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EC91-219 Nebraska Swine Report

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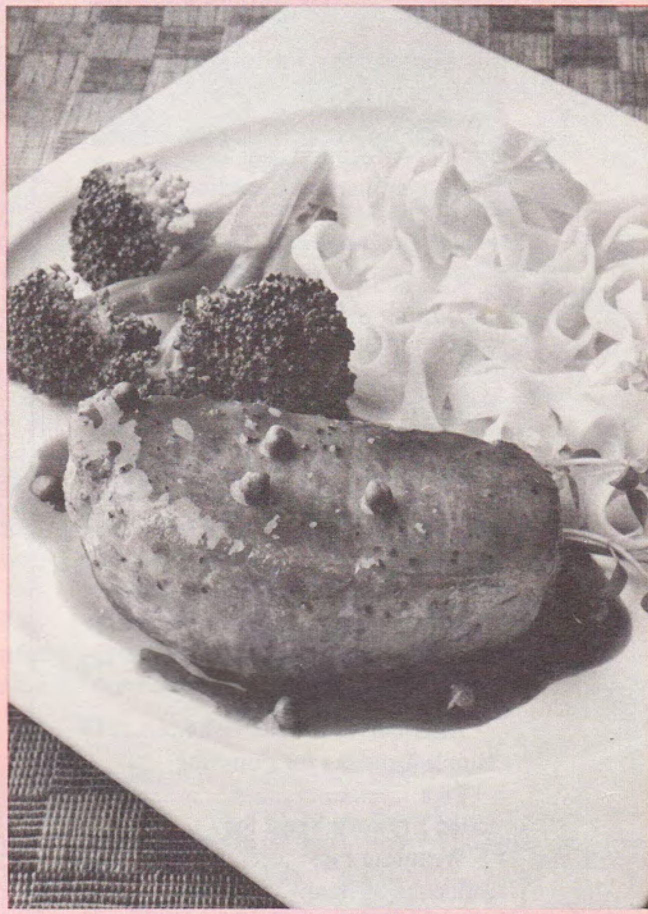

NEBRASKA SWINE REPORT

- Breeding
- Disease Control
- Nutrition
- Economics
- Housing

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

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ON THE COVER:

America's Cut© boneless pork chop ready for dinner. Courtesy of National Pork Producers Council.

The 1991 Nebraska Swine Report was compiled by William T. Ahlschwede, Extension Swine Specialist, Department of Animal Science.

Factors Influencing Fat and Caloric Content of Cooked Pork Lean

Chris R. Calkins[1]

Previous research (1988 Swine Report, p. 21), showed amount of external fat trimmed from pork cuts, cut type, and method of cookery influenced fat and caloric content of cooked pork lean. This study examined additional factors using more pork cuts. External fat trim, cooking method, cut type, carcass fatness, and endpoint cooking temperature were studied.

Paired sides from 45 hogs were selected to represent three levels of carcass fatness on the basis of last rib fat thickness (Fat = 1.1 to 1.6 inches; Medium = 0.75 to 1.1 inches; Lean = 0.75 inches or less). Carcasses were shipped to Loeffel Meat Laboratory and fabricated into boneless top-loin chops, bone-in loin and rib chops, and bone-in blade steaks. Cuts from alternating sides were trimmed to 0 inches of external fat while paired cuts were trimmed to .5 inches of fat.

Pork cuts (n=960) were cooked to 160 or 170°F by braising, broiling, microwaving, or roasting (Table 1). Cuts were lightly blotted (except those which were roasted), allowed to cool and dissected into lean, fat, and bone. The lean was analyzed for amount of moisture, fat, and protein. Caloric content was calculated using .0363 kcal per oz. of protein and .0767 kcal per oz. of fat (USDA procedures).

Table 1. Cooking methods for pork cuts.

Broiling	Place on Farberware Open-Hearth broilers. Turn over cuts at 95°F internal temperature.
Braising	Brown in oven-safe frying pan at 350°F with 1 tbs of water for 3 min. Turn over cuts and add 3 tbs of water. Cover pan and place in 325°F oven.
Microwaving	Place on rack in covered, oven-safe dish. Amana, 700-watt microwave at 70% power. Cook cuts 1.5 to 2.5 min and stop to record temperature. If additional cooking needed, proceed at 20 sec intervals.
Roasting	Place on rack in 355°F oven. Turn over at 95°F internal temperature.

Results

Fat and caloric content of cooked pork lean was influenced by carcass fatness (Table 2). Generally, those carcasses possessing greater fat thickness at the last rib produced cuts higher in fat and calories than cuts from carcasses with little fat at the last rib. This was especially true for rib and loin chops. Caloric content does not always mirror fat content since protein also contributes to energy content of the lean.

Boneless center cut pork chops.

Cooking method also had a strong influence on fat and caloric content (Table 3). Microwave cooking consistently resulted in the lowest fat and calories, while broiling generated the highest values. To a large extent, these differences can be explained by cooking losses. Greater moisture loss during cooking concentrates fat within the lean. The microwave cooking procedures generated lower cooking losses than normally associated with microwave

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Table 2. Fat and caloric content of cooked pork lean from carcasses variable in fatness[a].

Trait	Carcass fatness[b]	Top-loin chops	Loin chops	Rib chops	Blade steaks
Fat	Fat	6.43[d]	8.86[c,d]	9.69[d]	11.76[d]
	Medium	4.19[c]	8.99[d]	8.57[c]	11.01[c]
	Lean	6.10[d]	8.23[c]	8.36[c]	10.73[c]
Calories	Fat	170.08[e]	185.90[d]	196.04[d]	197.85
	Medium	151.33[c]	188.82[d]	184.06[c]	196.37
	Lean	160.69[d]	180.12[c]	182.93[c]	193.29

[a]Grams of fat or kcal per 3 oz of cooked lean.
[b]Last rib fat thickness: Fat = 1.1 to 1.6 inches; Medium = 0.75 - 1.1 inches; Lean = 0.75 inches or less.
[c,d,e]Fat and calorie means for a given chop type bearing different superscripts are different (P <.05).

Table 3. Fat and caloric content of cooked pork lean as affected by cooking method[a].

Trait	Cooking method	Top loin chops	Loin chops	Rib chops	Blade steaks
Fat	Broil	5.87[c,d]	9.05[c]	9.41[c,d]	12.06[d]
	Braise	5.42[b,c]	9.08[c]	8.78[c]	10.30[c]
	Microwave	4.75[b]	7.71[b]	7.30[b]	9.37[b]
	Roast	6.25[d]	8.95[c]	10.01[d]	12.95[e]
Calories	Broil	173.47[d]	194.85[c]	203.70[d]	208.67[c]
	Braise	155.52[b,c]	181.91[b]	179.68[b]	180.44[b]
	Microwave	152.75[b]	181.00[b]	176.73[b]	186.78[b]
	Roast	161.06[c]	182.02[b]	190.00[c]	207.46[c]

[a]Grams of fat and kcal per 3 oz of cooked lean.
[b,c,d,e]Fat and calorie means for a given chop type bearing different superscripts are different (P< .05).

cooking of meat. When more severe microwave methods are used (more watts of power, higher power setting) fat content may be elevated in the lean.

Similarly, higher endpoint cooking temperature increased concentration of fat and calories in pork lean (Table 4). This occurred in every case except the top-loin chops, for which no explanation can be offered. Since cooking loss is directly related to endpoint temperature, these results would be expected.

Trimming of external fat before cooking, rather than after cooking, did not consistently reduce fat and caloric content of pork (Table 5), although the trend was evident. Trimming fat before cooking reduced fat in the lean in earlier research (1988 Swine Report, p. 21).

Table 4. Fat and caloric content of cooked pork lean as affected by endpoint cooking temperature[a].

Trait	Endpoint temperature(°F)	Top-loin chops	Loin chops	Rib chops	Blade steaks
Fat	160	5.56	7.99[b]	8.26[b]	10.22[b]
	170	5.59	9.40[c]	9.48[c]	12.12[c]
Calories	160	159.08	176.12[b]	180.08[b]	183.69[b]
	170	162.31	193.77[c]	195.23[c]	207.98[c]

[a]Grams of fat or kcal per 3 oz cooked lean.
[b,c]Fat and calorie means for a given chop type bearing different superscripts are different (P<.05).

Table 5. Fat and caloric content of cooked pork lean as affected by external fat trim[a].

Trait	Fat trim (in)	Top-loin chops	Loin chops	Rib chops	Blade steaks
Fat	0.0	5.60	8.52	8.74	11.05
	0.5	5.54	8.87	9.01	11.29
Calories	0.0	161.67	183.52	186.65	194.88
	0.5	159.73	186.37	188.73	196.79

[a]Grams of fat or kcal per 3 oz cooked lean.

Conclusion

Cut type, carcass fatness, cooking method, and endpoint cooking temperature all exert a significant influence on the amount of fat and calories in cooked pork lean. Trimming of external fat before cooking is less important.

[1]Chris R. Calkins is Associate Professor, Department of Animal Science.

Selection for Increased Litter Size and Decreased Age at Puberty

Rodger Johnson
Dwane R. Zimmerman[1]

Swine genetics research at the University of Nebraska has focused, for nearly 25 years, on improving reproductive efficiency. One experiment, started in 1967, is nearly complete.

The experiment used the Nebraska Genepool pig population. This population is known throughout the world for experiments done with it and the knowledge gained about reproduction. This is the first of three articles summarizing results of long-term genetic studies with the Genepool population. The first article reports on direct responses in litter size of gilts and in age at puberty of gilts to selection for these traits.

Background

Population. The Nebraska Genepool is a 14-breed composite population formed in the early 1960's. The population was closed to outside introductions in 1965 and from 1967 to 1987 selection for different components of reproduction was practiced within population lines. At the end of the experiment four separate lines existed. History of the formation of the population and the formation of these four selection lines are shown in Figure 1.

Selection. From 1967 to 1976 two lines existed, one selected for high ovulation rate at 2nd postpubertal estrus of gilts (OR line), the other a randomly selected control (C line). During 1977 and 1978 both the OR and C lines were mated and selected randomly while the population was relocated to new facilities.

In 1979, the OR line was partitioned into three lines. One was selected for large litter size at birth of gilts (LS line), one for decreased age at puberty of gilts (AP line), and one selected randomly (RS line). The RS denotes relaxed, or random, selection for ovulation rate in the line previously selected for high ovulation rate. The C line also was maintained with random selection to the end of the experiment.

Every year from the start of the experiment all lines were maintained only with gilts reproducing and mated to boars of their same age. Thus, the population farrowed once per year and generation interval was one year. In each line there were about 40 litters by

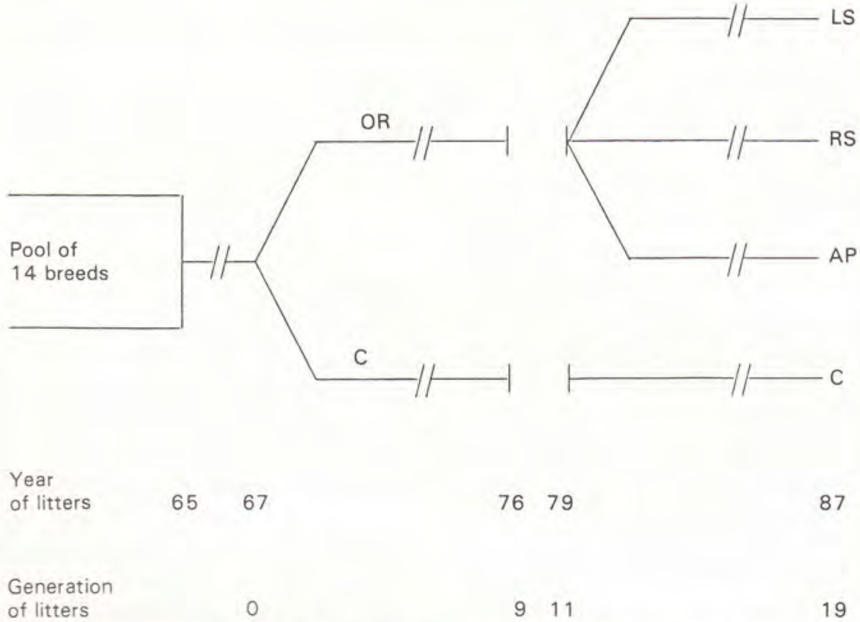

Figure 1. History of selection in Nebraska genepool population: Generation = generation of progeny, OR = ovulation rate, LS = litter size, RS = relaxed selection, AP = age at puberty and C = control. See text for details of formulation of lines.

15 sires each generation.

During selection for ovulation rate, number of ovulation sites on the ovaries was counted by laparotomy on all gilts in the OR line. Fifty gilts, of about 150 evaluated, with the highest number of ovulations were selected each generation. One son of each sire was selected randomly to maintain a broad genetic base within the line.

During selection for age at puberty the same selection rates and procedures as for the OR line were applied except the 50 youngest gilts at puberty were selected. Gilts were exposed daily to boars from about 125 days of age and age at puberty was defined as the age when gilts first gave the standing response to a boar.

Selection in the LS line was for large litters; boars and gilts were selected on the basis of total number of fully formed pigs in their dam's litter. Gilts were selected from the 17 largest litters each generation and one boar was selected from each of the 15 largest litters.

Selections in the C and RS lines were random each generation. At least one gilt from each litter and one son of each sire were selected to maintain these lines with minimum inbreeding.

Results

Selection for ovulation rate. Ovulation rate responded to selection. The number of eggs shed by gilts at second estrus increased by 3.71 during nine generations of selection. At that point, response in litter size at birth was positive, but small and not statistically significant. The interpretation then was that selection for ovulation rate did not cause litter size to increase.

The interpretation now is different and quite clear. It was important to have the high ovulation rate line undergoing random selection (RS line) during the second phase of the experiment. Litter size over the entire experiment for the OR, RS, and C lines is plotted in Figure 2. The average increase in litter size from selection for ovulation rate during the first nine generations was .09 $\pm$ .06 pigs.

Although not statistically significant, the response of .09 pigs was very real biologically. Notice that at generation nine there were two evaluations of differences between the OR and C lines. The difference was greater than one pig in both evaluations. Furthermore, from generations 10 to 20, the OR line (now the RS line) had larger litters than the C line. Both lines increased, but they increased at about the same rate. This increase was due to environmental trend, most of which occurred from generations 11 to 14, and reflects improved management as we learned to manage new facilities.

The important point is that the RS line had larger litters than the C line

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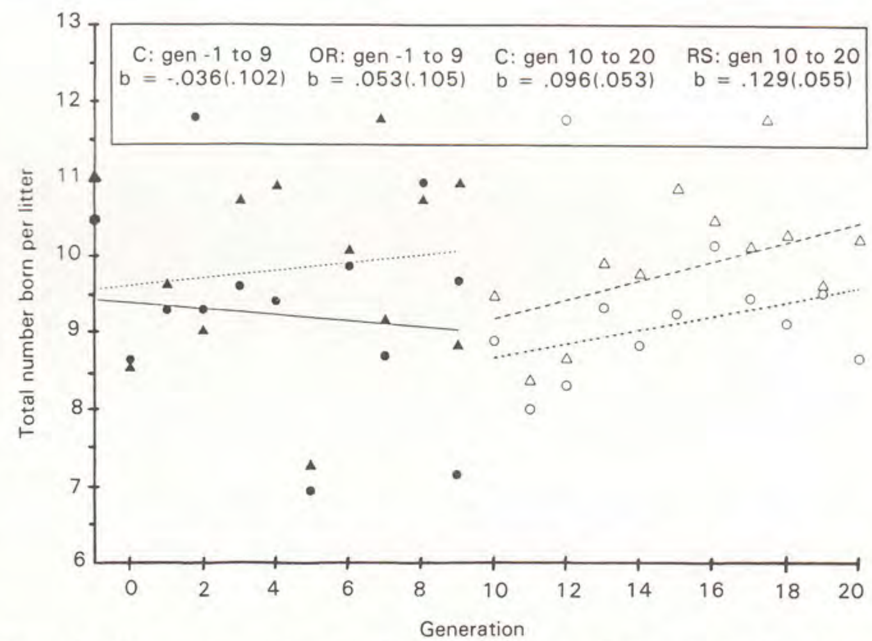

Figure 2. Means and regressions (SE) of means on generation for litter size during periods of selection for ovulation rate, generations -1 to 9, and relaxed selection, generations 10 to 20: C = control line, OR = ovulation rate line and RS = relaxed selection line.

every generation from 10 to 20. The average difference was .74 pigs per litter ($P < .01$), quite similar to a predicted response of .8 pigs at the end of generation 9.

The conclusions from this phase are that ovulation rate will respond to selection and it will lead to larger litters. However, in this population an increase of 3.7 eggs resulted in an increase of about .75 pigs per litter. Thus, only about 20% of the increase in ovulation rate was realized as a pig at term.

Selection for litter size and age at puberty. The second phase of the experiment determined the effectiveness of selection for increased litter size or decreased age at puberty in the population with high ovulation rate.

Total response from selection for litter size was assessed in two ways. The first was to estimate the mean genetic value of all lines from the beginning to the end of the experiment (Figure 3). The graph clearly shows the divergence between the OR and C lines during the early generations of the experiment. From generation 10 to 18, when selection was for litter size in the LS line and random in the RS and C lines, there was positive genetic trend in all lines. Response to selection for litter size was estimated to be about .5 pigs at generation 18 from the comparison of genetic values for the LS line to the mean of values for the RS and C lines.

The second analysis used only data for the LS, RS and C lines from generations 10 to 18. Response in litter size was evaluated by deviating mean litter size for the LS line from the mean of the RS and C lines and relating change over time to the selection applied. This procedure resulted in a realized heritability of .15 ± .05 and an estimate of total response of 1.06 pigs in the LS line at generation 18.

