1982

EC82-219 1982 Nebraska Swine Report

Layne C. Anderson
University of Nebraska-Lincoln

Austin J. Lewis
University of Nebraska-Lincoln, alewis2@unl.edu

Alex Hogg
University of Nebraska-Lincoln

Murray Danielson
University of Nebraska-Lincoln

D.B. Hudman
University of Nebraska-Lincoln

See next page for additional authors

Authors

Layne C. Anderson, Austin J. Lewis, Alex Hogg, Murray Danielson, D.B. Hudman, D.M. Danielson, M. A. Crenshaw, Roy L. Carlson, E.R. Peo Jr., J. D. Crenshaw, M. C. Brumm, Ron J. Johnson, Erik R. Cleveland, Rodger K. Johnson, Roger W. Mandigo, P.J. Cunningham, Phil David, T. E. Socha, William Ahlschwede, David P. Shelton, Richard O. Pierce, and Gerald Bodman

E. C. 82-219

1982

NEBRASKA SWINE REPORT

- Breeding
- Disease Control
- Nutrition
- Economics
- Housing

Prepared by the staff in Animal Science and cooperating Departments
For use in Extension, Teaching, and Research programs

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Leo E. Lucas, Director of Cooperative Extension Service, University of Nebraska, Institute of Agriculture and Natural Resources.

TEACHING RESEARCH EXTENSION

Institute of Agriculture and Natural Resources

Acknowledgments

The authors wish to express their appreciation to the following for grant or product support of Nebraska Research and Extension programs. The dedicated effort of the support personnel in the laboratories and research units is acknowledged and appreciated.

A. O. Smith Harvestore, Arlington Heights, IL

AMAX Chemical Corp., Greenwich, CT

American Cyanamid Company, Princeton, NJ

American Hoechst Corp., Somerville, NJ

American Stores Packing Company, Lincoln, NE

Armour Food Company, Madison, NE

Bettcher Industries, Inc., Vermillion, OH

Calcium Carbonate Company, Quincy, IL

Crow's Hybrid Seed Corn Co., Milford, IL

Dawes Laboratories, Inc., Chicago, IL

Diamond Shamrock Chemical Co., Newark, NJ

Dow Chemical Co., Midland, MI

Eli Lilly and Company, Indianapolis, IN

Farmland Industries, Kansas City, MO

Fats and Protein Research Foundation, Inc., Desplaines, IL

Geo. A. Hormel Packing Company, Fremont, NE

Hoffman-LaRoche, Inc., Nutley, NJ

Merck and Company, Rahway, NM

Monsanto Chemicals Company, St. Louis, MO

National Pork Producers Council, Des Moines, IA

Nebraska Farmer, Lincoln, NE

Nebraska Pork Producers Association

Nebraska SPF Accrediting Agency, Lincoln, NE

Norden Laboratories, Lincoln, NE

Pfizer, Inc., Terre Haute, IN

Rachelle Laboratories, Inc., Long Beach, CA

Smith Kline, Philadelphia, PA

Temple Tag, Temple, TX

Trojan, Conrad, IA

Urschel Laboratories, Inc., Valparaiso, IN

U.S.D.A./SEA, Beltsville, MD

Zimpro Corp., Chaska, MN

Contents

Issued January 1982, 8,000

On the cover: Feed grain production, grain storage and pigs are Nebraska's growing combination

The 1982 Nebraska Swine Report was compiled by William T. Ahlschwede, Extension Swine Specialist, Department of Animal Science.

This publication partially supported by the Nebraska Agricultural Experiment Station, Roy G. Arnold, Director

Lysine and Arginine in Growing-Finishing Diets

Layne C. Anderson
Austin J. Lewis[1]

Protein supplements, such as soybean meal, are added to swine diets primarily for their amino acid content. The proteins are broken down to amino acids in the pig's digestive tract. A pig uses the amino acids to synthesize its own proteins. Therefore, the amino acid content of a feedstuff is important. There are differences in the amount of essential (must be supplied in the diet) amino acids available in various feedstuffs. Requirements for specific amino acids are reasonably well defined. But, little is known about interactions of amino acids under different feeding regimens.

Interactions Tested

Most swine diets of cereal grains, such as corn and milo, are low in lysine. A typical corn-soybean meal finishing diet usually just meets the pig's requirement for lysine but contains excesses of other amino acids. Corn and soybean meal both contain the amino acid arginine in amounts higher than pigs need. Consequently, a standard corn-soybean meal diet contains about five times the National Research Council (NRC) requirement for arginine.

In poultry, where the arginine requirement is quite high compared to the lysine requirement, an antagonism exists between these two amino acids. Feeding excess levels of lysine reduces availability of arginine. It is possible that the high arginine level found in swine diets may lower the lysine availability and thus increase the total lysine requirement. If this is the case, decreasing the amount of arginine in the diet by appropriate dietary formulation should increase the availability of the lysine present. This would result in a reduction in the dietary lysine level needed to meet the pig's requirement and consequently a decrease in feed costs for the producer.

Four diets were formulated to contain either five, four, three or two times the NRC requirement for arginine (0.20% of the diet for the grower phase, 0.18% finisher), while the lysine content was held at the NRC requirement (0.70% grower, 0.61% finisher). Compositions of the four finisher diets are presented in Table 1. Grower diets were similar in feedstuff composition but formulated to contain higher nutrient levels. Sesame meal has a high arginine content (4.2%) compared to lysine content (1.3%), and so was included in diet 1 to raise the arginine:lysine ratio. Blood meal and dried whey were included in the other diets as they have lower arginine:lysine ratios.

Table 1. Composition of finisher diets formulated to contain different amounts of arginine.

	Diets			
Ingredient, %	1	2	3	4
Milo	82.22	86.85	86.02	67.65
Soybean meal, (44% CP)	8.35	7.60	2.33	--
Sesame meal, (42% CP)	5.13	--	--	--
Dried whey	--	--	6.04	29.80
Meat and bone meal	2.36	2.35	--	--
Blood meal	--	.91	2.46	.04
Vitamin premix	.89	.89	.89	.89
Limestone	.50	.69	.87	.69
Salt (iodized)	.25	.25	.25	.25
Dicalcium phosphate	.27	.38	.99	.41
Methionine HA,Ca (83%)	--	.05	.08	.10
Lysine HCl (78%)	--	--	.04	.12
Trace mineral premix	.05	.05	.05	.05
Composition, %				
Crude protein[a]	16.2	14.0	12.9	10.6
Lysine[a]	0.57	0.59	0.58	0.59
Arginine[a]	0.88	0.61	0.56	0.34
Calcium[b]	0.65	0.65	0.65	0.65
Phosphorus[b]	0.50	0.50	0.50	0.50

[a]Analyzed.
[b]Calculated.

Dietary analyses are also given in Table 1. Crude protein content decreased as arginine content decreased from diet 1 to diet 4. However, all four diets contained at least 100% of the NRC requirement for each of the essential amino acids. Previous research at Nebraska and elsewhere has shown that a finishing diet with as little as 10.6% crude protein can be satisfactory provided that all essential amino acid requirements are met.

One hundred and sixty crossbred pigs (112 barrows and 48 gilts) with an initial weight of 58 lb, were divided into four groups and fed the four different diets. Pigs were housed in a modified-open-front building with eight pigs per pen and five pens per treatment.

Pigs reached an average weight of about 95 lb during the 28-day grower phase, and were then switched to the finisher diets for

Table 2. Effect of arginine:lysine ratio on pig performance (whole trial) and carcass characteristics.[a]

Diet	Arg:Lys ratio[b] Grower and Finisher	ADG, lb[c]	ADFI, lb	F/G	Backfat, in[d]	Lea, sq in[e]
1	1.43:1 and 1.48:1	1.59	5.93	3.74	1.48	4.36
2	1.14:1 and 1.18:1	1.67	6.15	3.67	1.53	4.43
3	0.86:1 and 0.88:1	1.68	6.17	3.68	1.47	4.23
4	0.57:1 and 0.59:1	1.56	5.89	3.78	1.50	3.95

[a]Data are for the whole trial (initial wt 58 lb, final wt 213 lb). Carcass data are for barrows only.
[b]Ratio of arginine content to lysine content, first value is ratio in the grower phase, second value is ratio in the finisher phase.
[c]Quadratic effect $P<0.05$.
[d]Average backfat adjusted to a constant weight.
[e]Loin eye area adjusted to a constant weight. Linear effect $P<0.05$.

an additional 67 days. The average weight of pigs at the end of the experiment was 213 lb. Pigs were allowed free access to feed and water throughout the experiment. Carcass data were collected on the barrows (28 per treatment) at the end of the trial.

Results in Table 2 indicate average daily gain was highest for pigs fed diets 2 and 3, and lowest for those fed diet 4. Average daily feed intake exhibited a similar pattern. There were no significant differences in feed efficiency between the four diets. Backfat measurements were similar regardless of dietary treatment, but loin eye area decreased as the dietary level of arginine decreased. The decrease in protein level from diet 1 to diet 4 may have been responsible for the decrease in loin eye area.

Little Advantage

Under conditions of this experiment there was little advantage to decreasing the arginine:lysine ratio of growing and finishing swine diets by dietary formulation. A reduction in the dietary arginine content from five times to four times the NRC requirement increased average daily gain and feed intake somewhat, but further decreases in the arginine:lysine ratio did not further increase daily gain. Feed efficiency was not affected by the dietary arginine level. Some carcass characteristics were altered in the trial. Loin eye area decreased slightly as the arginine:lysine level decreased, but the average backfat measurements were similar for all treatments.

Although it is possible that different results might have been obtained if other feedstuffs had been used, excess arginine does not seem to be a problem in practical diets. As long as all amino acid requirements are met, swine producers using normal types of ingredients probably do not need to be concerned about amino acid interactions.

[1]Layne C. Anderson is graduate assistant, Austin J. Lewis is Associate Professor, Swine Nutrition.

Lameness in Swine

Alex Hogg[1]

Lameness of pigs is a problem in most swine production units. Arthritis is the most common cause. Therefore, it is not surprising that arthritis ranks second to abscesses as the most frequent reason for condemnation of pork carcasses or parts of carcasses in packing plants. In addition to arthritis, lameness in swine may be caused by nutritional deficiencies or imbalances, injury, or genetic disorders.

Tentative diagnosis is made from clinical signs and knowledge of age of affected pigs. Infectious causes of lameness often occur at specific times in the life cycle. Streptococcus arthritis affects pigs younger than three weeks while erysipelas arthritis affects pigs from eight weeks through adulthood. The diagnosis is confirmed by necropsy and bacterial culture of the affected joints.

Infectious Swine Arthritis

Most swine arthritis is caused by bacterial infections. The usual signs of this form of arthritis are lameness and swollen joints. The five most common bacterial agents involved in infectious swine arthritis are: Streptococci, Erysipelas, Mycoplasma, Corynebacteria and Hemophilus.

Streptococcal Arthritis

Streptococcal arthritis is sometimes called navel ill and occurs from birth to three weeks of age. Bacteria enter the body from navel infections or any break in the skin such as bite wounds, abraded knees, tail docking, ear notching, or clipping needle teeth.

Research in Denmark indicates that clipping needle teeth is a common cause of streptococcal arthritis. The needle teeth are hollow and the exposed pulp cavity provides an avenue of entry for bacteria.

Rough hair coat, fever, loss of appetite, lameness and swollen joints are clinical signs of streptococcal arthritis. Typical lesions are white or creamy pus in the joints. The common treatment is injection of penicillin or lincomycin on the first day of life. Some producers find it necessary to inject all pigs in every farrowing. Dihydrostreptomycin in large doses is toxic to the cranial nerve that controls balance. Therefore, avoid antibiotic combinations that include this antibacterial as a routine treatment on baby pigs.

Prevention—Keep all surgical instruments used for earnotching, tail docking, castration and teeth clipping clean and sanitary. Avoid knee abrasions on suckling pigs by installing carpeting or other soft material on the floor. A quick-drying coating that is made for the purpose is applied to knees of newly farrowed pigs by some producers.

High levels of feed-grade penicillin in the pre-breeding diets to help eliminate carrier sows is sometimes recommended. Additional preventive measures include cleaning and disinfecting farrowing crates and washing sows before they enter the crates.

Erysipelas Arthritis

Erysipelas affects pigs from eight weeks of age through adulthood. Erysipelas produces a chronic form of arthritis. Clinically, the joints are enlarged and very firm to the touch. The knee or hock joints are commonly affected but other joints, even those in the backbone, can be involved. Lesions exposed at necropsy show thickening from excessive growth of fibrous tissue around the joint. Erysipelas does not cause formation of pus in the joint cavity. Treatment consists of injections of antierysipelas serum and penicillin or lincomycin. Affected pigs must be treated early as there is a very poor response in chronic cases.

Prevention—Follow an erysipelas vaccination program. Vaccinate sows three weeks before farrowing. Vaccinate at weaning or before leaving the nursery at 8 to 10 weeks of age. On problem farms it may be necessary to give booster vaccinations when pigs weigh 100 to 125 lb.

Mycoplasmal Arthritis

Two species of mycoplasma, a very small bacterium, cause arthritis in pigs. *Mycoplasma hyorhinis* affects 3- to 10-week-old pigs and adults. *Mycoplasma hyosynoviae* affects 10- to 20-week-old pigs and adults. Clinical signs of mycoplasma infection include abdominal pain, labored breathing, fever, swollen testicles, arthritis and lameness. Hocks may be puffy and the animal may hold the affected leg forward or pick it up, indicating severe pain. Some pigs will be unable to get up due to the intense pain. Opening affected joints reveals very few lesions other than excessive fluid. The lack of lesions is sometimes a surprising contrast to the severe pain that the affected pigs exhibit. Diagnosis is made from gross lesions and confirmed by culture of the organism from the joint fluid.

Treatment—Give tylosin or lincomycin injections during the first 24 hours of the acute stage and repeat daily for 3 additional days. A single injection of a corticosteroid given at the time of initial treatment will reduce pain but administration of this drug should not be repeated.

Corynebacterial Arthritis

Corynebacterial arthritis is characterized by greenish pus in the cavity of affected joints. This organism has been cultured from the joints of pigs as young as two weeks of age. This form of arthritis is associated with injuries from rough floors or tail biting or other means of breaking the skin and giving this bacteria an avenue of entry into the body.

Hemophilus Arthritis

Two species of Hemophilus bacteria, *H. suis* and *H. parasuis* cause this form of infectious arthritis. Lesions are also frequently found in the chest and abdominal cavities. Hemophilus arthritis is becoming increasingly common.

