestone	6-02-632	.75	.75	.75	.75	.58	.58
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

^aCalculated to contain 22% protein, .80% Ca and .60% P (total).

^bCalculated to contain 20% protein, .79% Ca and .59% P (total).

^cCalculated to contain 18% protein, .64% Ca and .54% P (total).

^dPercent of whole oats.

^eContained (%): 20 Zn, 10 Fe, 5.5 Mn, 1.1 Cu and .15 I.

^fSupplied (per kilogram of premix): 1.76 g riboflavin, 8.8 g pantothenic acid, 8.8 g niacin, 8.8 mg vitamin B₁₂, 176 g choline chloride, 1,760,000 IU vitamin A, 176,000 IU vitamin D₃, 4400 IU vitamin E, 440 mg menadione dimethylprimidinal bisulfite (MPB) and 40 mg selenium.

^gContained (per kg of premix): 44 g chlortetracycline, 22 g penicillin and 44 g sulfamethazine.

TABLE 2. DAILY GAIN, DAILY FEED INTAKE, FEED PER GAIN, CLEANLINESS AND FECAL FIRMNESS SCORES OF PIGS FED A STARTER DIET CONTAINING ZERO AND TEN PERCENT GROUND WHOLE OATS.

Item	Diets ^a		Decks ^b		
	0% ^c	10% ^c	Top	Middle	Bottom
No of pigs	69	69	34	34	34
Avg initial wt, lb	12.0	12.0	12.8	12.7	12.7
Avg final wt, lb	39.6	40.3	42.3	41.9	41.7
Daily gain, lb	.70	.72	.73	.74	.75
Daily feed intake, lb	1.31	1.32	1.34	1.35	1.52
Feed per gain	1.89	1.84	1.83 ^d	1.82 ^d	2.04 ^e
Cleanliness score ^g	1.9	1.9	1.0 ^d	2.0 ^e	3.5 ^f
Fecal firmness score ^h	1.1	1.0	1.1	1.0	1.0

^a There were 12 cages per mean (6 pigs per cage in three trials and 5 pigs per cage in one trial).

^b There were 6 cages per mean (6 pigs per cage in two trials and 5 pigs per cage in one trial).

^c Ground whole oats.

^{d,f} Means within main effect on the same line are different (P < .05).

^g Cleanliness was scored from 1 to 5 (1 = clean and 5 = very dirty).

^h Fecal firmness was scored from 1 to 5 (1 = no scouring and 5 = very soft and watery).

INFLUENCE OF DIETARY CALCIUM AND PHOSPHORUS LEVELS AND GROWTH
RATE ON MINERAL CONTENT OF HAIR IN GILTS AND BARROWS OR BOARS¹

E. T. Kornegay², H. R. Thomas³ and H. S. Bartlett²

Human and animal clinicians continue to search for the biopsy material that is stable and easily acquired, transported, stored and analyzed, and which reflexes the nutritive status of the subject or animal in question. Hair has been proposed as such a material and has been studied more extensively in humans than in livestock.

The concentration of essential minerals in human, cattle and swine hair has been reported to be influenced by age, sex, season, breed, color and body location. The influence of diet on the concentration of essential minerals in hair is of considerable interest, but few controlled studies have been reported. Most studies reported have evaluated zinc and copper, and findings are controversial.

The purpose of this research was to evaluate the effects of dietary Ca and P and the influence of growth rate from birth to 60 to 70 days of age on the P, Ca, Mg, Cu, Fe, Mn, Na and K content of hair from gilts and barrows or boars.

Experimental Procedures

One hundred ninety-two barrows and gilts in trial 1 and 192 boars and gilts in trial 2 from slow or fast growth rate groups from birth to 60 to 70 days of age were used to evaluate the following dietary Ca and P combinations: 1) 100% NRC (1973) recommended Ca and P levels for barrows and gilts; 2) 125% Ca and P; 3) 100% Ca and 125% P; 4) 100% Ca and 75% P). Management, feeding and allocation to treatments have been described previously; animals were the same as used by Thomas and Kornegay (1980).

The initial hair sample was clipped from the right side of the pig with the final sample being taken from the same area. The hair samples were stored in plastic bags at room temperature until analysis. Sample preparation consisted of washing the hair in 10% Tween 80 and rinsing thoroughly with distilled, deionized water and then drying at 70 C in a forced air oven before wet ashing. Ca, Mg, Cu, Fe, Zn, Mn, Na and K were determined using a Perkin Elmer Model 403 Atomic Absorption Spectrophotometer. Phosphorus determinations were made colorimetrically according to A.O.A.C. (1965) methods. Laboratory procedures for serum minerals were described by Kornegay and Thomas (1980).

Data were analyzed for statistical significance by use of multivariate analysis of variance procedures with individual values used as the experimental unit. Duncan's multiple range test was used to determine sig-

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nificant differences among main treatment effects. Correlation coefficients were obtained from the residual sums of squares and sums of products. Thus, coefficients were corrected for treatment effects.

Results and Discussion

Some sex differences in the mineral content of hair were observed, but differences were usually not consistent from initial to final sampling and from trial to trial (tables 1 and 2).

With the exception of lower Cu in both trials and P in trial 2 for the fast growth rate group, the mineral content of final hair samples was not different between growth rate groups (tables 1 and 2). The initial hair content of Fe and Zn in trial 1 and P, Ca, Mg, Cu, Fe, Na and K in trial 2 were higher for the fast compared to the slow growth rate group. Pigs were assigned to growth rate groups based on daily gain from birth to 60 to 70 days of age.

The P content of hair was increased when 125% P was fed with 100 or 125% Ca but was not depressed when 75% P was fed with 100% Ca (tables 1 and 2). Dietary Ca and P did not consistently affect the Ca, Mg, Cu and Fe content of hair. The Zn and Mn content was not depressed when high Ca and P levels were fed, but the Zn and Mn content was increased when the low P levels was fed. There was little influence on dietary Ca and P levels on the Na and K content of hair.

Correlation coefficients of mineral hair values are presented in table 3. Very high positive correlation coefficients ($r < .7$) were observed between the Ca, Mg, Na and K content of hair; high positive coefficients ($r > .4 < .7$) were observed between the Mn content and the P, Ca, Mg, Fe, Na and K content; significant low positive coefficients ($r < .4$) were observed between the P content and the Ca, Mg, Cu, Fe, Na and K content, and the Cu and Mn content; significant low negative coefficients ($r < .3$) were observed between the Zn content and the Ca, Mg, Na and K content.

