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EC88-219 1988 Nebraska Swine Report

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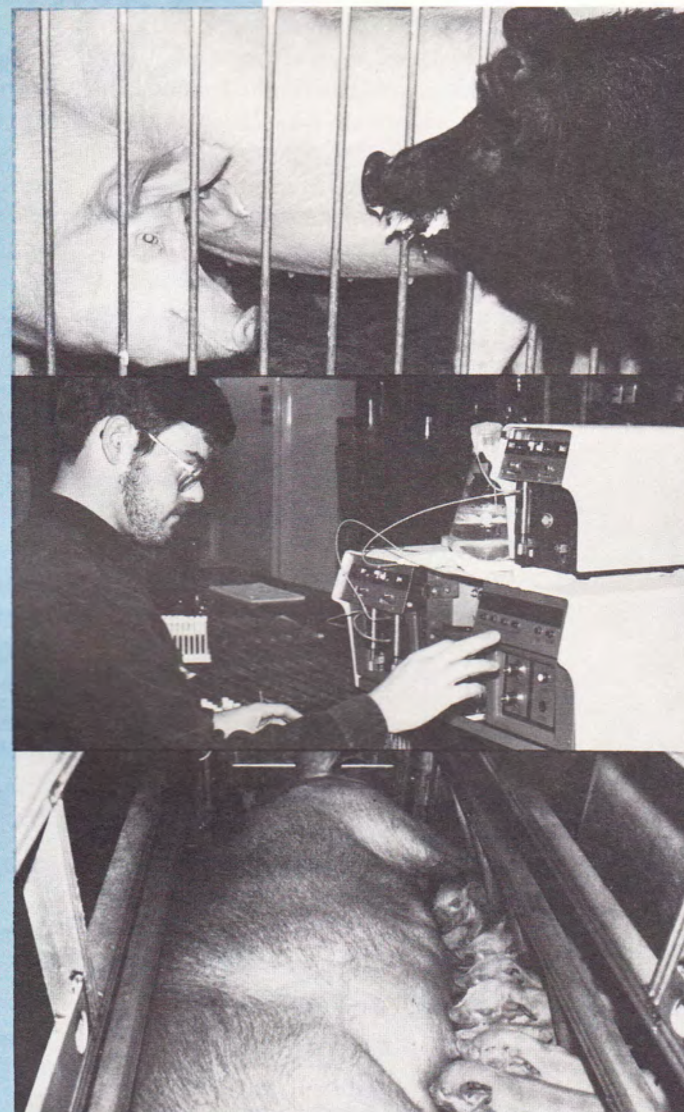

NEBRASKA SWINE REPORT

- 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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1988 NEBRASKA SWINE REPORT

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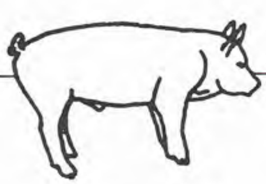

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The 1988 Nebraska Swine Report was compiled by William T. Ahlschwede, Extension Swine Specialist, Department of Animal Science.

Selection for Components of Litter Size in Swine: Summary of Five Generations of Selection

S. M. Neal, R. K. Johnson, D. R. Zimmerman and R. J. Kittok[1]

Litter size is an important contribution to the economic efficiency of pork production. As litter size increases, fixed production costs are spread over more hogs and the efficiency of the herd improves. Producers are taking advantage of breed differences and heterosis to maximize litter size with existing genetic material. Further improvement in litter size must come from selection within breeds or lines. These improved lines could be used in crossing programs by commercial producers to further improve litter size above levels achievable with stock available today.

Experimental work has shown that it is difficult to improve litter size by selection. Reasons for this are the low heritability of litter size and the relatively low selection differentials in the few experiments that have been reported.

The number of ova or eggs ovulated by a female during the estrous period in which she is mated sets the upper limit on litter size. The percentage of the eggs fertilized determines the number of live embryos entering the uterus. When mating is properly timed the percentage of eggs fertilized will approach 100 percent and the fate of the fertilized egg is determined largely by the uterine potential of the sow.

Uterine potential can be measured as embryo and fetal survival rate, the proportion of the eggs ovulated that are represented by a live embryo or fetus at some point in gestation, or by a live piglet at birth.

Ovulation rate and embryo survival rate are major components of litter size. An alternative to direct selection for litter size is to select for these components. The purpose of this report is to describe an experiment conducted at the University of Nebraska which attempted to increase litter size by selecting for an index of ovulation rate and embryo survival to 50 days of gestation.

Materials and Methods

The selection experiment was started in 1981 using a composite line of Landrace and Large White breeds. Five generations of selection have been completed. Selection was based on an index (I = 10.6 X Ovulation Rate + 72.6 X Embryo Survival Rate). Two lines were started from the same base population. One was a select (S) or index line in which selection was based on the index. The other line was a control (C) in which no selection was practiced. The control line was used to monitor environmental changes between generations and is the standard to which the selection line is compared to measure the effectiveness of selection.

Size of the index line was maintained at 43 to 45 litters by about 18 sires per generation. Each generation, all female progeny in the select line (about 160 gilts) were mated to approximately 20 sons of the 15 high indexing females of the previous generation. At 50 days of gestation, a laparotomy was performed on all pregnant females. This is a surgical procedure in which the reproductive tract is exposed through an incision in the abdomen. Ovulation sites on the ovary and number of fetuses in the uterus were counted.

Embryo survival was calculated for each gilt as the ratio of number of fetuses to ovulation rate. Females were ranked on index value and 43 to 45 high ranking females were selected and farrowed. The remaining females were culled before parturition. Progeny of the selected females were then mated for the next cycle of selection. Thus, of approximately 160 gilts mated each generation, the high ranking 45, based on index, were farrowed. Replacement boars were selected from the high ranking 15 sows.

Size of the control line was 42 litters per generation sired by 15 males. Females were randomly chosen, one or more per litter (approximately 55 were retained and 50 were mated each generation) Males were chosen one per half-sib family. One-half of the chosen control line females underwent laparotomy. Reproductive performance of these females (C-L) was compared to control line females that were not laparotomized (C) to measure the effects of the surgical procedure on litter size at birth. Selected index line females and all chosen control line females (laparotomy and no laparotomy) were farrowed.

Data collected at farrowing included total number of fully formed piglets born and number of mummified piglets. Crossfostering was done to standardize, as well as possible, the litter size reared by each dam. Pigs were weaned at 28 days of age and reared in single sex groups of 25 in raised deck nursery pens. Weanling pigs were fed a standard 18% protein corn-soybean meal pelleted diet to 56 days of age.

At about 56 days of age pigs were moved to modified open front buildings. Pigs were housed separately by sex in groups of ten head per pen. Both boars and gilts were fed a 16% corn or milo and soybean meal diet to about 125 lbs and a 14% protein diet thereafter.

Gilts were checked for estrus daily with intact boars to determine age at puberty. When the oldest female in a pen was 135 days of age, detection of estrus began for the entire pen. Gilts were monitored until they had expressed their second estrus. All females were mated at second, or later estrous periods and detection of estrus continued through the breeding season. Females were hand mated daily during estrus. After mating, females were moved to individual gestation stalls.

Results and Discussion

Generation means for ovulation rate, embryo survival and number of fetuses at 50 days of gestation for the two lines are shown in Figures 1, 2 and 3. It is clear from Figure 1, that ovulation rate in the select line increased during the five generations of selection. After five generations, mean ovulation rate for the select line (17.04) was about 3 ova higher than the mean for the control line (14.07).

Line means for embryo survival are plotted in Figure 2. The general trend in embryo survival for the select line relative to the control line was downward. The difference between the two lines at generation five was about 7 percent.

Figure 3 shows the plot of line means for number of fetuses at 50 days of gestation. The difference between the two lines at generation five was about 1 fetus. The positive trend in number of fetuses suggests that the increase in ovulation rate more than offset the reduction in embryo survival rate.

The difference in mean index value between the select and control lines at generation five was 26.4 index points. Realized heritability was calculated for the index by evaluating the amount of response in index points relative to the selection applied. The realized her-

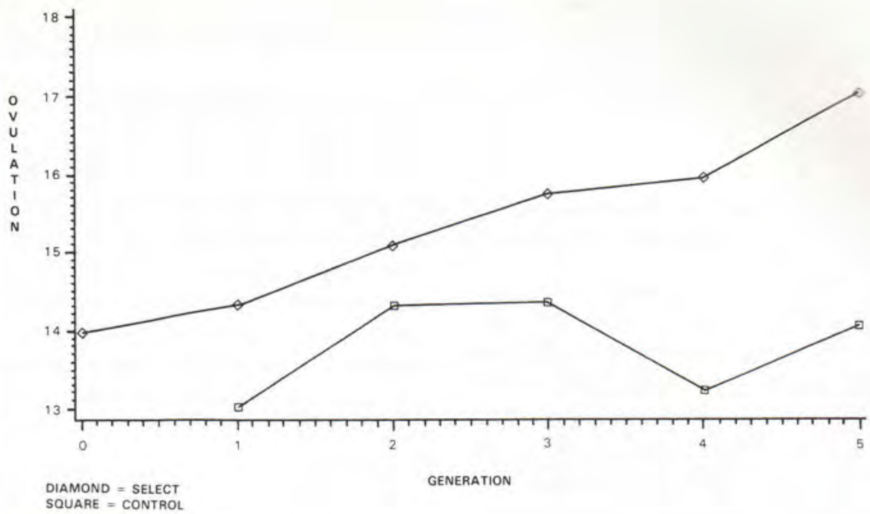

Figure 1. Mean Ovulation Rate

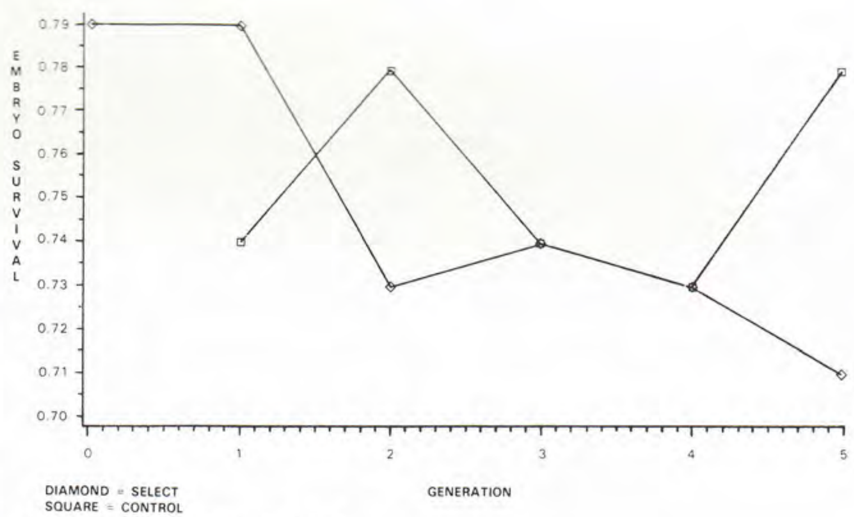

Figure 2. Mean Embryo Survival

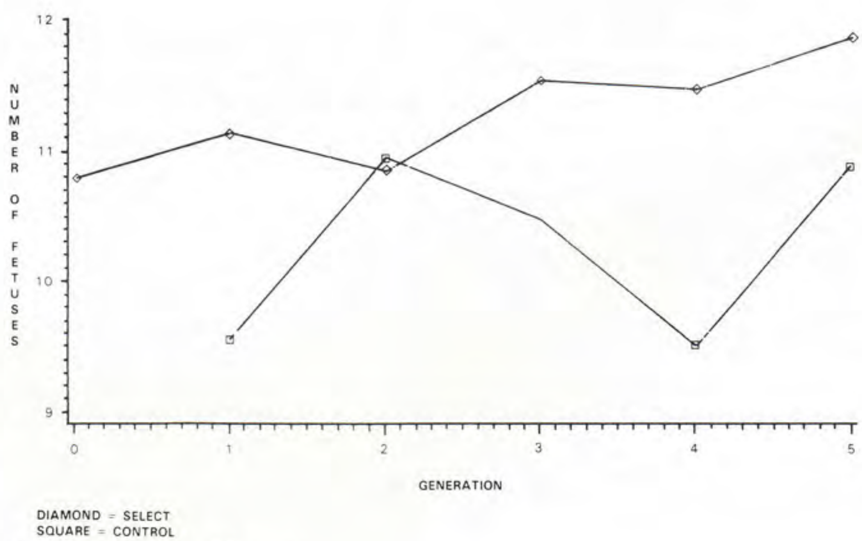

Figure 3. Number of Fetuses

bean meal diet to about 125 lbs and a 14% protein diet thereafter.