Treatment—Injections of penicillin and sulfathiazole in drinking water are the recommended treatments for *Hemophilus suis* or *H. parasuis* infections.

Nutritional and Injury Lameness

Calcium-phosphorus deficiencies or imbalances are the most common causes of nutritional lameness. Animals reluctant to get up are the major sign of nutritional lameness. Many of these animals have fractures of the bones or the vertebrae.

Excessive vitamin D in the ration occasionally causes nutritional lameness. The extra vitamin D can come from errors in mixing or simply by adding a vitamin premix to a diet formulated with a commercial protein supplement that already contains sufficient vitamin D.

A good deal of lameness is caused by injuries to the feet and legs. Rough floors and defective slats are common causes.

Osteochondrosis

Osteochondrosis is a degenerative condition of the articular cartilages that cover the ends of bones. It is fairly common in some groups of young growing pigs.

Clinical signs which become apparent as the disease progresses are "bucked knees" and very straight rear legs ("post legs"). The animal walks with a stilted gait. There is excessive lateral swaying in the hind quarters. Erosion of the articular cartilages that cover the end of the bones especially in the stifle and elbow joints, are typical lesions of osteochondrosis.

A Danish study indicated that 250 mg. of vitamin C per head per day in the feed was the treatment for osteochondrosis. This treatment has not yet been evaluated in the U.S.

Control

Attempts at controlling osteochondrosis by selection has been unproductive in herds in which it has been tried. Advice on control awaits further research that would explain the basic cause of osteochondrosis.

---

[1]Alex Hogg is Extension Veterinarian.

Diet supplementation.

Are Vitamins and Minerals Necessary?

Murray Danielson[1]

The need for vitamin and mineral supplementation in swine diets may be difficult to realize. After all, these additions represent a small fraction of the total diet and they don't change the diet appearance. However, each vitamin and mineral has a specific function in allowing animals to perform at their optimum level.

Importance Studied

The importance of vitamin and mineral supplementation of a growing-finishing diet was studied. Deletion of vitamin additions and mineral additions was studied. Four diet treatments were utilized. Diet 1 was considered the balanced basal 16% corn-soy diet. Diet 2 was comparable to diet 1 with the deletion of vitamins contained in the premix. Diet 3 was comparable to diet 1 with deletion of supplemental minerals. Diet 4 was comparable to diet 1 with deletion of both the vitamins in the premix and the supplemental minerals. Diet formulations are given in Table 1.

Sixty-four crossbred pigs averaging 33 lb were randomly allotted by weight to two replications with eight pigs per pen. The study was conducted during late fall and early winter months. A shelter with an adjoining concrete apron provided adequate space for each pen of pigs. Four barrows and four gilts shared each pen. Pigs were fed *ad libitum* with free access to water. Individual pig weight and diet intake was monitored at 14-day intervals. The study ended when the majority of animals in each of the replications weighed about 200 lb. Performance records are in Table 2.

Evidence relating to the effect of vitamins and minerals on pig performance (Table 2) demonstrates the importance of these diet additions. The decline in average daily gain was greater with deletion of supplemental minerals (17%) than with vitamin deletion (9%). When vitamins and supplemental minerals both were deleted, diet 4, daily gain reduction was more than 21 percent.

The quantity of feed required for each pound of gain (Table 2) was not appreciably different among the diets fed in this study. However, pigs fed diet 4 did consume about 6% more feed per pound of gain.

Big Question

Another aspect of this study should be emphasized. Of pigs fed diets 3 and 4, three from each of these groups developed umbilical hernias. Animals on these two diets appeared uncomfortable and were often observed to be piling. The mechanism necessary for proper body regulation requires the presence of certain vitamins and minerals. If absent in the diet, the consequence is uncomfortable pigs, both physically and psychologically. Thus, a reduction in performance.

The research leaves us with this question: can we ignore balanced diets and live with a potential reduction in performance in excess of 20 percent and with animals with less than desirable physical traits?

---

[1]Murray Danielson is Professor, Animal Science (Swine), North Platte Station.

Table 1. Experimental diet composition—16% protein.

	Diet structure			
Ingredient, lb	1 Basal	2 Basal—vitamins	3 Basal—minerals	4 Basal—vitamins-minerals
Ground corn	1478	1478	1478	1478
Soyben meal—44	410	410	410	410
Alfalfa-sun cured	50	50	50	50
Cyphos (18.5%P)	32	32	---	---
Limestone	10	10	---	---
Salt (iodized)	10	10	10	10
[a]Trace mineral mix	2	2	---	---
[b]Vitamin premix	3	---	3	---
Antibiotic mix	5	5	5	5

[a]Calcium Carbonate Company—swine trace mineral mix, 20% zinc.
[b]Provides 3,000,000 I.U. Vit. A, 504,000 I.U. Vit. D, 20 mg Vit. B_{12}, 3 g riboflavin, 16 g niacin, 9 g panthothenic acid and 200 g choline chloride.

Table 2. Pig performance data.

	Diets			
	1	2	3	4
No.pigs	16	16	16	16
Initial wt, lb	33.8	33.4	33.7	33.9
Final wt, lb	216.8	200.7	185.5[a]	179[b]
Daily gain, lb	1.56	1.42	1.30	1.23
Feed/gain	3.60	3.54	3.63	3.81

[a]Two pigs failed to complete study.
[b]One pig failed to complete study.

Alfalfa in Growing-Finishing Diets

D. B. Hudman,
D. M. Danielson
M. A. Crenshaw[1]

Alfalfa is not considered a common ingredient in swine diets today. However, several years ago alfalfa, in the form of pasture, was a common part of the diet. Alfalfa hay and dehydrated alfalfa meal frequently have been used in gestating sow diets to limit energy intake. The lower metabolizable energy value can be attributed to alfalfa's high fiber content.

There has been limited research work in feeding alfalfa hay to growing-finishing swine, although dehydrated alfalfa meal is used routinely in these diets.

Effect of Alfalfa

The effect of levels of alfalfa hay in diets for growing-finishing swine was studied. Diets were formulated with 0, 10, 20 and 30% alfalfa using a 14.3% crude protein alfalfa hay.

Dietary treatments were calculated maintaining the same level of lysine from natural ingredients in all diets based on 0% level of alfalfa hay in a 14% crude protein diet (Table 1).

Sixty-four crossbred pigs were randomly allotted by weight to the four dietary treatments, two replications, eight pigs per pen. The average weight of the pigs in the two replications was 73.4 and 91.6 pounds. There were equal numbers of barrows and gilts in each pen. Pigs were assigned to open front pens equipped with self-feeders and automatic waterers.

Individual pig weights and pen feed consumption were recorded at two week intervals (Table 2).

Average daily gains of pigs were similar for pigs receiving the 0, 10 and 20% alfalfa hay diets. Pigs receiving the 30% alfalfa hay diets gained significantly slower. The heavier pigs in replication 2 gained significantly faster than the lighter pigs although the feed per unit of gain was the same. This coincided with much higher feed consumption during the first four weeks of the test than could be attributed to the heavier weight of the pigs. This higher consumption may be due to the larger capacity of the digestive tract, more advanced physiological development of the tract for the utilization of fiber or faster feed passage.

The average daily feed consumption per pig was lower for pigs receiving diets containing alfalfa hay for the first four weeks of the experiment than the pigs receiving the corn-soybean meal diet. At the end of six weeks on test this trend was reversed for the remainder of the experiment. Possibly an adjustment to alfalfa hay or a lack of digestive tract capacity was responsible for the lag in feed consumption.

Pigs fed the 0% alfalfa hay diet required significantly less feed per unit of gain than the pigs consuming diets with 10, 20 or 30% alfalfa hay. The difference in feed conversion was anticipated due to the reported lower metabolizable energy value for alfalfa hay than corn or soybean meal it replaced.

This difference in feed required per unit of gain was 5 to 7% for the pigs reciving the 10 and 20% alfalfa hay diets. Therefore, it is not economically feasible to add alfalfa hay in diets for growing-finishing pigs unless the diet can be formulated for 5 to 7% less than the corn-soybean meal. This will need to be considered in the cost of processing, mixing and possibly the labor, to keep the feed flowing through the self-feeder.

Table 1. Composition of experimental diets.

	Level of alfalfa hay, %			
	0	10	20	30
Ground corn	81.22	72.42	64.02	55.225
Soybean meal (44%)	15.4	14.4	13.1	12.2
Alfalfa hay (14.33%)	---	10.0	20.0	30.0
Ground limestone	1.0	0.7	0.4	0.1
Dicalcium phosphate	1.0	1.1	1.1	1.1
Salt	0.3	0.3	0.3	0.3
Trace mineral mix[a]	0.08	0.08	0.08	0.08
Vitamin premix[b]	1.00	1.00	1.00	1.00
	100.00	100.00	100.00	100.00

[a]Trace mineral mix contains: 20% Zn, 10% Fe, 1.1% Cu, 5.5% Mn, .22% S and 12% Ca.
[b]Contributed: 1,500 I.U. vitamin A, 200 I.U. vitamin D_3, 1.25 mg riboflavin, 8 mg niacin, 8 mg pantothenic acid, 100 mg choline chloride and 7.5 mcg vitamin B_{12} per lb of diet.

Table 2. Performance of swine fed diets with different levels of alfalfa hay.

	% alfalfa hay in diets			
	0	10	20	30
Initial wt.	82.4	82.8	83.7	82.5
Final wt.	225.1	219.4	226.4	206.6
Avg. daily gain, lb.	1.70[a]	1.63[a]	1.70[a]	1.48[b]
Feed/gain, lb.	3.68[c]	3.95[d]	3.89[d]	4.37[d]

a vs b ($P<.05$)
c vs d ($P<.05$)

Summary

1. Feed only good quality alfalfa hay free of spoilage.
2. Grind the hay to comparable particle size of other ingredients in the diet (fine grind).
3. Utilize crude protein, lysine and dry matter of hay.
4. Limit ground alfalfa hay to 20% of the growing-finishing diet.
5. Lowered daily feed consumption can be expected for about 30 days when starting pigs on diets with 10% or more alfalfa hay.
6. Blend the diet well.
7. Ground alfalfa hay is bulky and management is necessary to prevent bridging in storage or a self-feeder.
8. Older, heavier swine utilize alfalfa hay more readily than younger growing-finishing swine.
9. Feed required per unit of gain will be 5 to 7% more than a corn-soybean meal diet.

---

[1]D. B. Hudman is Professor-Animal Science, Panhandle Station. D. M. Danielson is Professor-Animal Science, North Platte Station. M. A. Crenshaw is Swine Operations Manager, North Platte Station.

Nipple Waterer Position—Up or Down?

Roy L. Carlson and E. R. Peo, Jr.

An ideal swine waterer is one that is trouble-free, easy to use and that delivers clean, fresh water every time a pig needs a drink. Nipple waterers (sometimes called drinking taps) have taken the swine industry by storm because they nearly meet the requirements of an ideal waterer. However, we have much to learn about nipple waterers and how to use them.

Last year, we reported on water usage by baby pigs when nipple waterers were equipped with 1 mm or 2.5 mm orifices. In that study, nipple waterers were mounted with an upward angle of 45° with the tip of the nipple four inches from the pen floor. In one of the experiments, particles of coarsely ground corn lodged between the body of the nipple waterer and the stem causing water to run continuously. The problem was corrected by turning the nipple downward. A rule often followed in the industry has been to point nipple waterers upward for young pigs. We corrected the problem of feed lodging in the water valve but did not know if we had affected gains, feed conversion or water usage by baby pigs. Experiments were conducted in 1981 to determine the effect of orifice size and nipple waterer position on pig performance.

"Play Guards" Used

Pigs used in our studies were housed in double-deck 4′ x 4′ nursery pens with four pigs per pen and three pens per treatment. Treatments consisted of nipple waterers equipped with 2 mm or 2.5 mm orifices with the nipple pointing upward at 45° with the tip 4″ from the floor or pointing downward at 45° with the tip 12″ from the floor. Guards to prevent water wastage were installed on all waterers. An 18% protein starter diet containing 10% oats was fed in experiments 1 and 2, with 16″ and 20″ of feeder space for each experiment, respectively. A 20% protein pig starter was fed in experiment 3. Water usage was measured with TRISEAL meters.

Results of the first experiment are given in Table 1. Since there was some question as to whether or not young pigs would consume adequate amounts of water from a downward pointing nipple, we started the light-weight groups on nipple waterers equipped with either 2.0 mm or 2.5 mmm orifices that pointed upward. Heavier pigs were used to evaluate orifice size with the nipples pointing downward. There was little difference in gains or feed conversion of pigs between the two orifice sizes or nipple positions. But, there was a great difference in the amount of water used depending upon

Table 1. Effect of orifice size and position of nipple waterers on gains, feed conversion and water usage by young pigs (experiment 1).

	Orifice size and position			
	2 mm		2.5 mm	
Item[a]	Up	Down	Up	Down
Int. wt., lb.	16.4	22.5	16.2	24.0
Final wt., lb.	39.2	51.8	40.8	51.7
Avg. daily gain, lb.	1.10	1.37	1.17	1.27
Avg. daily feed intake, lb.[b]	1.98	2.76	2.14	2.39
Feed/gain	1.81	2.02	1.84	1.88
Water used/head/day, gal	3.83	1.81	4.45	2.49

[a]Data based on average of 3 pens; 4 pigs/pen. Duration of test 22 days.
[b]18% pig starter diet with 10% oats.

Table 2. Effect of orifice size and position of nipple waterers on gains, feed conversion and water usage by young pigs (experiment 2).

	Orifice size and position					
	2 mm		2.5 mm		Overall average	
Item[a]	Up	Down	Up	Down	Up	Down
Int. wt., lb.	17.3	17.5	17.4	17.6	17.4	17.6
Final wt., lb.	51.1	55.2	52.3	53.0	51.7	54.1
Avg. daily gain, lb.	1.05	1.18	1.09	1.11	1.07	1.14
Avg. daily feed intake, lb.[b]	2.07	2.35	2.52	2.15	2.29	2.25
Feed/gain	1.96	2.00	2.30	1.97	2.13	1.99
Water used/head/day, gal	5.41	1.69	4.62	2.01	5.02	1.85

[a]Data based on average of 3 pens; 4 pigs/pen. Duration of test 32 days.
[b]18% pig starter diet with 10% oats.

Table 3. Effect of orifice size and position of nipple waterers on gains, feed conversion and water usage by pigs with no previous experience with nipple waterers (experiment 3).