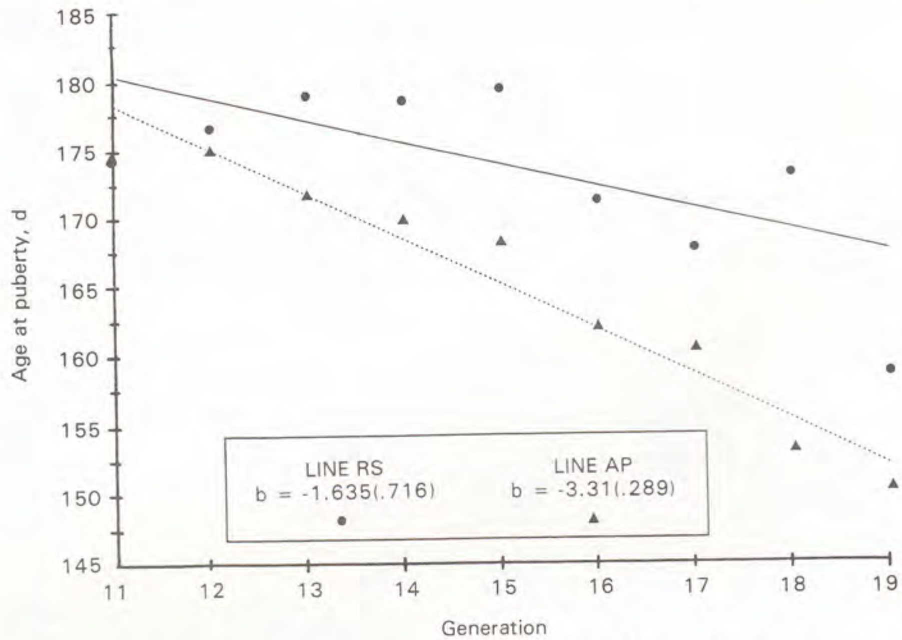

Figure 4. Means and regressions of means on generation for age at puberty from generations 11 to 19 (RS = relaxed selection, AP = age at puberty).

Response in age at puberty is shown in Figure 4. Age at puberty was only measured in the AP and RS lines. Age at puberty decreased in both lines, but decreased faster in the AP line. Total genetic decrease from eight generations of selection was estimated to be 15.7 days ($P < .05$). Realized heritability of age at puberty was .25 ± .05.

Selection for age at puberty did not cause a change in litter size. Mean genetic value for litter size during generations 10 to 18 for the AP line did not change. Thus, no correlated response in litter size of first parity gilts is expected from selection for decreased age at puberty.

Experiments are underway in cooperation with the University of Missouri to determine if rebreeding interval, litter size at later parities, and lifetime productivity of sows when gilts are first mated at their second estrus are affected by selection for decreased age at puberty.

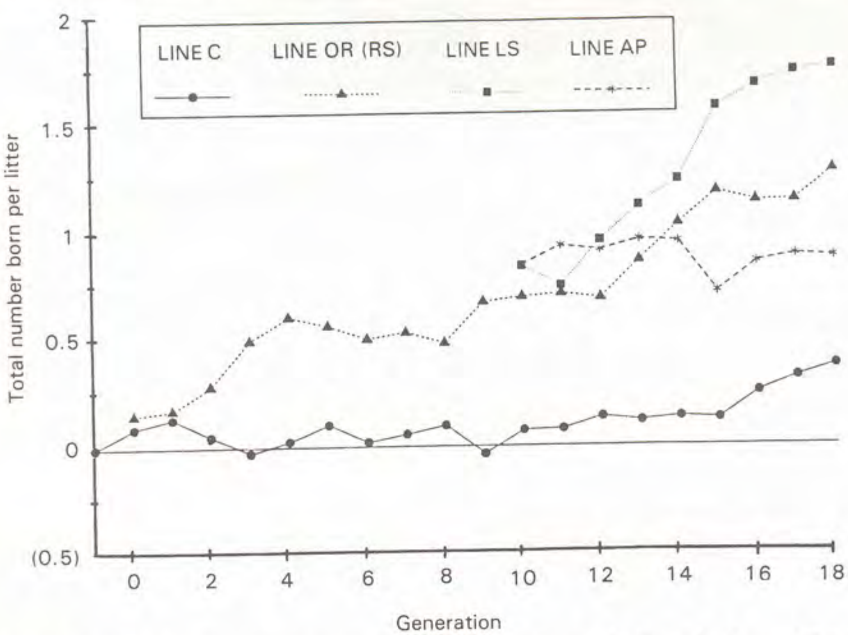

Figure 3. Best linear unbiased predictions of mean genetic value for litter size for ovulation rate (OR) and control lines (C) during period of selection for OR, generations -1 to 9, or subsequent period of relaxed selection (RS) or selection for increased litter size (LS) or decreased age at puberty (AP).

[1]Rodger Johnson and Dwane R. Zimmerman are Professors, Department of Animal Science.

Factors Affecting Litter Size for Pureline and Crossline Females

Rodger Johnson
Luis Gama[1]

The previous article reported that selection for three traits — ovulation rate, litter size after selection for ovulation rate, and age at puberty after selection for ovulation rate — was effective. During selection phases of the experiment all litters were produced by pureline gilts. It is important to know if responses observed also occur in sows and if selection for improved reproductive performance in purelines also improves performance of crossbreds. Realized levels of heterosis for litter size may depend on the previous genetic selection of lines or on parity of the females.

This, the second article, reports litter size at birth of 1st, 2nd, and 3rd parity females of Genepool lines and crosses of two of them with an unrelated population. Random samples of the lines were evaluated during three generations.

Design

The Genepool population, selection history, and responses to direct selection in the population are described in the previous article. At the end of 18 generations, there were four lines within the population. These are denoted as follows:

Line	Selection Background
C	randomly for 18 generations.
RS	increased ovulation rate, 9 generations, randomly 9 generations.
LS	increased ovulation rate, 9 generations, randomly 1 generation, increased litter size at birth, 8 generations.
AP	increased ovulation rate, 9 generations, randomly, 1 generation, decreased age at puberty, 8 generations.

Results in this article are for generations 19, 20, and 21, after selection had been ended in all lines and random selection was practiced within each line. During this time, gilts of each line were mated to boars of the same line. Gilts of the RS and LS lines also were mated to boars of an unrelated population.

This population (I) was a composite of half Large White and half Landrace breeds selected for an index of ovulation rate and embryo survival to 50 days of gestation. A random sample of the I line from the fourth generation of this index selection was mated to be contemporary to the Genepool population and was maintained with random selection thereafter. Pureline I females also were farrowed each generation.

The design, with types of females evaluated in each of three successive generations, is shown in Table 1. Samples of pureline RS, LS, I x RS, I x LS, and I females were retained to produce litters as second and third parity sows.

Each generation, first parity females of the RS and LS lines were mated either pure or to I line boars. All other matings of first parity females were pureline matings. All second and third parity sows were mated to unrelated crossbred boars of Duroc, Hampshire, Large White and Landrace breeding.

Results

Overall, litter size increased an average of .99 ± .30 pigs from first to second parity, and .66 ± .38 pigs from second to third parity. The interaction between genetic group and parity was not significant. Litter size increased similarly with parity for all lines and crosses.

Average litter size and number of litters by parity and genetic group are shown in Figure 1. Data for parity 2 and 3 of generation 21 are not yet available. In all parities, litter size was higher in LS than in RS dams and in I x LS than in I x RS dams, even though the differences were not large in second parity crossline sows.

Estimated line differences (Table 2) indicate that the superiority observed for LS gilts in the first parity increased in the second parity, but was only partially maintained in the third parity. Heterosis, the difference between crossline females and the average of the two purelines in the cross, ranged from .31 to 1.67 pigs per litter in different parities for I x RS and I x LS crossline dams. There was no consistent evidence that heterosis would be higher for one of the crosslines than the other.

Previous studies found that litter

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Table 1. Number of litters produced in the evaluation phase of genepool lines, by parity and generation of evaluation.

Line of dam	Line of sire	Parity 1			Parity 2[a]		Parity 3[a]	
		19	20	21	19	20	19	20
RS	RS	19	23	18	10	13	9	10
RS	I	18	18	20				
LS	LS	18	20	16	10	10	10	8
LS	I	18	20	19				
I	I	20	19	19	8	8	6	7
I x RS	RS	23	20	24	12	12	11	11
I x LS	LS	19	19	23	11	10	10	10

[a]Sires of litters from parity 2 and 3 sows are the same for all sows and are crossbred boars from another population.

Table 2. Estimated genetic differences between lines LS and RS and heterosis for litter size at different parities. Numbers in ( ) are heterosis in percentage.

Parity	Genetic Difference LS - RS	Heterosis[a] I x RS	Heterosis[a] I x LS
1	.83 ±. 35	.41 ± .39 (4.0)	1.67 ± .34 (15.7)
2	1.76 ± .80	1.07 ± .72 (9.6)	.31 ± .66 (2.7)
3	.44 ± .86	1.18 ± .76 (9.8)	1.47 ± .73 (12.1)

[a]Heterosis calculated as the average value for the cross minus the average value of the purelines in the cross.

size increases with parity up to about the fourth or fifth parity. This increase is due to an increase in both ovulation rate and embryo survival. Researchers have suggested that uterine capacity may be more of a limiting factor in first than in later parities. If so, selection practiced in first parity gilts might be poorly expressed in later parities. Our results clearly indicate that when selection for litter size was practiced in first parity gilts the response was maintained in second and third parity sows. Actually, line differences increased in second parity sows, but decreased in third parity sows. Further, the response obtained in purelines also occurred in crossline females.

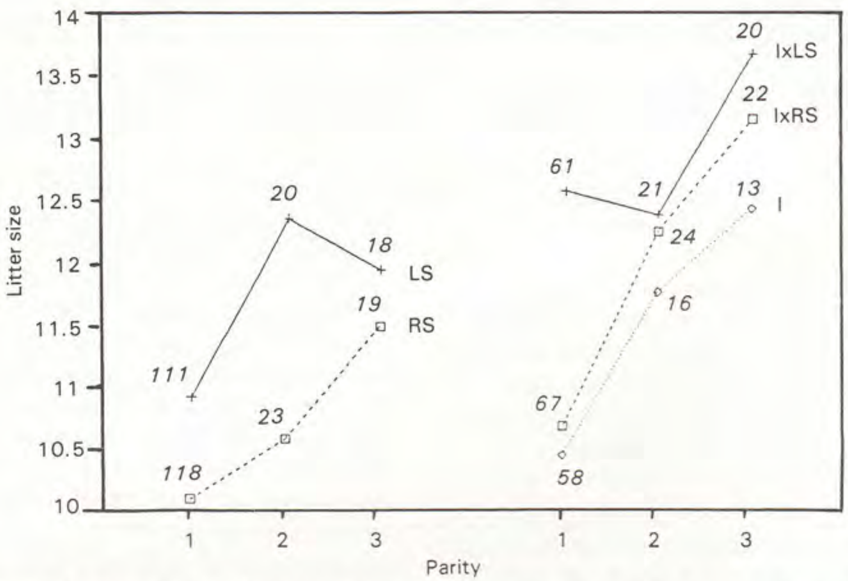

Figure 1. Average litter size by parity in the different lines (numbers in italic represent number of litters).

Conclusion

We conclude that selection for litter size in first parity sows will increase litter size in later parities and that heterosis will be maintained at high levels in crosses of lines selected for increased litter size.

[1]Rodger Johnson is Professor and Luis Gama graduate student, Department of Animal Science.

Contribution of Ovulation Rate and Uterine Capacity to Litter Size

Rodger Johnson
Luis Gama[1]

The previous two articles showed that direct selection for litter size in the Genepool population was effective. Researchers proposed several models to explain the nature of genetic variation for litter size. These models generally explained litter size as a function of several physiological components, including ovulation rate, embryo survival, and uterine capacity.

This experiment investigated how much of the response in litter size could be explained by an increase in ovulation rate or by an increase in uterine capacity in late gestation.

Design

The study was conducted with pigs of the LS line, selected for increased litter size for eight generations after nine generations of selection for ovulation rate, and the RS line, selected nine generations for ovulation rate and then randomly selected thereafter. Formation of the lines, selection procedures, and responses to selection were reported in the other two articles in this report.

A random sample of LS and RS line gilts in generations 18, 19, and 20 were mated to produce pureline (RS x RS and LS x LS) and crossline (I x RS and I x LS) litters. In generations 19, 20, and 21, I x RS and I x LS gilts were backcrossed to produce RS(I x RS) and LS(I x LS) progeny.

Two experiments were conducted to obtain information on ovulation rate, uterine measurements, and uterine capacity in LS and RS crossline gilts. In Experiment 1, 103 cyclic gilts of I x RS, I x LS, RS(I x RS) and LS(I x LS) breeding were slaughtered at about the same physiological age (9 to 16 days after their second estrus). Reproductive tracts were collected. Ovulation rate was estimated by counting corpora lutea on the ovaries. Length of each uterine horn was measured, uterine weight was obtained, and volume of physiological saline each uterus could hold in a standard test was determined. From this information, diameter of each uterus was determined.

In Experiment 2, one uterine horn and the ovary on its side were removed (unilateral hysterectomy-ovariectomy, UHO) 3 to 10 days after puberty in 109 gilts of the same crosslines used in Experiment 1. With this procedure there is nearly complete compensation in ovulation rate by the remaining ovary. Consequently, gilts have a normal ovulation rate, but only 50% of the normal uterine space. It is assumed that in all these gilts, ovulation rate exceeds uterine capacity and that there will be a loss of embryos down to the number each uterus can nurture. Thus, at any

Table 1. **Least squares means ± SE and number of gilts measured for the different traits and crosses in Experiment 1.**

Trait	I x RS	I x LS	RS(I x RS)	LS(I x LS)
Ovulation rate in cyclic gilts	14.5 ± .5	15.3 ± .4	14.6 ± .5	15.7 ± .5
Uterine length, in	122.8 ± 5.1	118.1 ± 4.3	120.1 ± 4.7	123.6 ± 5.5
Uterine weight, oz	22 ± 1	19 ± .8	21 ± .9	21 ± 1
Uterine volume, oz	39.5 ± 2.9	34.1 ± 2.4	40.7 ± 2.8	42.6 ± 3.1
Uterine diameter, in	.86 ± .02	.81 ± .02	.86 ± .02	.87 ± .02
N	24	33	25	21

Table 3. **Estimated differences between lines LS and RS (g_{LS} - g_{RS}) ±SE for the different traits.**

Trait	Genetic difference LS - RS
Ovulation rate, cyclic gilts	1.44 ± .73
Uterine length, in	-.2 ± 7.8
Uterine weight, oz	-2 ± 1.5
Uterine volume, oz	-2.2 ± 4.6
Uterine diameter, in	-.03 ± .03
Ovulation rate, puberty	-.63± .79
Ovulation rate, mating	1.15 ±.79
Fully formed piglets	.33 ± .64
Fully formed plus mummified piglets	-.38± .71

point during gestation, number of embryos or fetuses being maintained in the single uterus is a measure of half the uterine capacity of this gilt. This procedure allows differences among gilts in uterine capacity to be measured independent of differences among them in ovulation rate.

Gilts were mated by a fertile boar of an unrelated line as soon as they showed signs of estrus after the surgery, and given three additional opportunities to be bred. Pregnant gilts were slaughtered at 93 to 100 days of gestation and immediately after slaughter information was collected on ovulation rate at the estrus when mating resulted in pregnancy, number of fully formed pigs and number of mummified fetuses.

Results

Averages for the different crosslines and traits in Experiment 1 (Table 1) indicate higher ovulation rate in LS than in RS crosses. However, the only clear pattern for uterine measurements was that I x LS gilts always had the smallest measurements.

Averages for Experiment 2 (Table 2) indicate some advantage of LS(I x LS) gilts in ovulation rate at mating, even though they had the lowest ovulation rate at puberty. Uterine capacity, estimated as twice the number of fully formed pigs, was greatest in I x LS gilts, but differences among groups for number of fully formed pigs plus mummified pigs were minor.

Estimates of genetic differences between the LS and RS lines from both experiments are given in Table 3. The LS line had an advantage over the RS line of about 1.4 eggs in cyclic gilts and about 1.2 eggs in UHO-mated gilts, but lower ovulation rate at puberty. Uterine length, weight, volume, and diameter were all smaller in LS than in RS gilts, but differences were not statistically significant. Uterine capacity, estimated as twice the number of fully formed pigs in one uterine horn, was about .7 pigs higher in LS gilts. A higher number of mummified pigs was found in RS gilts than in LS gilts, as indicated by line differences in number of fully formed pigs plus mummified fetuses.

After nine generations of selection for ovulation rate in the first phase of the experiment, cumulative responses were 3.7 eggs and .8 pigs per litter, indicating that only 20% of the response in ovulation rate was represented as increased litter size. Previous work with the high ovulation line indicated that it had lower embryo survival at 30 (5.2% less) and 70 (10.6% less) days of gestation than the control line. These results were interpreted as meaning that either embryo survival or uterine capacity, or both, were limiting litter size response. We then felt that direct selection for litter size in the high ovulating line would place most selection pressure on uterine capacity and embryo survival.

Table 2. **Least squares means ± SE and number of gilts measured for the different traits and crosses in Experiment 2.**

Trait	I x RS	I x LS	RS(I x RS)	LS(I x LS)
Ovulation rate at puberty	13.3 ± .5	13.4 ± .5	13.2 ± .4	12.4 ± .5
N	24	24	37	24
Ovulation rate at mating	14.8 ± .6	14.5 ± .5	14.1 ± .4	15.3 ± .5
Number fully formed piglets	4.8 ± .5	5.7 ± .4	5.0 ± .4	4.8 ± .4
Number fully formed plus mummified piglets	5.7 ± .5	5.9 ± .5	6.0 ± .4	5.5 ± .5
N	17	22	31	21

Results were surprising. Selection for litter size after selection for ovulation rate resulted in further increases in ovulation rate and some increase in uterine capacity.