With the exception of Zn, the final level of all minerals was significantly correlated with the initial levels in trial 1 (table 3), but in trial 2 only Ca, Mg and Na levels were significantly correlated.

Correlation of hair minerals with daily gain, serum minerals and bone parameters revealed a few significant negative and positive coefficients, but the coefficients were generally very low ($r < .3$) and probably of little predictive importance. Values are not presented.

These results and other reports show that the mineral content of hair can be influenced by the dietary mineral levels fed, but that numerous factors can influence the response. The class and level of other minerals must be considered as they can be either complementary or antagonistic. Also age of animal and nutritive status influences results obtained. Sex, season, breed, color and body location have also been suggested as factors which could influence the mineral content of hair. With our present knowledge, the use of the mineral content of hair in accessing the mineral status of an animal appears to be of limited value.

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TABLE 1. HAIR MINERAL LEVELS OF BARROWS AND GILTS AS INFLUENCED BY GROWTH RATE AND DIETARY CALCIUM AND PHOSPHORUS LEVELS. TRIAL 1.

Items	Sex		Growth rate		Dietary Ca and P levels ^a			
	Barrows	Gilts	Fast	Slow	100% Ca 100% P	125% Ca 125% P	100% Ca 125% P	100% Ca 75% P
P, ppm								
Initial ^b	169	193	170	193	167	196 ^{de}	186 ^e	176 ^d
Final ^c	164	165	161	169	158 ^d	168 ^{de}	176 ^e	156 ^d
Ca, ppm								
Initial	501	525	550	477	493	482	523	556
Final	564	462	495	532	461	486	579	528
Mg, ppm								
Initial	100	97	97	100	98	100	104	92
Final	116	90	95	101	97	92	125	98
Cu, ppm								
Initial	10	10	10 ^f	10	10	10	10	10
Final	10	10	10 ^f	11	10	10	10	11
Fe, ppm								
Initial	44	47	42 ^f	49	43 ^d	48 ^e	45 ^d	47 ^d
Final	37	38	37	39	36 ^d	43 ^e	38 ^d	34 ^d
Zn, ppm								
Initial	222 ^g	189	193 ^f	217	209 ^{de}	218 ^{de}	200 ^d	195 ^e
Final	227	222	226	222	222 ^{de}	225	218 ^d	234 ^e
Mn, ppm								
Initial	6.1 ^g	7.9	6.6	7.5	6.7 ^{de}	7.1 ^d	7.0 ^{de}	7.4 ^e
Final	6.8	6.6	6.8	6.6	6.9 ^{de}	5.4 ^d	6.6 ^{de}	8.0 ^e
Na, ppm								
Initial	85 ^f	68	71	81	85	70	81	69
Final	117 ^g	86	101	103	99	92	102	113
K, ppm								
Initial	85	73	66	91	87	66	82	79
Final	153 ^g	95	117	132	115	101	142	139

^aTotal Ca and P, respectively for growing and finishing phases: 100% Ca & P - .65 and .50% Ca and .50 and .40% P; 125% Ca & P - .81 and .60% Ca and .63 and .50%; 100% Ca and 125% P - .65 and .50% Ca and .63 and .50% P; 100% Ca and 75% P - .65 and .50% Ca and .38 and .30% P.

^bMeans consisted of 24, 24 and 12 composite samples of 4 pigs each, respectively for sex, growth rate and dietary Ca & P levels.

^cMeans consisted of 96, 96 and 48 individual samples, respectively for sex, growth rate and dietary Ca & P levels.

^dWithin dietary Ca and P level, means on the same line with different superscript letters are significantly different (P < .05).

^fSignificant (P < .05) sex or growth rate effect.

^gSignificant (P < .01) sex or growth rate effect.

TABLE 2. HAIR MINERAL LEVELS OF BOARS AND GILTS AS INFLUENCED BY GROWTH RATE AND DIETARY CALCIUM AND PHOSPHORUS LEVELS. TRIAL 2.

Items	Sex		Growth Rate		Dietary Ca and P levels ^a			
	Boars	Gilts	Fast	Slow	100% Ca 100% P	125% Ca 125% P	100% Ca 125% P	100% Ca 75% P
P, ppm								
Initial ^b	163 ^d	143	139 ^d	167	149	152 ^f	158 ^f	153 ^f
Final ^c	166	159	155 ^d	170	143 ^e	172 ^f	165 ^f	169 ^f
Ca, ppm								
Initial	607 ^d	559	524 ^d	642	608	625 ^{fg}	517	582
Final	441 ^d	371	372	439	382 ^{ef}	431 ^{fg}	306 ^e	501 ^g
Mg, ppm								
Initial	227	222	205 ^d	244	227	242	203	226
Final	90 ^d	63	68	84	80	92	61	71
Cu, ppm								
Initial	13 ^d	12	12 ^d	13	13	13	12	12
Final	11 ^d	10	10 ^d	11	10	10	10	10
Fe, ppm								
Initial	36	33	31 ^d	37	33	36 ^{3f}	33	35 ^f
Final	39	37	38	39	38 ^{ef}	39 ^{3f}	33 ^e	43 ^f
Zn, ppm								
Initial	161	161	159	163	158	160 ^{ef}	164 ^{ef}	164 ^f
Final	196	193	191	198	191 ^e	194 ^{ef}	192 ^{ef}	202 ^f
Mn, ppm								
Initial	5.4 ^d	4.8	5.1	5.1	5.1	5.2	5.1	5.1 ^f
Final	6.2 ^d	4.9	5.2	5.8	5.2 ^e	5.1 ^e	5.2 ^e	6.5 ^f
Na, ppm								
Initial	163 ^d	113	108 ^d	168	131 ^{eg}	159 ^e	119 ^f	144 ^{ef}
Final	97 ^e	74	86	85	83	105	76	77
K, ppm								
Initial	188 ^d	123	121 ^d	190	149 ^{ef}	194 ^e	120 ^f	160 ^{ef}
Final	120	91	102	109	105 ^{ef}	137 ^e	81 ^f	97 ^{ef}

^aTotal Ca and P, respectively for growing and finishing phases: 100% Ca & P - .65 and .50% Ca and .50 and .40% P; 125% Ca & P - .81 and .60% Ca and .63 and .50% P; 100% Ca and 125% P - .65 and .50% Ca and .63 and .50% P; 100% Ca and 75% P - .65 and .50% Ca and .38 and .30% P.

^bMeans consisted of 24, 24 and 12 composite samples of 4 pigs each, respectively for sex, growth rate and dietary Ca & P levels.

^cMeans consisted of 96, 96 and 48 individual samples, respectively for sex, growth rate and dietary Ca & P levels.