	Orifice size and position					
	2 mm		2.5 mm		Overall average	
Item[a]	Up	Down	Up	Down	Up	Down
Int. wt., lb	38.4	38.5	38.7	39.2	38.6	38.8
Final wt., lb	49.9	49.9	50.6	51.0	50.3	50.7
Avg. daily gain, lb	0.42	0.42	0.42	0.42	0.42	0.42
Avg. daily feed intake, lb[b]	0.60	0.68	0.62	0.62	0.68	0.65
Feed/gain	1.47	1.68	1.50	1.46	1.49	1.57
Water used/head/day, gal	1.34	0.71	1.69	1.07	1.52	0.89

[a]Data based on average of 3 pens; 4 pigs/pen. Duration of test 7 days.
[b]20% protein pig starter.

whether the nipples were pointed up or down. Pigs on nipple waterers pointing upward used nearly twice as much water (4.14 gal/hd/day vs 2.15 gal/hd/day) as those exposed to nipple waterers pointing downward.

Experiment 2 was essentially a repeat of the first except all pigs weighed about the same when starting on test and had about 4" more feeder space. Results of this study are given in Table 2. Pigs on nipple waterers pointing downward gained 6.5% faster, were 7.0% more efficient in feed conversion and used 63% less water (1.85 gal/hd/day vs 5.02 gal/hd/day) than pigs on nipple waterers pointing upward.

A third experiment evaluated whether or not pigs with no previous experience with nipple waterers would be disadvantaged by starting on nipple waterers pointing downward. Results given in Table 3 indicate position of the nipple (pointing up or down at a 45° angle) has little effect on pig performance. Here again, water usage was much greater (1.52 gal/hd/day vs 0.89 gal/hd/day) by pigs exposed to nipple waterers pointing upward.

Point it Down

Even though "play guards" were used to reduce water wastage, it was obvious from day to day observations that the difference in water usage between the two positions was due to pigs playing more with the upward pointing nipple waterers. Our recommendation is to have the nipple waterer pointing downward in nursery pens. This could reduce water usage by as much as 50%. Lodging of feed particles in the valve is no problem when the waterer is placed in a downward position.

Water pressure measured 45 p.s.i. With this pressure, the 1 mm orifice gave satisfactory results with 30 to 40% less water used than by pigs in pens with nipple waterers equipped with the 2.5 mm orifice.

---

[1]Roy L. Carlson is Research Technician, Animal Science. E. R. Peo, Jr., is Professor-Swine Nutrition.

Copper Sulfate—

Growth Promotant For Swine

E. R. Peo, Jr.[1]

The use of copper as a growth promotant in swine has suddenly become widespread in the United States and in Nebraska. Research from Great Britain, Florida, Kentucky and elsewhere indicates that copper, acting like an antibiotic, will improve gains and feed conversion of growing-finishing swine.

Copper is an essential nutrient. We recommend that 10 ppm be added to the diet of all swine for normal growth, maintenance, and reproduction. Higher copper levels (125-250 ppm) are required to get an improvement in gains and feed conversion over that of swine fed diets without the extra copper. Generally, copper sulfate is used to supply high levels of copper to the diet.

Copper Cheaper

Undoubtedly, the current economic status of the swine industry has influenced the surge in high level copper feeding. Copper is much cheaper to add to diets than antibiotics ($1-$2/ton vs $5-$12/ton) and, as research has shown, often will improve gains and feed conversion of swine to about the same extent as commonly used antibiotics.

It has been reported that all classes of swine will gain faster and more efficiently when fed 125-250 ppm of copper. A positive response from copper feeding may occur in one situation but not in another. For example, data in Table 1 show that young pigs gained faster and more efficiently when fed diets with 250 ppm copper than those fed diets without supplemental copper. In contrast, the results of a large, regional study (10 corn belt States plus Kentucky) involving 142 pens and 934 pigs (Table 2) showed a 1.8% reduction in gains and a 1.6% reduction in feed efficiency for young pigs fed 125-250 ppm of supplemental dietary copper. On the other hand, in the regional study, gains and feed conversion were improved about 5% and 1.2%, respectively,when pigs were fed high levels of copper in the finishing phase (125 lb to market weight). The overall net effect of feeding copper from weaning to market was 2.8% better gains but only 0.8% improvement in feed conversion.

It is generally believed that most improvement in gains and feed efficiency obtained from feeding antibiotics to swine occurs with the young pig. Copper may or may not give a response in the young animal. One question often asked is what happens when copper and antibiotics are fed at the same time. Research at Kentucky and Ohio indicates that pigs respond to both copper and antibiotics and that they gain even faster and more efficiently when the two are fed in combination.

In a recent Nebraska study it was found that 250 ppm of copper depressed gains of young pigs about 8% in the absence of antibiotics but improved gains about 2% when chlortetracycline was included in the diet. Feed efficiency

Table 1. Effect of copper on gains and feed conversion of young pigs[a].

	Treatment		
	None	Copper (250 ppm)	Advantage for copper
Kentucky[c]			
Avg. daily gain, lb[b]	0.41	0.52	+27%
Feed/gain	2.01	1.89	+6.3%
Ohio			
Avg. daily gain, lb[d]	0.83	0.94	+13.2%
Feed/gain	2.04	1.94	+5.1%

[a]From Cromwell et al., 1980. Dist. Feed Conf. Report.
[b]Pigs weight range 15-30 lb.
[c]From Mahan. 1980. Ohio Swine Res. Rpt. 80-2:1.
[d]Pig weight range 17-65 lb.

Table 2. Effect of copper on gains and feed conversion of G-F swine.[a]

	%Improvement from copper	
	ADG	F/G
Grower		
125 ppm copper	-2.2	-2.2
250 ppm copper	-1.5	-1.1
Finisher		
125 ppm copper	+5.4	+1.7
250 ppm copper	+4.5	+0.7
Overall		
125 ppm copper	+2.1	0.0
250 ppm copper	+3.5	+1.5

[a]Adopted from report NCR-42 Committee on Swine Nutrition. 1974. JAS 39:512.

was improved 3.8% when copper and chlortetracyline were fed in combination (Table 3). During the finishing phase, there was no advantage in feeding copper. In fact, gains were depressed 12.6% with copper in the absence of antibiotic and were unaffected when fed in combination with the antibiotic. There were essentially no differences in feed conversion among the treatments (Table 4).

Results of the combined periods (growing and finishing) are shown in Table 5. When averaged across treatments, copper improved average daily gains 1.9% and feed conversion 1.4%. Both gains and feed efficiency were improved about 2.5% with the high level of chlortetracycline. This research, the regional study reported earlier (Nebraska was part of the regional study) and the research from Great Britain, Florida, Kentucky and Ohio, indicates that the expected response to copper may be variable. That is, improved gains and feed conversion may be obtained sometimes but not other times. So, do not be disappointed if pigs do not always respond to the feeding of high levels of copper.

Table 4. Effect of copper and antibiotic on gains and feed conversion of finishing pigs[a] (Neb. Exp. 81481)

	Copper (250 ppm)[b]		
CTC, gms/ton[c]	–	+	Avg. for antibiotic
	Avg. daily gain, lb		
0	1.96	1.74	1.85
25	1.90	1.88	1.89
50	2.02	2.04	2.03
Avg. for copper	1.96	1.89	
	Feed/gain		
0	3.05	3.04	3.04
25	3.08	3.12	3.10
50	2.88	2.88	2.88
Avg. for copper	3.00	3.01	

[a]Data based on average for 2 pens, 8 pigs/pen. Int. wt. 108 lb; final wt. 175 lb; test span 35 days.
[b]Copper added as copper sulfate.
[c]CTC = chlortetracycline.

Table 5. Effect of copper and antibiotic on gains and feed conversion of G-F swine[a] (Neb. Exp. 81414)

	Copper (250 ppm)[b]		
CTC, gms/ton[c]	-	+	Avg. for antibiotic
	Avg. daily gain, lb		
0	1.56	1.44	1.50
25	1.45	1.59	1.52
50	1.51	1.58	1.54
Avg. for copper	1.51	1.54	
	Feed/gain		
0	2.87	2.86	2.86
25	2.86	2.85	2.86
50	2.84	2.75	2.79
Avg. for copper	2.86	2.82	

[a]Data based on average for 2 pens, 8 pigs/pen. Int. wt. 37.2 lb; final wt. 175 lb; 91-day test.
[b]Copper added as copper sulfate.
[c]CTC = chlortetracycline.

Pluses and Minuses

In addition to the potential of copper sulfate in improving pig performance, the following attributes and potential problems merit consideration:

* Potential for overdose; 300-500 ppm will produce a toxicity particularly if diets are low in iron and zinc.

* Copper passes through the pig. The manure is highly corrosive to metal feeders, gates, slats.

* Copper increases the rate of sludge buildup in anaerobic storage facilities.

* Copper may inactivate lagoons.

* At current recommended application rates (10 to 20 tons per acre per year) copper does not accumulate in the soil profile to a significant amount.

Table 3. Effect of copper and antibiotic on gains and feed conversion of growing pigs[a] (Neb. Exp. 81414).

	Copper (250 ppm)[b]		
CTC, gms/ton[c]	-	+	Avg. for antibiotic
	Avg. daily gain, lb		
0	1.32	1.24	1.28
25	1.18	1.40	1.29
50	1.20	1.29	1.24
Avg. for copper	1.23	1.31	
	Feed/gain		
0	2.70	2.69	2.70
25	2.65	2.62	2.64
50	2.81	2.62	2.71
Avg. for copper	2.72	2.64	

[a]Data based on average for 2 pens, 8 pigs/pen. Int. wt. 37 lb; final wt. 208 lb; test span 56 days
[b]Copper added as copper sulfate
[c]CTC = chlortetracycline.

[1]E. R. Peo, Jr., is Professor-Swine Nutrition. The contributions of Mike Bromm to this paper are acknowledged and appreciated.

High Moisture Milo For Swine

J. D. Crenshaw and E. R. Peo, Jr.

Grain used to be harvested after it had "field dried" to a safe moisture level for storage, usually 14 to 16%. Even then, much of the grain went out of condition and became worthless for swine feed. Then grain drying systems were developed that allowed the crop to be harvested at higher moisture levels. Grain was then dried to a safe moisture level for storage. Problem solved? Yes, until the energy crisis and soaring prices of fuel for drying grain.

For years other methods for safely storing harvested high moisture grain have been available. With the energy crisis breathing down our necks, interest in storing high moisture grain by ensiling in oxygen-limiting silos (trench or upright), or ensiling and preserving the grain with organic acids, has been rekindled.

From a harvesting standpoint, high moisture grain storage is advantageous simply because the grain is taken directly from the field and put into storage, saving time and fuel costs by skipping the work and expense of grain drying. But what about nutritional value of ensiled high moisture grain? Most research indicates that the feeding value of high moisture grain and dry grain for swine is similar. Yet some research reports have varied from favorable to unfavorable for high moisture grain.

Field Trials

Recently, we conducted a series of field trials at the Arnold Schroder farm near Palmyra, Nebraska and two digestibility trials at the Nebraska Station to determine nutritional values of harvested high moisture and reconstituted milo for swine. Milo is the second most important feed grain in Nebraska.

At the Schroder farm, three groups of growing and finishing hogs were fed diets containing either harvested high moisture milo (HM) stored in an upright, oxygen-limiting silo or dry milo (DM) stored in a conventional grain bin. Fifty pigs were housed in a "Pig Poke-50" divided into two pens with one pen fed the HM diet and the other pen fed the DM diet. Two other groups of 50 pigs were tested according to the same procedures, but at later times.

Pigs were weighed and feed intakes recorded biweekly. The diets were mixed and fed either daily or every other day. Samples of the diets were analyzed for moisture and protein contents. Results of the field trials are given in Table 1. Performance data of the three groups were pooled and summarized for the growing phase (40 to 90 lb); the finishing phase (90 to 200 lb) and the combination of the two phases (40 to 200 lb).

During the growing phase, pigs fed the HM diets gained 4.8% faster, consumed 2.5 and 18.2% less feed and crude protein, respectively, and were 6.6% more efficient in feed to gain conversions than pigs fed the DM diets. Similar trends, except for gain, were evident during the finishing phase although the differences were not quite as pronounced. Upon combination of the phases, pigs fed HM milo diets gained the same, consumed 2.8 and 10.3% less feed and crude protein, respectively, and were 2.2% more efficient in feed to gain conversion than pigs fed the DM diets.

It is difficult to speculate as to whether or not the performance on less protein is real since the protein intake of pigs fed the high moisture milo met or exceeded NRC requirements. Thus, pigs on dry milo may have responded

Table 1. Performance of swine fed high moisture or dry milo diets[a].

Criterion	Growing phase			Finishing phase			Combined growing-finishing phase		
	High moisture		Dry	High moisture		Dry	High moisture		Dry
Average daily gain, lb	1.45		1.39	1.52		1.56	1.50		1.50
% Difference		+4.8			-2.8			0	
Average daily feed intake, lb[c]	3.46		3.55	5.16		5.34	4.63		4.76
% Difference		-2.5			-3.3			-2.8	
Feed to gain ratio[c]	2.40		2.57	3.37		3.43	3.08		3.15
% Difference		-6.6			-1.6			-2.2	
Average daily crude protein intake, lb	.60		.73	.86		.93	.77		.86
% Difference		-18.2			-7.1			-10.3	

[a]Conducted on the Arnold Schroder farm, Palmyra, NE. Values are the pen avg. of 3 groups of 25 pigs/trt.

[b]% Difference = (High moisture value—dry value) x 100 / dry value

[c]Values expressed on an equivalent dry matter basis.

similarly if they had been fed the lower amount of protein fed pigs on the high moisture milo diets. It was not our intention to feed different protein levels between the two groups. The feed was mixed with a proportioner, volumetric feedmill. Although the feed mix ratio for the two diets was checked weekly, unexplained differences in the protein content of the diets occurred.

Two studies were conducted at the Nebraska Station to determine effects of reconstitution (dry milo plus water followed by ensiling), or harvested high moisture milo, ensiled in air-tight containers, on digestibility of dry matter, energy, protein and lysine and their use by swine.

From an economical point of view, if one has a high moisture grain storage structure, it cannot be left empty for a few months. Therefore, to efficiently utilize the structure, dry grain can be reconstituted to a higher moisture level (23 to 30%) and allowed to ferment for about 21 days before feeding. Of course, the nutritional value of reconstituted grain must be superior to dry grain to justify this practice.