No significant changes were found in uterine measurements of non-pregnant gilts following selection for litter size. Nevertheless, the trend was for measurements to be less in the LS line than in the RS line. Because uterine capacity increased after selection for litter size, this would suggest uterine measurements in cyclic gilts are not good predictors of uterine capacity.

We observed fewer mummified fetuses in LS than in RS gilts. This caused us to examine number of mummified pigs at birth which were counted each generation during the selection phase and the evaluation phase of the experiment. Means are plotted in Figure 1. There was a reduction of .26± .14 mummified pigs per litter from eight generations of selection for litter size. In agreement, LS gilts had .22 fewer mummified piglets per litter during three generations of evaluation when selection was random. This is further evidence that selection for litter size in-

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creased uterine capacity.

Conclusions

In this experiment, litter size increased due to both an increase in ovulation rate and an increase in uterine capacity resulting in less wastage of pigs (fewer mummies) late in gestation. It is not yet clear how to maximize response in litter size from selection. These experiments suggest simultaneous selection for both ovulation rate and uterine capacity will be more effective than selection for either component alone or directly for litter size.

[1]Rodger Johnson is Professor and Luis Gama is graduate student, Department of Animal Science.

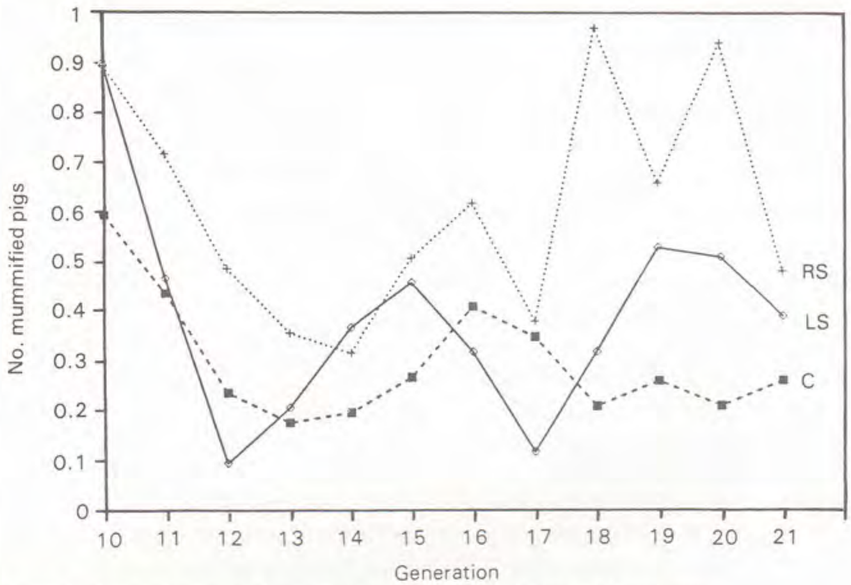

Figure 1. Average number of mummified pigs per litter, by line and generation.

Effects of Deworming on Sow/Litter Performance

Murray Danielson
Joel Wenninghoff
Randy Saner[1]

A generation or so ago household dish water and wash water were frequently used as an anthelmintic (dewormer). It was mixed with hog feed and fed in swill form. It was the lye in the homemade soap that was responsible for eliminating many of the worms present in the pig. In recent times the development of new feed products or additives has replaced many of the older methods used in pork production. The dewormer study reported here was with groups of animals treated with no dewormer, SAFE-GUARD®, ATGARD®, and IVOMEC®.

Procedures

Fifty-two pregnant crossbred females were selected and randomly assigned to one of four treatment groups 7-10 days before their predicted parturition date. Treatments were administered according to manufacturers' recommendations.

Females were from the same herd and genetically similar. None had been subjected to anthelmintic treatment before being bred. Females had been maintained in earthen open lot conditions before and during the gestation period. Females in all groups were known to be parasitized with roundworm. Other than anthelmintic treatment, all managerial practices were comparable for all treated groups.

Before treatment, individual weight and backfat thickness were recorded and a fecal sample taken from each animal. Each sow was thoroughly washed in a sow-wash adjoining the farrowing room. Sows assigned to SAFE-GUARD and ATGARD treatments were treated with an external parasiticide. They were then placed in a farrowing facility equipped with raised deck farrowing stalls. After entering the farrowing house, each sow was fed 4 lb/hd/day of a 14-15% corn-soy lactation diet until the day of parturition. After farrowing, they were ad libitum fed the lactation diet until weaning (21 days).

After farrowing, pig birth weight and number of pigs farrowed live were recorded for each litter. Pigs were weaned at 21 days, at which time number of pigs live and individual pig weight was recorded. Backfat measurements and weights were recorded for each adult female prior to farrowing and again at weaning. Average backfat was determined with a digital backfat indicator at three sites (first rib, last rib, and last lumbar vertebra). Average daily feed intake (ADFI) was recorded for each sow during the 21-day nursing period.

Following the pre-treatment sow fecal collection, individual fecal samples were taken at 7-day intervals for the following six weeks for determination

Table 1. Effect of anthelmintic treatment on sow performance.

Criteria	Control	Safe-Guard®	Atgard®	Ivomec®
No. of sows	13	13	13	13
Sow wt. pre-farrowing	372.6	375.9	369.5	376.2
Sow wt. 21 days post-farrow	336.2	335.8	337.2	339.4
% change in backfat	10.8	9.7	11.2	11.1
ADFI, lb.	13.70[a]	12.46[b]	13.26[ab]	12.90[ab]

[a,b]Significant difference $P < .10$.

Table 2. Effect of anthelmintic treatment on litter performance

Criteria	Control	Safe-Guard®	Atgard®	Ivomec®
No. of litters	13	13	13	13
No. pigs born live	9.08	9.92	9.15	10.15
Survival %	94.9	96.9	94.9	92.4
No. pigs weaned	8.62[a]	9.62[b]	8.69[ab]	9.38[ab]
Litter birth wt (lb.)	29.69	30.65	27.72	29.94
21-day litter weaning wt. (lb.)	97.72	106.38	98.37	105.62
Total litter wt. gain	68.03	75.73	70.65	75.68

[a,b]Significant difference $P < .10$.

of egg count.

Results

Sow performance indicated that the only significant difference among treatment groups was average daily feed intake during the 21-day lactation period (Table 1). Intake was reduced for all treated groups when compared to the control group (no dewormer).

Litter performance was comparable among treatment groups for all criteria except for number of pigs weaned (Table 2). The number of pigs weaned for the control group was reduced when compared to the Safe-Guard treatment.

Fecal egg counts for the respective treatment groups were reduced to zero following the third fecal collection.

Conclusion

Sows dewormed before farrowing consumed less feed during lactation even though they nursed and weaned more pigs than the control group. Total litter weight gain was greater for litters from dewormed sows.

[1]Joel Wenninghoff and Randy Saner are swine operation managers and Murray Danielson is Professor, Swine Nutrition, West Central Research and Extension Center, North Platte.

Which Is Best? Five Dietary Antibiotics for Growing-Finishing Pigs

Austin J. Lewis
Mark A. Giesemann[1]

Although benefits of including antibiotics in diets for pigs have been demonstrated in numerous experiments, there are persistent questions about the continued efficacy and cost effectiveness of antibiotics for growing-finishing pigs. Also, there have been few direct comparisons in a large-scale experiment of the several antibiotics commercially available. This experiment compared performance of growing-finishing pigs fed a control diet (no antibiotics) with the performance of pigs fed diets containing four commercially available antibiotics and one new antibiotic, not yet approved for use in pig diets.

Table 1. Antibiotics evaluated[a].

Antibiotic	Dietary concentration, g/ton	
	Growing	Finishing
None	—	—
Virginiamycin	10	5
Bacitracin methylene disalicylate	30	30
Tylosin	40	20
Chlortetracycline	50	50
Salinomycin[b]	25	25

[a]Antibiotic levels were those approved for growing-finishing pigs.
[b] Not yet approved for pig diets.

Procedures

Pigs were weaned at four weeks of age and housed in an environmentally controlled nursery. All were fed a simple corn-soybean meal diet (20% protein; 1.15% lysine) that contained AUREO S-P 250.

At 8 to 10 weeks of age, pigs were assigned to one of six dietary treatments for the growing-finishing period. Treatments and amounts of antibiotics added to the growing and finishing diets are listed in Table 1. During the growing period the diets contained 16% protein and 0.80% lysine, and during the finishing period they contained 14% protein and 0.65% lysine.

In this experiment there were 384 pigs, kept in eight pens of each of the six dietary treatments, with eight pigs per pen. During the experiment pigs were housed in a modified-open-front (MOF) building, and allowed ad libitum access to feed and water. When they were first moved to the MOF building, all pigs were fed the nursery diet (containing AUREO S-P 250) for a 1-week adjustment period. After the adjustment, the initial weights of the pigs were recorded and the growing diets were fed until 200 lb of feed had been eaten (about six weeks). The finishing diets were fed for the remainder of the experiment, which ended when the pigs weighed about 220 lb. The experiment was conducted during the spring and summer months.

Results

During the 6-week growing period, pigs fed diets containing antibiotics ate more feed than pigs fed the diet with no antibiotics (Table 2). Statistical analysis revealed that, when compared with pigs fed the control diet, the differences in feed intake were significant for the pigs fed diets with tylosin, chlortetracycline, or salinomycin. Pigs fed diets with antibiotics also gained weight faster than pigs fed the control diet during the growing period. In this case the differences (relative to the control) were significant for all of the antibiotics except bacitracin methylene disalicylate. Pigs

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Table 2. Effects of various antibiotics on the performance of growing-finishing pigs.

	No antibiotic	Virginia-mycin	Bacitracin MD[a]	Tylosin	Chlor-tetracycline	Salino-mycin
No. of pens	8	8	8	8	8	8
No. pigs/pen	8	8	8	8	8	8
No. pigs[b]	63	63	63	64	63	64
Growing period (6 weeks):						
Initial weight, lb	52.7	52.2	52.5	51.8	52.9	52.5
Final weight, lb	117.7	121.5	120.4	122.8	122.4	122.4
Avg. daily feed intake, lb	4.54^{c}	$4.67^{c,d}$	$4.68^{c,d}$	4.77^{d}	4.75^{d}	4.75^{d}
Avg. daily gain, lb	1.55^{c}	1.64^{d}	$1.62^{c,d}$	1.69^{d}	1.65^{d}	1.66^{d}
Feed/gain	2.93^{c}	2.83^{d}	$2.88^{c,d}$	2.82^{d}	$2.87^{c,d}$	$2.85^{c,d}$
Finishing period (9 weeks):						
Initial weight, lb	117.7	121.5	120.4	122.8	122.4	122.4
Final weight, lb	214.3	221.3	220.9	220.9	219.8	224.4
Avg. daily feed intake, lb	6.21^{c}	$6.37^{c,d}$	6.56^{d}	$6.33^{c,d}$	$6.35^{c,d}$	6.46^{d}
Avg. daily gain, lb	1.60^{c}	$1.66^{c,d}$	$1.67^{c,d}$	$1.62^{c,d}$	$1.62^{c,d}$	1.69^{d}
Feed/gain	3.86	3.83	3.93	3.89	3.92	3.81
Growing and finishing periods (15 weeks):						
Initial weight, lb	52.7	52.2	52.5	51.8	52.9	52.5
Final weight, lb	214.3	221.3	220.9	220.9	219.8	224.4
Avg. daily feed intake, lb	5.52^{c}	$5.67^{c,d}$	5.79^{d}	$5.69^{c,d}$	$5.69^{c,d}$	5.76^{d}
Avg. daily gain, lb	1.58^{c}	1.65^{d}	1.65^{d}	1.65^{d}	1.63^{d}	1.68^{d}
Feed/gain	$3.49^{c,d}$	3.43^{d}	3.51^{c}	$3.44^{c,d}$	$3.48^{c,d}$	3.42^{d}

[a] Bacitracin methylene disalicylate.

[b] There were 43 barrows and 21 gilts per treatment; one pig was removed from four of the six treatments for various reasons.

[c,d] Means in a row that do not share a common superscript differ ($P < .05$).

fed diets containing antibiotics also had better feed efficiencies (feed/gain) than pigs fed the control diets, although for most antibiotics these differences were not significant.

During the 9-week finishing phase, there was less response to the antibiotics than during the growing phase. This was expected because in general there is less response to antibiotics in the finishing phase than in the nursery and growing phases. Nevertheless, for each of the antibiotics, pigs receiving these diets ate more feed and gained weight faster than pigs fed the diet without antibiotics. Statistically, the only differences relative to the pigs fed the control diet were that pigs fed diets with either bacitracin methylene disalicylate or salinomycin consumed more feed, and the pigs fed salinomycin grew faster. There were no significant differences in feed efficiency during this period.

For the entire growing and finishing periods, pigs fed diets containing antibiotics ate more feed than pigs fed the control diet, although the differences were statistically significant only for bacitracin methylene disalicylate and salinomycin. Average daily gain was increased by all antibiotics. The increase ranged from 3 to 6%, depending on the antibiotic. This is a fairly typical level of response to an antibiotic during the growing-finishing period. Feed efficiency over the whole period differed among antibiotics, being best for virginiamycin and salinomycin and worst for bacitracin methylene disalicylate, but none of the feed efficiency values differed statistically from those of the control diet.

Conclusions

In this experiment, all antibiotics tested increased growth rate compared with a diet that did not contain an antibiotic. Most of the response was obtained in the growing phase, although there seemed to be some continued response in the finishing phase, particularly for bacitracin methylene disalicylate and salinomycin. Furthermore, most of the increase in growth rate was caused by an increase in feed intake, so that there was less improvement in feed efficiency.

The choice of antibiotic for a particular situation will depend on a number of factors including the cost of the antibiotic relative to the response that can be expected, the general disease level of the herd and other factors. The University of Nebraska Swine Diet Suggestions (EC 88-210) recommends a rotation of antibiotics (e.g., either annually or with changes in protein level) to reduce the likelihood of build up of resistance to a particular antibiotic within a herd.

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[1]Austin J. Lewis is Professor and Mark A. Giesemann is research technologist, Department of Animal Science.

When Do Sows Eat?

William C. Weldon
Austin J. Lewis[1]

Adequate feed intake during lactation is important for good sow and litter performance. Low feed intake during lactation can lead to poor weaning weights, an extended weaning to rebreeding interval, reduced litter size, injuries, and early culling of the sow. In the 1990 Nebraska Swine Report, we described feed intakes of lactating sows that had been given different levels of feed during gestation. In this report, we discuss performance and feeding behavior of these sows.

Table 1. Effect of gestation feeding level on voluntary feed intake and weight change during lactation.

	Gestation feeding level		
Item	Restricted	Ad libitum	Significance
No. of sows	8	7	
Gestation feed intake[a], lb	162.1	327.4	.01
Lactation feed intake, lb	334.2	174.2	.01
Total intake[b], lb	496.3	501.6	NS
Gestation wt gain[c], lb	60.1	103.6	.01
Lactation wt loss[d], lb	33.2	76.3	.01
Total weight change[e], lb	26.9	27.3	NS

[a]Intake during the final 40 days of gestation.
[b]Total feed intake from day 40 prepartum to day 28 postpartum.
[c]Gain during the final 7 weeks of gestation.
[d]Loss of weight from immediately post-farrowing to day 28 of lactation.
[e]Total weight change during the final 7 weeks of gestation and 4 week lactation.

Table 2. The effects of gestation feeding level on performance of litters.

	Gestation feeding level		
Item	Restricted	Ad libitum	Significance
No. of sows	8	7	
No. pigs born live	10.6	10.7	NS
No. pigs born dead[a]	1.1	2.1	NS
Litter wt birth, lb	32.2	31.2	NS
D 1 litter wt[b], lb	32.6	29.6	NS
No. pigs weaned	9.5	8.9	NS
D 28 litter wt, lb	161.9	144.8	NS
Litter wt gain d 28, lb	132.9	118.1	NS

[a]Numerical differences were due to problems associated with one sow.
[b]Day 1 litter weight is the weight of the litter after cross fostering.

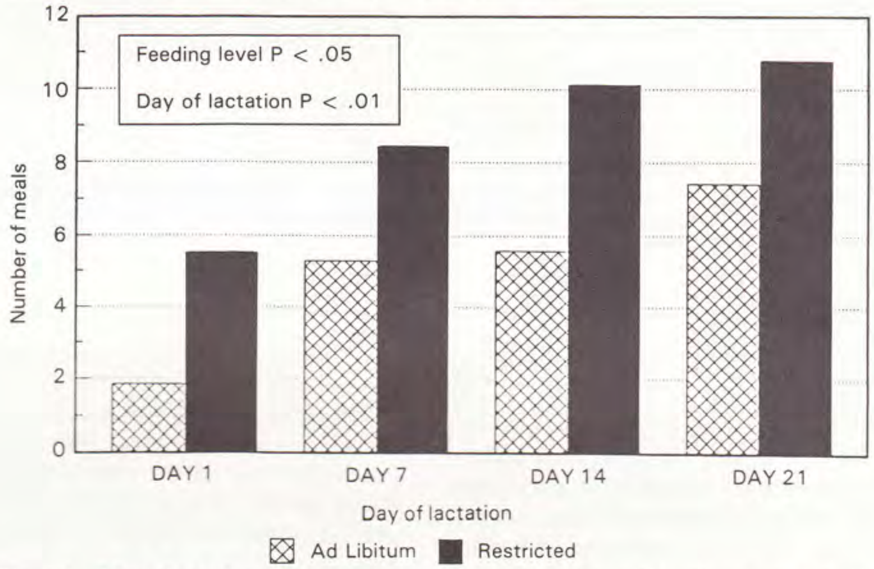

Figure 1. Effect of day of lactation on the number of meals consumed. All sows were allowed to eat ad libitum during lactation.