^dSignificant (P < .01) sex or growth rate effect.

^{e,f}Within dietary Ca and P level means on the same line with different superscript letters are significantly different (P < .05).

TABLE 3. CORRELATION COEFFICIENTS OF THE MINERAL HAIR VALUES. TRIALS 1 AND 2.

Items	Mineral ^a								
	P	Ca	Mg	Cu	Fe	Zn	Mn	Na	K
P, Trial 1	1.00	.21**	.31***	.30***	.27***	.14 ^T	.50***	.42***	.32***
Trial 2	1.00	.35***	.35***	.17*	.18*	.13 ^T	.56***	.25**	.23**
Ca, Trial 1		1.00	.96***	-.18*	.09 ^T	-.29***	.43***	.70***	.82***
Trial 2		1.00	.88***	.04	.13 ^T	-.16*	.48***	.72***	.81***
Mg, Trial 1			1.00	-.16*	.14 ^T	-.30***	.48***	.76***	.86***
Trial 2			1.00	.09	.17*	-.21**	.53***	.79***	.86***
Cu, Trial 1				1.00	.28***	.34***	.22**	-.03*	-.10 ^T
Trial 2				1.00	.12	.02	.20	.17	.15 ^T
Fe, Trial 1					1.00	.06	.40***	.15 ^T	.11
Trial 2					1.00	-.06	.40***	-.01	.01
Zn, Trial 1						1.00	.01*	-.22 ^T	-.27*
Trial 2						1.00	-.15	-.14 ^T	-.18*
Mn, Trial 1							1.00	.56***	.49***
Trial 2							1.00	.38***	.39***
Na, Trial 1								1.00	.94***
Trial 2								1.00	.97***
Initial vs									
Final,									
Trial 1	.37*	.79***	.79***	.55***	.40*	.17	.46***	.47***	.69***
Trial 2	.06	.69***	.49**	.04	-.25	.23	.33 ^T	.44*	-.04

*** (P < .001), ** (P < .01), * (P < .05), ^T (P < .10).

^aCorrelation of individual values: 192 pigs in each trial.

^bCorrelation of pen values: 48 pens in each trial.

INTERRELATIONSHIPS OF VARIOUS FEEDLOT PERFORMANCE, SERUM MINERALS,
STRUCTURAL SOUNDNESS AND BONE PARAMETERS IN BARROWS, BOARS AND GILTS¹

E. T. Kornegay², H. R. Thomas³, J. H. Carter³, L. B. Allen²,
C. C. Brooks³ and K. H. Hinkelmann⁴

Numerous interrelationships have been speculated to exist among various feedlot performance, serum minerals, structural soundness and bone parameters, yet there is little scientific data to support or refute.

A positive relationship between growth rate and the incidence and severity of joint lesions (leg weakness) was reported for genetically selected fast and slow growing lines of boars (Grondalen and Vangen, 1974) and in boars in which growth rate was reduced by restricting feed intake (Reiland, 1976). However, Nakano *et al.* (1979) reported no significant relationship between growth rate and the incidence and severity of joint lesions. Miller *et al.* (1976) observed that soundness of the rear legs was negatively correlated with daily gain; whereas, Drewry (1975) found a small positive relationship between visual soundness index and daily gain. Thus, the evidence is limited and inconclusive to support the belief that the faster growing pigs are less structurally sound.

Fritschen *et al.* (1971) and Fritschen and Underdahl (1971) reported a negative linear relationship between daily gain and metatarsal breaking strength; whereas, Cromwell *et al.* (1974) and Parker *et al.* (1975) found no relationship between growth rate and metatarsal or humerus breaking strength and metatarsal ash.

A significant negative correlation has been reported between daily gain and feed per unit of gain suggesting that the faster gaining boars were more efficient (Miller *et al.*, 1976; Hines and Conley, 1976).

The objective of the research reported herein was to determine the interrelationships between feedlot performance, serum minerals, structural soundness and bone parameter in barrows, boars and gilts.

Experimental Procedure

Performance, serum minerals, soundness scores, and bone data collected on barrows, boars and gilts in studies reported by Kornegay and Thomas (1980), Kornegay *et al.* (1980) and Thomas and Kornegay (1980) were subjected by sex in each trial to multivariate analysis of variance. Detailed experimental procedures were described previously. Correlation coefficients were obtained from the residual sums of squares and sums of products. Thus, coefficients were corrected for treatment effects. The number of animals for each trial were: Gilt 1 (96), Gilt 2 (96), Gilt 3 (96), Barrow 1 (96), Barrow 2 (96), Boar 1 (96), Boar 2 (192). Animal values were used for comparisons except those involving DF and FG, in which case pens were used.

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Results and Discussion

Correlation coefficients are presented in table 1. Average daily gain from birth to eight weeks of age was not significantly correlated with the overall daily gain on test which suggests that early growth rate or weight at about eight weeks of age is a poor predictor of the later growth rate.

High positive correlation coefficients ($P < .01$) were observed between daily gain (DG) and daily feed intake (DF) in all trials. These high phenotypic correlations agree well with genetic correlations reported in the literature. There appeared to be no relationship between DG and feed per gain (FG); however, DF was positively correlated with FG. These data show that pens of pigs which eat more grow faster. Although there was no relationship between DG and FG, pens of pigs having the greatest DF were the least efficient. However, reports in the literature suggested that faster gaining boars were more efficient.

Serum calcium levels (SCa) were not correlated with DG, DF and FG. Although a few significant coefficients were observed between DG, DF and FG and serum phosphorus (SP) and serum magnesium (SMg), in general, coefficients were low indicating only weak relationships.

There was no relationship between DG and soundness scores or pad scores. Although there were some inconsistencies, a positive relationship was observed between DG and metacarpal dried weight and breaking strength. Little, if any, relationship appeared to exist between daily feed intake and feed per gain and bone parameters. Serum Ca, P and Mg were not consistently related to metacarpal dried weight, breaking strength or ash. Dried weight was positively correlated to breaking strength in four trials and to ash in two trials. Breaking strength was only correlated to ash in one trial.

The lack of significant correlation coefficients between growth rate and structural soundness score agrees with the suggestion of Bereskin (1979) that selection for rapid growth in pigs does not appear to be a hindrance to soundness. Further, these results although not in complete agreement offer some support for a positive relationship between growth rate and bone weight and breaking strength. However, there was no relationship between growth rate and ash as a percent of dried fat-free bone. There appeared to be little, if any, relationship between daily feed intake and feed per gain and the bone parameters.