In trial 1, dry milo was left as whole grain or rolled, then reconstituted to 25% moisture and ensiled in air-tight containers for at least 21 days before feeding. The two reconstituted milo types were compared to dry milo to determine the effects of physical form before reconstitution on digestibility criteria (Table 2) when fed to growing (60-70 lb) swine. Reconstitution (25% moisture) appeared to enhance protein and lysine digestibility of milo compared to dry milo.

For the second trial, we reconstituted whole milo to 30% moisture and compared its digestibility to harvested high moisture (30%) and dry milo (Table 2). Dry matter, energy, protein and lysine digestibility criteria were improved when pigs were fed reconstituted (30% moisture) milo compared to harvested high moisture and dry milo.

Results Positive

Results of research on the nutritional value of high moisture grain are far from conclusive. However, in general, it appears that high moisture grain is at least equal to the nutritional value of dry milo and that the fermentation high moisture grain undergoes during ensiling may make the grain more digestible for swine. Our best estimate at this time is that it will take 3% more dry matter to produce the same gain in swine with dry milo than it will with high moisture milo.

Energy economics, convenience and compatibility with ongoing programs are important factors to consider as to whether or not a high moisture grain storage and feeding system is to be part of a swine production program.

---

[1]J. D. Crenshaw is Research Technician, Animal Science. E. R. Peo, Jr., is Professor-Swine Nutrition.

Table 2. Effect of milo type on digestibility criterion for growing swine.

	% Moisture	Dry matter[a] digestibility,%	Apparent digestible[a] energy intake (Mcal/day)	Apparent protein[a] digestibility%	Apparent lysine[b] digestibility%
Trial 1					
Rolled reconstituted milo	25	91.0	3.81	85.6	92.2
Whole reconstituted milo	25	90.2	3.76	83.3	91.5
Dry milo	13	90.0	3.65	83.1	88.7
Trial 2					
Whole reconstituted milo	30	89.7	3.71	86.0	91.9
Harvested high moisture milo	30	87.2	3.61	82.8	88.6
Dry milo	14	88.1	3.41	79.4	89.6

[a]Treatment means based on the average of six pigs.
[b]Treatment means based on two samples. Each sample was a composite of 3 pigs per treatment.

Sale, movement = stress

Starting Feeder Pigs

M. C. Brumm[1]

Sale and movement of feeder pigs can be very stressful to the young pig. Sources of stress include mixing of strange pigs, sorting, disease exposure, feed and water deprivation and change in housing.

Proper post-arrival management to overcome stress is a major concern of feeder pig finishers. One facet of post-arrival management of importance is the diet of newly arrived pigs. Currently, there are many opinions about the proper ingredients in this "receiving diet."

Two Diets Studied

Effects of two sources of pigs and two receiving diets on health and performance of purchased feeder pigs were studied at the

University of Nebraska's Northeast Station.

In each of two trials, 240 pigs were bought from a single owner within 150 miles of the research facility. An additional 240 pigs were purchased at feeder pig auction barns in northern Arkansas and southern Missouri, some 500 to 650 miles distant. Pigs arrived on consecutive days and were penned by source adjacent to each other in pens with partially slotted floors.

For the first five days post-arrival, all pigs had immediate access to drinking water containing a commercial sulfa-electrolyte solution.

All pigs were limit-fed the experimental receiving diets (Table 1) for 10 days on the solid floor area of each pen twice daily followed by *ad libitum* feeding for three days. After the 13-day receiving period, all pigs were fed a common 16% crude protein corn-soy base grower diet containing ASP-250. At 125 pounds, pigs were fed a 14% crude protein finisher diet containing 20 g/ton Tylan until slaughter.

Results

In both trials, pigs from the one-owner source gained significantly faster than distant-auction pigs for the first 13 days post-arrival (Table 2).

In trial 1, pigs from the one-owner source gained significantly faster for the entire trial than the distant-auction pigs. In trial 2 there was no difference between sources of pigs in overall rate of gain. There was no difference in the efficiency of gain in trial 1. In trial 2 the distant-auction pigs were more efficient.

Pigs fed diets containing 20% whole ground oats tended to have a poorer feed conversion for the first 13 days in both trials (Table 3). However, there were no differences on overall animal performance due to receiving diet in either trial.

A significantly greater number of distant-auction pigs were treated for a variety of health ailments in both trials. In addition,

Table 1. Composition of feeder pig receiving diets.

	Experimental diets, % composition		
Item	Corn-Soy (CS)	20% Oats (O)	20% Oats + 5% lard (OL)
Corn	72.6	54.5	48.2
Soybean meal (44%)	21.0	19.1	20.4
Dehy alfalfa	2.5	2.5	2.5
Oats		20.0	20.0
Lard			5.0
Dicalcium phosphate	1.0	1.0	1.0
Limestone	1.3	1.3	1.3
Salt	.5	.5	.5
Trace mineral mix	.05	.05	.05
Vitamin-antibiotic mix	1.0	1.0	1.0
Selenium mix	.05	.05	.05
Calculated analysis			
Protein	16.1	16.0	16.0
Fiber	3.2	4.8	4.8
ME, Kcal/lb	1363	1302	1431

Table 2. Effect of source of pig on performance of purchased feeder pigs.

	Trial			
	1		2	
Item / Source	One owner	Distant owner	One owner	Distant owner
Pig weight, lb.				
Initial	59.6	55.2	38.5	38.5
13-day[ab]	78.2	62.9	49.1	47.3
Final[a]	205.7	189.2	206.1	205.3
ADG, lb.				
13-day[ab]	.99	.57	.81	.68
Final[a]	1.50	1.36	1.50	1.50
F/G				
13-day[b]	2.43	3.64	2.43	2.73
Final[b]	3.31	3.25	3.38	3.21

[a]Source means differ in trial 1, P<.05.
[b]Source means differ in trial 2, P<.05.

Table 3. Effect of receiving diet on performance of purchased feeder pigs.

	Trial					
	1			2		
Item / Diet	CS	O	OL	CS	O	OL
Pig weight, lb.						
Initial	57.6	57.6	57.6	38.5	38.5	38.5
13-day[a]	68.0	67.1	68.6	47.7	47.7	48.8
Final	199.8	196.2	196.2	207.2	205.3	204.6
ADG, lb.						
13-day[a]	.77	.73	.84	.70	.73	.79
Final	1.43	1.43	1.43	1.52	1.50	1.52
F/G						
13-day[b]	2.91	3.45	2.75	2.57	2.73	2.45
Final	3.28	3.31	3.27	3.28	3.30	3.30

[a]Diet means differ, trial 2, P<.05.
[b]Diet means differ, trial 1, P<.05.

Table 4. Relative health of purchased feeder pigs.

	Trial			
	1		2	
Item / Source	One owner	Distant owner	One owner	Distant owner
Pigs treated[ab]	0	17	3	18
Pigs dead[b]	5	6	0	5

	1			2		
Diet	CS	O	OL	CS	O	OL
Pigs treated	10	2	5	7	6	8
Pigs dead[c]	6	0	5	3	1	1

[a]Source means differ, trial 1, P<.05.
[b]Source means differ, trial 2, P<.05.
[c]Diet means differ, trial 1, P<.05.

death loss was greatest for the pigs trucked from the distant auctions.

Discussion

Results in Table 4 indicate that from purchase to market, acceptable performance levels were achieved by pigs from both sources. However, pigs purchased at a distant-auction market and transported for an extended period of time may be slower to start on feed and may experience more health-related problems. There are three possible explanations. First, there is the possibility of a climate effect. In both of these trials at the Northeast Station, pigs were trucked from near the Missouri-Arkansas border. Another possible explanation is that auction pigs are mixed and sorted by size before sale whereas the one-owner pigs are taken directly from a nursery pen to the finishing facility. The one-owner pigs in this study came from a common genetic and management background while the auction pigs were assembled from a variety of backgrounds. A third explanation is the length of time the auction pigs were trucked without feed and water. The one-owner pigs were without water a maximum of five hours while the distant-auction pigs were without feed and water a minimum of 23 hours in trial 1 and 15 hours in trial 2. A combination of water and feed deprivation and distance traveled probably added up to a severe stress on the feeder pigs.

The inclusion of 20% whole ground oats did not reduce the incidence or severity of scours in this study but tended to reduce the number of sick pigs and lower the death loss compared to no oats in the receiving diet or oats plus lard. While initial 13-day performance was poorest on this diet, the slower start may have allowed the pig to withstand a health stress at a later time. Further research is planned to investigate this possibility.

[1]M. C. Brumm is Assistant Professor, Animal Science, Northeast Station, Concord, Nebraska.

Stopping Starlings

Ron J. Johnson[1]

A misguided Shakespeare buff named Eugene Schieffelin brought starlings (*Sturnus vulgaris*) from Europe to New York City in 1890 and 1891 because he wanted to introduce all the birds mentioned in Shakespeare's plays. Unfortunately Schieffelin wasn't able to foresee the problems that starlings would cause for swine producers and for other agricultural producers.

Those first starlings increased in number, spread across the country, and have been causing headaches for farmers ever since. At swine facilities they consume feed and contaminate the feed and water with their droppings. Starlings may also be one way that diseases such as TGE (transmissible gastroenteritis or baby-pig disease) can be transferred between facilities. Recent information shows that TGE virus can pass through the digestive tract of starlings and be infectious in the starling feces. TGE may be introduced to a swine facility in several other ways, including on boots or vehicles, by stray animals, or by new swine added to the herd. So, stopping starlings won't necessarily stop TGE spread, but it may help.

A new NebGuide entitled "Starlings and Their Control" (number G81-580) is available at county extension offices. It contains the basic information needed to control starling problems. The contents include facts about starlings such as the size, color, flight, foods, reproduction, movements, and legal status. It has a section on economic impact and another one on controlling damage. The controlling damage section includes information on habitat modification at feedlots and sheltered areas. It briefly describes frightening and trapping techniques and it details the step-by-step use of the toxicant Starlicide Complete. Instructions suggest that when using this toxicant, prebaiting and exposing the bait for only three days will give the best control.

Recent information shows these two points important for ensuring good bait acceptance. Leaving the bait exposed for long periods of time or not prebaiting may cause starlings to reject the bait or to accept it less readily. When using Starlicide Complete, fresh bait is best. Bait kept on hand from one winter to the next may lose some of its potency. Bait kept for two winters may not work at all. Efforts are being made now to improve the shelf life of this material.

Researchers at the University of Nebraska and in the U.S. Fish and Wildlife Service are continuing to study starling problems to find better ways to reduce the problems they cause. However, starlings can be controlled at swine facilities using the information we currently have. So, if you're having problems with starlings and want to do something about them, pick up a copy of the new NebGuide at your county extension office, and follow the steps for stopping starlings.

[1]Ron J. Johnson is Extension Wildlife Specialist.

Lean Growth Selection Improves Efficiency

Erik R. Cleveland, Rodger K. Johnson, R. W. Mandigo, and E. R. Peo, Jr.[1]

Efficiency of pork production depends largely on herd feed efficiency. A major component of herd feed efficiency is the rate of food conversion of growing pigs. Selection is the only route to long term genetic improvement in feed efficiency of commercial pigs.

By and large, Nebraska breeders are selecting for a combination of faster growth rate and decreased backfat. The effect of this type of selection on the rate and efficiency of growth and on the degree of fatness of growing pigs is examined here.

Efficiency of growth can also be improved by restricting daily feed intake. Limited feeding reduces the rate of fat growth relatively more than the rate of lean growth. This improves efficiency of growth because the energy costs of fat growth are higher than the energy costs of lean growth. However, absolute growth rate is reduced and restricting daily intake may not reduce total production costs when per day non-feed costs are considered. Also, the effects of restricting feed intake may differ for pigs that differ in growth rate and degree of fatness.

This experiment compared the rate, efficiency and composition of growth in a line selected for increased growth rate and decreased backfat and a randomly selected control line. Three levels of daily feed intake were used.

The Experiment

Five generations of selection for rate of lean growth were completed in the Nebraska Gene Pool population. Selection was for an index of increased average daily gain from 56 days of age to 175 pounds and decreased backfat at 200 pounds. The index was I = 100 + 130 ADG (lb/day)—100 BF (in). The total genetic change from five generations of selection was an increase of 12% (.15 lb/day) in growth rate and a decrease of 5.4% (.09 in) in backfat (see the 1979 Nebraska Swine Report).

Following the experiment's selection phase, 53 barrows (83 days of age) from the lean growth select and the unselected control line were assigned to three feeding levels while 33 littermate barrows were slaughtered to obtain initial body composition. Barrows were individually fed for 105 days at an appetite feeding level (appetite), 91% of appetite (appetite 91) and 82% of appetite (appetite 82). Pigs on the appetite intake were allowed access to the feeder for two one-hour periods per day. Pigs on appetite 91 and appetite 82 intake levels received a single meal per day. The appropriate restriction was based on the daily consumption for pigs of the same weight receiving the appetite intake level.

All pigs were slaughtered at the completion of the test and both the initial slaughter sample and the test pigs were dissected in such a way that the composition (fat, protein, water and ash) could be determined for the whole body and for the carcass.

During the trial, the diet (16% protein corn-soybean meal ration) was analyzed for digestible energy. The combination of individual intakes and the difference between the final composition of the test barrows and the initial composition of littermates allowed the comparison of rate and efficiency of lean and fat growth for pigs from the select and control lines at three levels of daily feed intake.

Table 1. Backfat, feed conversion ratio and daily gain by line and feeding level.

Trait	Select line			Control line		
	AP[a]	AP91[a]	AP82[a]	AP[a]	AP91[a]	AP82[a]
Number	8	8	7	10	10	10
Avg. daily gain, lb.	1.70	1.55	1.30	1.55	1.42	1.24
Avg. daily intake, lb.	5.31	4.92	4.01	5.37	4.54	4.17
Backfat, in.	.98	.96	.89	1.18	1.03	1.07
Feed/gain	3.18	3.06	3.12	3.44	3.25	3.26

[a]AP = appetite, AP91 = appetite 91, AP82 = appetite 82.

Table 2. Body composition by line and feeding level for the final slaughter group.