Methods

Data from 15 crossbred first litter sows are included in this report. Seven sows were allowed ad libitum access to feed from day 60 of gestation until weaning at day 28 of lactation. Eight sows were restricted to 4 lb of feed daily until day of farrowing. All sows were allowed to eat ad libitum throughout lactation. All sows were housed in crates during the experiment. Room temperature was maintained at 70°F and overhead lights were on from 7:00 a.m. to 11:00 p.m. each day. Sows were allowed to consume feed ad libitum as soon as farrowing was completed. Fresh feed was added to the feeders at 7:15 a.m. and 5:00 p.m. daily. Litters were equalized to 10 pigs by day 3 of lactation. Feed intake was recorded daily and performance was evaluated weekly by weighing the sow and litter. Feeding behavior was characterized at five different times during the reproductive cycle. On day 105 of gestation, and days 1, 7, 14, and 21 of lactation, sows were continuously observed during a 24-hour period and the time and amount of each meal consumed recorded. Sufficient light was available from the heat lamps to allow observation of sows when overhead lights were off.

Results

The two different feeding levels

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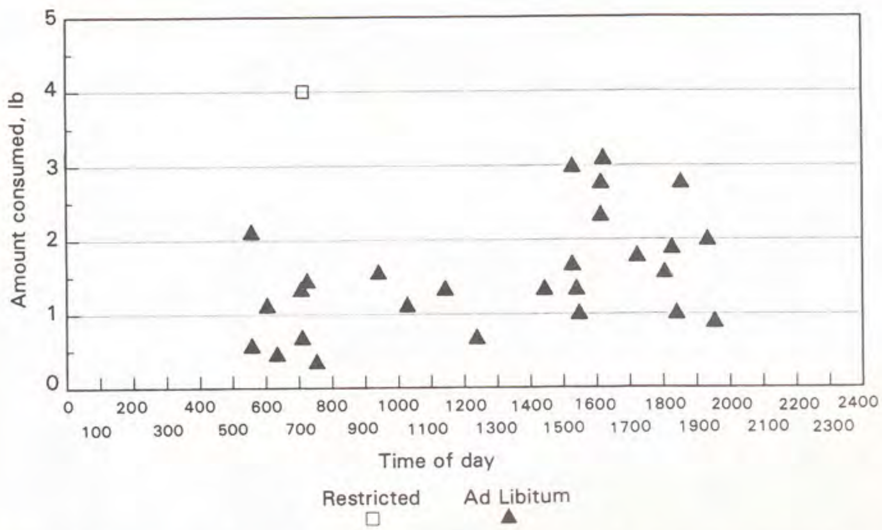

Figure 2. **Size and time of meals consumed on day 105 of gestation. Sows were either restricted to four lb of feed daily or allowed to eat ad libitum during gestation. Times are based on a 24-hour clock.**

during gestation resulted in distinctly different feed intakes during lactation, and consequently, different patterns of weight change over the course of the reproductive cycle (Table 1). However, total intake over the final 40 days of gestation and the 28-day lactation was not different between the two groups of sows. Therefore, our treatments resulted primarily in a change in the distribution of feed intake during the reproductive cycle.

Sow Performance

Performance of sows fed two different levels of feed is listed in Table 2. The number of sows was too small to properly evaluate reproductive traits, but there were no differences observed in the number of pigs born live, born dead, or weaned between the two groups. Also, there were no differences in litter weight or litter weight gain of litters from sows fed restricted quantities of feed compared with litters from sows allowed to consume feed ad libitum during gestation. We did not observe any detrimental effects on performance when sows were allowed free access to feed immediately after farrowing.

Feeding Behavior

Sows fed restricted amounts of feed during gestation consumed more meals during lactation than sows given ad libitum access to feed during gestation (Figure 1). The average size of meals during lactation also tended to be greater in restricted fed than ad libitum fed sows (1.42 vs 1.05 lb). Day of lactation did not affect the average size of meals during the course of lactation, but sows in both groups ate more meals as lactation progressed.

Feeding activity varied. During gestation (Figure 2) sows allowed to eat ad libitum had two distinct times of feeding activity. One in the morning (6:00-10:00) and one in the late afternoon and evening (3:00-8:00). No meals were consumed between 9:00 p.m. and 5:00 a.m. Restricted-fed sows received only one meal (at 7:15 a.m.).

During lactation (Figure 3), there was a change in feeding pattern as lactation progressed. The four panels in Figure 3 represent the patterns of feeding activity observed during the four periods of lactation. Two points can be made from the graph of meals from day

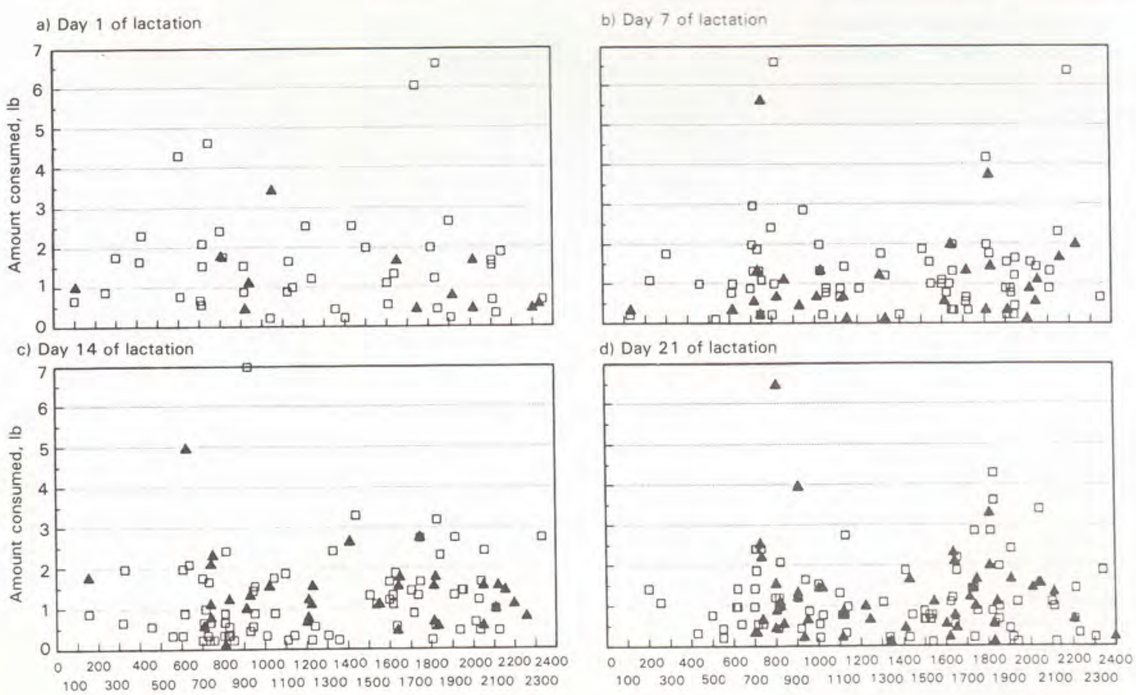

Figure 3. **Time and size of meals consumed at four periods of lactation. Sows fed four lb of feed daily during gestation are represented by □. Sows allowed to eat ad libitum during gestation are represented by ▲. Times are based on a 24-hour clock.**

1 of lactation (panel a). First, it is apparent that sows restricted in feed intake during gestation ate more meals on the first day of lactation than sows allowed to consume feed ad libitum during gestation. Second, there was no obvious pattern in the meals. Sows seem to eat throughout the day. Implications of these data are that if sows are to maximize intake during this early period of lactation, feed must be available for consumption throughout the day.

On day 7 of lactation (panel b) sows previously restricted in intake continued to eat more meals than sows allowed to eat ad libitum during gestation. We also start to see a congregation of meals in the morning and in the afternoon and evening. On day 14 of lactation (panel c), we see results similar to those observed on day 7. By day 21 of lactation (panel d) we see again two distinct times of high feeding activity, one in the morning and one in the afternoon and evening with very few meals consumed when the lights were off.

Implications

Full feeding sows during gestation results in large weight gains during gestation and large weight losses during lactation. The results demonstrate that the pattern of feeding changes during lactation. To maximize feed intake during lactation, we recommend that fresh feed be made available during the periods when feeding activity is high (during mornings, afternoons, and evenings). Remember that when sows under-consume feed during lactation energy is not the only nutrient that is deficient. Inadequate intakes cause mobilization of not only fat, but also protein and mineral reserves to meet the large nutrient requirements of providing milk to the offspring. Therefore, it may be beneficial to feed sows during gestation so they will maximize their voluntary intake of feed during lactation. Swine Diets Suggestions (EC 88-210) recommends feeding sows housed inside 4-4.5 lb of a corn/milo-soybean diet during gestation, followed by allowing sows to eat ad libitum during lactation. This will provide nutrients when they are required rather than storing and subsequently mobilizing them to support lactation.

[1]William C. Weldon is graduate assistant and Austin J. Lewis is Professor, Department of Animal Science.

Manganese — Critical Trace Mineral For Sows

Steven L. Christianson
Ernest R. Peo, Jr.[1]

Failure of sows to express estrus (heat) soon after weaning causes an extended weaning-to-breeding interval, a major problem facing pork producers striving for maximum production. Failure to rebreed is generally a greater problem for first litter sows than for older sows. Recently, research has been conducted on the effect of dietary energy and protein level on the weaning-to-breeding interval with results being quite variable.

Table 1. Basal diet[a,b].

Ingredients	%
Corn	74.57
Isolated soy protein	7.50
Cornstarch	7.50
Tallow	4.50
Calcium carbonate	2.15
Monosodium phosphate	2.45
Salt	0.20
Trace mineral premix[c]	0.13
Vitamin premix[c]	1.00
	100.00

[a]Basal diet is calculated to contain 5 ppm Mn. $MnSO_4$ replaced corn to increase the Mn concentration of the other two diets.
[b]Diet formulated to provide 13% CP, .90% Ca and .80% P.
[c]Premixes provide vitamins and trace minerals to meet or exceed NRC (1988) requirements, except for Mn.

The trace element manganese (Mn) has been shown to be a necessary dietary nutrient for adequate reproductive performance in a number of species, including swine. The current (1988) NRC requirement for total Mn in sow diets is 10 ppm. The University of Nebraska recommends adding 22 ppm to the feed via a trace mineral mix (see University of Nebraska Swine Diet Suggestions, EC 88-210). Since there is considerable variance between the NRC requirement for sows and levels being added routinely to sow diets in the field, we conducted research to determine the effects of three levels (5, 10, and 20 ppm) of total dietary Mn on reproductive performance in the sow.

Treatment Groups

Sixty-six crossbred gilts were divided into three groups and offered feed containing either 5, 10, or 20 ppm dietary Mn. The dietary treatments were started on day 92 of the first gestation period and continued through three reproductive cycles. Sows were fed 4.0 lb/head/day of a corn-isolated soy protein (purified soybean meal) diet (Table 1) during gestation and allowed ad libitum access to the same feed during lactation.

The criteria of response were sow weight and last rib backfat thickness on day 109 of gestation and day 21 of lactation, percentage of sows showing estrus by day 7 and 14 postweaning, and pig weight and litter size at birth and day 21 postfarrowing. Milk samples were collected on day 14 of lactation to

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Table 2. Effect of dietary Mn on sow weight and backfat.

		Weight, lb.		Backfat, in.	
Mn ppm	No. sows	d 109 Gestation	d 21 Lactation	d 109 Gestation	d 21 Lactation
Avg. of 3 parities					
5	18	406.3	359.1	.60	.56
10	15	413.4	359.1	.63	.58
20	15	425.0	369.0	.66	.62
4th parity					
5	9	482.6	435.0	.68	.68
20	9	522.7	467.2	.74	.70

Table 3. Effect of dietary Mn on percentage of sows showing estrus following weaning.

Parity	Days postweaning	No. Sows	Mn, ppm 5	10	20
1	≤ 7 d	66	81.4	87.0	90.5
	≤ 14 d		95.5	91.3	95.2
2	≤ 7 d	58	89.5	80.0	89.5
	≤ 14 d		94.7	81.0	94.7
3	≤ 7 d	48	100.0	100.0	100.0
	≤ 14 d		100.0	100.0	100.0

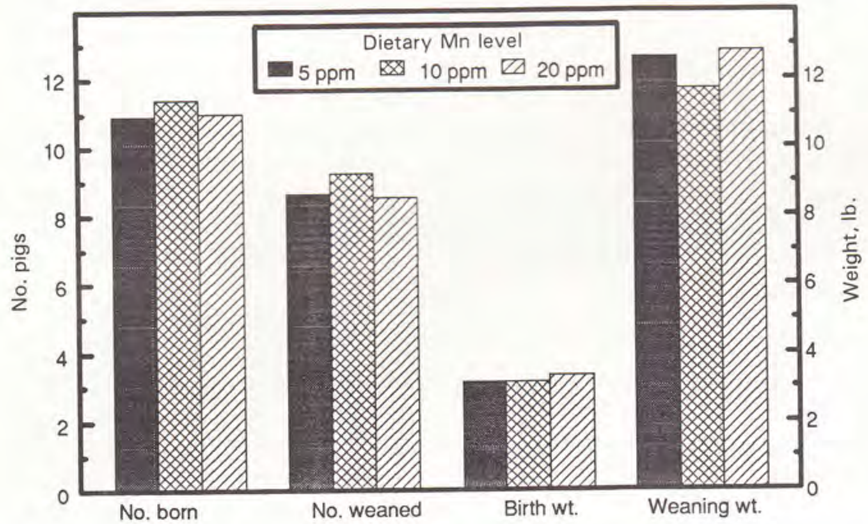

Figure 1. Litter size and weight for first three parities.

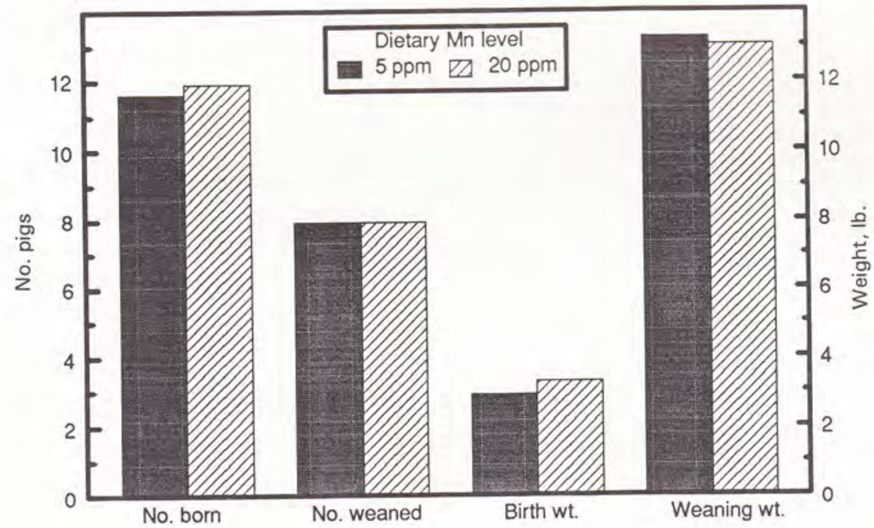

Figure 2. Litter size and weight for fourth parity.

monitor Mn concentration.

After three reproductive cycles, nine sows from the 5 ppm Mn and nine from the 20 ppm dietary treatments were continued through a fourth parity. These fourth parity sows had consumed their respective dietary treatments of either 5 or 20 ppm Mn for about one year. Again, sow weight, pig weight, litter size and concentration of Mn in the milk of the sows were used to evaluate adequacy of 5o and 20 ppm dietary Mn.

What Was Found

Weight and backfat thickness are indicators of a sow's condition following weaning, with thin sows often experiencing decreased reproductive performance. The weight and backfat measurements of the sows at day 109 of gestation and day 21 of lactation are shown in Table 2. Sow weight and backfat thickness increased as the dietary Mn level was increased, resulting in sows which appeared to be in better condition after a 21-day lactation. While the sows consuming 5 ppm Mn had less backfat than those consuming the other dietary treatments, their postweaning estrus activity was not severely affected (Table 3). The percentage of first litter sows showing estrus within seven days postweaning tended to improve as the level of dietary Mn increased (Table 3).

Litter size at birth and weaning for the first three parities was not affected by the Mn level in the diet (Figure 1). However, birth weight of pigs improved as the level of Mn in the diet was increased (Figure 1). Although the weight of pigs at birth was greater, this did not result in heavier weaning weights or greater survivability of the pigs.

Previous work has shown that the Mn concentration of milk is affected by Mn intake. Our results agree with these findings. The Mn content in sow's milk increased as Mn concentrations increased in the diet (Figure 3). The Mn concentration of milk from all sows decreased as they remained on the study, perhaps indicating a lowering of body Mn reserves over time. The effects of dietary Mn on sow and piglet performance of fourth litter sows were similar to those found through the first three reproductive cycles. The pigs from sows consuming 20 ppm Mn were heavier at birth than those from sows fed 5 ppm. Litter size and weaning weights were not affected by dietary Mn level (Figure 2). Sows consuming 20 ppm Mn were heavier at day 109 of gestation and day 21 of lactation than those consuming 5 ppm (Table 2), but the amount gained during gestation and lost during lactation did not differ between the two groups.

Although the concentration of Mn in the milk was lower in sows fed 5 ppm Mn than those fed 20 ppm (Figure 4), we found that the concentration of Mn in the milk increased through day 7 of lactation for all sows regardless of dietary treatment, perhaps due to a greater Mn intake (more feed consumed) with ad libitum feed consumption. The drop in milk Mn concentration from day 7 to 14 of lactation for those sows fed 5 ppm suggests that this dietary level of Mn was inadequate to sustain Mn concentration throughout lactation, since no decrease in milk Mn occurred with 20 ppm dietary Mn. The milk Mn concentration was similar for third and fourth parity sows (Figure 3) suggesting that body Mn reserves had reached their lower limit by the end of the third parity.