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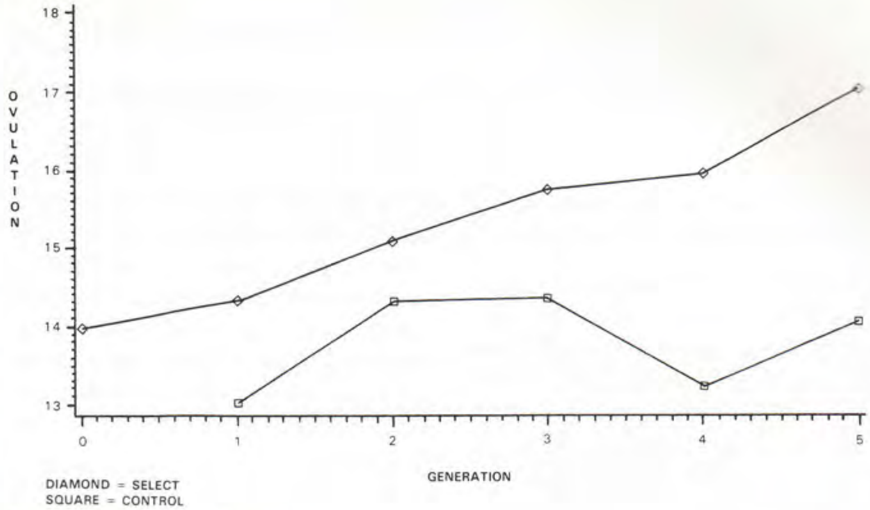

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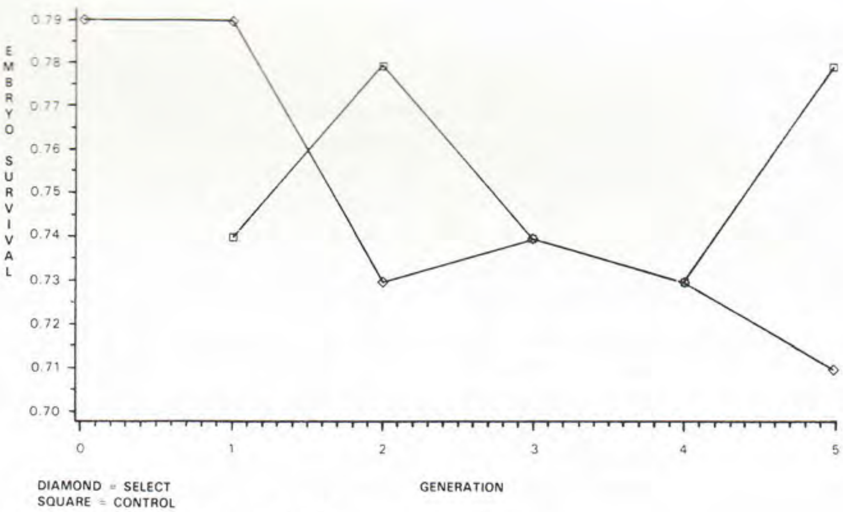

Figure 2. Mean Embryo Survival

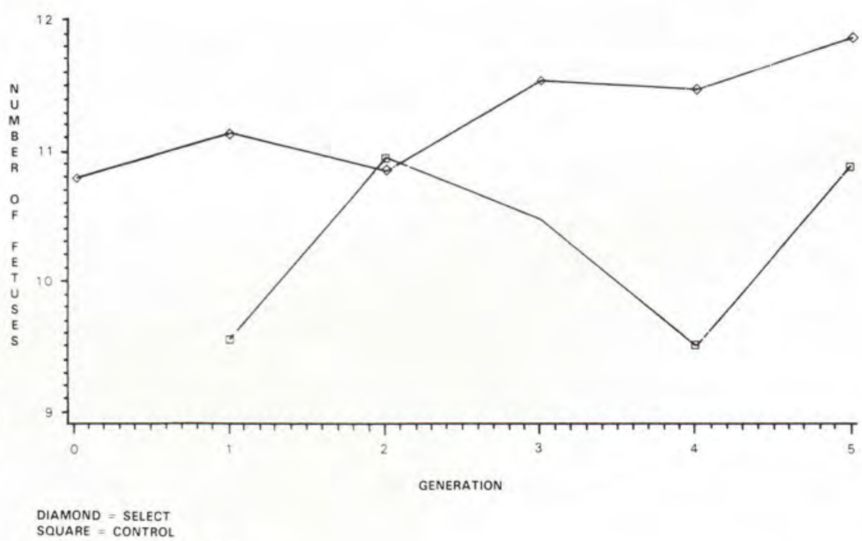

Figure 3. Number of Fetuses

Differences in Follicle Stimulating Hormone Concentrations During the Periovulatory Period in High Ovulating Select and Control Line Gilts

Dwane R. Zimmerman and Colleen R. Kelly[1]

The importance of litter size to the economic efficiency of the pork production is well documented. While choice of more prolific breeds and crossbreeding systems have produced a gradual increase in average litter size in Nebraska and the U.S. in recent years, average number of pigs weaned remains below 8 pigs per litter.

Litter size at birth is the product of number of ova produced (ovulation rate), percentage of ova fertilized by sperm to form embryos and percentage of embryos and fetuses that survive prenatally and are born as live offspring. Ovulation rate sets the upper limit for litter size and, therefore, is an important component of litter size.

Genetic selection for high ovulation rate (Select line) in the UNL Gene Pool population increased ovulation rate by about 3.5 ova over a contemporary control line after 9 generations of selection and established that ovulation rate is a moderately heritable trait in swine. Ovulation rate has also been increased by selection for ovulation rate in mice, index selection for ovulation rate and fetal survival in pigs and selection for litter size in mice and sheep.

Ovulation rate differences may be a function of the number of growing follicles on the ovaries, concentrations of gonadotropic hormones (FSH, follicle stimulating hormone, and LH, luteinizing hormone) that reach the ovaries to stimulate follicles to grow to ovulatory size and responsiveness of follicles to gonadotropic hormones.

It was established in the early 1970's that LH concentration increases during late proestrous of the estrous cycle and reaches maximum concentrations with onset of estrus, 30-36 hours before ovulation. However, it was not until the mid-1980's that sensitive assays became available to characterize circulating concentrations of FSH during the estrous cycle.

Follicle stimulating hormone concentrations also have been reported to peak near the onset of estrus, coincident with the preovulatory LH surge, in pigs, sheep and laboratory rats. This is followed by a second surge of FSH within 24 hours of the onset of estrus when circulating concentrations of LH are low.

LH seems to be involved with stimulation of maturation of selected follicles rather than determination of number of follicles to be ovulated. In previous experiments conducted on select and control line gene pool gilts, no difference in LH concentrations were observed during the proestrous and estrous periods of the estrous cycle.

The role or significance of periovulatory discharges of FSH with respect to regulation of ovulation rate and in explaining the genetic difference in ovulation rate produced by selection is unknown in the pig. However, it has been demonstrated in laboratory rats that the second surge of FSH is responsible for recruitment and development of the follicles that will ovulate at the next estrus. Similarly, a high correlation has been reported in sheep between magnitude of the second FSH surge and number of antral follicles present at the subsequent estrus, two weeks later.

The present experiment was conducted to evaluate whether differences in plasma concentrations of gonadotropic hormones, FSH and LH, during the periovulatory period of the estrous cycle are associated with the ovulation rate difference between high ovulating select and control gene pool lines of pigs developed at UNL.

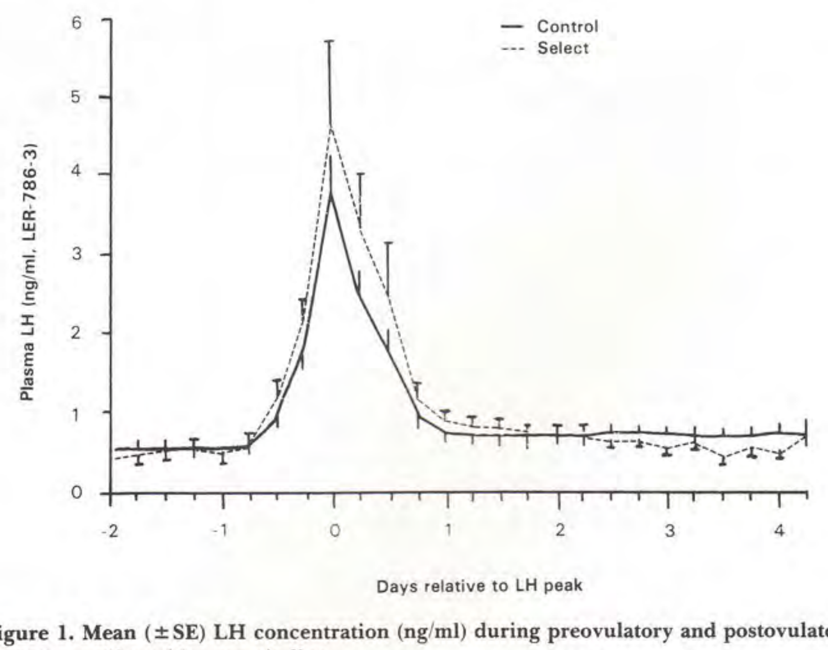

Figure 1. Mean (±SE) LH concentration (ng/ml) during preovulatory and postovulatory periods as affected by genetic line.