Trait	Select line			Control line		
	AP[a]	AP91[a]	AP82[a]	AP[a]	AP91[a]	AP82[a]
Number	8	8	7	10	10	10
% fat in body	31.6	27.9	27.0	35.1	32.2	30.1
% protein in body	13.9	14.6	14.7	13.3	13.7	14.1
% water in body	50.9	53.4	53.6	47.9	49.9	51.4
% lean in body	67.5	71.1	71.6	64.0	66.6	68.7
% fat in edible section	32.1	27.3	26.4	37.7	33.9	30.8
% protein in edible section	13.6	14.3	14.6	12.5	13.4	14.0
% water in edible section	53.3	57.0	57.6	48.9	52.0	54.3
% lean in edible section	67.8	72.4	73.3	62.1	66.1	68.9

[a]AP = appetite, AP91 = appetite 91, AP82 = 82.

The Results

Lean growth pigs had less backfat, grew faster and required less feed/gain than control pigs (Table 1). Restricted feeding reduced the feed energy above maintenance that was available for growth and reduced both average daily gain and backfat. Appetite fed pigs were less efficient than appetite 91 and appetite 82 fed pigs. Improved feed efficiency occurred because restricted fed pigs were leaner and lean deposition requires less feed than fat deposition. Also, restricted fed pigs were lighter at slaughter and had a lower average daily maintenance requirement. Over a weight constant

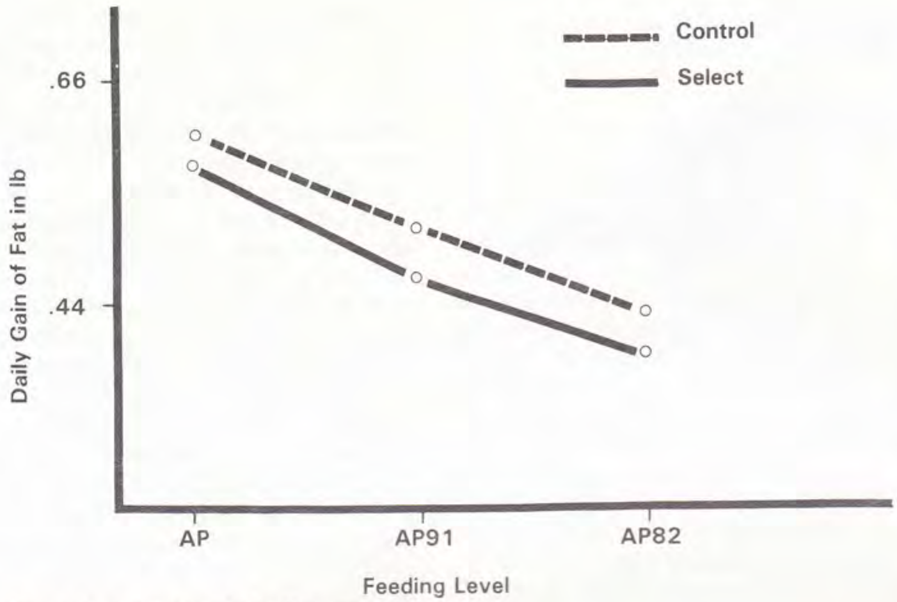

Figure 1. Daily fat gain by line and feeding level.

interval appetite 91 and appetite 82 fed pigs would have more days of maintenance (because of slower growth rate) which would reduce their feed efficiency advantage. There was no further improvement in feed efficiency from appetite 91 to appetite 82 feeding.

If grain prices become extremely high, it may be advantageous to restrict the feeding level in market pigs. However, increased costs of additional days to market must be considered. The appetite 91 fed pigs gained about .14 lb/day slower than appetite fed pigs. Over a weight range of 40 to 220 lb it would take pigs from the select line fed at the appetite intake level about 10 more days to reach 220 lb than the select pigs fed at the appetite level. The difference in feed efficiency would result in a total savings of about 22 lb of feed per pig. If the per day non-feed costs are $.15 and feed costs $.08/lb, the net savings from appetite 91 feeding would be $.26/head. In the control line, which was fatter and slower growing than the select line, reducing intake to the appetite 91 level would result in about 11 more days to 220 lb and would save about 34 lb of feed. The net savings in the control line is $1.07/head. This is some indication that restricting intake may be a more useful tool for reducing production costs and improving carcass merit in fat type pigs than in lean type pigs.

Even at heavier final test weights, the select line had a lower proportion of fat and higher proportions of protein, water and lean in the whole body and in the edible lean section (belly, butt, ham, loin, picnic and trim) than the control line (Table 2). If these lines were slaughtered at a constant final weight, the line differences in composition would be even larger. Index selection for high average daily gain and low backfat was effective in improving body composition. Appetite fed pigs had a higher proportion of fat and lower proportions of protein, water and lean than appetite 91 and appetite 81 fed pigs.

Figures 1-2 graphically demonstrate the growth rate of body components over the 105-day test period. Select line pigs deposited less fat and more lean per day than control line pigs. Index selection for low backfat and high average daily gain was effective in increasing the rate of lean deposition.

As feed intake declined, the daily fat gain declined (Figure 1). Restricted feeding reduced the energy intake which was used for fat deposition. In both lines the daily gain of protein, water and lean changed very little from appetite to appetite 91 feeding. Since the select line pigs were leaner than the control line, they had a higher daily protein requirement. Both lines were fed a 16% protein diet but at the appetite 82 feeding level the select line did not consume enough feed per day to meet its protein requirement. This resulted in a sharp decline in protein, water and lean deposition.

Figures 3 and 4 graphically demonstrate the amount of feed required per unit of body lean (or edible lean) deposited. Select line pigs required less feed per unit of total lean (or edible lean) depo-

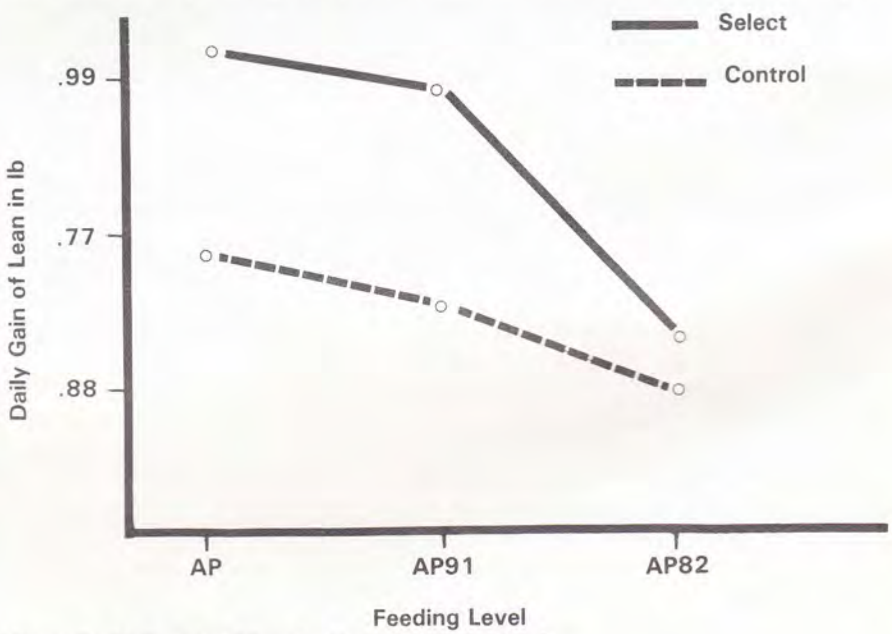

Figure 2. Daily gain of lean by line and feeding level.

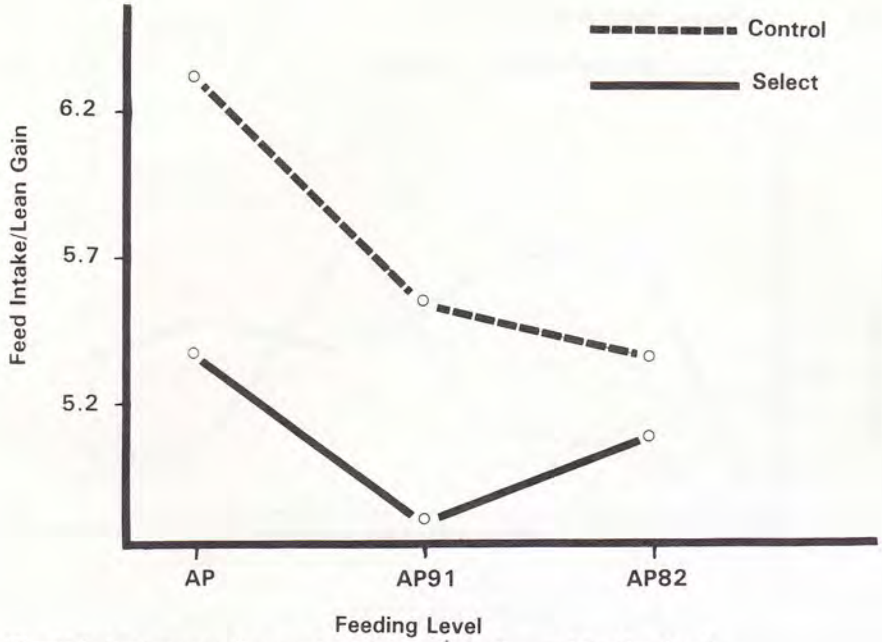

Figure 3. Feed required per unit of lean gain by line and feeding level.

improved the conversion of feed energy into carcass lean.

Restricted feeding reduced average daily gain, backfat and feed efficiency. Body composition improved with restricted feeding and restricted feeding reduced daily fat and lean gain. The quantity of feed required per unit of lean gain was also reduced by restricted feeding. There was little or no improvement in most traits from appetite 91 to appetite 82 feeding. Restricting intake may be a more effective tool for improving performance in fat type pigs than in lean type pigs.

The genetic merit for food conversion should be improving in purebred herds that are rigorously selecting replacement breeding stock for fast growth rate and low backfat. In addition to following a planned crossbreeding program, the single most important method available to commercial producers to genetically improve the rate, composition and efficiency of growth is to purchase breeding stock from breeders with on-farm, whole-herd performance testing programs who are selecting their own replacements because they are superior for measures of growth and fat.

sited than control line pigs. Index selection for high average daily gain and low backfat resulted in a 15 to 18% reduction in the amount of feed required per unit of lean deposited.

Appetite 91 fed pigs required less feed per unit of lean (or edible lean) gain than appetite fed pigs (Figures 3 and 4). Since appetite 91 fed pigs were leaner than appetite fed pigs, they used a greater proportion of their feed intake for lean deposition. Secondly, appetite 91 fed pigs were lighter at slaughter than appetite fed pigs which would result in greater efficiency.

There was little or no improvement in the amount of feed required per unit of lean (or edible lean) gain from appetite 91 to appetite 81 feeding. Apparently the appetite 82 feeding was too severe a restriction to further improve efficiency.

There was some indication that the daily maintenance requirement will increase from lean growth selection. Energy costs of maintenance are higher for lean animals than for fat animals of the same weight. The cost would be more important in the breeding herd than in market animals but the improved efficiency in market pigs from lean growth selection would probably offset any loss in efficiency caused by greater maintenance requirements.

Summary

Index selection for high average daily gain and low backfat improved average daily gain, backfat and feed efficiency. The method also improved body composition and decreased daily fat gain while increasing daily lean gain. The amount of feed required per unit of lean gain declined while the maintenance requirement increased slightly from lean growth selection. Index selection for high average daily gain and low backfat

---

[1]Erik R. Cleveland is graduate student, Animal Science. Rodger K. Johnson is Professor-Swine Breeding. R. W. Mandigo is Professor-Meats. E. R. Peo, Jr., is Professor-Swine Nutrition.

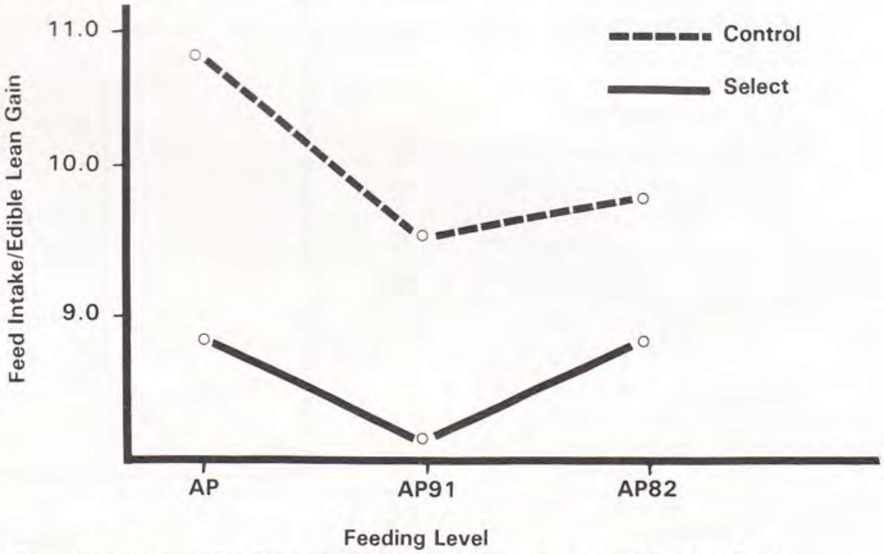

Figure 4. Feed required per unit of edible lean gain by line and feeding level.

No Adverse Responses From Lean Growth Selection

**Erik R. Cleveland,
Rodger K. Johnson,
and
P. J. Cunningham[1]**

Profitability of a swine enterprise depends on reproductive efficiency, feed conversion, growth rate and the quality of the product produced. Feed efficiency, growth rate and carcass merit can be improved by index selection based on growth rate and probe backfat. However, the advantages derived from improvement of selected traits could be offset by any undesirable correlated responses in other economically important traits.

Five generations of selection for increased average daily gain and decreased backfat reduced backfat by 5.4% and increased average daily gain by 12% (see the 1979 Nebraska Swine Report). Correlated changes in reproductive performance and in carcass characteristics are presented in this report.