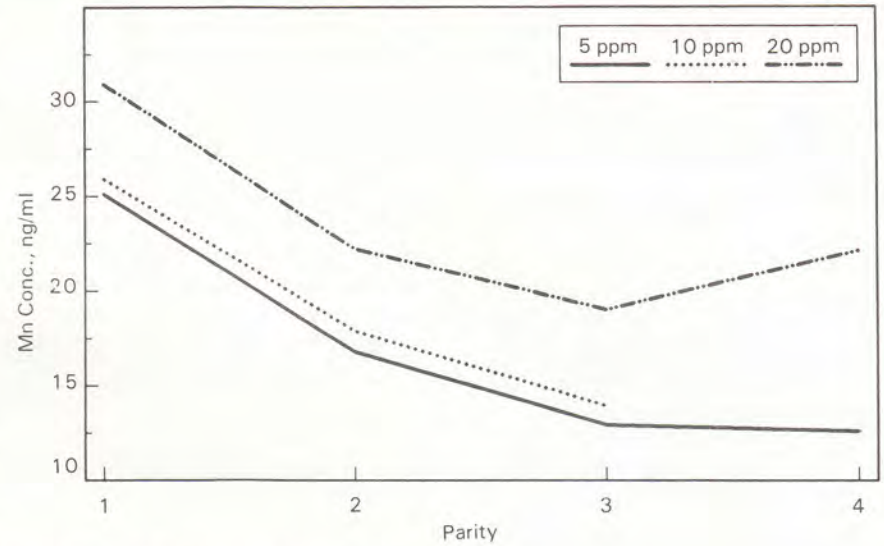

Figure 3. Milk Mn concentration on day 14.

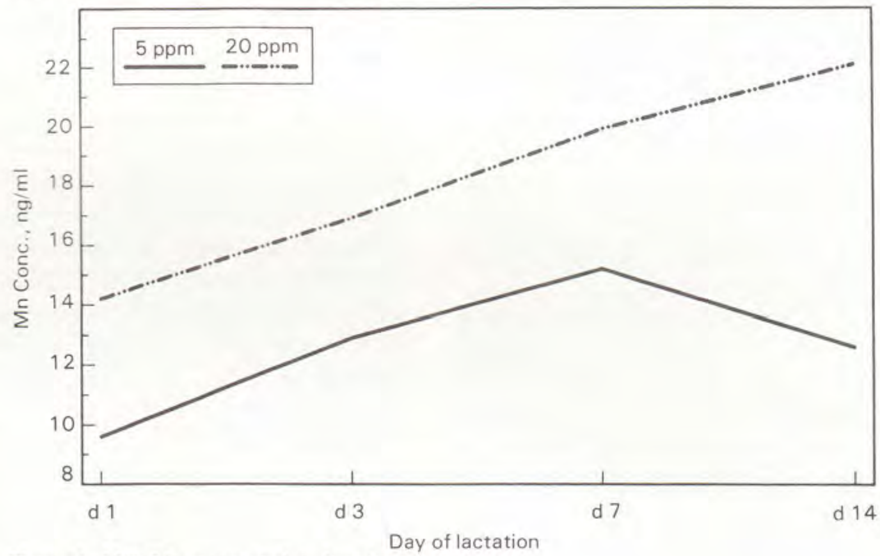

Figure 4. Milk Mn concentration, fourth parity.

Conclusions

Results indicate that dietary Mn level affects birth weight and sow milk Mn concentrations, and may play a role in the weaning-to- breeding interval in first litter sows. The current NRC requirement of 10 ppm Mn in the gestation and lactation diet needs to be reevaluated since we found that sows will respond favorably to 20 ppm Mn in the diet. This is particularly true considering the increase in birth weight of the pigs from sows fed 20 ppm Mn.

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Acid Steeping of Corn and Grain Sorghum: Effects on Nutrient Digestibility

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Grain sorghum is an important feedstuff for growing-finishing pigs. However, it is generally considered to have only 95% feeding value of corn. University of Nebraska research has focused on ways to improve sorghum as a feedstuff for pigs through various processing methods. Wet milling is a process in which cereal grains are heated in acid solutions to liberate their starch. This acid steeping helps free the starch from the protein matrix in the grain kernel. Compared to the starch in corn, the starch in sorghum is freed less easily from the protein matrix. This research was to determine if acid steeping could be used to increase the digestibility of corn and sorghum by pigs.

Corn vs Sorghum

The first experiment involved corn and cream, yellow, and bronze sorghum varieties. Although the color of sorghum has little or no relationship to nutritional value, sorghums are often identified and marketed by their color. Grains were steeped (soaked) in a .25% sulfurous acid solution. Corn was steeped

(Continued on next page)

Table 1. Effect of steeping on energy digestibility of corn and grain sorghum-based diets, experiment 1[a,b,c].

Grain:	Corn		Cream sorghum		Yellow sorghum		Bronze sorghum		CV, %
Steeping:	NST	ST	NST	ST	NST	ST	NST	ST	
Dry matter digestibility, %[d,e]	88.6	91.4	91.0	90.3	90.2	88.9	88.1	87.3	1.8
Digestible energy, kcal/g[d,e,]	3.51	3.66	3.57	3.57	3.52	3.48	3.49	3.47	1.8
Metabolizable $energy_n$, kcal/g[d,f,g,]	3.31	3.45	3.35	3.36	3.32	3.29	3.31	3.28	1.8

[a]Each mean represents a 5-day collection from six barrows (60 lb). Daily feed intake = .05(body weight)$^{.9}$.
[b]Grains were either not steeped (NST) or steeped (ST) in .25% sulfurous acid; corn for 48 hours at 126°F and grain sorghum for 24 hours at 118°F.
[c]Metabolizable $energy_n$ = metabolizable energy corrected for nitrogen balance.
[d]NST vs ST by corn vs sorghum, $P < .01$.
[e]Bronze vs cream and yellow $P < 02$.
[f]Bronze vs cream and yellow $P < .07$.
[g]Corn vs sorghum $P < .01$; cream vs yellow $P < .04$.

for 48 hours and sorghum for 24 hours. These times are typical of the wet milling process (water penetrates the seed coat of sorghum more rapidly than that of corn). Typical wet milling temperatures of 126°F for corn and 118°F for sorghum were employed. After steeping, the liquor was discarded and the grains were air-dried.

To determine the effect of steeping on nutrient digestibility, 48 barrows (60 lb) were fed eight different diets containing steeped and non-steeped grains. Six barrows were fed each of the diets. All eight diets contained 87.5% grain with sufficient casein (milk protein) to supply 15% crude protein in the diet. Sand was added as a diluent. Diets were supplemented to provide vitamins and minerals to meet or exceed the NRC requirements. Pigs were fed .05 X (body weight)$^{.9}$ daily. Barrows were individually housed in metabolism cages and all urine and feces were collected during a 5-day period.

Steeping improved the energy digestibility of diets containing corn, but decreased the energy digestibility of sorghum-based diets (Table 1). Bronze sorghum was less digestible than the cream and yellow varieties. Cream sorghum tended to be slightly more digestible than yellow sorghum.

Whether the different effects of steeping for corn and sorghum were due to differences between the two grains or were caused by differences in the time and temperature of steeping was unclear. Thus, the second experiment was conducted to determine the effect of duration of acid steeping on nutrient digestibility.

Time and Temperature

In the second experiment corn and two sorghums (bronze and a mixture of yellow varieties) were steeped. The grains were steeped in a solution of .3% sulfurous acid and .1% lactic acid. The three grains were steeped for 0, 12, 24, and 48 hours to yield a total of twelve treatments. Steeping temperatures were the same as used in experiment one. After steeping, liquor was discarded and grains air-dried. Diets were fed to 72 barrows (82 lb) with six barrows per treatment. Diets were 65% grain and 32.5% soybean meal (44% crude protein). Vitamin and mineral supplementation met or exceeded NRC requirements. Daily feed intake was .05 X (body weight)$^{.9}$. Barrows were individually housed in metabolism cages and urine and feces collected for 5 days.

Steeping corn and yellow sorghum for up to 24 hours decreased nutrient digestibility. After 48 hours of steeping digestibility improved to values similar to or greater than non-steeped grains (Table 2). Digestibility of nutrients in bronze sorghum decreased as steeping time increased. Overall, corn-based diets had higher digestible and metabolizable energy contents than sorghum-based diets. Nitrogen digestibility was greater for corn-based diets than sorghum-based diets. In contrast to the first experiment, bronze sorghum-based diets were

Table 2. Effect of steeping time on the digestibility of corn and grain sorghum-based diets, experiment 2[a,b,c].

Grain:	Corn				Yellow sorghum				Bronze sorghum			
Time, hours:	0	12	24	48	0	12	24	48	0	12	24	48
Dry matter digestibility, %[d]	89.5	89.3	88.9	89.7	89.7	88.8	87.6	89.6	90.8	90.9	90.0	90.1
Digestible energy, kcal/g[e]	3.55	3.51	3.46	3.52	3.53	3.43	3.38	3.48	3.56	3.51	3.46	3.45
Metabolizable $energy_n$, kcal/g[e]	3.39	3.29	3.26	3.35	3.34	3.26	3.20	3.31	3.37	3.34	3.28	3.25
Nitrogen digestibility, %[f]	88.3	88.0	88.5	89.6	87.6	85.6	85.8	86.9	87.2	86.5	85.5	85.5

[a]Each mean represents a 5-day collection from six barrows (82 lb). Daily intake = .05(body weight)$^{.9}$.
[b]Gains were steeped in a .3% sulfurous acid and .1% lactic acid solution. Temperatures were 126°F for corn and 118°F grain sorghum.
[c]Metabolizable $energy_n$ = metabolizable energy corrected for nitrogen balance.
[d]Yellow vs bronze, time quadratic $P < .01$; time quadratic by yellow vs bronze $P < .04$; CV = 1.2%.
[e]Corn vs sorghum, yellow vs bronze $P < .04$; time linear, time quadratic $P < .01$; time linear by yellow vs bronze, time quadratic by yellow vs bronze $P < .06$; DE, CV = 1.4%; ME_n, CV = 1.6%.
[f]Corn vs sorghum $P < .01$; time quad. $P < .05$; CV = 2.1%.

more digestible than diets containing yellow sorghum.

Summary

Results of the second experiment clearly illustrate the reason differences were observed in first experiment. Corn responded similarly to yellow sorghum to time of steeping. Nutrient digestibility decreased through 24 hours of steeping and then increased at 48 hours of steeping to levels similar to or greater than non-steeped grains. Steeping bronze sorghum decreased nutrient digestibility. This explains why, in the first experiment, steeping sorghum for 24 hours decreased digestibility while steeping corn for 48 hours increased digestibility. Whether recovering the soluble nutrients in the steeping liquor would have resulted in improved digestibility of grains is unknown. Differences in nutrient digestibility among sorghum varieties were not consistent. In general, acid steeping as performed in these experiments, did little to increase nutrient digestibility of corn and several grain sorghum varieties.

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[1]Mark A. Giesemann is research technologist, Austin J. Lewis is Professor and Ernest R. Peo, Jr., is Professor Emeritus, Department of Animal Science.

Pseudorabies Program Alternatives for Nebraska

James Friesen
Larry Bitney
Azzeddine Azzam[1]

The presence of pseudorabies virus (PRV) in the United States has been documented since the early 1900's. However, the disease was not a major concern to pork producers until the early 1970's. At that time, herds infected with PRV began experiencing losses through mortality and reduced performance much more severe than those reported earlier. Consequently, pseudorabies became a disease of economic importance.

A control program for PRV in pigs was established in Nebraska in 1987, designed to reduce the spread of PRV to uninfected herds. Currently, the Nebraska pork industry can proceed in one of three directions regarding pseudorabies: (1) Collectively attempt to eradicate the disease; (2) Continue the existing program's control measures; or (3) Relax control efforts and live with higher infection rates.

Pursuing any one of these options depends in part upon costs of the disease to Nebraskans. This study analyzed costs of alternative strategies for dealing with pseudorabies in Nebraska on an industry-wide basis. Five scenarios were considered. The first two were alternative eradication plans, designed to eradicate the disease from the state over a ten-year period. The third was a continuation of the control program, for an indefinite period of time. The last two scenarios were based on no control efforts and alternative assumptions about the disease's spread.

Procedures

Pseudorabies related costs were estimated for each year in the future for each of the five scenarios. These costs were then discounted to their present value using a five percent real rate of interest (before inflation) and totaled to facilitate a comparison of the scenarios. The "total present value of costs" estimate for each scenario can be thought of as the amount of money which must be deposited in a savings account at the beginning of the period, earning interest at a five percent real rate, in order to pay for all pseudorabies related costs when they are incurred in the future. The least cost scenario, by this analysis, is considered the "best" alternative. Cost categories quantified in this study include PRV vaccines, serologic testing, costs of infection, costs of cleaning infected herds, program administration costs, and a cost adjustment for secondary sectoral price shifts related to pseudorabies program status.

An epidemiological simulation model, embodying the dynamics of disease flows, was developed to estimate the impacts of pseudorabies under each of the scenarios. Input for the model included assumptions about infection rates, vaccine use, rates of herd cleanup, current demographic characteristics, and the current levels of infection. The model was run for the first 10 years of each scenario, yielding estimates of numbers of infected herds and other disease related statistics. For non-eradication scenarios, model output from year 10 was assumed to represent each year beyond year 10 for cost purposes.

Scenario Descriptions

Eradication Scenario #1: Eradication efforts start in the western portion of the state, spreading eastward over a five-year period. Infected herds are identified by testing of cull sows and boars.

Eradication Scenario #2: Eradication efforts begin in all areas of the state at the same time. To identify infected herds, all farms selling pigs during the first two years are required to maintain a pseudorabies program status.

Control Program Scenario: A continuation of the current control program indefinitely into the future. The program involves quarantine of infected herds and restrictions on hog movement based on a voluntarily obtained herd program status.

No Program Scenario #1: All administrative programs are dropped, and the disease is allowed to "run its course" in the state.

No Program Scenario #2: Similar to No Program Scenario #1, but with alternate values of an epidemiological factor, resulting in higher PRV prevalence rates over the initial ten-year period.

Results

Levels of the percent of breeding

(Continued on next page)

herds infected (estimated prevalence) on a statewide basis over the 10 years are presented in Figure 1. Eradication scenario #2, which employees immediate statewide eradication efforts, shows a faster progression towards cleanup than eradication scenario #1. The control program scenario quickly reached equilibrium prevalence level of 10.5% at the end of year three. Both "no program" scenarios exhibited increases in prevalence throughout the 10 year period. "No program" scenario #1 reached a 12.8% infection level while "no program" scenario #2 reached 17.3%. The only difference between the two "no program" scenarios is values of disease spread factors beyond producer control. The two scenarios may be thought of as a high and low estimate of what would really happen in a "no program" situation.

Costs were applied to the epidemiological model output, yielding estimates of total annual pseudorabies related costs by scenario. The eradication and control program scenarios are initially highest in cost. The picture changes by year 10. By this time, prevalence is sufficiently lowered in the eradication scenarios so that total pseudorabies related costs are the lowest of all scenarios.

Each scenario has some pseudorabies related costs which extend beyond ten years. In the eradication scenarios, a small number of herds remain infected at the end of year 10. Surveillance testing also is assumed to continue for 15 years. For the control program scenario and both "no program" scenarios, losses due to pseudorabies infections were assumed to continue into perpetuity.

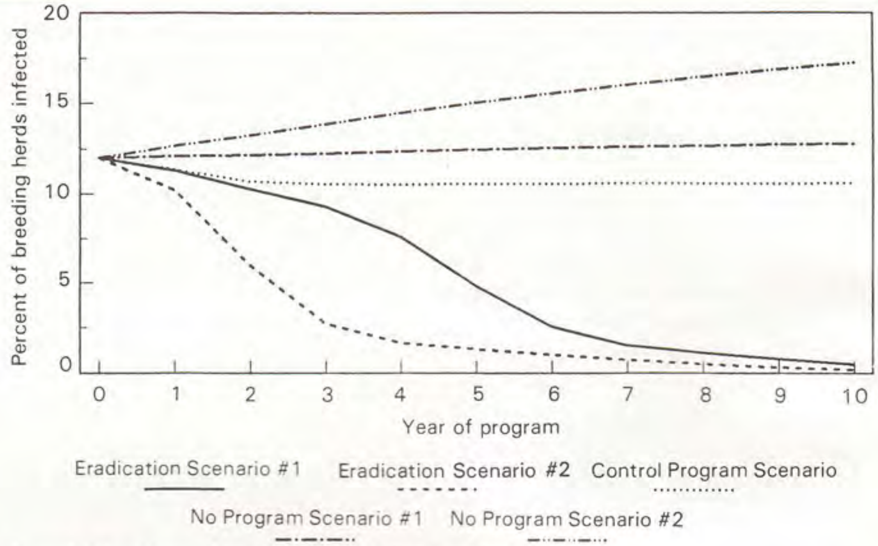

Figure 1. Prevalence of pseudorabies in Nebraska, 10 years, by scenario.

The present value of costs for each scenario are itemized in Table 1. Figure 2 shows graphically the present value of the costs within 10 years and total perpetual costs for each scenario. As this graph shows, *the present value of pseudorabies related costs to be incurred within the next 10 years is roughly similar for all scenarios.* Present values of ten-year costs range from a low of $30.3 million to a high of $33.7 million. When costs beyond 10 years (into perpetuity) are included, however, the two eradication scenarios easily qualify as the least cost alternatives with total present value of costs of $34.4 and $32.4 million compared to total present value of costs in excess of $75 million for each of the other scenarios.