Procedures

Cyclic gilts from the Control (C, randomly selected, n = 11) and Select (S nine generations of selection for increased ovulation rate followed by seven generations of random selection, n = 9) lines of the UNL Gene Pool population (derived from 14 different breeds) were used to characterize differences in gonadotropic hormones during the preovulatory and postovulatory phases of the estrous cycle. Gilts were individually girth tethered in an environmentally regulated room on campus. A cannula was then inserted into an ear vein of each gilt on day 14 or 15 of the estrous cycle. Blood samples were collected during four periods (0500, 1100, 1700 and 2300 hours) daily beginning two days before anticipated estrus and continuing through day 4 post-estrus (day 0 = first day of standing estrus). Sampling within a period consisted of five blood samples at 15 min intervals. Plasma samples were analyzed for concentrations of FSH, LH, estradiol and progesterone using radioimmunoassay procedures.

Results and Discussion

This sample of the select line population expressed only a slight advantage in ovulation rate compared to the control line (14.6 vs 13.9). Evaluation of the line difference in ovulation rate in the previous generation, using a much larger sample size and progeny representation from all sire groups, revealed the line difference to be 3.9 ova. Thus, sample size probably was too small to accurately reflect the true line difference in ovulation rate.

Hormone concentrations were standardized for each gilt relative to when the peak in the preovulatory LH surge occurred. Hormone values for each gilt within each line were then averaged for each day and changes in hormone concentration over time were compared between lines. The peak in the preovulatory LH release, depicted as day 0, occurs on the average near the onset of estrus. Thus, -2 would be 2 days before onset of estrus and day 4, 4 days after onset of estrus.

The characteristic preovulatory LH surge was evident for each genetic line (Figure 1). Mean LH concentrations were at baseline levels during the first 36 hours of sampling in both C and S gilts. The preovulatory LH surge of both lines began between the second and third sample period of day -1. Concentrations of LH increased rapidly during the next 12 to 18 hours and peaked during first sample period of day 0. Following the LH peak, LH concentrations declined steadily for 18 to 24 hours, returning to baseline values between the last sample period of day 0 and the first sample period of day 1. No significant line differences in mean LH concentration were detected during the preovulatory period even though LH concentration tended to average higher in S than in C gilts (2.48 vs 1.95 ng/ml) and the peak concentration of LH averaged higher (4.79 vs 3.83 ng/ml) in S than C gilts.

Two distinct FSH surges were observed during the periovulatory period (Figure 2). Baseline concentrations of FSH averaged .13 ng/ml during the first 30 to 36 hours of sampling. On day -1, FSH concentrations increased 2- to 5-fold above baseline and peaked at values greater than .4 ng/ml during the first sample period on day 0. Following the preovulatory FSH peak, mean concentrations of FSH declined to half of their peak concentration within 18 to 24 hours.

The second FSH surge began approximately 24 hours after the preovulatory LH peak, rising steadily from the beginning of day 1 through the first half of day 2. Mean FSH concentrations during the second and more prolonged FSH surge were typically two or more times greater than during the preovulatory FSH surge. FSH concentrations began to decline during the latter half of day 2, but had not returned to baseline by the end of sampling, midway through day 4 of the estrous cycle.

Plasma FSH concentrations increased faster during the 12 hours preceding the preovulatory FSH and LH peaks and tended to peak at higher concentrations in S (.88 ng/ml) than C (.54 ng/ml) gilts. Gilts from the S line maintained a higher mean FSH concentration than C

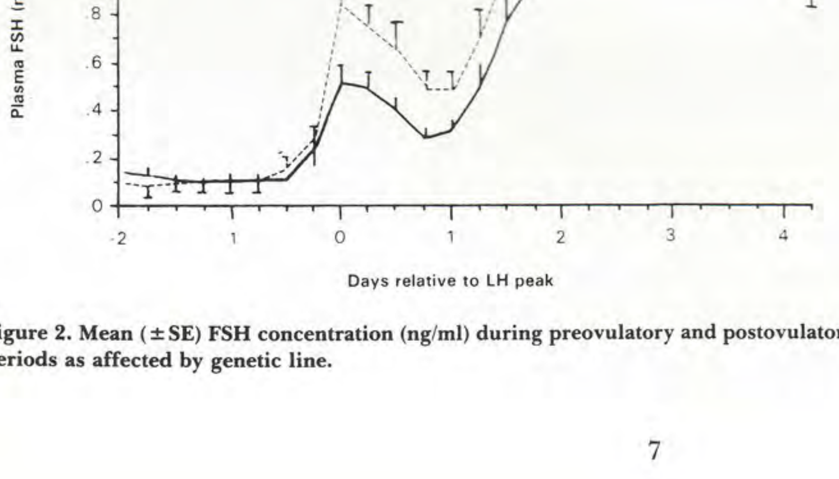

Figure 2. Mean (± SE) FSH concentration (ng/ml) during preovulatory and postovulatory periods as affected by genetic line.

gilts during the entire descending portion of the preovulatory FSH surge, but the rate of decline to a low point was similar between S and C gilts.

Concentrations of FSH increased at a similar rate in both lines during the ascending portion of the second FSH surge. Mean FSH concentrations during the second surge averaged 1.35 vs 1.19 ng/ml in S and C gilts. Peak values of FSH were two or three times greater than preovulatory peak concentrations in both lines (C, 1.46 vs S, 1.74 ng/ml). Following the second FSH peak on day 2, FSH concentrations began to decline. The decline tended to be more rapid, however, in S than C gilts (Figure 2).

No line differences in estradiol concentrations were detected during the periovulatory period. Mean estradiol concentration increased linearly from initiation of blood sampling on day -2 until peak concentrations were attained about 12 hours before the LH peak. Estradiol concentration declined to baseline by the end of day 0 in both lines.

Progesterone concentrations were similar for S and C line gilts on each day of the periovulatory period. Progesterone concentration remained low from the start of blood sampling on day -2 until the second half of d 1 when it began to increase in a linear fashion in both lines until the end of blood sampling on day 4.

Whether the higher concentration of plasma FSH observed in select line gilts during the periovulatory period is responsible for selection and recruitment of larger numbers of follicles for the subsequent ovulation must await more detailed evaluation of differences in follicle populations during the period just preceding ovulation as well as the period just after the second surge of FSH.

A second, equally intriquing question is why FSH attains higher concentrations in high ovulating select line gilts during the periovulatory period. There is growing evidence that FSH and LH secretion are controlled by separate mechanisms. While LH secretion during the estrous cycle is regulated by the negative feedback effects of the ovarian steroids, estradiol and progesterone, recent evidence suggests that another ovarian factor, inhibin, secreted by ovarian follicles is largely responsible for regulating the amount of FSH secreted by the anterior pituitary gland.

It was recently reported by Australian researchers that high ovulating Boorola Merino ewes not only had higher plasma FSH concentrations during the follicular phase of the estrous cycle, but had only one-third the ovarian inhibin content of control Merino ewes.

Whether lower inhibin production in high ovulating select line gilts is responsible for the higher FSH concentrations observed during the periovulatory period is presently under investigation. This and other possibilities are being evaluated as part of an ongoing research program designed to gain a clearer understanding of the physiological basis of genetic differences in ovulation rate and the physiological factors which regulate ovulation rate.

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[1]Dwane R. Zimmerman is Professor and Colleen R. Kelly is a graduate student, Department of Animal Science.

Effects of Selection for Litter Size and Age at Puberty On Growth, Feed Efficiency and Carcass Traits

Rodger K. Johnson and Greg Bussler[1]

Increasing litter size would cause fixed production costs to be spread over more market pigs and reduction in age at puberty could allow gilts to be mated at younger ages, reducing the costs of developing replacement gilts. If these changes are made genetically, efficiency of the herd will be improved unless the improvements are offset by undesirable changes in growth and carcass traits.

Few reports of the effects of selection for reproduction on growth and carcass traits are available. At the University of Nebraska, lines are being selected for either increased litter size or decreased age at puberty. After seven generations of selection, an experiment was conducted to evaluate differences between the selected lines and an unselected control line for growth and carcass traits. The results of that experiment are contained in this report.

Population

The Gene Pool population, a 14-breed composite, was formed in the early 1960's and was closed to outside introductions in 1965. From 1967 to 1977, the population contained two lines, one selected for high ovulation rate and the other a randomly-selected control. At the end of nine generations of selection, gilts in the line selected for high ovulation rate ovulated about 3.5 eggs more than gilts in the control line. Litter size was only about .5 pig larger.

From 1977 to 1979 no selection was practiced in either line. In 1979, the high ovulation rate line was randomly divided into three lines. In subsequent generations one line was selected for increased litter size (line LS), one line was selected for decreased age at puberty (line AP) and one line was selected randomly (line RS). The ovulation rate control line (line C) was also maintained with random selection. The RS notation, which represents relaxed selection, denotes a line selected for nine generations for high ovulation rate and then selection was relaxed in subsequent generations. This describes a line with a different selection history than line C, which has been selected randomly since 1967. Lines LS, AP and RS had the same base in 1979, but were selected differently thereafter. Thus, comparisons of lines LS and AP to line RS measure the effects of selection for either increased litter size or decreased age at puberty. Comparison of lines RS and C measures the long-term effects of the previous selection for high ovulation rate.

From the initiation of these populations, in 1979, each line has been maintained with 40 to 45 litters by 15 sires per generation. All litters were from gilts so generation interval was one year.

The barrows from the present experiment were from the seventh generation of selection for litter size and age at puberty. For purposes of this report, generations were counted from 1979, which is designated generation 0, when selection for these traits was initiated.

Table 1. Mean Performance for the Gene Pool Lines.

	Number born/litter			Trait: Age (Age) and weight (WT) at puberty & probed backfat (BF)			
Gen	Line[a]	n	Mean	n	Age	Wt, lb	BF, in[b]
	C	89	8.9	42			.98
0	RS	76	9.5	47	174.1	196	1.10
	LS			41			1.07
	AP			79	174.3	188	1.15
	C	33	9.5				
7	RS	44	10.2	55	173.0	179	1.05
	LS	36	11.0				
	AP	45	9.9	156	153.0	156	1.16

[a]C = control, RS = relaxed selection, LS = litter size, AP = age at puberty.
[b]adjusted for weight.

Table 1 contains average performance for litter size, age and weight at puberty, and probed backfat thickness for the lines in generation 0 and generation 7. During this interval, several evaluations of ovulation rate have been made on gilts from lines RS and C. Differences between these lines have consistently been between 2.5 and 3.0 eggs, a little lower, but similar to what existed when selection for ovulation rate was terminated.

Experimental Procedure

A total of 177 barrows from generation 7 were finished and slaughtered at 220 lb to evaluate the four lines for growth, feed efficiency and carcass traits. At about 57 days of age, 123 barrows were assigned to a modified open-front finishing building and reared in groups of 10 per pen. Each pen contained barrows from each line of similar age. Feeding of these barrows was *ad libitum*. A 16 percent protein corn-soybean meal diet was fed until the barrows weighed 75 lb. They were finished on a 14 percent protein diet.