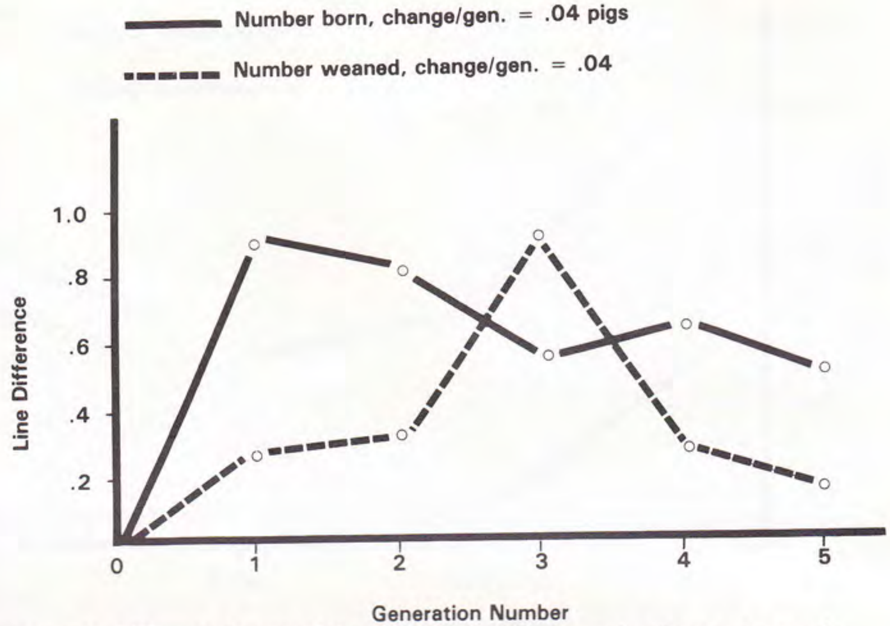

Figure 1. Difference between Select and Control line in number born and weaned.

Selection Experiment

Selection for lean growth (index of backfat and average daily gain) was started in 1971 and ended in 1976. Average postweaning daily gain (ADG) was used to measure growth rate because it includes less preweaning environmental effects (amount of milk received, litter size, etc.) and has a higher heritability than other measures of growth. Since average probe backfat (BF) is easily measured and is a relatively accurate indicator of carcass leanness, it was the second

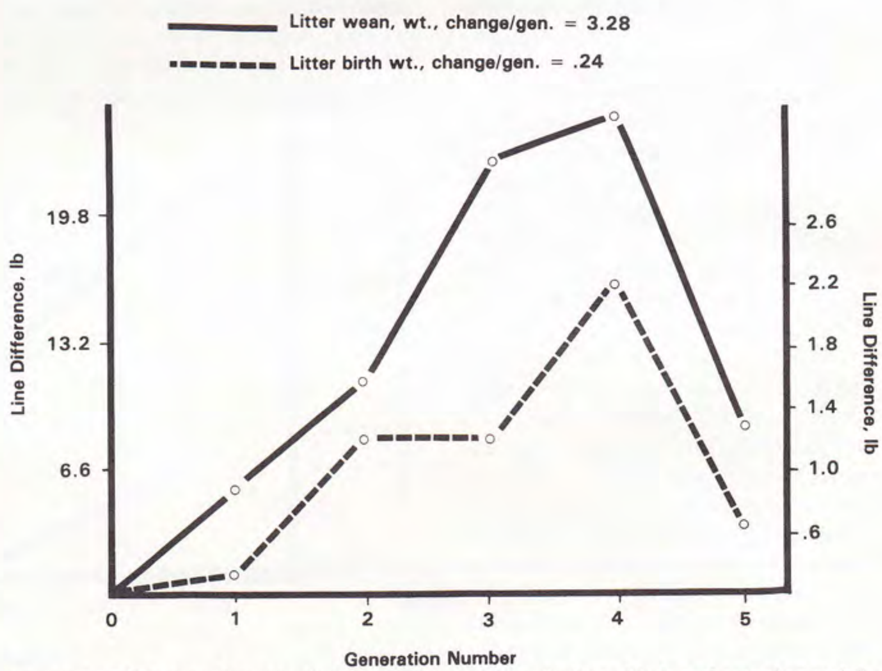

Figure 2. Difference between Select and Control line in litter birth and weaning weight.

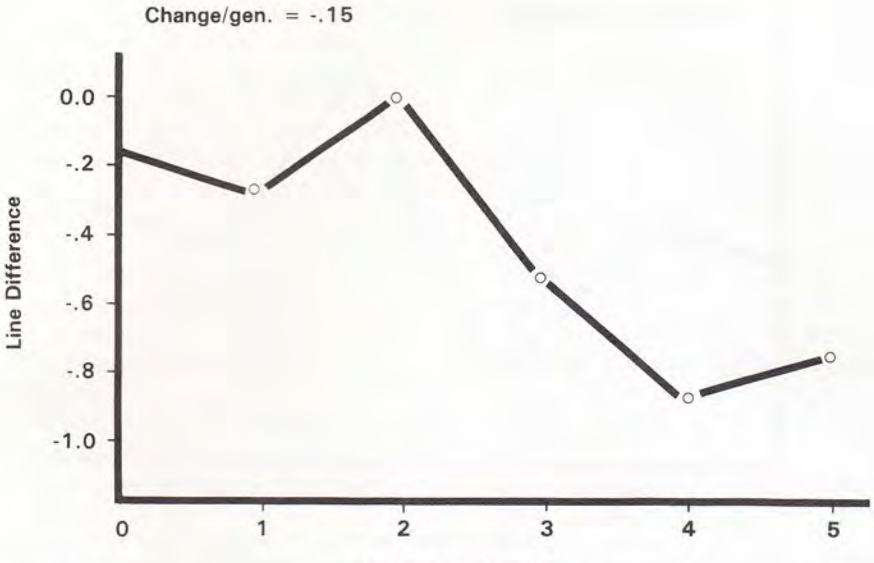

Figure 3. Difference between Select and Control line in teat number.

component used in lean growth selection.

The select line was selected on the following index (I): I = 100 + 130 ADG, lb/day—100 BF, in. A second line (control) was randomly selected to maintain the same genetic merit over all generations. The control line was used to adjust the select line for yearly environmental fluctuations.

Litter traits were measured on 221 gilts which farrowed litters. Teat number was counted within 24 hours of farrowing on 2,242 pigs of both sexes. Within each litter one or two pigs were randomly selected for carcass evaluation. Carcass traits were measured at 224 lb on 331 pigs of both sexes.

Correlated Responses

For each trait the difference between the select and control line was calculated for each generation. The average change in the line difference per generation measures the genetic change per generation in the correlated trait in the select line.

The line difference for number born and number weaned per litter was positive in every generation (Figure 1) indicating that the select line had larger litter sizes than the control line. There were fluctuations in the line difference between generations. The average increase of .04 ± .08 pigs per litter was small and could easily have been caused by random fluctuations between lines over time. Index selection was not detrimental. These data indicate a weak favorable genetic relationship between the index and litter size.

Line differences were also positive for litter weights at birth and at weaning which indicate that the select line produced heavier litters than the control. The line differences increased up to generation 4 and then declined (Figure 2). The average increase in the line difference (3.28 ± 2.09) for litter weaning weight was fairly large but could also have been due to random fluctuations. The line difference for teat number decreased by .15 ± .05 teats per generation (Figure 3). However, this did not have a detrimental effect on litter size or weight.

In general, index selection on average daily gain and back fat had a small positive effect on all reproductive traits except teat number. These data indicate a weak relationship between the index and reproductive traits.

Index selection decreased carcass backfat by .03″ per generation and increased loin eye area by $.12''^2$ per generation (Figure 4). This resulted in an increase of .10% per generation in percent ham and loin. Since selection was on average daily gain and backfat, carcass backfat was expected to decline. The line difference for carcass backfat, however, did not decline at a linear rate. Index selection did not apply the same amount of selection pressure on both traits in the index in each generation.

The line differences for carcass length fluctuated between generations (Figure 5). This fluctuation may be due to the sample of pigs slaughtered or to a weak genetic

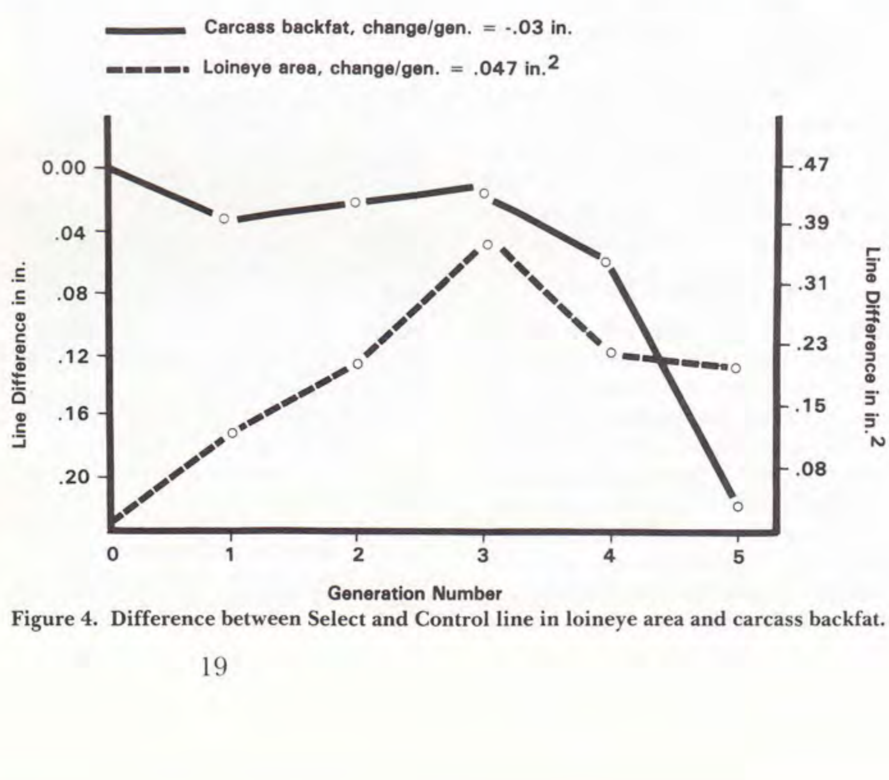

Figure 4. Difference between Select and Control line in loineye area and carcass backfat.

relationship between the index and carcass length. It is possible that lean growth selection would eventually increase mature body size which would increase carcass length. In general, index selection for increased average daily gain and backfat improved carcass merit.

Summary

Index selection is the most effective method to improve the overall genetic merit of livestock. Traits not included in the index may also change during selection if a genetic relationship exists between the index and the unselected traits. Index selection based on backfat and average daily gain had small positive effect on litter size and litter weights. At best, we probably should conclude that selection on this index will have no detrimental effect on reproduction. Index selection for average daily gain and backfat had a negative effect on teat number but was effective in improving carcass merit.

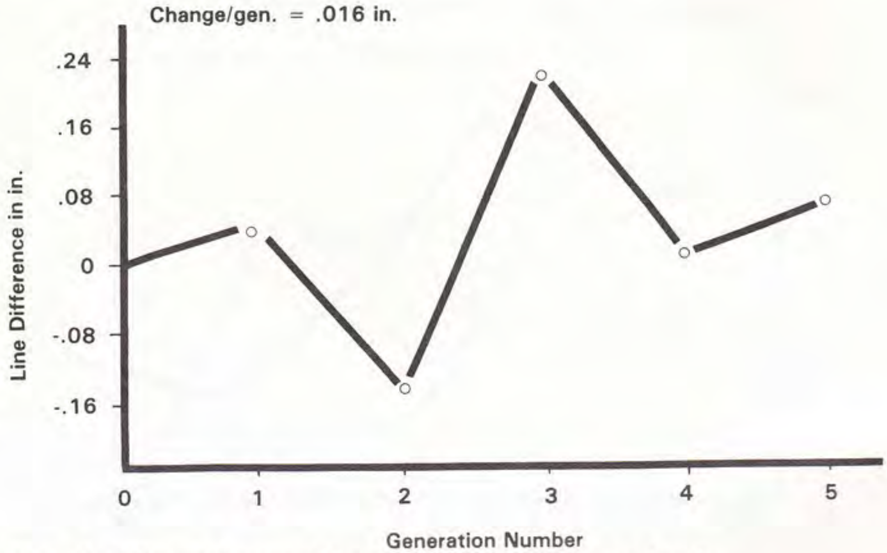

Figure 5. Difference between Select and Control line in carcass length.

[1]Erik R. Cleveland is a graduate student, Animal Science. Rodger K. Johnson is Professor-Swine Breeding. P. J. Cunningham is former Professor-Swine Breeding.

Selection Practices and Genetic Trends in SPF Herds

Phil David,
Tom Socha,
William T. Ahlschwede
and Rodger Johnson[1]

The rate of long term genetic improvement in the commercial swine industry depends on the rate of improvement in the source of purchased breeding stock.

Records from 688,250 pigs farrowed in 165 Nebraska SPF herds from 1960 through 1979 were available to study selection practices, genetic trends and phenotypic trends. Traits evaluated were litter size at birth, 140-day weight and backfat at 220 pounds.

Data Collected by SPF

Records for each pig included sire and dam identification, breed, herd, sex, contemporary group, date of birth, live pigs born in litter and weight adjusted to 140 days of age. Backfat at the first rib, last rib and last lumbar vertebra was measured on all pigs that were certified, i.e. females with 149-day weight in excess of 150 lb and males with 140-day weight in excess of 170 pounds. Data were collected by the SPF organization. Of available records, about 15% were used in this study.

A usable record had to include parental identification, date of birth, breed, sex, herd, contemporary group and 140-day weight. Data were not utilized if more than 60% of the records from any breed-herd-year subclass were incomplete. Breed-herds with less than 1,900 records before the editing procedures were not analyzed. Barrows were excluded from analyses of growth and backfat.

Only herds in which on-farm selection had been practiced were of benefit. A minimum of 9 males and 76 females which were raised and subsequently produced offspring on the same farm were considered necessary.

After editing, the total number of records was 101,606 from 18 herds representing three breeds, 1971 through 1979.

Selection Practices

Most selection pressure was on 140-day weight. The average selected female was 13.4 lb heavier than her contemporary average while the average selected male was 21.6 lb above average. Across herds, the 140-day weight superiority for selected females ranged from 8.1 to 22 lb. The range for selected males was 7.3 to 28.6 lb.

In most herds low backfat was not an important criteria in selecting replacements. It appeared that breeders were picking replacements that were average in backfat. Overall, selected females had .012″ less backfat than the average of their contemporary group. Selected males were .033″ better than average. The range across herds in backfat superiority of selected females was from .014″ fatter to .033″ leaner than average. The average for selected males was from .046″ fatter to .059″ leaner than average.

Observed selection differentials indicated that very few breeders were paying attention to litter size when making selection decisions.

Herds differed somewhat in the relative emphasis given to each trait in selection decisions. No herd was realizing all the selection that could have been applied. The average breeder was realizing 11% of the potential selection differential for backfat for female selection and 22% for male selection. The percentage of the maximum possible selection differential being realized for 140-day weight was 40% for females and 50% for males. The best herds were realizing about 30% of the maximum backfat selection differential and 65% of the maximum 140-day weight selection differential for male selection. However, some herds were getting a zero selection differential for backfat but only realizing 30 to 40% of the maximum potential selection differential for weight. Factors besides backfat, weight and litter size were influencing selection decisions.