A comparison of present value of costs for the two eradication scenarios in Table 1 reveals differences between the two eradication scenarios. While eradication scenario #2 involves higher producer level costs for herd program status testing, producers also incur smaller losses due to infection. Thus, the total costs for eradication scenario #2 are lower than for eradication scenario #1.

By classifying certain costs as costs of administering a pseudorabies program, the direct producer borne costs may be analyzed. For the eradication and control program scenarios, program level costs include circle testing, cull sow and boar testing (FPCT), surveillance testing, and administrative costs. Direct producer level costs are also lowest for eradication scenario #2.

Table 1. Summary of present value of costs at 5% discount rate, by scenario (millions).

Cost category	Eradication Scenario #1	Eradication Scenario #2	Control program scenario	No program Scenario #1	No program Scenario #2
Vaccine costs	$2.60	$1.85	$9.67	$23.72	$23.93
Herd status testing	3.90	5.85	9.94	0.81	0.81
Circle testing *	0.63	0.20	2.15		
FPCT testing *	0.55				
Surveillance testing *	2.07	2.22	3.63		
Cleanup costs	6.36	6.95	3.57	1.43	1.49
FP producer infection	0.92	0.80	1.95	6.80	8.31
FF producer infection	3.91	2.07	19.37	19.01	23.75
SS producer infection	7.56	6.50	20.95	23.70	24.43
Administrative *	5.14	5.14	10.62		
Total present value of costs	$33.64	31.58	$81.85	$75.46	$82.72
Adjustment for sectoral effects	$0.75	$0.85	$0.08	$0.04	($0.16)
Adjusted present value of costs	$34.39	$32.43	$81.92	$75.51	$82.56
10-year costs	$32.23	$30.26	$33.73	$30.57	$32.64
Costs beyond 10 years	2.16	2.17	48.19	44.93	49.91
Producer borne	$26.00	$24.87	$65.52	$75.51	$82.56
Program borne	8.39	7.56	16.40	0.00	0.00

Note: FP = Feeder pig; FF = Farrow to finish, and SS = Seed stock producers.
* = Costs allocated as program borne costs.

Conclusions

Given the background data and

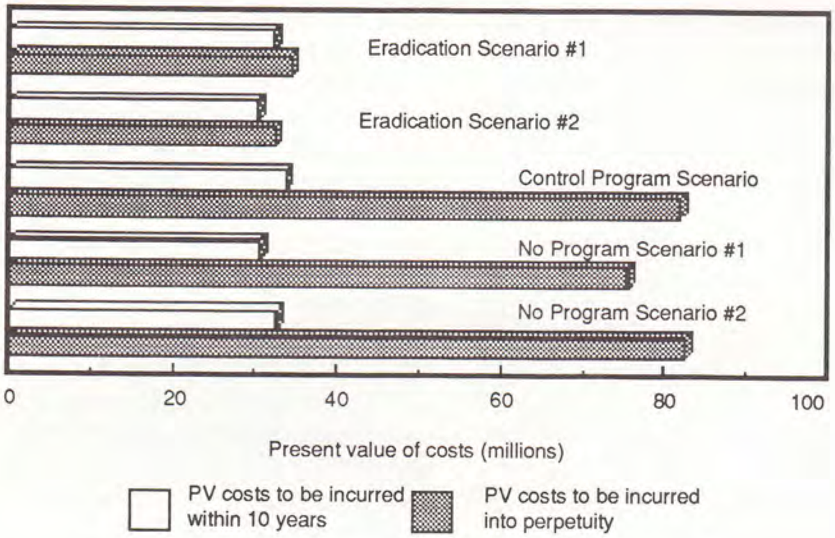

Figure 2. Present value of costs, 5% discount rate, by scenario.

assumptions used in this study, the least cost alternative for dealing with pseudorabies appears to be an eradication program. At a 5% discount rate, the estimated total present value of costs for the eradication scenarios studied amounted to no more than $34.4 million, while cost estimates for alternate scenarios totaled at least $75 million. Even though the eradication scenarios resulted in the lowest estimated total present value of costs, the costs which producers and the industry would incur within ten years under an eradication program appear to be similar to the costs which would be incurred for a control or no program scenario. However, the Nebraska pork industry, through eradication, could eventually eliminate the estimated $5.5 million in costs currently being incurred annually.

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[1]James Friesen is graduate student. Larry Bitney is Professor, and Azzeddine Azzam is Assistant Professor of Agricultural Economics. Funding for this study was provided by the Nebraska Pork Producers Association.

Nipple Drinkers for Finishing Pigs

Michael C. Brumm
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Finishing pigs at nipple waterers

Water is often the neglected nutrient in pork production. While textbooks and other references suggest that water be available free choice, they fail to offer specific recommendations as to the number of drinking spaces and delivery rates.

In modern production facilities, decisions have to be made concerning the number of drinking devices to install in a pen and the appropriate delivery rate for nipple drinkers. The cost of water, if purchased from a rural water district, and the cost of storage and disposal of wasted water has led to an increased desire to understand the water availability needs of pigs.

Regional Action

The NCR-89 regional committee on Confinement Management of Swine has been investigating water flow delivery rates from nipple drinkers and the appropriate number of pigs per nipple drinker. As a part of these investigations, University of Nebraska and Purdue University scientists conducted an experiment to investigate the effect of delivery rate and number of pigs per nipple drinker on weight gain, feed efficiency, and drinking behavior of finishing pigs during summer conditions.

Each site had two pens of pigs per treatment combination. Pigs at both sites were provided 8.5 square feet of floor space each. At the University of Nebraska Northeast Research and Extension Center at Concord, the pigs were housed 8 or 16 per pen in a mechanically ventilated, partially slatted confinement facility managed all-in-all-out. Pigs were housed in totally slatted mechanically ventilated continuous flow facilities with 11 or 22 pigs per pen at the Purdue University Swine Center near West Lafayette, IN.

Water was provided by one Edstrom (Edstrom Industries, Waterford, WI) nipple drinker per pen at both sites. The drinkers had an adjustable orifice that was set to deliver 1 or 4 cups of water per minute. Water delivery rates were recorded in each pen weekly and readjusted as necessary to within 0.1 cup of the desired rate.

At both sites, pigs were fed a 14% crude protein corn-soybean meal based diet containing no growth-promoting feed additives and 0.25% (Purdue) or 0.3% (Nebraska) added salt. Trials were started when pigs averaged about 130

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Table 1. Finishing pig performance influenced by flow rate and number of pigs per nipple drinker.

Item	Site	Flow (cup/min) 1	Flow (cup/min) 4	No pigs/drinker 8/11	No pigs/drinker 16/22
ADG, lb					
0-28 d	NE	1.60[a]	1.71[b]	1.74[c]	1.57[d]
	IN	1.35	1.41	1.44	1.31
Overall	NE	1.70	1.79	1.80	1.69
	IN	1.42	1.43	1.44	1.41
ADF, lb	NE	6.20	6.34	6.38	6.15
	IN	5.10	5.14	5.09	5.15
F/G	NE	3.66	3.54	3.55	3.65
	IN	3.61	3.59	3.54	3.65

[a,b]P < .1;
[c,d]P < .05

pounds and continued until the pigs averaged 230 pounds.

Trials at both locations were started in late May and ended in August, 1990. Air temperature minimums and maximums were recorded daily 2 ft above floor level. No sprinklers or other wetting devices were used during warm weather because they could have served as a water source and possibly confounded results of the experiment.

On days 27 and 55, one pen of pigs on each treatment combination at each location was continuously observed for drinking behavior and nipple contact time from 7 to 11 am.

Results and Discussion

Results are presented by location in Table 1. Large differences in performance were observed between locations. These differences cause some difficulty in directly comparing results.

For the first 28 days, pigs at the Nebraska station grew slower when either flow was restricted or the number of pigs per drinker was increased. The trend was the same at the Purdue site. For the entire feeding period, there was a numeric trend at the Nebraska site for pigs with restricted water access to grow slower. It is not certain if this small difference was due to the restricted water access.

The lack of response to flow rate at the Purdue station may be a function of overall pig performance. The pigs in the continuously populated finishing facility at Purdue grew 0.3 pounds slower per day and ate 1 pound of feed less per day than the pigs at the Nebraska station. Air temperatures (Table 2) were not much different between the sites with more variation evident in Nebraska as shown by the larger standard deviation.

The total time per pig of nipple drinker contact during a four hour period is presented in Table 3. At 4 cups/minute, regardless of the number of pigs per drinker, the pigs averaged about two minutes of drinker contact per pig in a four hour observation period.

At a flow rate of 1 cup/minute, the amount of drinker contact time was influenced by the group size. While total drinker contact time was 2-5 times that of the high flow rate, pigs in pens with more pigs per drinker spent more time in contact with the nipple drinker on both observation days.

At both stations, several pigs were often observed trying to drink at the same time in the large group sizes with 1 cup/minute flow rates. At all observation times, the pens with large group size (16 or 22 pigs/drinker) and 1 cup/minute flow, one pig tended to dominate the drinker. This domination may be related to the expression of peck order when stressed (limited water availability). With smaller group sizes (8 or 11 pigs) this competition was not observed, even with the low flow rate.

At the 1 cup/minute flow rate, little water was observed to be wasted during the drinking process. Any water that did escape from the mouth of the pig at the drinker was often lapped up by another pig waiting to drink. At 4 cups/minute flow, many pigs were observed to waste water in the drinking process. Some pigs were observed to be somewhat fearful of the high flow rate and would nip at the water delivery device in an apparent attempt to reduce the rate of delivery.

Conclusions

Because of the large differences in performance between Purdue and University of Nebraska pigs, no firm recommendations are possible. However, it appears from these results that a delivery rate of more than 1 cup/minute is advisable for finishing pigs. The rate of 4 cups/minute appears to be more than adequate, especially if water conservation is a concern. These results also suggest one nipple drinker is not adequate for 16 or 22 pigs per pen.

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Table 2. Air temperature — daily minimums and maximums.

Site	Minimum	Maximum
	°F	
NE	70.2 (±5.4)	85.9 (±7.7)
IN	72.5 (±3.7)	82.9 (±5.6)

Table 3. Time (minutes/pig) of nipple contact for four hour period.

Period	Pigs/drinker:	Flow rate 1: 8 or 11	Flow rate 1: 16 or 22	Flow rate 4: 8 or 11	Flow rate 4: 16 or 22
		min			
Day 27		4.3	9.6	1.9	1.8
Day 55		6.1	8.6	2.0	2.5

(Flow rate in cups/minute.)

Dried Brewer's Yeast for Weanling Pigs

Duane E. Reese
Brian S. Knust
Clyde H. Naber
Mark A. Giesemann[1]

Complex pig starter diets are important for successful management of early weaned pigs. In addition to ingredients like dried whey, fat and fish meal, dried brewer's yeast (DBY) has been considered an important component of some complex starter diets. Because DBY contains high levels of many B-vitamins, it served as a major source of B-vitamins in pig starter diets before vitamin premixes were available. Today, B-vitamins can be added to swine diets for a relatively small cost. Therefore, the need for DBY in pig starter diets is much less clear.

Procedure

We conducted two studies to examine the role of DBY in corn-soybean meal based starter diets. All diets were formulated to contain 1.2% lysine. Levels of other nutrients met or exceeded NRC requirements. A vitamin premix was added at a constant rate to all diets to supply the desired levels of B-vitamins.

In the first study, 64 crossbred pigs were weaned at 21 to 24 days of age (initial wt 14.1 lb) and assigned to four treatments. Dietary treatments consisted of combinations of two levels of DBY (0 and 2%) and two levels of edible dried whey (0 and 15%). The diets were self-fed in meal form during the 5-week trial.

In the second study, 128 crossbred pigs were weaned at 21 to 28 days of age (initial wt 14.7 lb) and assigned to four treatments. The treatments consisted of a corn-soybean meal based control diet and diets with three different sources of DBY, each added at a level of 2% of the diet. Dried whey was not included in any of the diets. The diets were self-fed in meal form during the 4-week trial.

Results

In the first study, pigs fed the diet containing 2% DBY without whey ate less feed and grew more slowly and less efficiently than pigs fed the other diets (Table 1). In contrast, when dried whey was present in the diet the addition of DBY had little or no effect on pig performance. Thus, the response to DBY in this study depended upon the level of whey in the diet.

Results of the second study suggest that there are differences among sources of DBY for weanling pigs. Pigs fed source B ate less feed and grew more slowly and less efficiently than pigs fed the control diet or diets containing either source A or C (Table 2). Pigs fed source A consumed more feed and tended to gain faster than pigs fed the control diet.

Conclusion

Results from these studies leave the benefit of adding 2% DBY to weanling pig diets in doubt. In most diets the addition of the DBY was not advantageous and in some cases it was deleterious. Furthermore, adding 2% DBY to diets (normal suggested range is 1-3%) increased the cost of one ton of feed $35. Adding B-vitamins via a premix to swine diets costs about $2/ton of complete feed and is more economical.

The variation we observed between sources of DBY demonstrates the need for careful attention to ingredient quality, especially in starter diets. Ingredients need to be carefully chosen so they promote high rates of feed intake at weaning. Because starter diets contain a variety of ingredients that must be high quality for best results, we suggest that most producers rely on the expertise of feed manufacturers and purchase complete feeds for pigs until they weigh about 20 lb. Thereafter, pigs can be switched to farm produced feeds with good results.

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Table 1. Effect of dried brewer's yeast (DBY) and dried whey (DW) on performance of weanling pigs[a].

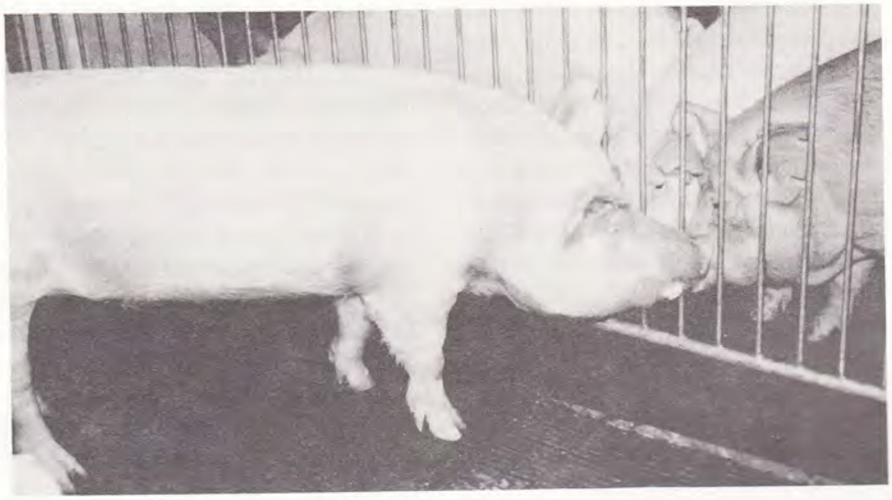
	Diet			
Item	0% DBY 0% DW	0% DBY 15% DW	2% DBY 0% DW	2% DBY 15% DW
Daily feed, lb[b]	1.46	1.65	.98	1.57
Daily gain, lb[b]	.90	.99	.31	.96
Feed/gain[b]	1.63	1.66	3.19	1.63

[a]Four pens of 4 pigs/diet; 5-week trial.
[b]DBY by DW interaction P < .01.

Table 2. Performance of weanling pigs fed various sources of dried brewer's yeast[a].

	Diet			
Item	Control	Source A[b]	Source B[c]	Source C[d]
Daily feed, lb	1.13[x]	1.28[y]	.99[z]	1.20[xy]
Daily gain, lb	.73[x]	.82[x]	.53[y]	.74[x]
Feed/gain	1.55[x]	1.57[x]	1.87[y]	1.62[x]

[a]Eight pens of 4 pigs/diet; 4-week trial.
[b]NPC, Inc. Payette, ID.
[c]Coors, Golden, CO.
[d]Wisconsin Products, Milwaukee, WI.
[x,y,z]Means with the same letter are not significantly different (P>.05).



Fenceline boar contact with gilts in confinement.

Influence of Boar Contact on Age at Puberty in Gilts

Dwane Zimmerman
Jeff Damme
Darryl Barnhill
Jung-Ho Son
Robert Knox[1]

Replacement gilts should be managed to express first estrus at an early age so their reproductive potential is optimized and they are regularly expressing estrus once they enter the breeding pool.

Boar exposure is an essential part of any successful gilt development program because the boar is the most powerful natural stimulus for induction of early puberty in gilts. Providing gilts with once daily contact (15 to 30 minutes), or continuous contact (fence line or physical) with sexually mature boars (>10 months) are equally effective methods of inducing early puberty in gilts. Recent research has attempted to determine the minimal amount of boar exposure (frequency and duration of boar contact) required to induce early puberty in gilts. Results of these experiments are particularly useful for producers who opt to stimulate puberty in gilts using limited contact with boars.

Duration of Daily Boar Exposure

Australian researchers recently reported that five minutes of daily boar exposure produced a similar age at first estrus as continuous contact with boars. Other Australian researchers compared the effectiveness of 0, 2, 10 and 30 minutes of daily boar exposure starting at 160 days of age. The percentage of gilts attaining puberty within 80 days following start of boar contact was similar for all treatments (avg = 88%) except for gilts isolated from boars (0 minutes group = 46%). Interval to first estrus following start of daily boar exposure was extended in gilts receiving 2 minutes of daily boar exposure (24 days) when compared to gilts receiving 10 minutes (8 days) and 30 minutes (11 days) of boar exposure each day. Interval to first estrus was substantially longer (58 days) in gilts isolated from boars. Nebraska research previously demonstrated that 15 and 30 minutes of daily boar exposure produced comparable first estrous responses in gilts.