Serum P levels were positive correlated with growth rate which suggests that high serum P levels are compatible with a fast growth rate; however, there appeared to be no relationship between serum P and bone parameters. The lack of a significant relationship between breaking strength and ash was surprising.

These results offer no support for the belief that stronger, more dense bones produce more structurally sound animals. Kornegay and Thomas (1980) and Kornegay *et al.*, (1980) reported that dietary Ca and P levels did not influence soundness scores of barrows, boars or gilts.

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Table 1. Correlations Coefficients for Feedlot Performance, Serum Minerals, Soundness Scores and Bone Parameters in Gilts, Barrows and Boars Fed Varying Dietary Calcium and Phosphorus Levels

Item	Sex and trial						
	Gilts ₁	Gilts ₂	Gilts ₃	Barrow ₁	Barrow ₂	Boar ₁	Boar ₂
DGB vs DG	.23	.03	-.10	.11	.15	.14	-
DG vs DF	.83***	.90***	.92***	.86***	.87***	.78***	.48***
FG	-.16	.22	.44	-.10	.15	.14	-.06
SCa	.12	-.10	-.04	.03	.03	.01	.02
SP	.46***	.32**	-.17	.21*	.24*	-.06 ^T	-.05
SMg	-.33***	.11	-.17	-.36***	-.03	-.20 ^T	.13
CS	.14	-.09	-.05	.18 ^T	.09	.01	.19*
PS	-.04	-.02	.20 ^T	.11	.09	.02	-.01
DW			.32**	-.28**	.28**	.26*	-.01
BS			.23*	-.23*	.23*	.25*	-.16
Ash			.17	-.17	-.01	.16	-.11
DF vs FG	.42 ^T	.62**	.76**	.41	.61**	.72***	.64***
SCa	.40	.32	-.20	.09	.22	-.25	-.18
SP	.62**	.13	.20	.42 ^T	.03	-.33	.08
SMg	-.51*	.29	.04	-.53*	-.09	-.27	-.13
CS	.46 ^T	-.18	.03	.21	-.42*	.17	-.10
PS	.12	-.28	.27	.23	.41	.01	.01
DW			.24	-.55*	.23	.50*	-.05
BS			.18	-.47 ^T	.57*	.28	-.28 ^T
Ash			.41 ^T	.06	-.20	.53*	-.02
FG vs SCA	-.17	.21	.11	.23	.51*	-.20	-.18
SP	-.09	-.24	.17	.10	-.10	-.25	.08
SMg	.07	.43 ^T	.12	.18	.06	.18	-.13
CS	.06	.24	-.03	-.16	-.52*	.16	-.26
PS	-.60*	-.03	.20	.01	.27	.02	.01
DW			-.03	-.14	.12	.11	-.05
BS			-.02	.22	.37	.17	-.28 ^T
Ash			.06	.30	-.04	.63**	.02
SCa vs SP	.12	-.04	.07	-.18 ^T	.06	.16	.01
SMg	.09	.35***	.34**	-.01	.19 ^T	.44***	.56***
CS	.09	-.02	-.02	-.29**	-.34	-.14	.03
PS	-.02	-.15	.19 ^T	-.19	-.05	.10	-.18*
DW			.07	-.01	-.15	.11	-.07
BS			.10	.13	.06	.11	.15 ^T
Ash			-.22*	-.06	-.10	-.06	.25**
SP vs SMg	-.05 ^T	.01	.22*	.19 ^T	-.01	.06	.10
CS	.19 ^T	-.13	.15	.06	-.10	.04	.15 ^T
PS	-.12	-.08	-.10	.05	.23*	.27*	-.02
DW			.01	.06	.13	.23*	-.11
BS			-.06	-.15	-.03	.18	-.03
Ash			.10	-.20 ^T	-.14	.28**	-.24**
SMg vs CS	.02	-.08	.10	.03	-.07	.03	.01
PS	.01	-.16	.12	.07	-.04	.17	-.22
DW			.05	.27*	.02	.05	-.21**
BS			-.02	.12	.01	.12	.07
Ash			-.30**	.03	-.01	.11	.01
CS vs PS	.14	.28**	-.09	.18	.05	.24*	.07
DW			-.13	-.16	-.04	.04	.04
BS			-.02	.07	-.04	-.08	-.13
Ash			.15	.05	-.02	-.10	-.05
PS vs DW			.12	-.02	.16	.26*	-.23**
BS			.03	-.01	-.03	.16	.01
Ash			-.09	.12	.13	.08	.03
DW vs BS			.33**	.15	.22*	.47***	.15 ^T
Ash			.21 ^T	.01	.01	.22*	.01
BS vs Ash			-.01	.11	.04	.16	.19*

Individual values were used for daily gain from birth (DGB), daily gain (DG), serum Ca (SCa), serum P (SP), serum Mg (SMg), committee soundness score (CS), pad score (PS), dried metacarpal weight (DW), metacarpal breaking strength (BS) and metacarpal ash; pen means were used for daily feed (DF) and feed per gain (FG) and for other parameters when correlated with DF and FG. All values adjusted for treatment effects.
 *(P < .01); ***(P < .001); ^T(P < .10).

PALATABILITY AND DIGESTIBILITY OF ANIMAL, VEGETABLE AND BLENDED FATS BY EQUINE¹

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The addition of fat to poultry and certain livestock rations for its caloric value has become a widely used practice. It is particularly critical for the horse industry, which is primarily a recreational enterprise, to develop new systems or modify conventional feeding systems to minimize the use of grain. Currently corn and oats supply the energy in most horse concentrates. The main source of energy in these grains is carbohydrates. Fats and oils supply 2.25 times as much energy as carbohydrates. Therefore, it appears that one way to increase the energy intake of the horse is to incorporate this concentrate source of energy.

Experimental Procedure

Single Mixture Palatability Experiment.

A series of ration formulation and palatability trials were conducted to establish preference and ranking of ten selected fats and oils. Detailed results of these trials were reported in V.P.I. & S.U. Res. Div. Rep. 175 (1979). The ten fats were ranked (table 1) according to preferences by eight Saddlebred horses in cafeteria palatability trials.

In order to obtain a direct comparison of the relative palatability of the most preferred fat from each classification, (animal, vegetable, blend), three trials were conducted with individually fed geldings and fillies. The four geldings and four fillies were allotted to concentrate mixtures containing 15% corn oil, blend no. 3, peanut oil and inedible tallow. Prior to beginning of the measurement of consumption, the amounts of concentrate mixtures were increased gradually until all horses refused some. Measurements were then recorded for 10 days. The animals were reallocated to the diets after each trial with the restriction that no animal receive the same diet during two successive trials.