Phenotypic and Genetic Trends

The average herd was decreasing in back fat at the rate of -.014" per year and decreasing in 140-day weight by .33 lb per year. These trends include both genetic and environmental change. Sires were often used for several months. The change in progeny performance over time allows the genetic trend to be estimated.

There was virtually no genetic change occurring in backfat over the time interval of this study. The estimated genetic change was an increase of .004" per year. The average genetic change in 140-day weight increased 1.32 lb per year.

Both the phenotypic and genetic time trends for backfat were small indicating little change over time for the environmental effect on backfat. However, 140-day weight was improving gentically but declining phenotypically. This suggests changes over the years in environmental factors, which were detrimental to rate of growth. Perhaps these changes are the result of new facilities and/or technology that reduced labor demands but were not beneficial to growth rate. Also, weaning age was declining over this 10-year interval which would likely cause some reduction in 140-day weight.

Boars are introduced into herds to make genetic improvement and to broaden the genetic base of a herd. The assessment of the relative genetic merit of home grown and introduced males indicated that there was very little average difference in genetic merit for backfat. For 2 of 18 herds, the average home-raised boar was significantly superior to introduced boars and for 2 other herds, the reverse was true. The remainder of the herds were introducing sires about equal in genetic merit to those selected from their own herd.

For 140-day weight, 12 of 18 herds were selecting boars from their own herd that were superior to introduced sires. The difference was significant for only five herds. In only two herds was the 140-day weight genetic merit of introduced sires superior to that of home-raised boars.

In general, introducing outside sires caused very little genetic change. Also, the number of boars introduced was considerably higher than was necessary to maintain a broad genetic base. In order for this to be an important means of genetic improvement, breeders need to be more aware of selection practices in the herds from which sires are obtained. Introduction of fewer sires and more attention to on-farm performance test records seems to be a better alternative.

Using achievable selection differentials and the National Swine Improvement Federation Index for backfat and growth rate, the expected annual change in backfat and 140-day weight are -.028" and +4.4 lb, respectively. In comparison, the average Nebraska SPF breeder is changing at the rate of + .004" of backfat and + 1.32 lb in 140-day weight. The mechanism by which the rate of response will be increased is to select more intensely among home-raised boars and gilts and more careful identification of superior animals when introducing new breeding stock.

---

[1]Phil David is a graduate student, Animal Science. Tom Socha is Secretary-Manager, Nebraska SPF Accrediting Agency. William T. Ahlschwede is Extension Swine Specialist. Rodger Johnson is Professor-Swine Breeding.

Grain Handling for Swine Enterprises

David P. Shelton, Richard O. Pierce, and Gerald R. Bodman[1]

Quality feed is a requirement for all successful swine production enterprises. Feed represents the largest single cost of pork production. Thus, even small percentage savings in feed handling and processing can return large dividends.

Feeding program alternatives available range from the purchase of a complete feed to buying individual nutrients and using home grown grains to prepare a diet. An evaluation of the production enterprise is necessary to determine the most cost-effective method of feed preparation.

A commercial feed provides a convenient nutritional program that requires minimal labor by the swine producer. The producer depends on the company personnel for proper diet formulation and mixing. The feed industry assumes the responsibility of quality control and making sure diets are formulated at the proper nutrient levels for maximum performance. Use of a commercial feed reduces on-farm equipment requirements to a bulk storage bin or feed storage area and a distribution system.

On-farm processing provides a good option for producers with home grown grains or access to a grain supply. Grain storage facilities allow the producer to take advantage of seasonal grain prices, whether he is buying or selling.

Most producers find a cost advantage of about $25 per ton when comparing the delivered cost of all ingredients with the delivered cost of complete feeds. This difference in cost covers all fixed and operating costs, including a fair charge for labor to operate the on-farm system. Higher annual tonnages of feed provide greater returns to on-farm processing. The break-even point between commercial feed and on-farm processing is usually in the range of 300 to 400 tons of feed per year. This would be equivalent to the feed requirements of a 50-sow farrow-to-finish operation or about 1,200 head of feeder pigs finished to market weight. While price is often the determining factor in the decision to use a commercial feed or employ on-farm processing, additional factors should be considered.

Factors in On-Farm Processing

1. *Labor.* On-farm processing may reduce feed costs but more labor will be required. There must be time to study, interpret, and plan the nutritional program. Mixing feed involves a willingness to devote management time to purchasing and handling ingredients, maintaining quality control, and staying up-to-date on additives. If an employee will be responsible for feed processing, some training and supervision must be given to avoid costly errors. Time must be devoted to maintenance of equipment.

2. *Feed ingredient supply.* There must be a readily available supply of ingredients (grain, soybean meal, premixes, base mixes, vitamins, minerals, feed additives, etc.) at a competitive price. Bulk buying in volume at discount prices is essential to the success of a farm-mixing program. However, caution must be exercised in a volume buying and storage program to avoid degradation of ingredients, particularly vitamins. For many vitamin/mineral mixes the maximum storage time is 90 days, beginning with the day of manufacture.

3. *Equipment and facilities.* Equipment needs include storage bins, mills, grinders, mixers, accurate scales and conveying equipment. Fixed investments mean some loss of flexibility. Investment in feed processing equipment is a commitment to stay in the livestock business. Only by steady use over a period of time can the investment be recovered.

Enough feed storage space must be provided to carry the system for a reasonable period of time. Make allowances for bad weather, delayed deliveries, and rush seasons. A minimum two-week supply of diet ingredients is recommended. Compare price advantages for timely, seasonal, or volume purchases against the cost of storage. Volume purchases of grain and soybean meal may reduce the number of adjustments required in diets due to changes in moisture content, protein, energy, fiber, etc.

4. *Quality control.* By mixing on-farm, the responsibility for quality control of the feed ingredients in diet formulation lies with the producer. With grain it is important to evaluate moisture content and test weight, and to determine if mold is present or if insect damage has occurred. The feeding of moldy grain can result in reduced gains, poor feed conversion efficiency, reproduction problems, and in extreme cases, heavy death losses. Proper handling of grain at harvest and during storage can help avoid these problems.

On-Farm Grain Storage

Since a swine diet commonly contains more than 80 percent grain, careful attention must be given to grain harvesting, drying and storage. Before harvest, thoroughly clean the combine and all other grain handling equipment to remove all traces of old grain and foreign material. If this material is not removed, it may serve as a source of mold and insect infestation of the new grain.

Thoroughly clean storage bins to remove all traces of old grain. If possible, clean the area under the perforated floor to remove broken kernels and grain dust which provide an excellent breeding area for insects. After cleaning, spray the inside of the bin with a residual treatment of malathion. Be sure to observe all safety precautions and label restrictions. Avoid putting new grain on top of old grain in a bin.

Check the outside of the bin for deterioration and/or damage. Repair roof leaks or sidewall damage.

Check and service drying or aeration fans and any burners or heaters. Check, repair or replace electrical equipment and connections if necessary.

Grain drying is used to reduce grain moisture to levels acceptable for safe storage. Grain does not necessarily need to be dried to low moisture levels, depending on intended use and storage length. The maximum moisture contents (the wettest grain in the bin, *not* the average moisture) at which corn or milo can be stored with proper aeration are given in Table 1. Aeration systems do not have

Table 1. Safe storage moisture contents for good quality corn and milo held with proper aeration.

Length of storage time or use	Maximum safe moisture content (%)
To be fed out by early spring	18
To be sold as #2 grain by spring	15½
To be stored for up to one year	14
To be stored longer than one year	12

Table 2. Recommended grain temperatures.

Season	Temperature management
Fall	–Ensure grain is cool after drying –Cool to 30°F by late fall
Winter	–Maintain grain at 30°F
Spring	–Gradually warm grain to 60°F by early summer
Summer	–Maintain grain as close to 60°F as possible

the capacity to significantly reduce moisture contents, so do not exceed allowable storage periods.

Grain quality will not improve during storage. At best, quality can only be maintained. For this reason, store only high quality grain. There are four main causes of grain storage problems:

1. *Poor quality grain going into storage.* Grain going into storage should be dried to the proper moisture level and should be clean. A rotating grain cleaner is recommended to remove fines as well as broken or cracked kernels. This will improve airflow through the grain and lessen the potential for insect problems, since many of the common grain insects will only attack broken or cracked kernels.

2. *Improper aeration management.* The aeration fan should provide at least 1/10 cfm per bushel of grain and be operated to maintain grain temperatures within 15 to 20°F of the average outside air temperature. Proper aeration management reduces moisture migration, convection currents, and subsequent condensation of moisture in the grain. Contrary to a common notion, properly stored grain does not "sweat" during planting time. This surface moisture is due to condensation on cool grain and occurs as a result of improper aeration and grain temperature management. Table 2 lists recommended grain temperatures as a function of season of the year.

3. *Improper insect control.* Insect control is often necessary, especially for grain stored longer than one year. In addition to thoroughly cleaning equipment and bins and storing only clean grain, this involves monitoring insect development and using fumigation or other control methods as necessary.

4. *Inadequate observation.* Failure to monitor grain condition throughout the storage period is probably the most frequent mistake. Grain conditions change as outside conditions change. A small area which starts to heat or otherwise "go out of condition" can quickly get out of control and spoil the entire bin. Inspect grain regularly, preferably on a weekly basis. Think of the grain as being the same as cash in the bin, and consider how frequently it would get checked if that were the case. Some of the areas and conditions to check when monitoring grain quality include:

*Grain surface for condensation, crusting, wet areas, and insects.

*Bin roof for condensation and leaks.

*Grain mass for non-uniform temperatures, high moisture pockets or layers, and insects.

*Exhaust air coming off the grain for any off-odors.

On-farm grain storage can be used successfully as a part of the swine feeding program. It is necessary, however, to carefully manage that system to prevent a serious economic loss. The management includes:

1. A well designed storage system with proper aeration capacity.

2. Storing only clean grain at the proper moisture content.

3. Checking the grain condition regularly and correcting any problems before they get out of hand.

More detailed grain drying and storage management information is presented in the publications AED-20 "Managing Dry Grain in Storage" and MWPS-22 "Low Temperature and Solar Grain Drying". These publications are available from the Agricultural Engineering Plan Service.

---

[1]David P. Shelton is Extension Agricultural Engineer, Northeast Station. Richard O. Pierce is Extension Agricultural Engineer-Processing and Materials Handling. Gerald R. Bodman is Extension Agricultural Engineer-Livestock Systems.

Value of crossbreeding.

Crossbreeding Systems Analysis

William T. Ahlschwede[1]

Pork producers realize the value of crossbreeding. Commercial producers in the United States appear to be in a transition period, caught between rotational crossbreeding systems and terminal crossbreeding systems using specialized sow lines.

Continuous farrowing schedules in modern production units have made rotational crossbreeding systems difficult to operate. Reports of excellent sow productivity using white sows in terminal crosses are abundant. To compare the various crossbreeding systems, a computer crossbreeding systems analysis program was developed. The program provides estimates of the productivity of various crosses and their economic outcomes.

Analysis System

The crossbreeding systems analysis program operates in three segments;

1. Calculation of expected breed composition and heterosis level.

2. Estimation of conception rate, litter size farrowed, litter size weaned, age at market, fat thickness and feed efficiency for the particular cross.

3. Projection of an economic outcome.

Procedures for calculation of breed composition and heterosis level are based on genetic theory. Procedures for estimating performance levels of the crosses for the various traits use weighted means of breed averages with added increments for heterosis corresponding to the heterosis advantage for a given trait and the heterosis level in the given cross.

For conception rate and litter size born, the dam's genotype and heterosis level are used in the calculations. Litter size weaned is calculated by multiplying litter size born by survival rate. Survival rate is determined by averaging the expected survival based on the sow's genotype and heterosis level and the survival based on the piglet's genotype and heterosis level. This recognizes the possibility of different genotypes (breed composition) in the sow and the offspring and that they both contribute to piglet survival. For both conception rate and survival, heterosis effects are based upon percent failures rather than percent successes. Conception rate is also allowed to be influenced by heterosis in the boar. Crossbred boars with 100% heterosis reduced the number of open sows by half.

Expected performance for age at market (220 lb), backfat thickness and feed efficiency (feed/gain from 40 to 220 lb) are calculated using the offspring genotypes and heterosis levels. Breed averages and heterosis effects are based on those reported by the North Central Region Swine Breeding Committee in the NCR-62 Bulletin (Table 1).

Table 2. Heterosis level, expected performance and economic outcome with three breed rotation.

Mating boar x sow	Heterosis Sow	Heterosis Pig	Conception rate	L.S.	Weaned	Age at Mkt.	Fat	F/G	100 litters expected return
3 breed rotation									
Hampshire x Y,D,H. . .	86	86	80%	11,25	8.56	169	1.07	3.26	$7,525.90
Duroc x H,Y,D. . .	86	86	83%	10.59	7.95	165	1.12	3.27	$5,363.92
Yorkshire x D,H,Y	86	86	85%	10.59	8.02	166	1.15	3.28	$5,547.60
Average of three sire generations									$6,145.82

Economic Projections

Economic projections are used to provide a single number comparison among the systems studied. While there are many approaches to an economic evaluation of pig performance which yield different projections, the method used appears to give reasonable weightings to the various factors.

The economic analysis is based on a unit size of 100 litters. It assumes that managers are able to adjust size of the breeding herd to keep the farrowing house full. Thus, systems with larger litter sizes weaned sell more pigs. Changes in conception rate show up as differences in the number of sows in the breeding herd needed to produce 100 litters. Sows more or less than the 125 needed with an 80% conception rate were assigned a cost or savings of $28 each, representing twice the feed cost for an eight-week breeding period. A base cost of $300/litter (7½ pig average) at 40 lb was used to represent the breeding herd costs of boar and sow depreciation, buildings, feed, health, labor, investment and utilities. Returns to management and non-specific overhead were not assigned as costs. A marginal cost of $5/pig was added to the litter cost as litter size increased. During the finishing period, a $14 charge/pig was made to cover all non-feed costs. A 5¢/day adjustment was made for pigs reaching market weight sooner or later than 180 days. Feed was charged at 7¢/lb for the 40 to 220 lb weight range based on the F/G value of the cross. All pigs were sold for 45¢/lb ($99/pig) regardless of fat thickness. At base levels of performance (80% conception, 7.5 pigs weaned, 180 days to market and 3.5 F/G) production costs averaged about 44¢/lb.