Barrows were weighed one week after being placed in the building and every 28 days thereafter until they weighed 220 lb. At the time of the last weight, barrows were probed for backfat and slaughtered. Hot weight, length and fat thickness on the midline at the first rib, last rib and last lumbar vertebra were measured on each carcass.

Fifty-four barrows were individually-fed. At about 68 d of age they were moved to an individual feeding unit and fed the same diet as the group-fed barrows. One week later they were weighed on-test. Pig weight, probed backfat thickness and feed consumption were recorded for each barrow at 28-days intervals until they weighed 220 lb. They were then slaughtered and carcass data were collected in the same manner as described for group-fed barrows.

The number of individually-fed barrows ranged from 12 to 15 per line. All had different sires. Every sire of each line had progeny in the set of barrows that were group-fed. There were 115 litters represented in the group-fed barrows.

Results

The regression of Weight on Age was plotted for group-fed (Figure 1) and individually fed (Figure 2) barrows of each line. There were no significant differences among lines in rate of growth. At older ages, group-fed barrows from line RS tended to be heavier than barrows of other lines. For individually fed barrows, both RS- and AP-barrows were heavier than LS- and C-barrows, but on-test weight for AP-barrows was 6 lb heavier than for barrows of other lines. Thus, consistent with group-fed barrows, individually-fed RS-barrows tended to have more rapid growth than barrows from other lines.

Feed efficiency was evaluated using data from the individually-fed pigs. Gain from the beginning of test to each weigh-day was plotted against feed intake for the same period for each line. There were no significant differences among lines in feed efficiency.

Table 2. Average Daily Gain and Feed Efficiency. Ratio for Barrows of Each Line.

Line[a]	Average daily gain, lb/d Ind.	Average daily gain, lb/d Group	Feed Efficiency, f/g Ind.
C	1.58	1.45	3.58
RS	1.69	1.54	3.65
LS	1.61	1.45	3.60
AP	1.67	1.43	3.83

[a]C = control, RS = relaxed selection, LS = litter size and AP = age at puberty.

Test average daily gain and feed efficiency (F/G) were calculated for each pig. Means for each line are in Table 2. Average daily gain, although highest for line RS, did not differ significantly among lines for individually-fed pigs. For group-fed pigs, average daily gain was significantly higher for line RS than for the other lines. The lines did not differ significantly in overall feed efficiency.

The more rapid growth rate for line RS than for other lines is difficult to interpret. Growth rate could be higher in line RS than C because selection for increased ovulation rate may have caused a correlated increase in rate of growth. But lines AP, RS and LS all had the high ovulation rate line as their base, and a correlated increase in growth rate should have also occurred in lines LS and AP. If this did happen, subsequent selection for high litter size and low age at puberty caused a correlated decrease in average daily gain and caused lines LS and AP to have rates of gain similar to that of line C after seven generations of selection. This explanation is biologically plausi-

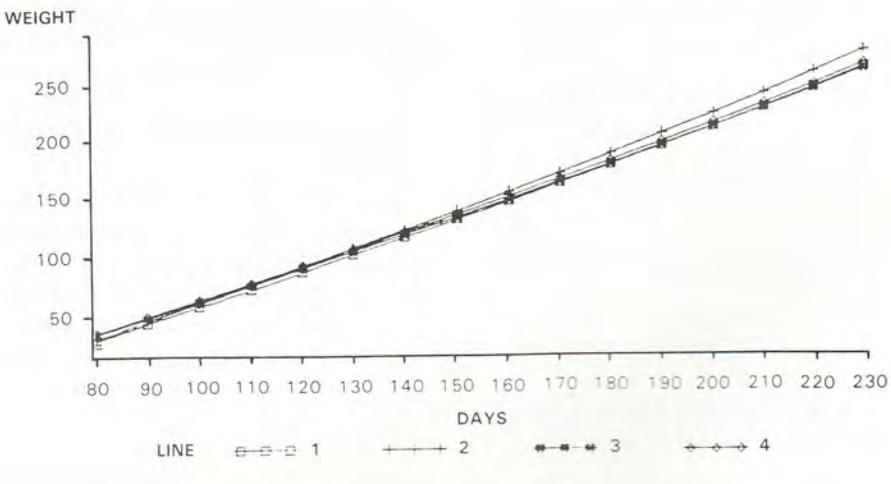

Figure 1. Regressions of weight on age in group-fed pigs.

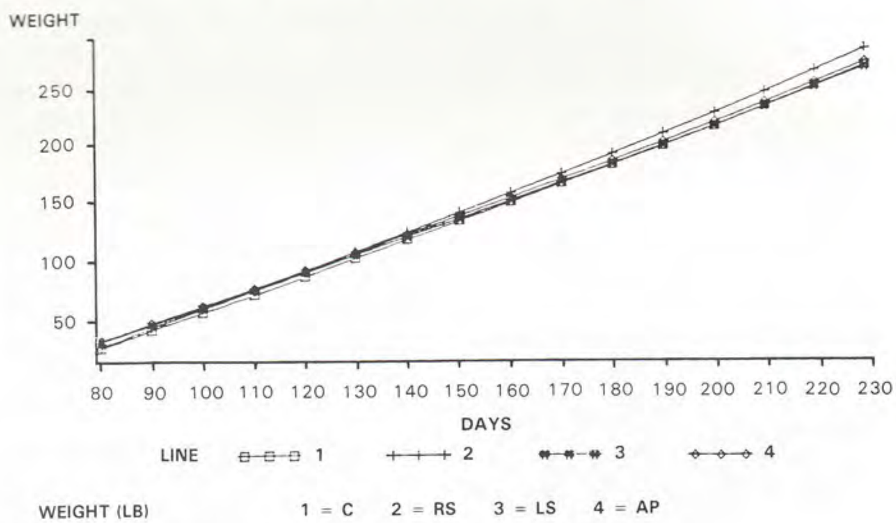

Figure 2. Regressions of weight on age in individually-fed pigs.

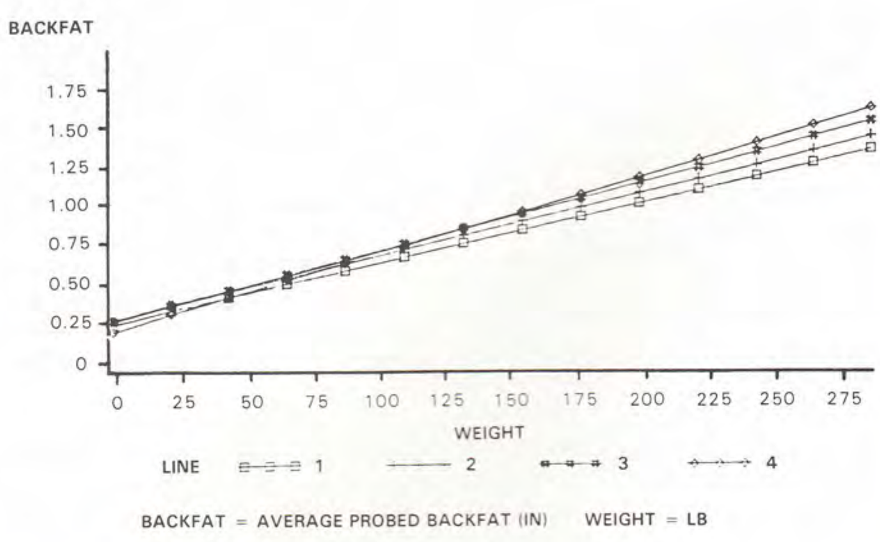

Figure 3. Regressions of backfat on weight in group-fed pigs.

ble. It is also possible that these differences are not genetic line difference and were caused by the relatively small sample size for each line.

Backfat thickness is plotted against weight in Figure 3. Line AP was depositing fat at a faster rate than line RS, while line C and LS did not differ significantly from line RS. The rate of deposition of probed backfat in inches per lb of weight was .019, .020, .022 and .024 for lines C, RS, LS and AP, respectively. The relationship between backfat and age was also investigated and AP-barrows were depositing more fat per day of age than other barrows. Thus, differences between line AP and other lines in probed backfat were increasing as barrows got older and heavier. This result indicates that a correlated increase in probed backfat accompanies response to selection for decreased age at puberty. Selection for litter size did not alter rate of fat deposition.

Means for carcass traits for each line are in Table 3. Carcass weight, adjusted for liveweight at slaughter, did not differ among lines.The selection background of these lines did not affect dressing percentage.

Carcass length was less and backfat thickness greater for line AP than for line RS in both groups of pigs. These differences were significant in group-fed barrows. This indicates that selection for early sexual maturity produced a pig with a shorter, fatter carcass. Selection for litter size did not cause any significant correlated changes in either group of pigs.

All lines that were derived from the high ovulation rate line (lines RS, LS and AP) were fatter than line C. The difference in fat between line RS and C was significant in group-fed barrows. This result is consistent with the difference between lines for probed backfat in generation 0 and indicates that a small increase in backfat occurred from selection for increased ovulation rate.

Selection for decreased age at puberty caused a decrease in carcass length and an increase in rate of fat disposition in this population. No significant correlated responses from selection for litter size were found.

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[1]Rodger K. Johnson is a professor and Greg Bussler is a graduate student, breeding & genetics, Department of Animal Science.

Table 3. Means of carcass traits[a] for barrows of each line.

	Hot weight, lb		Length, in		Ave backfat, in	
Line[b]	Ind	Group	Ind	Group	Ind	Group
C	164	164	31.9	31.8	1.70	1.59*
RS	163	164	32.0	31.9	1.73	1.75
LS	165	165	32.0	32.0	1.78	1.74
AP	165	163	31.4	30.9*	1.76	1.87*

[a]Adjusted for variation in live weight.
[b]C = control, RS = relaxed selection, LS = litter size, AP = age at puberty.
*Line mean is different from mean for line RS (P<.05).

Litter Size as Affected by Chromosomal Abnormalities in Swine Ova

Franklin Eldridge, Julie Farver-Koenig and Dwane Zimmerman[1]

Litter size in pigs is a function of the number of ova ovulated, the number of ova fertilized, and the number of embryos surviving to parturition. Genetic selection over several generations in the University of Nebraska Gene Pool population has resulted in an increase of 3.4 in the average number of ova ovulated. Litter size, however, has been increased only about 0.7 pigs per litter when compared with a contemporary control line. Previous studies have shown that embryo mortality is clearly higher in the line selected for higher ovulation rate. The present study is one more step in the search to identify the factors which prevent the higher ovulation rate from being fully effective in increasing litter size.

Chromosomal abnormalities have been found to be associated with early embryo losses in several species . In humans, for example, over 60 percent of the involuntary abortions occurring in the first trimester of pregnancy have been found to be associated with chromosome abnormalities. In pigs, few studies have been made on chromosomes of early embryos and none have been reported on the chromosomes of the ova.

Experimental Procedures

The University of Nebraska Gene Pool Population was developed from 14 breeds and was divided into two lines. One line (RS) was selected for high ovulation rate for 9 generations and then randomly mated for an additional 6 generations. The other line (C) was maintained as a contemporary control. These lines made an ideal population to study the frequency of chromosomal abnormalities related to the rate of embryo mortality as affected by differences in ovulation rate. For the experiment 29 gilts from the RS line and 33 from the C line were used.