Digestion Experiments

In the digestion experiments mature gelding ponies weighing approximately 240 kg equipped with harness and collection bags, were used. Each trial consisted of a 7-day transition period, a 7-day preliminary period and a 7-day period during which total fecal collections were made. Each animal was fed 2000 g of the experimental diet twice daily at 12 hr intervals. Animals were exercised at a medium walk for 45 min each day at a constant speed on a mechanical walker.

Digestion Experiment I. Eight ponies were assigned to two groups of four on the basis of weight. The animals within each group were randomly allotted to the four columns of two 4 X 4 Latin squares. Diets with the following fats were used: 1-None (Control); 2-Corn oil; 3-Inedible tallow; 4-Animal-vegetable blend no. 3. The fats were included in the diet at 10%. The ingredient composition of the diets is shown in table 2.

¹Supported by John Lee Pratt Animal Nutrition Program. Some ration ingredients were supplied by Jacob Stern & Sons, Inc., Jenkintown, PA, Planters Peanuts, Suffolk, VA and Best Foods, Union, NJ.

Digestion Experiment II. This experiment was conducted to study the digestibility of diets containing different levels of different fats. Diets were formulated to contain 0, 7.5 and 15% added corn oil, peanut oil, blend no 3 and inedible tallow. Four trials were conducted with nine ponies. The animals were allotted to the nine experimental diets for each trial, with the restriction that no animal receive the same diet in successive trials. The ingredient composition of the diets is shown in table 3.

Results

Single Mixture Palatability Experiment

As shown in table 4, when the animals were allowed access to single fat mixtures only, the results differed from those found in the cafeteria trials. It appeared that all fat mixtures were consumed in similar amounts. Although inedible tallow was ranked next to last in the cafeteria trials, it tended to be consumed in greater amounts than corn oil in the single mixture palatability trials. It appears that horses prefer diets containing corn oil when given a choice. However, when the animals were offered only one diet, it was readily consumed in quantities equal to or greater than the diet containing corn oil. In conclusion, all the highest ranked fats from the palatability trials were consumed in similar amounts when the horses were not given a choice.

Digestion Experiment I.

The apparent digestibility of dry matter, crude protein, ether extract and Van Soest components are given in table 5. There was no significant change in the dry matter digestibility from the addition of fat to the diet, but there was a trend for the corn oil diet to have the highest digestibility. The apparent digestibility of crude protein of the diet containing corn oil was higher ($P < .05$) than for diets containing blend no. 3 or inedible tallow. Crude protein digestibility of the basal diet was intermediate and not different from the corn oil or other diets. The apparent digestibility of ether extract was increased ($P < .05$) by the addition of all three fats. The average values were 47.9, 81.4, 78.7 and 79.7% for the diets containing no fat, corn oil, blend no. 3 and inedible tallow, respectively.

Apparent digestibility of cell contents for the diets containing no fat, blend no. 3 and inedible tallow were similar (70.91, 71.28 and 69.37% respectively). However, the value for the diet containing corn oil tended to be higher (73.24%). Neutral detergent fiber digestibility was higher ($P < .05$) for diets containing no fat and corn oil, compared to the diets containing blend no. 3 and inedible tallow. Although the digestibility for acid detergent fiber was not significantly different between diets, there was a trend for lowered digestibilities for diets containing inedible tallow and blend no 3.

The apparent digestibility of the fatty acids in the diets was increased ($P < .05$) by the addition of the three fats (table 6). The diet with corn oil had the highest diet fatty acid digestibility ($P < .05$). Values for the diet with blend no. 3 tended to be higher than for the diet with inedible tallow. When calculated by difference, the digestibility of fatty acids in the fat followed similar trends as the values for the diet fatty acids digestibility. When the digestibilities were corrected for metabolic fecal fat, the true digestibility of the fatty acids in the diet containing corn oil increased ($P < .05$) approximately 25 percentage units over the value for the basal diet. Values for the diets containing inedible tallow and blend no. 3 were similar, but were much lower than the value for the corn oil diet. From the true digestibility data it appears that the fatty acids in corn oil, when included in a diet at the 10% level, are more digestible than those in inedible tallow or blend no. 3.

The apparent digestibility of energy in the diet increased ($P < .05$) with the addition of 10% corn oil (table 7). The values for the other two fats were similar to those for the basal, with inedible tallow being slightly higher. When the apparent digestibility of energy in the fat was calculated by difference, the energy in corn oil was 95.4% digestible. The values for the two other fats were much lower.

The apparent absorption of calcium tended to be highest for the basal diet, but the differences were not significant (table 8). Apparent absorption of phosphorus was low for all diets and was not affected by the addition of fat. The apparent magnesium absorption was not significantly different among diets, but the value for the blend no. 3 diet tended to be lower.

Digestion Experiment II

The apparent digestibilities of proximate and Van Soest components are shown in table 9. Significant differences ($P < .05$) were noted between fat levels for the digestibility of dry matter. Diets containing peanut oil had higher ($P < .05$) dry matter digestibility than diets containing inedible tallow. The digestibility of dry matter for diets containing corn oil and blend no. 3 was intermediate. The apparent digestibility of crude protein varied from 75.9% to 83.8 and showed no significant effects due to the addition, type or level of fat. The apparent digestibility of ether extract in the basal diet was lower ($P < .05$) than for the diets with added fats. All diets containing 15% fat had higher ($P < .05$) ether extract digestibilities than did diets containing 7.5% fat.

The apparent digestibility of cell contents was highest ($P < .05$) for the diet containing peanut oil and similar among other diets. The apparent digestibility of neutral detergent fiber followed the pattern of cell contents. The apparent digestibility of acid detergent fiber was not affected by the addition of fat to the diets, however, the values tended to be higher for the diets with added fat.

The addition of fat to the diet significantly increased the apparent digestibility of fatty acids (table 10) over that of the basal diet. Among the fat containing diets, corn oil diets had greater apparent fatty acid digestibilities than diets containing inedible tallow and blend no. 3. Values for the peanut oil diets were intermediate and not different from those for the other fat diets. The 15% fat diets had consistently higher ($P < .05$) fatty acid digestibilities than the 7.5% diets. When the apparent digestibility of the fatty acids in the diets was calculated by difference, differences among fats or levels of fat were not significant. However, the average values were higher for corn oil and peanut oil diets. The true digestibilities ranged from 84.3% for the 15% corn oil diet to 71.7% for the basal, but these differences were not significant due to the large amount of animal variation.