Frequency of Boar Exposure

Another important question to answer is the frequency of boar contact required for optimal pubertal response. A recent Australian study evaluated the effect on interval to puberty of 0, 2, 5 or 7 days per week of boar exposure. Boar exposure was started at 175 days and involved 30 minutes of physical contact with a mature boar on the days gilts were assigned to receive boar exposure. The proportion of gilts reaching puberty within 60 days (by 235 days of age) was similar for all groups that received boar exposure. Overall, gilts that received boar exposure had significantly higher cycling rates (avg = 92%) than gilts isolated from boars (38%).

Interval from start of boar exposure to first estrus differed among gilts subjected to different frequencies of boar contact, but the magnitude of the differences varied with season of year. During the season when gilts exhibited slower sexual maturation, evidenced by 0% of non-boar exposed gilts attaining puberty by termination of the experiment at 235 days of age, intervals were long and differed little among the three boar exposure treatments (average interval to first estrus = 28, 33.5, and 37 days for gilts receiving 7, 5 and 2 days of weekly boar exposure, respectively). All intervals were substantially shorter than in gilts not provided boar contact (>60 days). Intervals to first estrus were much shorter in non-boar exposed gilts in the other two seasons (avg 48 and 44 days, respectively). Gilts provided boar exposure, regardless of frequency, expressed shorter intervals to first estrus than non-boar exposed gilts in both seasons. Daily boar exposure (7 days/week) produced a more rapid pubertal response than 5 days (M-F) of boar exposure per week (13.5 vs 25.5 day interval to first estrus when averaged across both seasons). Likewise, 5 days of boar contact appeared more effective than 2 days (consecutive days) of boar exposure per week (25.5 vs 32.5 day interval to first estrus when averaged across both seasons).

The small numbers of gilts representing each treatment each season may be responsible for some of the inconsistencies between treatments in different seasons. The authors interpreted the lack of consistency in response between different frequencies of boar exposure in different seasons to mean that gilts have a different threshold of sensitivity to boar stimuli in different seasons. This interpretation is consistent with results of previous studies conducted at Nebraska and elsewhere on the effects of sexual maturation of the gilt. These studies demonstrated that age of gilt at start of daily boar exposure (10 to 30 minutes/day) has a big influence on the type of pubertal response obtained.

Age Effects

Providing gilts contact with boars at younger ages (135 to 160 days of age, depending on potential of gilts for young age at first estrus) when gilts are in early stages of sexual maturation, produces the earliest average age at first estrus. However, gilts of this age generally respond slowly and variably to boar contact. Gilts that are in more advanced stages of sexual maturation when boar contact is started show a more rapid pubertal response than gilts that are in early stages of sexual maturation.

When boar exposure is started at a later stage of sexual maturation for most gilts in the group (e.g., at 160 to 190 days of age, depending on potential of gilts to express early age at puberty), gilts respond rapidly and synchronously (30 to 90% express estrus within 10 days) to start of contact with mature boars. Most gilts in this case are in advanced stages of sexual maturation and are highly responsive to boar exposure. Consequently, a synchronized first estrus is triggered in most gilts in a relatively short time. Gilts not responding rapidly at this age are primarily the slow maturing gilts that are very late to reach puberty.

Our interpretation of the seasonal effects on pubertal responses induced by different frequencies of boar exposure (reported by Australian researchers) is that it may be difficult to observe differences in pubertal responses when most gilts are in early stages of sexual maturation when boar contact is started. All gilts respond slowly, much like they do when exposed to the boar at a young age. In seasons when gilts are more sexually mature at a given chronological age, gilts are able to respond rapidly when boar stimulus is adequate (e.g., to daily boar exposure). When boar contact is not adequate to induce a maximal response (e.g., 2 days of boar contact/week), gilts respond more slowly and differences between treatments are observed.

Nebraska Study

If this hypothesis is correct, it should be possible to observe a different response to frequency of boar exposure when gilts are exposed to boars at different stages of sexual maturation (ages) in the same season. With this idea in mind, an experiment recently concluded at Nebraska evaluated the effect of age of gilt when boar stimulus is applied (135 vs 165 days) on first estrous response to different frequencies of boar exposure (D, once daily vs AD, alternate day). Duration of boar exposure (BE, 5 vs 15 minutes/day) was included as a third variable to determine whether frequency and duration of boar exposure interacted with one another. Nonboar exposed gilts (NBE), that were isolated from boars, were included as controls.

The experiment used 160 December farrowed Gene Pool (14 breed composite) gilts maintained at the UNL Agric. Res. Develop. Center Swine Unit. Gilts were allocated to confinement pens (6' x16', 8 gilts/pen) with partially slotted floors at about 125 days. BE treatments were then started at either 135 days or 165 days of age.

Frequency of boar exposure significantly influenced age at first estrus, but the response was dependent on age of the gilts at start of boar exposure (Table 1). Gilts provided daily contact with boars starting at 165 d attained puberty 18 days earlier than gilts that received alternate day boar exposure. However, gilts first exposed to boars at 135 days reached puberty at similar ages in response to daily and alternate day boar exposure. Gilts not given boar exposure were delayed reaching puberty compared to both daily and alternate day boar exposed groups (Table 1).

Duration of boar exposure (5 minutes vs 15 minutes) did not affect age at puberty and did not influence pubertal responses to frequency of boar contact or age of gilt at start of boar contact. Gilts receiving 5 minutes and 15 minutes of boar exposure averaged 186.5 days and 187.5 days of age at first estrus, respectively.

These results indicate that alternate day boar exposure is not adequate stimulus to trigger a rapid estrous response in prepubertal gilts. However, when BE stimuli are started at a younger age, (i.e., 135 days, an age too early to trigger a rapid pubertal response) alternate day boar exposure induces a pubertal response comparable to daily boar exposure. More research is needed regarding the effect of frequency of boar exposure on age at puberty in gilts and how boar exposure interacts with stage of sexual maturation in gilts to influence pubertal responses.

Table 1. Pubertal response (age, d) to frequency of boar exposure as influenced by age of gilt.

Age of gilt, d	Frequency of boar exposure: Daily	ALT. D	None
135	184.6	182.4	204.2
165	181.1	199.4[d]	205.1
Overall	182.9[b]	190.9[c]	204.7[d]

[a]Age x frequency interaction, $P < .01$.

[b,c,d]Overall means with different superscripts differ, $P < .01$.

Summary

1. Five minutes of daily contact with mature boars is sufficient to stimulate early puberty in gilts providing gilts have adequate opportunity for physical contact with the boars.

2. Gilts that are 165 days of age appear to require daily boar exposure to obtain rapid and maximal pubertal response.

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Load cells under feed bin.

Digital readout of the feed bin weight.

Feed Intake Patterns on Midwest Hog Farms

Michael C. Brumm
Gene G. Gourley
Diane K. Fraser
W.M. Greenley[1]

Feed intake (disappearance) by growing-finishing pigs is influenced by season (temperature) and management factors. On most farms, feed intake cannot be directly observed. The amount of feed which is gone from feeders and bins can be measured as an indicator of feed intake. Changes in feed intake occur readily because this is one of the few adjustments a pig can make in response to changes in environmental conditions in many production facilities. Unless diet formulations are changed to account for changes in feed intake, intake of critical nutrients may be less than adequate and limit lean growth rate.

The relationship between season and feed disappearance in growing-finishing facilities for 68 hog farms in the upper Midwest (mostly Iowa and southern Minnesota) was examined using data from the Swine Graphics Inc. data base at Webster City, IA. Data in Figure 1 represent more than 14 million pig days for the period July, 1986 through June, 1988. Average pig inventory weights for individual farm records ranged from 75 to 190 lb. The average monthly inventory weights are given in Table 1.

Outside and Inside Patterns

Within this data set, facilities were classified as "outside" and "inside". Inside facilities included all categories of confinement facilities where pigs did not have outside access or bedding.

A question to ask when examining Figure 1 is how does this pattern of disappearance compare to some standard of expected intake? The National Research Council (NCR), in its 1988 publication "Nutrient Requirements of Swine" included a formula for calculating expected feed intake of corn-soybean meal based diets for growing-finishing pigs. The formula assumes

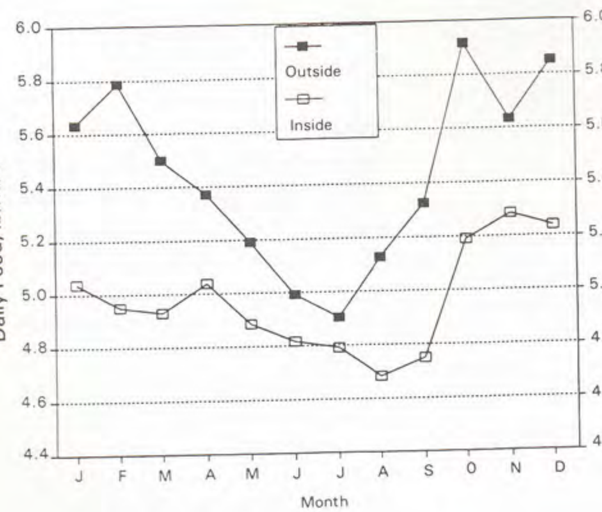

Figure 1. Feed disappearance on midwest hog farms, July, 1986 - June, 1988.

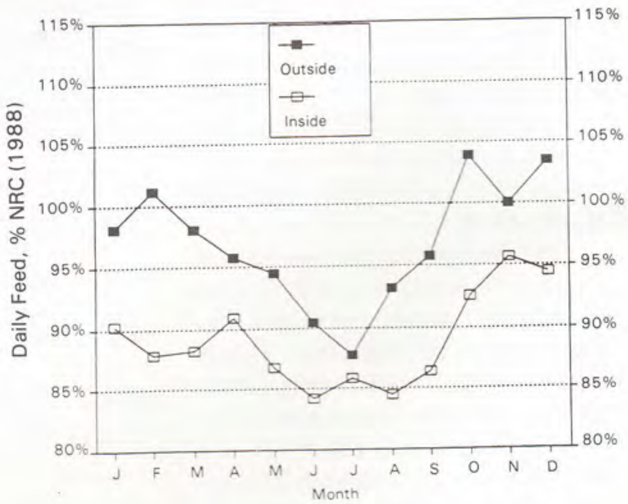

Figure 2. Feed disappearance of midwest hog farms, July, 1986 - June, 1988.

Table 1. Monthly average inventory weights on surveyed farms.

Month	Facility Inside	Outside
	---------- lb ----------	
January	134	141
February	136	138
March	134	136
April	132	136
May	136	131
June	140	132
July	134	134
August	133	130
September	130	133
October	135	139
November	131	136
December	132	138

that pigs are housed in a thermal-neutral environment with minimal social stress. The formula is based on pig weight, a variable known to influence feed intake directly.

Figure 2 contains the data in Figure 1 with feed intake expressed as a percentage of the NRC predicted value. Expressed in this manner, feed intake is corrected for the slight differences in pig inventory weight noted in Table 1.

When expressed as a percent of the NRC predicted intake, it is evident that for a majority of the year, growing-finishing pigs on these farms consumed less feed (had less feed disappearance) than predicted. It is evident from Figures 1 and 2 that outside-housed pigs consumed more feed than inside-housed pigs during all months. The lowest feed disappearance for outside-housed pigs was in July, with an increase in disappearance beginning in August. In contrast, feed disappearance for inside-housed pigs was lowest in June, July, August, and September and increased disappearance did not occur until October. For both groups of pigs, feed disappearance was greatest during October, November, and December.

Several management factors may have contributed to much of the variation noted. Confinement barns in the upper Midwest have traditionally been constructed to be warm in the winter months. Often, this construction, and the resulting management limitations, results in facilities that retain heat in the summer months as well. Crowding contributes to heat problems. As feed disappearance decreases in hot weather, pigs continue to be added to pens in continuous-flow "inside" facilities. Feed intake is then further reduced because of the effects of crowding. For many facilities, it is October before the weather and facilities cool sufficiently to allow this crowded situation to be resolved.

Cooler temperatures lead to increased feed disappearance during October, November, and December for both inside and outside housed pigs. Some would argue that the increased disappearance is also attributable to "new" corn being included in the diets at the same time.

Implications

In Table 2, the average pig performance for growing-finishing herds on the Swine Graphics record scheme for 1987, 1988, and 1989 are compared to the NRC expected values for growth rate and feed conversion efficiency.

The depression of feed and nutrient intake relative to expected values can probably explain in a large part the failure to achieve the expected level of performance. The challenge for producers becomes one of how to manage to avoid this depression in intake.

For inside-housed pigs with feed disappearance patterns similar to those of Figures 1 and 2, summer management of intake needs greater attention. This may involve management to cool pigs (sprinklers and/or less crowding), or diet modifications to increase intake of nutrients.

As record systems for growing-finishing pigs become more sophisticated, more producers, consultants, and nutritionists will consider expected disappearance of nutrients in diet formulations. This will represent a major change in formulation strategy because most producers change diets only in response to pig weight (i.e. 16% grower to 100-120 pounds and 14% finisher thereafter).

Diet formulation based on expected nutrient disappearance will challenge many current feed and nutrition suppliers. Suppliers will be asked to formulate diets for a given genetic type (high vs low lean gain potential) with a given disappearance history in a certain facility. Economics of individual nutrients will be considered in diet formulation, not just total ingredient cost.

As part of a sophisticated record scheme, many producers in the future will use electronic load cells or other weighing devices on their feed storage and delivery systems. Use of such devices will allow daily monitoring of feed disappearance and calculation of nutrient disappearances.

Technology to implement this level of sophistication is already being used by the broiler, layer, and turkey industries. While not all pork producers will use weighing devices on their feed delivery systems, the successful producer of the future will be aware of feed disappearance patterns and the impact of these patterns on the profitability of the enterprise.

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Table 2. Comparison of growth and feed efficiency for growing-finishing swine versus NRC (1988) expected performance.

Weight range	Source	Average daily gain	Feed:gain
lb		lb/d	
50-110	Swine Graphics, 1987	1.25	2.77
	Swine Graphics, 1988	1.25	2.68
	Swine Graphics, 1989	1.27	3.00
44-110	NRC, 1988	1.54	2.72
110-235	Swine Graphics, 1987	1.53	3.58
	Swine Graphics, 1988	1.49	3.80
	Swine Graphics, 1989	1.59	3.49
110-242	NRC, 1988	1.80	3.79

Lean Buying Programs in Nebraska, Western Europe

William T. Ahlschwede[1]

Discussions on increasing the lean content of pork carcasses generally result in questions about the adequacy of premiums for lean at the market place. "I'll not produce leaner hogs until I'm paid for them" is a common attitude. Those who buy market hogs assert that premiums are available for superior hogs. When hogs are sold live, it is difficult to determine if premiums for leanness are paid. When hogs are sold on a carcass weight and grade basis, the price differential for leanness is usually apparent.

Merit buying programs used by packers purchasing Nebraska hogs have been studied. Grade and yield sheets supplied by customers of six packers have been evaluated along with material supplied by each packer. In addition, merit buying systems from Denmark, West Germany, and England were evaluated for comparison. This report will include brief descriptions of the merit buying systems and comparisons of lean premiums offered in the US and Europe.

Fat-O-Meter in use in Danish slaughter plant.

Two components generally determine the price of carcasses in merit buying systems. One component is grade. Grade may be a visual score, a classification based on measured fat thickness or an estimated carcass lean percent based on carcass measurements. The second component is carcass weight. With minor variations, the packers evaluated all prefer and offer the most money for carcasses from hogs weighing between 220 and 250 lb. The size of the discount for carcasses falling outside the preferred range varies, depending upon the packers product mix. All are quite explicit in stating the weight they prefer and the discounts applied to hogs which are not of the preferred weight.

Merit Buying Systems

Geo. A. Hormel operates a pork plant in Fremont. The Hormel merit buying system assigns carcass grades based on measured fat thickness at the last rib on the midline of the split carcass. The highest grade is for carcasses with 0.8 in fat or less. Six additional grades are defined on 0.2 in increments up to 1.81 in and higher. Carcasses in the 160 to 180 lb range (210 to 245 lb live) have the highest value. The "Hormel Butcher Lean Guide to Pork Value" is a table which defines carcass value for each weight and grade class as a percent of the base price. Thus the premium for lean is larger when market prices are high.

John Morrill and Company operates plants in Sioux City, IA and Sioux Falls, SD. Both plants slaughter and process Nebraska Hogs. Morrill prices carcasses based on weight and percent lean as estimated by the Fat-O-Meter. The Fat-O-Meter utilizes a probe with a reflected light to measure the depth of the fat and lean at the 10th rib. The measurements are recorded by computer and the carcass lean content and price are calculated. Morrill pays most for carcasses in the 154 to 183 lb range (210 to 250 lb live). Within weight ranges, carcasses are priced according to lean percent. Base carcass price is for 45% lean, with premiums or discounts of 0.5% per percentage point above or below. Carcass values by lean percent and weight range are defined as a percentage of the base price.

Farmland Foods operates a plant at Crete. Farmland's merit buying system is based on grades corresponding to fat thickness as measured by the Fat-O-Meter. Carcasses with less than 1.2 in fat at the 10th rib over the loin muscle are graded No 1 (+$2.25 per cwt carcass), up to 1.49 in fat are No 2 (+$1.15), up to 1.79 in fat are No 3 (base price) and above 1.8 in fat are No 4 (-$2.25). Farmland pays most for carcasses from hogs in the 220 to 250 lb weight range.

Swift Independent Packing Company (operated by Monfort, a division of ConAgra) at St. Joseph, MO, slaughters Nebraska hogs. Swift pays most for carcasses in the 161 to 183 lb range (220 to 249 lb live). Carcasses are visually graded as Tenderlean (+$2 per cwt carcass), Premium (+$1), Base at base price, Over finished (-$2) and Medium (-$7).

TriMiller at Hirum, UT, purchases some Nebraska hogs. Their merit buying system is based on measured carcass fat thickness on the midline at the last rib. TriMiller uses a matrix which prices carcasses by weight range on 0.1 in classes as a percentage of the base price. Carcasses which fall in the 168 to 185 lb range (230 to 255 lb live) receive the highest prices, with no weight penalty for hogs up to 265 lb with less than 1.0 in of fat.