The ova for chromosomal analysis were obtained by flushing the oviducts, which had been surgically removed from each gilt. Collection of ova was approximately 61 hours after onset of standing heat as checked twice daily with an intact boar. The objective was to allow the ovulation process to be as complete as possible, but to obtain the oviduct before the ova had moved into the uterus. The timing of removal of each oviduct allowed collection and treatment of the ova as soon as the oviduct had been received. This minimized the potential for deterioration of ova in the excised oviduct. The entire process from finding the ova to the final fixation of the ova on microscope slides took about 10 minutes.

The microscope slides were stained with Giemsa and were evaluated microscopically at 1000X. Ova with 19 structurally normal meiotic chromosomes were classified as normal. Those with over 19 chromosomes, or with structurally abnormal chromosomes were classified as abnormal, and those with fewer than 19 chromosomes were classified as indeterminate. Ova in which the chromosomes were not clearly defined, indicating that they had not reached the first stage of meiotic division were classified as immature.

Table 1. Ova characteristics.

Description	RS line	C line	Difference
No. of gilts	29	33	
Ovulation rate (av.)	15.7	13.4	2.3
Immature ova (%)	4.0	0.0	4.0
Chromosomal abnormalities (%)	14.3	7.1	7.2
Total (%)	18.3	7.1	11.2
Estimated mortality[a]	2.9	1.1	1.8
Observed mortality[b]	3.2	2.3	0.9

[a]-Immature ova and ova with abnormalities are expected to not survive, even though fertilized. Estimated as follows: — RS (15.7 × .183 = 2.9), C (13.4 × .071 = 1.1).

[b]-Data from Lamberson, W. 1984. Selection for Reproductive Traits in Swine. PhD Thesis, UNL.—RS (15.7 × .204 = 3.2), C (13.4 × .169 = 2.3).

Figure 1. Photomicrograph of a normal (19.×) swine ovum in the metaphase II stage of meiosis.

Results and Discussion

Gilts in the RS line produced 2.3 more ova and had a significantly larger number of immature ova and more chromosomal abnormalities in their ova than the C line (Table 1). The ovulation rate difference between lines was slightly lower than the line differences observed in previous experiments but was still sizable and reflected the success of genetic selection for higher ovulation rate.

The RS line has been shown in previous studies to have an average litter size of about 0.7 more pigs than the C line. The significantly higher frequency of "immature" ova in the RS group may indicate that ova which normally would not be ovulated are being recruited for ovulation. These ova may be in the follicles which were destined to become atretic in control line females.

Embryo death may be caused by a number of factors. In the first few days after ovulation, chromosomal abnormalities may be one of the major reasons for embryo mortality. The results of this experiment indicate that in the RS line there were 4.0 percent immature ova compared to 0.0 percent in the C line. In addition, there were 14.3 percent chromosomal abnormalities in the RS line compared to 7.1 percent in the C line. (Table 1.).

Adding these together, 18.3 percent of the ova were either immature or abnormal in the RS line and 7.1 percent in the C line. The average number of ova ovulated in the RS line was 15.7, and in the C line was 13.4.

In a previous study of these lines the embryo mortality in the RS line was 3.2 pigs and in the C line 2.3 pigs. The estimated embryo mortality caused by ova immaturity and chromosomal abnormalities in this study of 2.9 in the RS line and 1.1 in the C line would be well within reason. These estimates would ac-

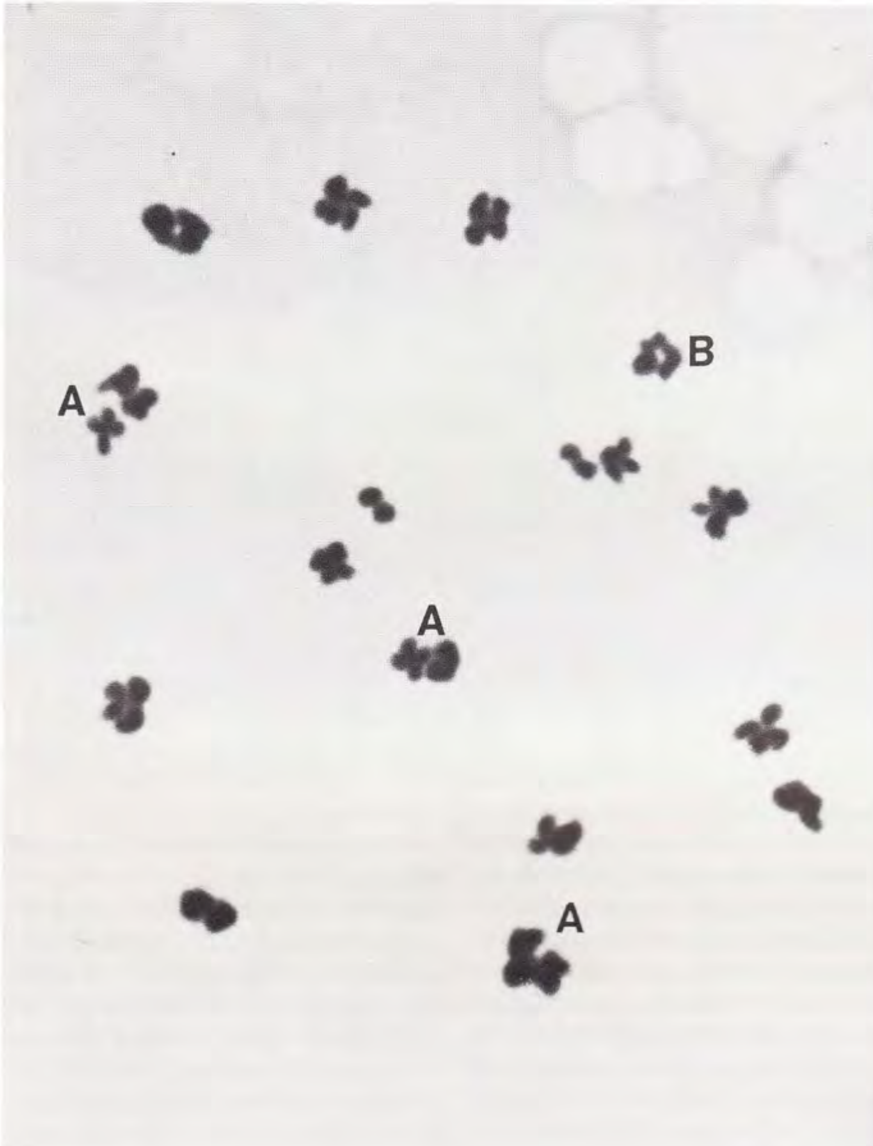

Figure 2. Photomicrograph of an abnormal swine ovum. A total of 20 chromosomes are present. A) Two chromosomes are present in these locations. B) One acrocentric chromosome with one chromatid bent.

count for 91 percent of the mortality in the RS line and 48 percent in the C line in the previous study.

Ovulation rate is recognized to be a quantitatively-inherited trait, influenced by a number of genes. Genetic selection for higher ovulation rate would increase the frequency of the genes which cause more ova to be ovulated, but selection could also be against some genes which normally inhibit the ovulation of some ova. Immature ova, or ova with chromosomal abnormalities, might normally stimulate follicles to become atretic. The results of this experiment support the hypothesis that some of the increase in ovulation rate may have been against those genes which inhibit ovulation of defective ova.

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[1]Franklin Eldridge is Professor Emeritus, Cytogenetics, Julie Farver-Koenig is a former graduate student, and Dwane Zimmerman is Professor, Swine Physiology, Department of Animal Science.

Boar Exposure-When and How Much To Use?

Dwane R. Zimmerman[1]

Use of the boar is an essential component of a successful management program for gilts and sows. Boar exposure is the most powerful stimulus available for induction of early puberty in gilts. The presence of the boar is also necessary for accurate detection of estrus. But, when and how the boar exposure stimulus is applied to females during the prebreeding and breeding periods is important.

Replacement Gilts

It is well established from research conducted at Nebraska and England that gilts provided with once daily or continuous contact (fence line or physical) with sexually mature (at least 10 months old) boars attain puberty earlier than gilts that are isolated from the presence of boars.

The boars exposed to the gilts should be reasonably mature since the amount of pheromone, the stimulatory hormone released externally via the saliva during courting, is known to increase as the boar matures. Age is not the only consideration, however, when selecting the boar for use. Gilts also are stimulated by vocalizations of the boar. Thus, it is desirable to use boars that are good at boar chanting or at "talking to the gilts."

Younger boars being used regularly for breeding are a good choice for fence-line contact with gilts because they are sexually and physically active. They identify readily with estrous females and are usually at the fence providing gilts with olfactory (odor) and auditory (sound) stimuli. Old or obese boars that are physically inactive **should not** be routinely used in fence-line situations. They may be producing abundant pheromones, but will not maintain sufficient contact with the gilts for adequate stimulation. Young, inexperienced boars (6-8 mo), on the other hand, may provide sufficient contact, but may not be producing adequate amounts of pheromone nor adequate boar chanting.

Providing gilts once-daily contact with boars has been demonstrated to be as effective as providing continuous fence-line contact with boars for stimulating onset of puberty in gilts. There seems to be some question, however, regarding the duration of boar exposure needed each day. English researchers have suggested that a 30-minute period of boar exposure is needed each day. Previous Nebraska research obtained a comparable pubertal response to the boar when gilts were provided with either 15 minutes of contact with boars each day or continuous fence-line contact with boars. This suggested, but did not prove, that 15 minutes of daily boar exposure was adequate to obtain the boar stimulatory effect.

To answer this question directly, an experiment was conducted in 1986 to determine whether 30 minutes of daily boar exposure is more effective than 15 minutes of daily boar exposure for stimulating pubertal estrus in gilts. The experiment was conducted in confinement at the Mead Swine Research Unit and involved 160 winter-born gene pool gilts. All gilts were brought to a neutral pen in groups of 7 or 8 where they received direct contact with mature sterilized boars for either 15 or 30 minutes each day starting at approximately 150 days of age. All gilts, regardless of treatment, were observed continuously for the first 10 minutes of boar exposure and signs of estrus recorded for each gilt. All gilts were checked again for signs of estrus at the end of the 15-minute period. Gilts on the 30-minute treatment were observed again for symptoms of estrus just before they were returned to their own pens.

The results of this experiment confirmed our earlier observations. Duration of daily boar exposure failed to influence age at puberty. Gilts attained puberty at 183 and 184 days in response to 15 and 30 minutes of daily boar exposure, respectively.

The timing or age of gilts at boar exposure has an important bearing, however, on the response obtained. Gilts exposed to boars too early during development (before 125 days of age) will be delayed in reaching puberty compared to gilts provided contact with a mature boar between 135 and 160 days of age. While providing contact with mature boars before 160 days stimulates individual gilts to attain puberty at the earliest possible age, withholding boar exposure until after 160 days of age induces a more rapid and more synchronous estrous response (30-90% of gilts in estrus in 3-10 days).