The apparent digestibility of energy in the diet was higher ($P < .05$) for diets containing corn oil than diets containing inedible tallow or blend no. 3 (table 11). The digestibility of energy in the peanut oil diet was intermediate and not significantly different from that for the other fat diets. When calculated by difference, the digestibility of energy was not significantly affected by kind or level of fat. However, values were highest for corn oil and lowest for inedible tallow and blend no. 3. These data indicate that the energy contained in vegetable oils is more digestible than animal sources of fat.

The apparent absorption of calcium, phosphorus and magnesium are presented in table 12. The apparent absorption of calcium was highest for animals fed the diets containing corn oil ($P < .05$) and lowest for those fed diets containing inedible tallow. There was no depression of calcium absorption due to type or level of fat. The apparent absorption of phosphorus was not affected by type or level of added fat. Apparent absorption of magnesium was higher ($P < .05$) for the basal diet than for the diet containing blend no. 3. There were no significant differences among fats or levels of fats, but values tended to be lower for the diets containing the fats.

TABLE 1. RANKING OF TEN FATS BASED ON INTAKES RELATIVE
TO CORN OIL

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

TABLE 2. INGREDIENT COMPOSITION OF DIETS. DIGESTION EXPERIMENT I

Ingredient	IRN	Fat, % of diet ^a	
		0	10
		----- kg/day -----	
Alfalfa hay, sun-cured, mid-bloom	1-00-063	1.18	1.05
Beet pulp, sugar, dehy.	4-00-669	.47	.44
Sugarcane molasses, dehy.	4-04-695	.23	.21
Corn, grain	4-02-931	1.06	.95
Oats, grain	4-03-309	1.06	.95
Fat		--	.40

^aFat level calculated as percent on as fed basis.

TABLE 3. INGREDIENT COMPOSITION OF DIETS.
DIGESTION EXPERIMENT II

Ingredient	IRN	Fat, % of diet ^a		
		0	7.5	15.0
-----kg/day-----				
Alfalfa hay, sun-cured, early bloom	1-00-059	.93	.86	.79
Wheat bran	4-05-190	.47	.43	.40
Corn cobs, grnd	1-02-782	.35	.33	.30
Cane molasses	4-04-6966	.35	.33	.30
Corn grain	4-02-931	.93	.86	.79
Oats grain	4-03-309	.93	.86	.79
Dicalcium phosphate	6-01-080	.04	.03	.03
Fat		--	.30	.60
		4.00	4.00	4.00

^aFat level expressed as percent on as fed basis.

TABLE 4. CONSUMPTION OF CONCENTRATES MIXTURES WITH
DIFFERENT KINDS OF FATS

Kind of fat	Level of fat	Consumed ^a	
		G/day	Percent of total
	%		
Corn oil	15.0	4607	27.3
Inedible tallow	15.0	4794	28.4
Peanut oil	15.0	3736	22.1
Blend no. 3	15.0	3740	22.2

^aEach value the mean of six animals.

Table 3. Apparent Digestibility of Components by Ponies Fed Diets Containing Different Fats.
Digestion Experiment I.

Kind of fat	Level of fat	Component					
		Dry matter	Crude protein	Ether extract	Cell contents	Neutral detergent fiber	Acid detergent fiber
	%	%	%	%	%	%	%
None (basal)	0	72.1	74.9 ^{ab}	47.9 ^a	70.91	57.45 ^a	53.09
Corn oil	10	73.0	76.7 ^b	81.4 ^b	73.24	56.40 ^a	54.08
Blend no. 3	10	71.0	71.9 ^a	78.1 ^b	69.37	49.16 ^b	46.91
Inedible tallow	10	70.6	70.2 ^a	79.7 ^b	71.28	53.08 ^{ab}	49.55

^{a,b} Means in the same column with different superscripts are different (P<.05).

TABLE 6. DIGESTIBILITY OF FATTY ACID BY PONIES FED DIETS CONTAINING DIFFERENT FATS. DIGESTION EXPERIMENT I.

Kind of fat	Level of fat %	<u>Apparent digestibility</u>		True digestibility ^b %
		Diet %	Fat ^a %	
None (basal)	0	44.43		69.73 ^c
Corn oil	10	75.60 ^d	95.42 ^c	94.62 ^d
Inedible tallow	10	68.54 ^e	71.43 ^d	73.48 ^e
Blend no. 3	10	69.04 ^e	75.44 ^d	74.19 ^e

^a Calculated by difference (Crampton and Harris, 1969).

^b Calculated using Bryant's (1969) equation.

^{c,d,e} Means in the same column with different superscripts are different (P<.05).

TABLE 7. APPARENT DIGESTIBILITY OF ENERGY BY PONIES FED DIETS CONTAINING DIFFERENT FATS. DIGESTION EXPERIMENT I

Kind of fat	Level of fat %	Apparent digestibility	
		Diet	Fat
Basal (none)	0	69.35 ^a	
Corn oil	10	74.42 ^b	94.43
Blend no. 3	10	69.67 ^a	70.38
Inedible tallow	10	70.43 ^a	74.36

^{a, b} Means in the same column with different superscripts are different (P<.05).

^cCalculated by difference.

TABLE 8. APPARENT ABSORPTION OF MINERALS BY PONIES FED DIETS CONTAINING DIFFERENT FATS. DIGESTION EXPERIMENT I.

Kind of fat	Level of fat %	Mineral		
		Calcium %	Phosphorus %	Magnesium %
None (basal)	0	27.5	8.5	27.9
Corn oil	10	24.9	9.7	29.1
Blend no. 3	10	21.0	1.5	21.6
Inedible tallow	10	11.6	12.2	26.4

TABLE 9. APPARENT DIGESTIBILITY OF COMPONENTS BY PONIES FED DIETS CONTAINING DIFFERENT LEVELS OF VARIOUS FAT. DIGESTION EXPERIMENT II.

Kind of fat	Level of fat	Apparent digestibility of components					
		Dry matter ^a	Crude protein	Ether extract ^a	Cell contents	Neutral detergent fiber	Acid detergent fiber ^a
	%	%	%	%	%	%	%
None (basal)	0	74.90 ^{b,c}	79.11	70.46 ^b	66.85 ^b	44.31 ^b	41.67 ^b
Corn oil	7.5	73.68 ^{b,c}	76.26	80.58 ^c	63.69 ^b	42.68 ^b	40.59 ^c
	15.0	75.58 ^{b,c}	77.54	90.19 ^c	67.80 ^b	46.75 ^b	45.86 ^c
Peanut oil	7.5	73.63 ^b	76.83	82.82 ^c	60.07 ^c	54.50 ^c	52.92 ^c
	15.0	81.00 ^b	83.83	94.22 ^c	80.14 ^c	72.23 ^c	71.59 ^c
Inedible tallow	7.5	71.23 ^c	75.99	77.82 ^c	58.11 ^b	43.13 ^b	39.26 ^c
	15.0	74.20 ^c	76.54	87.15 ^c	56.37 ^b	48.29 ^b	46.68 ^c
Blend no. 3	7.5	74.38 ^{b,c}	77.32	79.78 ^c	62.72 ^b	46.42 ^b	44.61 ^c
	15.0	74.29 ^{b,c}	75.91	84.57 ^c	63.56 ^b	51.46 ^b	50.76 ^c

^aDifferences between fat levels ($P < .05$).