Economic projections are intended to compare crossbreeding systems. The differences between the projections of two crosses is much more meaningful than any one specific projection.

Three Breed Rotation

Table 2 shows expected performance and economic projections for the three sire generations of a Hampshire, Duroc, Yorkshire three-based rotation. The breed composition varies considerably from generation to generation in a rotational cross, the breed of sire accounting for 57%, the grandsire breed 28% and the great-grandsire breed 14%. The heterosis level is 86%. The changing breed composition accounts for the noticeable changes with generation in the performance and outcome of this rotational crossbreeding system.

Table 3 shows performance levels and economic outcomes of several terminal crosses. These all represent white sows mated to a terminal boar. Terminal crosses are the last cross in a production system. All pigs produced go to slaughter. Replacement gilts are produced by other crosses. The

Table 1. Breed averages for performance traits used in analysis.

Trait	Hampshire	Duroc	Yorkshire	Landrace
Conception	0.85	0.85	0.72	0.69
Litter size	9.00	9.60	10.80	10.00
Survival	0.66	0.66	0.72	0.84
Age	183.00	172.00	177.00	180.00
Fat	1.00	1.20	1.20	1.40
F/G	3.30	3.33	3.35	3.60

Table 3. Heterosis levels, expected performance and projected economic outcome of terminal cross.

	Mating boar x sow	Heterosis Sow	Heterosis Pig	Conception rate	L.S.	Weaned	Age at Mkt.	Fat	F/G	100 litters expected return
Terminal crosses										
1	Hampshire x Y-L F_1	100	100	74	11.65	9.55	168	1.13	3.32	$10,493.80
2	Duroc x Y-L F_1	100	100	74	11.65	9.55	163	1.23	3.33	$10,561.20
3	H-D F_1 x Y-L F_1	100	100	87	11.65	9.55	166	1.18	3.33	$11,091.50
4	H-D x Y-L, Y-L. . .	50	100	86	11.02	8.87	166	1.18	3.33	$8,416.00
5	H-D x Y-L Y	50	100	86	11.24	8.83	165	1.15	3.30	$8,644.75
6	H-D x Y-HL	87½	100	89	11.36	8.99	167	1.13	3.33	$9,200.66
7-L	H-D x L,Y,L. . .	67	100	86	11.09	9.11	166	1.19	3.35	$9,102.10
7-Y	H-D x Y,L,Y. . .	67	100	87	11.38	9.08	165	1.16	3.31	$9,490.49

strategy of terminal cross systems is to use the highly productive cross to produce most of the pigs while committing a small number of litters to producing replacement gilts from less productive crosses. In situations where replacement gilts are purchased, all litters produce terminal crosses. The specialized sows are purchased.

The first step in evaluating terminal crossbreeding systems is to compare the productivity of the terminal crosses. The second step will be to include the less productive crosses producing replacement gilts. Table 3 shows the comparison for various terminal crosses. The differences among crosses are due to breed composition and heterosis level. The first three crosses (line 1, 2 & 3) utilize F_1 Yorkshire-Landrace sows, the first when mated to a Hampshire boar, the second mated to a Duroc boar and the third when mated to a $HxDF_1$ crossbred boar. Except for conception rate, the expected performance of the third cross is equal to the average of the first two crosses. The research on which the programming is based indicates that crossbred boars are superior to purebred boars for conception rate. The conception rate advantage was that the crossbred boars left only half as many open sows.

The F_1 Yorkshire-Landrace sows in terminal crosses were considerably superior to the three-breed rotation. The advantage was $44-49/litter depending upon which sire was used. The superior performance is primarily in litter size weaned. This is due to a combination of breed composition and high levels of heterosis. In these terminal crosses, heterosis in the sow and the pig is 100%. For sow productivity, the high litter size of the Yorkshire and the high survival of the Landrace were an excellent combination. Compared to the three breed rotation, the 14% improvement in heterosis (86 to 100%) helped improve on litter size and piglet survival. The Hampshire, Duroc, Yorkshire rotation lacks the ideal breed composition for litter size found in the F_1 Yorkshire-Landrace sow. The projected advantages of these terminal crosses compared to the rotation were sufficiently large to encourage further consideration. In round numbers, the $50/litter advantage offered by the four-way terminal cross (line 3) over the average of the three sire generations in the Duroc, Hampshire, Yorkshire rotation is worth going after.

Other Terminal Crosses

Going after the $50 is not always easy. The first step is to consider a broader range of terminal crosses. Lines 4 through 7 of Table 3 show several other terminal crosses. Many other possibilities exist. In each of these cases, the H-D F_1 terminal sire is used. First, the comparisons among the crosses are simplified if the sire is the same. Secondly, the research upon which the breed averages are based indicated low conception rates for Yorkshire and for Landrace females. The conception rate advantage of the crossbred boars yields conception rates with these sows which are acceptable in production units.

Line 4 shows terminal crosses produced by F_2 Yorkshire-Landrace sows. This sow is produced by breeding an F_1 Yorkshire-Landrace sow to an F_1 Yorkshire-Landrace boar. While the breed composition of this sow is ½ Yorkshire and ½ Landrace, the heterosis level is only 50%. The productivity of this terminal cross suffered substantially compared to the cross above it in Table 3. The difference, $25/litter, was due to the reduction in sow heterosis. This sow is the equivalent of several others which are being suggested and used in commercial production units. If the F_2 sow is bred back to an F_1 Yorkshire-Landrace boar, the resulting gilts are equivalent—½ Yorkshire, ½ Landrace and have 50% heterosis.

If one starts with crossbred sows of any breed composition and breeds them to F_1 Yorkshire-Landrace boars and breeds gilts from the cross produced to F_1 Yorkshire-Landrace boars, sows equivalent to the F_2 sow are produced. As the F_1 Yorkshire-Landrace boar is used back on each successive generation of gilts, the breed composition rapidly approaches 50% Yorkshire and 50% Landrace and the heterosis level goes to 50%. Productivity of the sows during the early generations are similar to the F_2 because a higher heterosis level compensates for a less desirable breed composition. Although these types of sows have been recommended in many areas, the reduction of 68 pigs/100 litters is not an attractive target.

Yorkshire Backcross Sows

A second alternate to F_1 Yorkshire-Landrace sows for terminal crosses are Yorkshire backcross females (line 5). These are produced by breeding F_1 Yorkshire-Landrace sows to Yorkshire boars. As with the F_2 sow, the heterosis level is 50%. Substituting some Yorkshire for Landrace improved slightly the performance of the pigs, but reduced survival. The economic outcome was essentially the same as with the F_2 sow.

Line 6 of Table 3 shows a quarter Hampshire sow with 100% heterosis. This sow is produced by breeding a Hampshire-Landrace F_1 sow to a Yorkshire boar. This sow was superior to the two above (lines 4 and 5) in the table but does not measure up to the F_1 Yorkshire-Landrace. If produced as indicated, the 100% sow heterosis level compensates for some of the loss from substituting Hampshire for some of the Landrace in the sow. This cross produced at a $30/litter advantage to the three-breed rotation, but at a $19 disadvantage to the F_1 sow (line 3). If the sow was produced by a Y-H x Y-L mating, sow heterosis dropped to 75% and the economic outcome was reduced by approximately $14 per litter.

Rotaterminal System

Line 7 represents the two terminal crosses in a rotaterminal crossbreeding system. In this system, the replacement gilts are produced using a criss-cross or two-breed rotation between Yorkshire and Landrace. These gilts can be mated to produce either terminal cross market hogs or more replacement gilts. Line 7-L shows the Landrace sired sow in the terminal cross. Line 7-Y shows the Yorkshire sired sow. The sow in 7-L is 67% Landrace and 33% Yorkshire. The sow in 7-Y is 67% Yorkshire and 33% Landrace. Both have 67% heterosis. Since the breed composition is slightly different, the performance in the terminal cross was also different. The line 7 crosses compared favorably with line 6, but still were at a disadvantage to the use of F_1 sows. The interest in the rotaterminal system is based on its simplicity in producing the replacement gilt. Compared to the F_1 sow, the rotaterminal has reduced sow heterosis and a more variable breed composition. The $18 average/litter difference in returns must be weighed against the differential cost and ease of producing or acquiring replacement gilts.

All of the sows producing the terminal crosses in Table 3 are white sows. They are quite different in productivity. When one adds to these all of the possibilities using Chester Whites along with

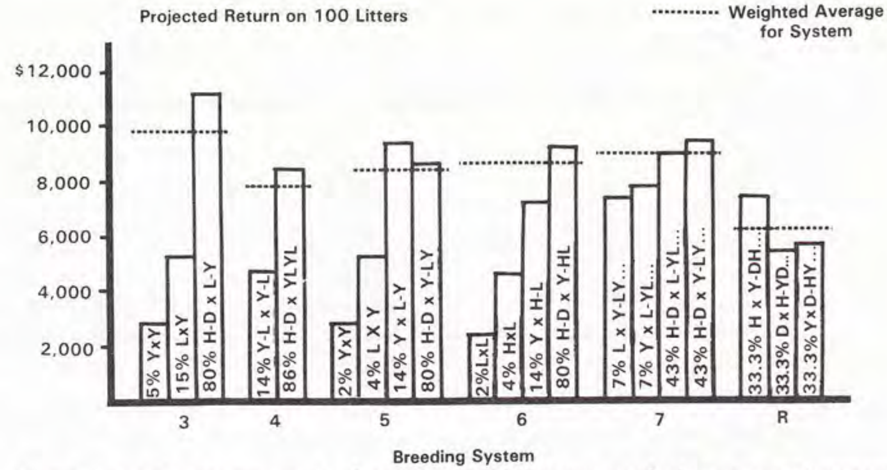

Figure 1. Mating components of crossbreeding systems producing own replacement females.

Yorkshire and Landrace in producing terminal sows, it becomes apparent that "white sow" is not adequately descriptive.

Production Systems

The rest of the story for terminal crosses has to do with the lower production in the matings required to produce the replacement gilts. For purchasing sows, the economic projections in Table 3 give some basis for calculating the value difference between types of gilts at purchase. Figure 1 is provided to indicate production system values when replacement gilts for terminal crosses are produced on the farm. Only boars are purchased. Since the economic projections assume fairly heavy boar use, boar costs might be higher with some of the smaller breed groups in several of the systems. The vertical bars in Figure 1 represent the economic projection for 100 litters for each part of the various production systems. The horizontal line indicates the system average return when component crosses are weighted by their proportion in the system.

In system 3, corresponding to line 3 of Table 3, it was assumed that 80% of the litters produced terminal crosses. To produce the F_1 Yorkshire-Landrace replacement gilts, 5% of the litters were purebred Yorkshire and 15% were Landrace x Yorkshire. With this herd division the average economic outcome was $9,800 on 100 liters. This is a three-tiered system which requires both purebred Yorkshire sows and crossbred sows. Three types of boar are used.

System 4 is a two-tiered system. It is based on the F_2-type sow. Replacement gilts are produced by breeding half Yorkshire-half Landrace sows to F_1 Yorkshire-Landrace boars. Hence, all sows in the system have the same breed composition and heterosis level. About 14% are bred to produce replacement gilts, the rest to produce terminal crosses. Only two types of boars are required. This system averages $7,882 for 100 litters.

The backcross sow is shown in system 5. This is a four-tiered system using three types of boars. Like system 3, 20% of the matings are committed to producing replacement gilts. Two percent of the litters are purebred Yorkshire, 4% are Landrace-Yorkshire, 14% are Yorkshire backcross matings and the remaining 80% are terminal crosses. This system averages $8,488/100 litters.

The quarter Hampshire sow produces the terminal cross pigs in system 6. It is similar to system 5, both in complexity and in economic outcome. Both are four-tiered systems and both have several small breeding groups. System 6 is based on 2% purebred Landrace matings, 4% Hampshire x Landrace, 14% Yorkshire x Hampshire-Landrace and 80% terminals. This system averages $8,612/100 litters.

The rotaterminal, system 7, is a

split two-tiered system, using three types of boars. All of the sows are Yorkshire-Landrace rotation sows, half Yorkshire sired, half Landrace sired. Fourteen percent are bred to white boars (half to Landrace, half to Yorkshire) to produce replacement gilts. The remainder (43% Landrace sired, 43% Yorkshire sired) are bred to produce terminal offspring. This system averaged $9,086/100 litters.

The rotation cross system from Table 2 is also shown in Figure 1 as system R. Averaged over the three boar breed generations, its expected outcome was $6,146/100 litters.

White Sows

The crossbreeding systems analysis reported here indicates that with careful breed selection and heterosis control, terminal crosses can offer large production advantages and added returns when compared to the three-breed rotation. Not all terminal crosses were equivalent. Some white sows had a $26 disadvantage/litter to other white sows. When production systems were put together to include producing replacement gilts on the same farm, the advantages of the terminal crosses were reduced when compared to the Hampshire, Duroc, Yorkshire rotation, but they were still substantial.

The advantage of the F_1 Yorkshire-Landrace sows in system 3 was sufficiently large when compared to the rotation ($37/litter) to be given serious consideration. The rotaterminal, with a system advantage of $29/litter offered an intermediate position. It should be operationally easier to manage than system 3, but not as productive. The quarter Hampshire sow (system 6), offers another intermediate type sow. For those who believe that they need some Hampshire in the sow for ruggedness, this is an alternative. The production system producing these replacement gilts is tedious.

The rotational cross has historically been the system of choice. However, with continuous farrowing, it is difficult to operate. It really involves three types of sows and three breeds of boars. The penalty for making wrong matings in a rotation is as high as $50/litter due to reduced heterosis and less desirable breed composition. The so called ease of operation of the rotational cross applies to seasonal farrowing operations which replace all of the breeding herd, including boars, each year. Such extensive production practices will not be common in Nebraska during the 1980's.

---

[1]William T. Ahlschwede is Extension Swine Specialist.

Find Your Future

in

ANIMAL SCIENCE

at the

UNIVERSITY OF NEBRASKA

CURRICULUM OPTIONS

Undergraduate programs for Animal Science majors and for other students in the College of Agriculture help develop the student's capability to cope with problems of Nebraska's livestock industry. Because of the size of this livestock industry—65% or more of Nebraska's agricultural income—all agriculturists who work in Nebraska must understand livestock production. Many options are available in the undergraduate Animal Science program. These include:

1. Production—Beef, Sheep & Swine
2. Range Production
3. Dairy
4. Science
5. Business
6. Education
7. Poultry
8. Communications