To maximize the estrous synchrony response, relocate gilts outside and provide once daily direct contact or continuous fence-line contact with boars. This treatment should precede the breeding period by three to four weeks to obtain heat grouping at the appropriate time and to insure that replacement gilts have experienced at least one estrous period before they are bred. Gilts **should not** be penned next to boars during the breeding period, however, because it impairs efficiency of heat detection.

Older gilts (175-190 days of age) will normally show a more rapid estrous response to boar exposure than younger gilts (160-175 days of age). However, well-managed, early maturing breeds or breed crosses will respond as readily at 160 days as slower maturing stocks at 190 days of age. When imposed in confinement, the combination of relocation and boar exposure seems to add nothing over boar exposure alone.

Detection of Estrus

The presence of a boar is needed to achieve a high rate of estrous detection. This was established nearly 30 years ago by French scientists who were studying the factors of importance in a successful swine artificial insemination program.

It was determined from the French research that only 50 percent of estrous females would express standing heat (the immobility reflex) in response to back pressure applied by the observer when the boar was not present. Estrous response increased from 50 percent to 75 percent when estrous gilts were played a recording of boar grunting during courting and to 80 percent when estrous gilts were placed in a pen previously occupied by a mature boar. Rate of estrous response increased to 90 percent when both auditory and olfactory stimulation were provided. Another 7 percent of estrous gilts responded when sight of the boar was provided in addition to odor and sound. Three percent of estrous gilts required actual contact with the boar to trigger the immobility reflex. Thus, the boar is a necessary stimulus for obtaining a high rate of estrous detection in pigs.

Detection of estrus is a labor-intensive activity, but is an essential

feature of a successful hand-breeding program. One may devise pen layouts that bring females being checked for breeding into fence-line contact with adult boars. This will facilitate detection of the estrous response in gilts that respond readily to boar stimuli and will allow the remaining time to be used to check the other females in the group.

Contact with boars during the period of heat detection should be novel, or new. Gilts being checked for estrus should not be housed next to boars. Females that receive prior contact with boars are usually slow to respond to the heat check boar and may not be detected until the next day, if at all. Thus, females should be kept isolated from boar stimuli between heat checks to detect estrus rapidly and to attain a high rate of estrous detection in hand breeding programs.

Another question that frequently surfaces in regard to hand breeding concerns how long females need to be exposed to the boar at each heat check to obtain a high rate of estrous detection. This was the second objective of the UNL study described above which evaluated the effect of duration of boar exposure (15 vs 30 minutes/day) on age at puberty in gilts.

Gilts were brought to a neutral heat-check area where they were exposed to a boar for the prescribed period of time. All gilts, regardless of treatment, were observed continuously and any signs of estrus recorded after 10 and 15 minutes of observation. Additional signs of estrus, if any, were recorded for gilts on the 30-minute treatment at the end of the 30-minute observation period.

Pubertal or first estrus was detected by 15 minutes in 98 percent of the gilts exposed to boars for 30 minutes and 100 percent of gilts exposed to boars for 15 minutes daily. However, 6 percent of the 30-minute gilts failed to show estrus within 15 minutes on the first day of pubertal estrus. During the second cycle, estrus was detected in all gilts on each treatment within 15 minutes, but the first day of second estrus could not be detected until after 15 minutes in 3.7 percent of gilts on the 30 minute treatment. Fifteen minutes of boar exposure each day appears adequate to attain a high rate of estrous detection.

Summary

1. Mature, sexually-active boars, either via fence-line contact or direct daily contact with gilts, should be used to stimulate early puberty and to obtain some degree of natural synchrony of first estrus in gilts.
2. Fifteen minutes of daily boar exposure appears adequate to stimulate early puberty in gilts.
3. During the breeding period, gilts should be isolated from boars or boar stimuli between heat checks to facilitate rapid and accurate heat detection.
4. Accurate estrous detection can be achieved with 15 minutes of boar exposure each day.

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[1]Dwane R. Zimmerman is Professor, Department of Animal Science.

Relationship of Different Techniques For Evaluating Mating Behavior in Boars

D.G. Levis, J.J. Ford, and R.K. Christenson[1]

Sexual behavior of the boar has received little attention compared to other phases of the boar's reproductive capacity, such as sperm production. The sexual behavior of the boar influences his fertility and overall reproductive efficiency. Sexual behavior of a mature boar covers a wide range of reproductive activity from complete lack of interest in the female to normal copulation with ejaculation.

Different traits have been employed to assess sexual behavior in boars, including time to copulation, the number of copulations within a designated time, and subjective scores. The following experiment was conducted to: 1) determine the relationship between an initial evaluation method and three subsequent methods, and 2) determine whether a boar's observed sexual behavior with a tethered female or group of females in the presence of humans is representative of his spontaneous sexual behavior when housed with a group of females.

Animals

Initial Evaluation. Forty 10-month-old boars were evaluated for sexual behavior in a 5-minute standardized evaluation procedure. Each boar was placed in the test pen with an estrous-induced ovariectomized gilt tethered in a separate pen within the test pen for a period of one minute before the evaluation. After the familiarization period, the boar was allowed access to the side and rear of the tethered gilt for 5 minutes. The test pen was described in the 1984 Nebraska Swine Report. Boars were evaluated four times, on two consecutive days for two weeks.

Subsequently 18 boars were selected on the basis of classification into high, medium or low levels of sexual behavior. The boars were classified using an index which considered time to first mount, time mounted with penis exposed, time mounted with penis unexposed, time ano-genital sniffing, time nosing side, and elapsed time to copulation. These behavioral characteristics were recorded separately to the nearest one second for each evaluation. The index gave the highest scores to boars with the highest sexual activity.

Evaluation Procedures

After the initial evaluation for sexual behavior, all boars were evaluated by the following three procedures.

Tethered female, 10-min. This method was exactly the same as the one used to initially classify the boars, except the boars had 10 minutes of direct physical contact with the female. The same index was used. Boars were evaluated on two consecutive days.

Female group, 10-min. Two estrus and one non-estrus females were maintained as a group in a 8 ft x 12 ft pen. Boars had 10 minutes of direct physical contact with females. The same sexual behavior traits were recorded as in the evaluation with tethered females, plus the amount of time spent head mounted. Boars were evaluated on two consecutive days.

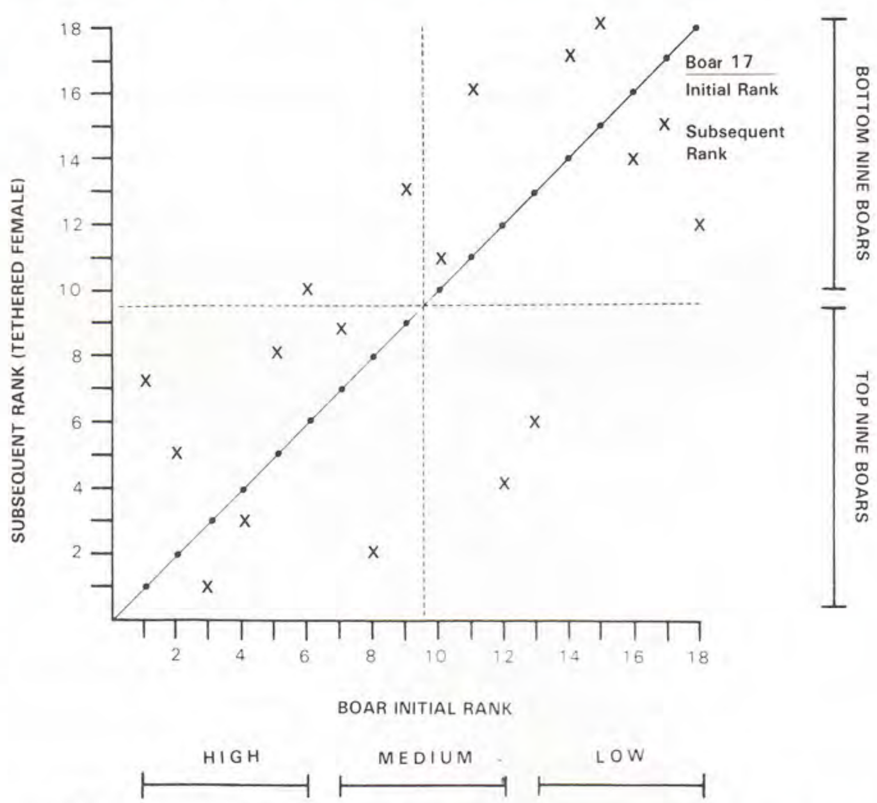

Figure 1. Subsequent rank of boars when evaluated for 10 minutes with a tethered female as related to initial rank for boars 1 through 18. Rank is based on sexual behavior index scores.

Cohabitation. Three pens (8 ft x 12 ft) with three females per pen were established so one boar from each level of sexual behavior classification could be evaluated simultaneously. Two days before entering a pen of females, each boar was individually housed in a 4 ft x 12 ft pen adjacent to the females. A preliminary study indicated that boars previously housed for at least 30 days in a 2′ x 7′ stall, needed an exercise period before being turned into a pen of females.

Boars were only allowed visual and fence-line contact with their respective pen of females. After the exercise period, a 125-hour, unrecorded time block was allowed for establishment of social interactions among the boar and non-estrous females. Sexual behavior was videotaped for 113 continuous hours, beginning 48 hours after two females (ovariectomized gilts) received a single intramuscular injection of 1.5 mg of estradiol benzoate. The 113-hour time block was used to evaluate a boar's sexual behavior when females were coming into estrus, were in estrus, and were going out of estrus. Time mounted was used as the evaluation criteria for the cohabitation ranking.

The order of testing was arranged so that one boar from each of the three classification groups was assigned to each of the six possible test orders.