^{b,c}Values with different superscripts (levels of fat combined) are different ($P < .05$).

TABLE 10. DIGESTIBILITY OF FATTY ACIDS BY PONIES FED DIETS CONTAINING
DIFFERENT LEVELS OF VARIOUS FATS. DIGESTION EXPERIMENT II^a

Kind of fat	Level of fat %	Apparent digestibility ^c		True digestibility ^b %
		Diet ^c %	Fat ^a %	
None (basal)	0	51.62 ^f		71.66
Corn oil	7.5	74.82 ^d	84.90	83.70
	15.0	80.24 ^d	87.07	84.32
Peanut oil	7.5	70.31 ^{d,e}	78.49	77.59
	15.0	79.27 ^{d,e}	86.28	83.24
Inedible tallow	7.5	64.06 ^e	70.23	72.35
	15.0	72.73 ^e	77.65	77.09
Blend no. 3	7.5	68.74 ^e	76.32	75.68
	15.0	71.00 ^e	75.80	75.54

^aCalculated by difference (Crampton and Harris, 1969).

^bCalculated using Bryant's equation (1969).

^cDifference between fat levels ($P < .05$)

^{d,e,f}Values with different superscripts (levels of fat combined) are different ($P < .05$).

TABLE 11. APPARENT DIGESTIBILITY OF ENERGY BY PONIES FED DIETS CONTAINING
DIFFERENT LEVELS OF VARIOUS FATS. DIGESTION EXPERIMENT II.

Kind of fat	Level of fat %	Apparent digestibility,%	
		Diet ^b %	Fat ^a %
None (basal)	0	56.33 ^c	
Corn oil	7.5	72.14 ^d	86.82
	15.0	77.56 ^d	90.07
Peanut oil	7.5	70.28 ^{d,e}	81.66
	15.0	71.87 ^{d,e}	84.42
Inedible tallow	7.5	65.53 ^e	72.53
	15.0	69.43 ^e	75.68
Blend no. 3	7.5	64.29 ^e	75.54
	15.0	68.41 ^e	77.28

^aCalculated by difference (Crampton and Harris, 1969).

^bDifference between fat levels ($P < .05$).

^{c,d,e}Values with different superscripts (levels of fat combined)
are different ($P < .05$).

TABLE 12. APPARENT ABSORPTION OF MINERALS AND ASH BY PONIES FED DIETS CONTAINING DIFFERENT LEVELS OF VARIOUS FATS. DIGESTION EXPERIMENT II.

Kind of fat	Level of fat %	Mineral		
		Calcium %	Phosphorus %	Magnesium %
None (basal)	0	44.71 ^{a,b}	23.71	49.51 ^a
Corn oil	7.5	60.16 ^a	21.00	39.35 ^{a,b}
	15.0	51.16 ^a	25.56	37.34 ^{a,b}
Peanut oil	7.5	36.09 ^{a,b}	15.57	33.46 ^{a,b}
	15.0	51.81 ^{a,b}	40.88	57.24 ^{a,b}
Inedible tallow	7.5	35.91 ^b	30.40	39.94 ^{a,b}
	15.0	38.02 ^b	25.34	44.41 ^{a,b}
Blend no. 3	7.5	56.96 ^{a,b}	21.00	40.72 ^b
	15.0	32.96 ^{a,b}	21.16	29.95 ^b

^{a,b} Values with different superscripts (levels of fat combined are different ($P < .05$)).

ACCEPTANCE AND CONSUMPTION TIME OF
LARGE AND SMALL PELLETS BY HORSES

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Use of pelleted feeds for horses has become widespread in recent years. Two pellet sizes, 1/2 inch and 10/64 inch, have been most popular. Due to the greater energy cost in manufacturing the large 1/2 inch pellet, it was of interest to determine if there were any differences in acceptability and consumption rate between the two pellet sizes. A series of feeding trials were conducted in cooperation with Southern States Cooperative of Richmond, Virginia.

Trial 1.

Ten horses, three weanlings and seven mature mares and geldings were weighed and offered both large (1/2 inch) and small (10/64 inch) pellets in a divided feed trough at the rate of 1 1/2% of body weight for the horses and 2 1/2% for the weanlings daily. The pelleted feed fed to the horses was a complete feed containing roughage, grain and minerals ("Bonanza"). The feed for the weanlings was concentrate mixture ("Colt Maker") in pellet form. Long hay was fed to the weanlings at the rate of .75% of body weight. The horses were individually fed twice daily. The feeding period was adjusted so that the horses could consume slightly more than the 1 1/2 or 2 1/2% of their body weight of either or both pellets.

The results of this two week feeding trial are given in table 1. With the exception of two horses, there was a definite preference for the small pellet. The two horses that preferred the large pellet may have had previous experience with this size pellet. The horses consumed 62% and the weanlings 91% of the total amount consumed in small pellets. There were no digestive problems observed and only small difference in wastage between the two pellet sizes.

Trial 2.

To evaluate consumption time, the seven horses and three weanlings were assigned at random to either the large or small pellet group. Each horse was individually fed twice daily and the time required to consume the .75% (horses) or 1.25% (weanlings) allotment of large or small pellets was measured three or four times a week for two weeks. At the end of the two week period, the groups were switched to the other pellet size and the study was repeated for an additional two weeks. Feeding behavior and wastage as well as consumption time were monitored. The pellets fed were the same as used in trial 1.

As shown in table 2, most of the horses required slightly more time to consume the feed in small pellets. The pattern for the weanlings differed somewhat in that two of the three spent less time consuming the small pellet than the large pellet. Again, no digestive or intake problems were observed in either group.

¹Southern States Cooperative, Richmond, VA.

Trial 3.

In this trial the daily allotment of pelleted feed was offered in a single feeding and time of consumption, intake problems such as choking and wastage were evaluated. The horses and weanlings were assigned at random to either the large pellet or small pellet group. Feeding and management procedures were similar to those of trial 2 except that the daily allotment of pellets were fed at one time in the afternoon.