IBP operates hog slaughter plants at Madison, NE, and Council Bluffs, IA. IBP's merit buying system is not a carcass weight and grade system like

Table 1. Relative value of pork carcasses within packer merit buying systems for hogs in the 230 to 245 pound weight range[a,b].

	Hormel		Farmland		Tri-Miller	IBP		Morrill	
Fat, in	Grade	%	Grade	%	%	Grade	%	%	% Lean
0.4-0.5	1+	107	1	103.3	110	1	103.7	107.5	60
								107.0	59
.51-0.6	1+	107	1	103.3	110	1	103.7	106.5	58
								106.0	57
.61-0.7	1+	107	1	103.3	109	1	103.7	105.5	56
								105.0	55
.71-0.8	1+	107	1	103.3	108	1	103.7	104.5	54
								104.0	53
.81-0.9	1	104	1	103.3	109	2	101.9	103.5	52
								103.0	51
.91-1.0	1	104	1	103.3	108	2	101.9	102.5	50
								102.0	49
1.01-1.1	2	102	1	103.3	106	3	100.0	101.5	48
								101.0	47
1.11-1.2	2	102	1	103.3	104	3	100.0	100.5	46
1.21-1.3	3	100	2	101.7	102	4	98.2	100.0	45
								99.5	44
1.31-1.4	3	100	2	101.7	98	4	98.2	99.0	43
								98.5	42
1.41-1.5	4	96	2	101.7	94	5	96.3	98.0	41
1.51-1.6	4	96	3	100.0		5	96.3	97.5	40

[a]Base price, conditions of sale and dressing percent vary from plant to plant.
[b]Programs in place September 1, 1990.

Table 2. Merit buying systems in Germany, Denmark, and England during June 1989.

	Germany		Denmark		England		
% lean	DM/kg[a]	% base	Kr/kg[a]	% base	in fat	pence per lb[a]	relative value
62	3.21	112.60	15.10	106.3	up to 0.32	114.5	101.3
61	3.17	111.20	14.95	105.3	0.33-0.59	116.5	103.1
60	3.13	109.80	14.80	104.2	0.60-0.67	113.0	100.0
59	3.09	108.40	14.65	103.2	0.68-0.75	108.5	96.0
58	3.05	107.00	14.50	102.1	over 0.76	98.0	86.7
57	3.01	105.60	14.35	101.1			
56	2.97	104.20	14.20	100.0			
55	2.93	102.80	13.90	97.9			
54	2.89	101.40	13.60	95.8			
53	2.85	100.00	13.30	93.7			
52	2.80	98.20	13.00	91.5			
51	2.75	96.50	12.70	89.4			
50	2.70	94.70	12.40	87.3			
49	2.65	93.00	12.10	85.2			
48	2.60	91.20	11.80	83.1			
47	2.55	89.50	11.50	81.0			
46	2.50	87.70	11.20	78.9			
45	2.45	86.00	10.90	76.8			
44	2.40	84.20	10.60	74.6			
43	2.35	82.50	10.30	72.5			

[a]Prices in local currency.

those described above, but rather a system which buys hogs on a live weight basis with the price determined by the cutout history of the producers last several loads of hogs. Although it is difficult to determine premiums and discounts from the kill sheets IBP provides to those who have sold hogs, the IBP system is designed to pay a premiums of $2.50 per cwt for carcasses which grade #1 (0.8 in fat or less) and $1.25 for #2 (0.81-1.00 in fat), base price for #3 (1.21-1.4 in fat) and discounts of $1.25 for #4 (1.41-1.6 in fat) and $2.50 for fatter hogs. The non-discounted weight range is 220 to 250 lb live. In the leanest grades, weights above 250 are not discounted.

Except for IBP, the payment to the producer on all of the systems described above is determined by carcass weight and carcass price.

The grade premiums for the Hormel, Morrill, Farmland, TriMiller, and IBP merit buying programs are shown in Table 1 for hogs weighing 230 - 245 lb. The Swift grades and premiums are not included in the table because they are not tied to specific fat thickness or lean content measurements. For comparison, the Farmland and IBP grade premiums have been converted to a percentage of base price using a $50 live hog market. The premiums are shown relative to carcass fat thickness.

There is some difficulty in arranging the grades in the table. Hormel, TriMiller and IBP use a similar fat measurement (on the midline of the split carcass at the last rib) in determining grade. Farmland uses Fat-O-Meter fat thickness, measured over the loin muscle between the 10th and 11th ribs. Depending on the fatness of the carcass, the Fat-O-Meter reading tend to be 0.1 to 0.2 in less than the last rib midline measurement.

The Morrill lean percentages are arranged so that equivalent carcasses appear on the same line in the table. Because the Fat-O-Meter lean content considers both muscle thickness and fat thickness, the correspondence between the lean percent scale and fat thickness scale is not perfect. The table shows an approximate assignment based on the results of split loads sold under both systems and tests where both measurements were performed on the same hogs.

For comparison of the systems, consider a load of hogs which range in lean content from 43% to 59%. This is the range found in a load of 120 hogs sold at Morrill at an average weight of 230 lb and 49% carcass lean. A companion load sold to Hormel the same day with the same average weight averaged 0.91 in fat. The corresponding range in value at Morrill (from Table 1) is 8 percent (107%-99%). At Hormel, the corresponding range in value is 7%; at Farmland 1.6%; at TriMiller 12% and at IBP 5.9%. The base price falls at a different point on the table for each

(Continued on next page)

packer. This must be kept in mind as systems and base price bids are evaluated.

Among these five packers, the incentive to improve leanness when selling on the merit system is largest at Tri-Miller and least at Farmland. Although the differences are small, Morrill shows more price spread than Hormel and Hormel more spread than IBP. At a weight of 240 lb and live price of $50 per cwt, differences between the best and worst hog would be about $9.60 at Morrill, $8.40 at Hormel and $7.08 at IBP.

Table 2 shows figures similar to Table 1 from three merit buying systems in Europe from June and July of 1989. Germany is represented by a single plant in northern Germany. The Danish system is used throughout the country. The system from England is a single plant. All three systems are shown for the weight class which includes 220 lb hogs.

Both the German and Danish systems are based on percent lean as determined by Fat-O-Meter, or similar device. In both cases, the premiums for carcasses leaner than the base level are more than 1% per percent lean (about 1.4% in Germany, 1.05% in Denmark). Below the base value, the discounts are larger, 1.75% per percentage point in Germany and 2.1% in Denmark. The Morrill system (Table 1) offers 0.5% differential per percentage point.

The English system, based on probed fat thicknesses, has a large discount for the fattest class. Carcasses with more than 0.76 in fat are docked 13.3% relative to the middle fat class. The grade with the least fat, less than 0.33 in, are paid less premium than those with 0.33 to 0.59 in fat. If few pigs fall in the fattest grade (as is the case with the US systems), the premiums in England are of a magnitude similar to that offered by Morrill, Hormel and IBP. As indicated by the scale, English market hogs are considerably leaner than their US counterparts.

Based on the values in Table 1, it appears that considerable premium is offered for leanness by most packers who buy hogs in Nebraska. However, these premiums appear to be about half as large as those offered in Germany and Denmark. Premiums offered to English pork producers appear to be similar to those in Nebraska.

The perception among pork producers that premiums for leanness are small can be attributed to several factors. The first is the failure to market hogs at the weight the packer prefers. One packer representative observed that for many producers, the discounts for light and heavy hogs obscures the grade premium. Merit buying reports from pork producers selling to six packers serving Nebraska indicate a range in weight discounts of $0.25 to $2.00 per cwt on a truck load average. In some cases, weight discounts were larger than grade premium.

A second factor which tends to make leanness premiums seem small is the competition among packers for hogs. As apparent in Table 1, the buying systems are not the same, reflecting in part the different markets individual packers supply. Yet they bid for the same hogs. Competition among packers with different uses for the same hogs tends to make premiums for leanness less apparent. A third factor, which became apparent when packers changed grading systems to include actual measurements, is that hogs sometimes aren't as lean as we think they are.

Evaluation of merit buying systems of six packers purchasing market hogs from Nebraska producers revealed a wide range of premiums for leanness. On a fifty dollar market, several pay eight to ten dollars more for the leanest hog on a load than the fattest. Discounts for hogs too light or too heavy often reduced the apparent premium for leanness. The best premiums for leanness in the Nebraska market appear to be about half as large as those offered producers in Denmark and Germany. Three of the six US packers studied reported that their merit buying systems were in the process of revision. These changes will bring more uniformity to the programs and larger average premiums for leanness.

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Does Particle Size of Corn and Grain Sorghum Affect Pig Performance?

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Improving feed use can have a great impact on the cost of production, given the large percentage of total costs represented by feed. Feed efficiency of nursery, growing, and finishing pigs is improved by processing grain to reduce diet particle size.

Procedure

Corn and grain sorghum were processed through either a 1/2, 1/4 or 1/8

Table 1. Diet composition, %.

Ingredient	Grower[a]	Finisher[a]
Grain[b]	75.45	81.35
Soybean meal, 44% CP	21.25	15.50
Dicalcium phosphate	1.10	0.95
Limestone	0.80	0.80
Salt	0.30	0.30
Trace mineral mix[c]	0.05	0.05
Se premix[c]	0.05	0.05
Vitamin premix[c]	1.00	1.00
	100.00	100.00

[a]Grower diet fed from 56 to 116 lb; finisher diet fed from 116 to 232 lb.
[b]Grain sources: corn or grain sorghum (NK2656).
[c]Provided vitamins and trace minerals to meet or exceed NRC (1988) requirements.

Table 2. Particle size (in microns) of the grain and complete diets.

Screen size	Grain		Complete diet	
	Corn	Sorghum	Corn	Sorghum
Coarse grind				
1/2 inch	1008	986	980	965
Fine grind				
1/4 inch	856	854	864	814
1/8 inch	872	800	863	813

inch screen to achieve three different particle sizes. The hammers were turned to present a new edge for processing at the start of the study. The hammermill motor speed was set at 1725 rpm. Corn diets were formulated to contain 16 and 14% crude protein for the grower and finisher phases, respectively. Grain sorghum replaced corn on an equal weight basis in the sorghum diets (Table 1). Although the sorghum diets were higher in crude protein, diets from both grain sources had the same calculated lysine level (0.80% grower and 0.65% finisher).

Two hundred forty pigs were randomly allotted to the six diets with four blocks, based on weight within sex. Ten pigs (five barrows and five gilts) were housed in each of 24 pens in a modified-open-front building. The initial weight of the pigs was 56 lb. The switch from grower diet to finisher diet occurred at an average weight of 116 lb. The study ended with pigs averaging 232 lb.

Particle size of the grain and complete diets was determined with sieves ranging in size from 150 to 3,350 microns.

Results and Discussion

Research at other institutions suggests that the optimum dietary particle size is approximately 800 microns (1/32 inch) with as uniform particles as possible. Many factors can influence diet particle size, such as screen size, grain kernel size, hammermill tip speed, condition of the hammers and screen, and the feeding rate into the hammer mill. Particle size of the ground grain and diets used in this study are shown in Table 2. Since particle size of both grains was similar when processed through the 1/4 and 1/8 inch screens, data for these treatments were combined giving two types of grind: coarse (1/2 inch screen) and fine (1/4 and 1/8 inch screens).

Results of the study are shown in Table 3. During the grower phase, pigs consumed more of the sorghum diet regardless of particle size. While daily gain was similar for pigs fed corn and sorghum based diets, there was an increase in gain and improved feed efficiency as particle size decreased. This was particularly evident for pigs fed the sorghum diet, primarily because of the high feed/gain of pigs consuming the coarse-ground sorghum diet, which contained some whole berries.

During the finisher phase, pigs continued to consume more of the sorghum diet, following the trend seen in the grower phase. Feed intake was lower with the fine grind for both grain sources, while daily gain was not significantly affected by grain source or particle size in this phase of the study. With the gain being similar for grain sources, the higher feed intake of the sorghum diets at each particle size resulted in larger feed/gain for sorghum, an effect similar to that observed in the grower phase. Particle size also affected feed efficiency, with the pigs fed the coarse-ground diets having larger feed/gain.

If the diet is ground very fine, problems with gastric ulcers in pigs, feed bridging in feeders and bulk bins, dustiness, and increased power usage for processing are possible. Other researchers have suggested that if dietary particle size is above 750 microns these problems are minimized. We incurred no health or feeder management problems.

Conclusion

Results of this study indicate that particle size has an effect on both corn and sorghum diets in the growing and finishing phases of pig production. Reducing the average particle size of corn or sorghum-based diets to about 850 microns resulted in good overall performance of growing and finishing pigs. The presence of whole berries in the coarsely ground sorghum-based diet likely contributed to the 6.9% increase in feed/gain compared with fine-grinding. Thus, it would be necessary to use a 1/4 inch or smaller screen when grinding grain, especially sorghum, to achieve an average dietary particle size of about 850 microns.

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Table 3. Effect of grain source and particle size[a].

	Corn		Grain sorghum	
	Coarse	Fine	Coarse	Fine
Growing phase				
Daily feed intake, lb[b]	4.39	4.34	4.50	4.48
Daily gain, lb[c]	1.72	1.75	1.63	1.77
Feed/gain[d,e]	2.55	2.48	2.76	2.53
Finishing phase				
Daily feed intake, lb[f]	6.39	6.11	6.58	6.35
Daily gain, lb	1.75	1.75	1.69	1.75
Feed/gain[d]	3.65	3.49	3.89	3.63

[a]Means for coarse grind represent four pens of ten pigs each and means for fine grind represent eight pens of ten pigs each from 56 to 116 lb (grower), and 116 to 232 (finisher).
[b]Corn vs grain sorghum, $P < .10$.
[c]Particle size, $P < .05$.
[d]Corn vs grain sorghum, $P < .001$. Particle size, $P < .001$.
[e]Particle size X Grain, $P < .05$.
[f]Corn vs grain sorghum, $P < .05$. Particle size, $P < .05$.

Nebraska Swine Enterprise Records and Analysis Program

Michael C. Brumm
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The Nebraska Swine Enterprise Records Program continues to expand. Beginning in 1991, the program is available to all pork producers in Nebraska.

The Nebraska Swine Enterprise Records Program is primarily a do-it-yourself program. Producers record information in a hand-kept record book. The Program is designed to help producers collect the information necessary to determine cost of production, as well as level of efficiency for selected parameters.

The current cost of the program is $60 per hog enterprise per year. For this fee, new enrollees receive two training sessions on data collection, assignment of shared expenses, determination of fixed expenses and two individual six-month summaries.

Averages for farrow-finish, farrow-feeder pig and feeder pig finishing enterprises for the first six months (January through June) of 1990 are given in Tables 1, 2, and 3. Also included are values for producers who submitted data for the period January, 1989 through June, 1990.

In addition to the overall average, each summary has a column which contains the average values for producers that ranked in the high 1/3 for profit and a column for the low 1/3 for profit for the January, 1989 through June, 1990 period.

Corn and milo were priced at $2.40/bu and $3.90/cwt respectively for the six month period ending June 30, 1990. For the 12-month period ending June 30, 1990, the respective corn and milo prices were $2.31/bu and $3.83/cwt.

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Table 1. Selected items for farrow-finish enterprises.

Item	Jan. 1 - June 30, 1990 Average	High Profit	Low Profit	July 1, 1989 to June 30, 1990
No. of farms	42	14	14	14
Profit/cwt pork produced	$19.55	$26.56	$12.14	$16.53
Total cost/cwt pork produced	$41.33	$36.55	$46.65	$39.52
Total variable cost/cwt pork produced	$37.20	$32.94	$42.68	$35.88
Total feed expense/cwt pork produced	$25.37	$23.13	$27.89	$25.31
Average cost of diets/cwt	$6.84	$6.63	$7.12	$6.54
Feed/cwt pork produced, lb	371	351	392	387
Pigs weaned/female/year	15.7	16.1	14.1	15.3
Pigs weaned/crate/year	64.4	69.6	56.1	63.1

Table 2. Selected items for farrow-feeder pigs enterprises.

Item	Jan. 1 - June 30, 1990 Average	High profit	Low profit	July 1, 1989 to June 30, 1990
No. of farms	20	7	7	8
Profit/cwt pork produced	$40.91	$58.30	$25.66	$27.79
Total cost/cwt pork produced	$67.77	$62.83	$70.87	$63.17
Total variable cost/cwt pork produced	$56.43	$54.41	$56.99	$54.59
Total feed expense/cwt pork produced	$33.49	$31.44	$34.15	$33.53
Average cost of diets/cwt	$8.53	$7.89	$8.49	$8.60
Feed/cwt pork produced, lb	393	399	401	388
Pigs weaned/female/year	18.1	18.7	16.2	17.3
Pigs weaned/crate/year	86.9	86.4	82.0	71.1
Average wt of feeder pig sold, lb	47.8	44.6	49.4	47.9

Table 3. Selected items for feeder pig finishing enterprises.

Item	Jan. 1 - June 30, 1990 Average	High profit	Low profit	July 1, 1989 to June 30, 1990
No. of farms	15	5	5	8
Profit/pig sold	$28.08	$39.47	$19.27	$21.76
Profit/cwt pork produced	$14.11	$21.08	$8.55	$11.50
Total cost/cwt pork produced	$32.28	$30.99	$34.04	$32.18
Total variable cost/cwt pork produced	$29.03	$27.03	$31.22	$29.17
Total feed expense/cwt pork produced	$22.60	$22.34	$22.91	$23.12
Average cost of diets/cwt	$6.45	$6.56	$6.64	$6.68
Feed/cwt pork produced, lb	352	342	345	347
Weight of feeder pig purchased, lb	45.0	44.9	44.2	46.8
Price/head of feeder pig purchased	$54.20	$48.37	$59.03	$47.67