Results

High Level. Five of six boars (83.3%) initially assigned as having a high level of sexual behavior remained in the top nine (top half) positions when subsequently evaluated with a tethered female for 10 minutes (Figure 1), a group of females for 10 minutes (Figure 2), or a group of females for 113 hours (Figure 3). The boar that did not remain in the top nine did mate twice when evaluated with a tethered female, once when evaluated with a group of females, and five

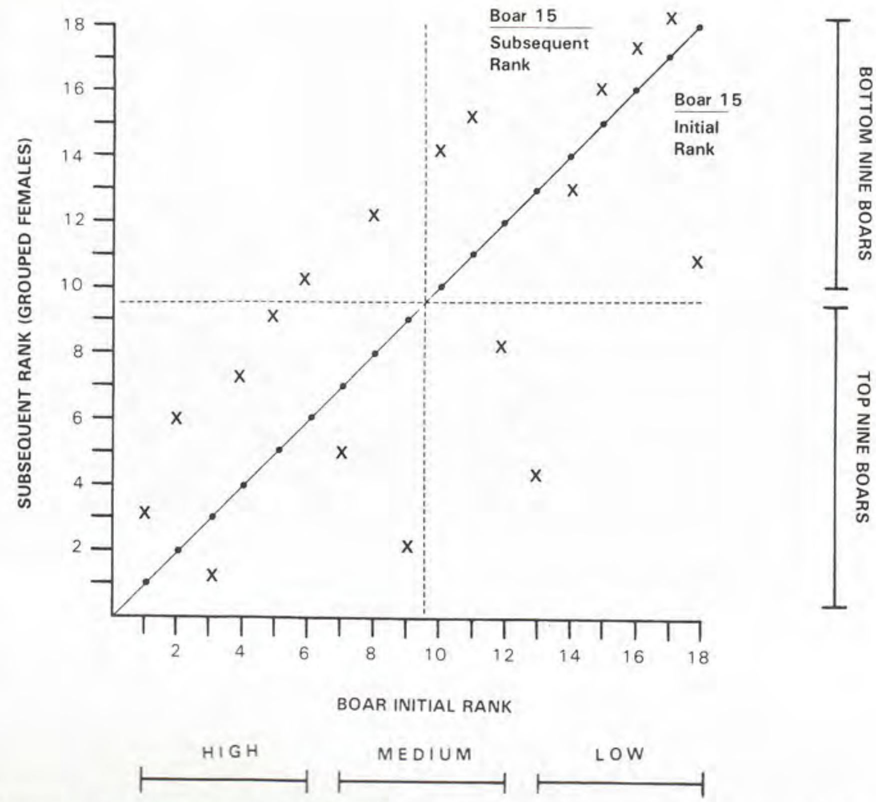

Figure 2. Subsequent rank of boars when evaluated with a group of females as related to initial rank. Rank is based on sexual behavior index scores.

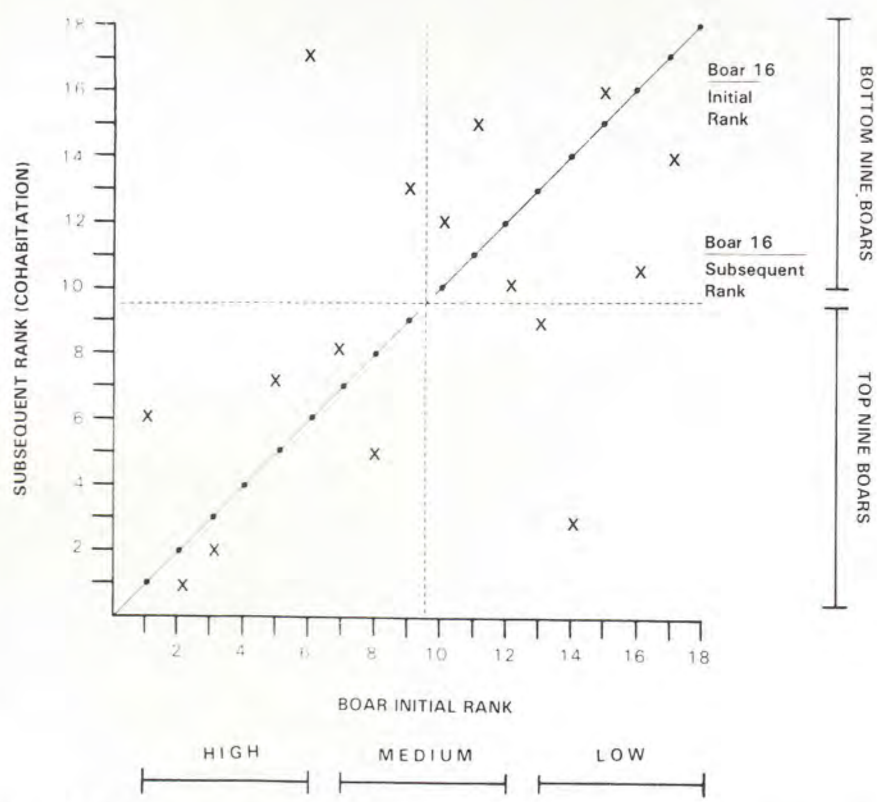

Figure 3. Subsequent rank of boars when evaluated in a cohabitation environment with females as related to initial rank. Cohabitation rank is based on total time mounted.

times when evaluated in a cohabitation environment.

Medium Level. In general, the boars initially ranked in the middle remained in the middle category in all subsequent evaluation methods. All medium level boars did mate twice when evaluated with a tethered female or group of females for 10 minutes; however, only 50 percent (3 of 6) of the boars mated during the cohabitation period.

Low Level. Five of the six boars in the low group of the initial ranking remained in the bottom nine positions when evaluated with a tethered female or group of females for 10 minutes. One low level boar (initial rank of 13th) moved up to the top nine category because he mated twice when evaluated with a tethered female or group of females for 10 minutes. This boar did not mate in the cohabitation environment. Four of the six low-level boars remained in the bottom nine category when evaluated in a cohabitation environment. The two boars that moved into the top nine category showed considerable mounting activity, but failed to mate. This change in rank might be excepted since the initial sexual behavior ranking equation had a weighted component for ability to copulate, whereas, the cohabitation rank is based solely on length of time mounted.

All Levels. The initial evaluation procedure predicted 77.8 percent (7 of 9) of the boars which would remain in the top nine and bottom nine positions in all three subsequent evaluation methods.

Cohabitation Matings. The number of matings per boar and the number of different estrous females mated by each boar during the cohabitation period are shown in Figure 4. It is clearly seen that the initial top nine boars performed the best. While seven of the top nine boars mated at least four times (Figure 4A), only three boars mated both estrous sows (Figure 4B). The absence of a human evaluator did not appear to change the results.

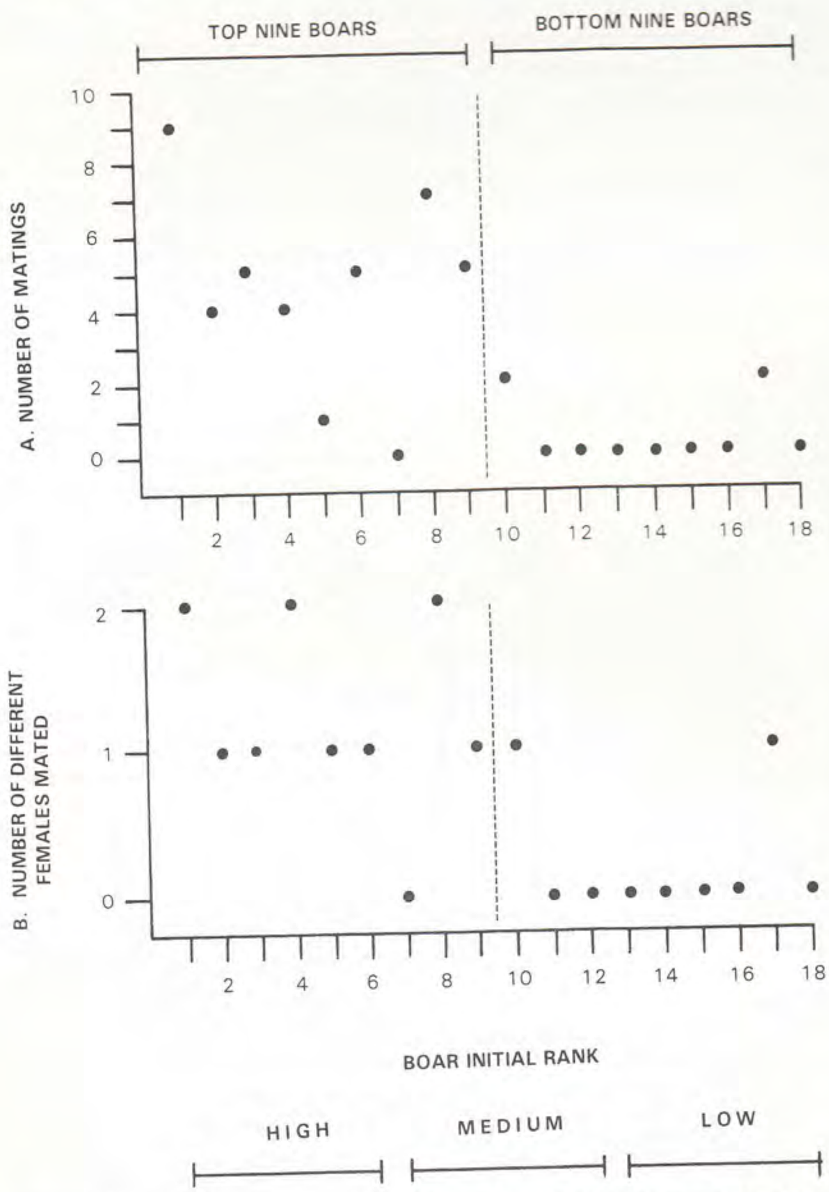

Figure 4. Number of matings per boar and number of different estrous females mated during cohabitation as related to initial rank.

Conclusions

The initial index correctly identified 83.3 percent (5 of 6) of the boars from the high level category which would remain in the top nine positions in the three subsequent evaluation methods. The initial index also correctly identified 83.3 percent (5 of 6) of the boars from the low level category which would remain in the bottom nine positions when subsequently evaluated with a tethered female or group of females for 10 minutes. The initial index was less reliable for predicting which boars would remain in the bottom nine positions during cohabitation, because the initial equation was weighted for ability to copulate; whereas, the cohabitation rank is based solely on length of time mounted.

Overall, 77.8 percent (14 of 18) of the boars were correctly identified as being in the top nine or bottom nine when subsequently evaluated.