The consumption times for the horses in each group are shown in table 3. Essentially no difference was seen in the average consumption time for each group, 105.8 vs 102.3 min. There was no evidence of choking or digestive disturbances under this feeding regime. The weanlings would stop eating before their feed was consumed entirely.

Trial 4.

In trial 4, the consumption of two physical forms of feed, pellet and textured, were compared with and without the addition of a high energy supplement containing fat. The supplement was substituted for an equal weight of feed (186 grams/feeding). Six horses were assigned at random to either the pellet or textured feed group. The three horses receiving pelleted feed were fed 1.5% of their bodyweight in two feedings daily. The three horses fed the textured feed received .75% bodyweight daily plus .75% bodyweight hay. The three weanlings received 1.25% bodyweight in textured feed and 1.25% bodyweight in hay. The animals were provided two equal portions of their diets, one with the high energy supplement and one without. The horses has access to the two feeds for two 20-minute periods daily. The weanlings were allowed 25 minutes twice a day. Hay was fed after the morning feeding.

As shown in table 4, the horses and the weanlings preferred the feed without the supplement. The discrimination against the supplement was greater at the beginning of the two week trial. Comparing the first 4 days with the last 4 days intake indicated a greater acceptance of the supplement toward the end of the trial. The supplement tended to sift out of the feed, particularly the pellets, and accumulate in the bottom of the feed trough.

Trial 5.

The acceptability of varied levels of the high energy supplement was examined by feeding three levels 1, 2 and 5 times the recommended amount. Two horses and a weanling received each level mixed in a textured grain mixture. All horses were fed at the rate of 1.25% bodyweight grain and .75% of hay. The horses received either 93, 186 or 465 grams of supplement at each of two feedings daily.

The consumption performance is shown in table 5. As the level of supplement was increased, there was progressively greater refusal of the grain mixture. The horses would tolerate 2 times the recommended level fairly well, but not five times. Hay consumption was essentially unaffected. More importantly, there were no observable adverse effects from feeding the high level. No digestive problems were seen and the feces appeared normal.

Summary

In general, horses preferred the small (10/64) size pellet over the large 1/2 inch pellet. There was little difference in consumption time between the two pellets. Feeding pellets twice a day is recommended particularly with weanlings to assure complete consumption. From a management standpoint, the small pellet appears to be equal to the large pellet in all respects.

The high energy supplement was acceptable to the horse at the recommended level of feeding. It appears that an adaptation period may be necessary to insure normal intake. Feeding the supplement at five times the recommended level had no adverse effect other than some depression of feed intake.

TABLE 1. PREFERENCE TRIAL: LARGE VS SMALL PELLET - TRIAL 1

Horse No.	Pellet Consumption, grams			Waste Score ¹	
	Large Pellet	Small Pellet	% of Total	L	S
	<u>Per day</u>	<u>Per day</u>			
36	2038	7022	77.5	-	-
38	2426	4058	62.6	1	0
39	4741	3256	40.7	3	3
40	3629	1756	32.3	1	0
2	2243	4333	65.9	1	1
4	2735	4763	63.5	4	3
5	1188	6091	83.7	-	-
B♀	80	3710	97.9	-	-
B♂	603	2974	83.1	-	-
S♀	283	3467	92.5	-	-
$\bar{X}$ Horses	2714	4468	62%	1.43	1.0
$\bar{X}$ Weanling	322	3384	91%	-	-

¹Waste score: 0 - no waste, 4 - considerable.

TABLE 2. CONSUMPTION TIME - LARGE VS SMALL PELLET (MIN./FEEDING)^a - TRIAL 2

Horse No.	Large pellet	Small pellet	Diff.
36	34.10	39.25	+5.15
40	41.40	46.91	+5.51
5	34.00	34.67	+0.67
38	37.33	42.10	+4.77
39	29.42	28.10	-1.32
2	37.92	36.40	-1.52
4	43.67	46.30	+2.63
B♀	62.60	58.42	-4.18
S♀	48.33	59.20	+10.87
B♂	62.40	54.50	-7.90

^aData combined from periods 1 and 2 in Phase II. Animals fed small pellets in period 1 received large pellets in period 2 and vice versa. The same amounts were fed in both periods.

TABLE 3. ONCE/DAY FEEDING
FEED CONSUMPTION (MIN.) - TRIAL 3

<u>Large</u>		<u>Small</u>	
<u>Horse No.</u>	<u>Time</u>	<u>Horse No.</u>	<u>Time</u>
36	104.83	38	106.50
40	110.50	39	97.33
5	102.00	2	96.67
		4	108.67
$\bar{X}$	105.78		102.29
B ♀	135	S ♀	135
B ♂	135		
$\bar{X}$	135		135

TABLE 4. CONSUMPTION OF PELLETTED AND TEXTURED FEED WITH OR WITHOUT HIGH ENERGY SUPPLEMENT ADDED - TRIAL 4.

Pelleted (Bonanza)					Textured (Performance Champ)						
Horse No.	No supplement		Supplemented ^a		Horse No.	No supplement		Supplemented ^a		Hay	
	Offered g	% Consum.	Offered g	% Consum.		Offered g	% Consum.	Offered g	% Consum.	lb. fed	% Consum.
4	8738	52.9	8738	50.9	38	3234	91.8	3234	44.1	5.96	85.1
36	7388	68.0	7388	29.0	40	2876	91.8	2876	25.4	4.75	79.2
39	6162	<u>68.0</u>	6162	<u>50.0</u>	44	2672	<u>88.5</u>	2672	<u>47.2</u>	4.85	<u>80.8</u>
		63.0		43.3			86.37		38.9		81.7
Colt Maker											
Horse No.	No supplement		Supplemented ^a								
	Offered g	% Consum.	Offered g	% Consum.							
S.Filly	2384	92.7	2384	52.3							
B.Filly	2894	74.8	2894	31.3							
B.Colt	2808	<u>86.9</u>	2808	<u>58.2</u>							
		84.8		47.3							

^a186 grams High Energy Supplement.

TABLE 5. EFFECT OF THREE LEVELS OF SUPPLEMENT ON FEED INTAKE - TRIAL 5

	Supplement level ^a		
	1 (186 g)	2 (372 g)	5 (930 g)
No. horses	3	3	3
Feed/day, g	4322	4959	3826
Refusal/day, g	.5	48	228
Hay fed, lbs.	6.4	7.4	6.7
Hay refused, lbs.	.29	.52	.51

^aHigh energy supplement, daily intake.