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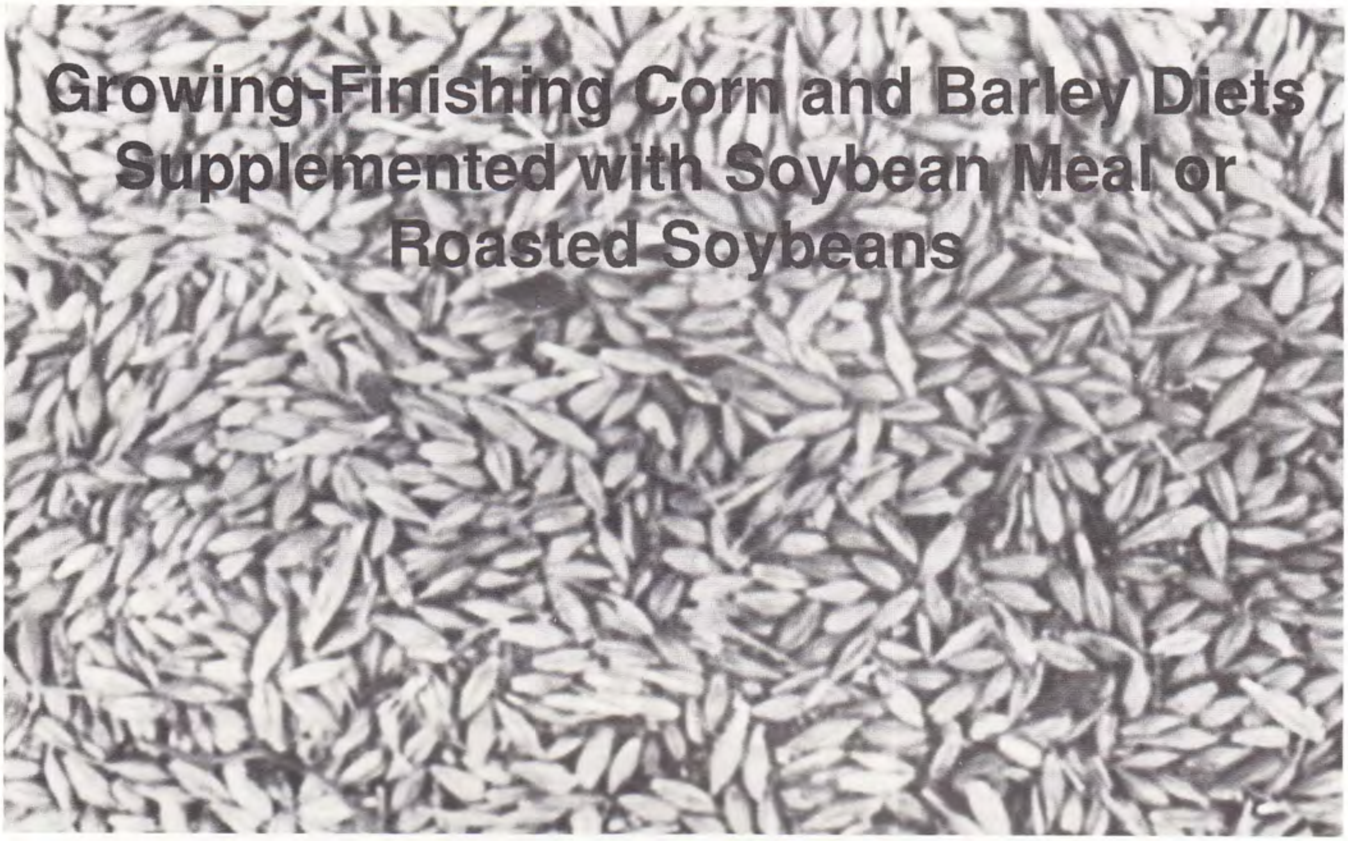
[1]D.G. Levis is a reproductive physiologist, South Central Research and Extension Center, Clay Center. J.J. Ford and R.K. Christenson are research physiologists, U.S. Meat Animal Research Center, Clay Center.

Growing-Finishing Corn and Barley Diets Supplemented with Soybean Meal or Roasted Soybeans



Murray Danielson[1]

Barley has been extensively used in swine diets in many areas of the world. It may be effectively used as a replacement for corn and other cereal grains. When compared to corn, barley supplies 15 to 17 percent less metabolizable energy, 32 percent more protein and 67 percent more lysine. The lower energy level is due primarily to the greater percentage of indigestible fiber in barley. In barley-soybean meal diets, barley provides most of the energy, 55 to 70 percent of the protein, up to 60 percent of the lysine and significant quantities of the minerals and vitamins.

With increased emphasis on alternative cropping systems, barley definitely has a role in pig feeding.

Table 1. Composition of growing-finishing diets.

	Diet							
	1G	2G	3G	4G	1F	2F	3F	4F
Ingredients:	Grower[a]				Finisher			
	%							
Corn	71.25	65.80	--	--	76.90	72.90	--	--
Barley	--	--	75.65	70.95	--	--	81.70	78.60
Soybean meal	22.10	--	17.70	--	--	81.70	78.60	
Roasted soybean	--	17.70	--	16.45	--	11.65	--	
Alfalfa hay	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Dicalcium phosphate	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
Calcium carbonate	.35	.35	.35	.35	.35	.35	.35	.35
Iodized salt	.50	.50	.50	.50	.50	.50	.50	.50
Trace mineral premix[b]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Vitamin premix[c]	.10	.10	.10	.10	.10	.10	.10	.10
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Protein	16.2	16.2	16.1	16.1	14.2	14.2	14.1	14.1
Lysine	.80	.83	.78	.80	.66	.68	.63	.64
Methionine + cystine	.59	.56	.53	.51	.53	.51	.47	.45
Calcium	.79	.77	.77	.78	.75	.76	.76	.77
Phosphorus	.58	.58	.62	.62	.57	.62	.61	.61

[a]CSP-250 provided per lb of diet: 50 mg chlortetracycline, 50 mg sulfathiazole and 25 mg procaine penicillin.

[b]Trace mineral premix provided per lb of diet: Zn, 34 mg; Mn, 14 mg; Fe, 40 mg; Cu, 4 mg; I, .45 mg.

[c]Vitamin premix provided per lb of diet: vitamin A, 1500 IU; Vitamin D_3, 252 IU; riboflavin, 1 mg; niacin, 8 mg; pantothenic acid, 4.5 mg; choline chloride, 100 mg; vitamin B_{12}, 10 mcg; Se, .05 mg.

Improved barley varieties support growth rates comparable to similar diets using other cereal grains. However, because of the lower digestible energy content of barley diets, feed consumption may be higher and feed efficiency may be 5 to 10 percent poorer than with comparable corn-based diets. Additional fat or oil improves the physical characteristics of barley diets resulting in the reduction of dust as well as reducing feed wastage. Roasted soybeans could possibly provide adequate fat to improve these physical characteristics of barley.

The intent of the study reported here was to compare the performance of growing-finishing pigs fed barley and corn in diets supplemented with either soybean meal or roasted soybeans.

Experimental

Four dietary treatments were used in this study (Table 1). Values used for calculating these diets appear in Table 2. All pigs were fed a 16 percent protein grower diet, followed by a 14 percent protein finisher diet from 130 lb live weight to the end of the study. All diets were fed in pellet form.

The 128 crossbred pigs initially averaging 47 lb were used in the study. They were allotted by weight to four replications with eight pigs per experimental pen. The study was started in November. A shelter with an adjoining concrete apron provided adequate space for each pen of pigs. Four barrows and four gilts shared each pen. Diets were fed *ad libitum* with free access to water. Pigs were weighed and feed intake monitored at 14-day intervals. The study was terminated when the animals in each replication weighed near 220 lb. Individual backfat measurements were taken as the study was terminated. Backfat was adjusted to 220 lb using the National Swine Improvement Federation (NSIF) procedure. Live animal performance is shown in Table 3.

Discussion

The average daily gain was fastest for the pigs fed the corn diet supplemented with soybean meal (Diet 1) However, differences in the pig gain among the treatments were not significant. There was a slight reduction in daily feed intake for the corn and barley diets supplemented with roasted soybeans which could be partially responsible for the slight reduction in growth rate of the pigs receiving these diets.

The pigs fed the corn-roasted soybean diet (Diet 2) had the lowest daily feed consumption in this study. With each supplement source, daily feed consumption was greater for the barley diet than for the corn diet. All of the diets supported acceptable feed efficiency. The additional gross energy in the diets supplemented with roasted soybeans improved the feed efficiency of the pigs consuming these diets. The improvement in feed efficiency was less with the barley diet. This is probably due to the higher fiber content of the barley.

The adjusted 220 lb backfat thickness was decreased when barley replaced corn. The increased gross energy (fat) intake by replacing soybean meal with roasted soybeans increased the backfat in each of the corn and barley supplemented diets by .04 inches as shown in Table 3.

Table 2. Values used in calculating diets.

	%				
	Protein	Lysine	Methionine + cystine	Calcium	Phosphorus
Corn	8.5	.24	.38	.02	.14
Barley	10.5	.35	.36	.05	.20
Alfalfa hay	15.0	.80	.37	1.20	.24
Soybean meal	44.0	2.80	1.40	.25	.33
Dicalcium phosphate	--	--	--	24.00	18.50
Limestone	--	--	--	38.00	--

Table 3. Pig response when fed corn and barley diets supplemented with soybean meal or roasted soybeans.

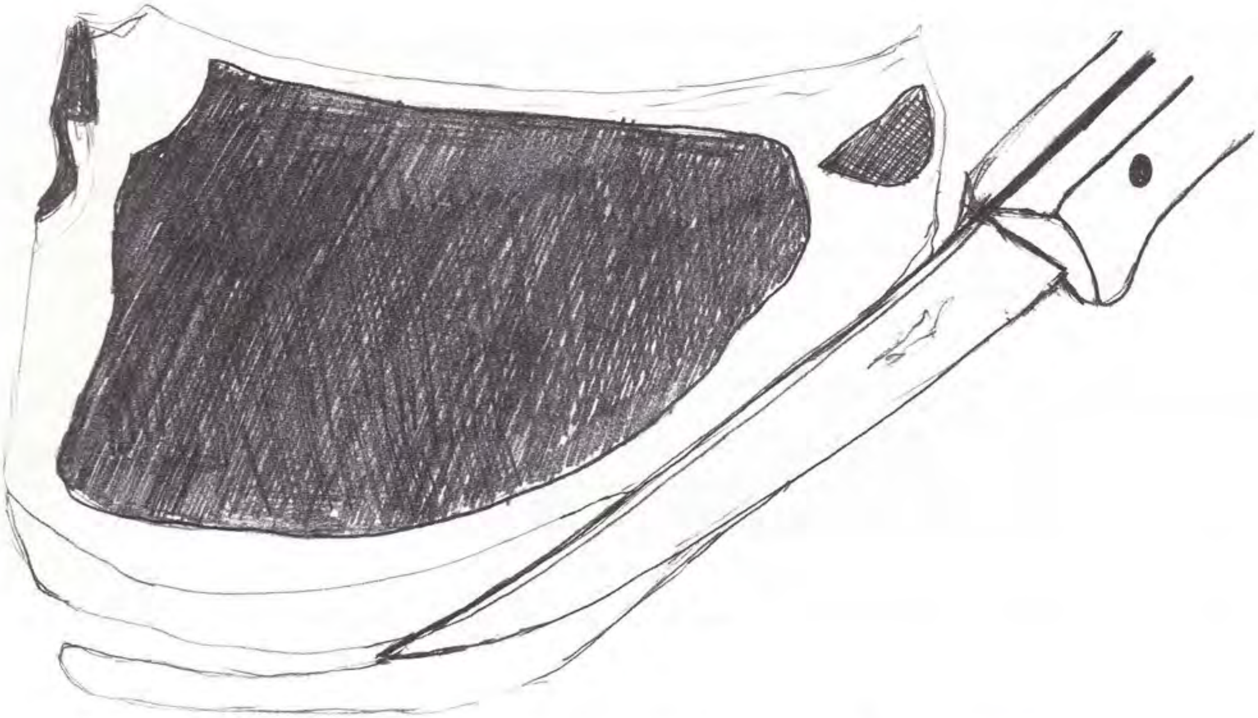
	Diet			
Item:	1	2	3	4
No of pigs	32	32	32	32
Pigs/pen	8	8	8	8
Initial wt, lb	47.5	47.7	47.6	48.1
Final wt, lb	222.1	218.4	221.5	221.8
Avg daily gain, lb	2.0	1.95	1.99	1.98
Avg daily feed, lb	5.96	5.45	6.05	5.75
Feed/Gain	2.99	2.79	3.04	2.90
Backfat, in, adj 220 lb	.86	.90	.76	.80

Summary

The performance of the pigs in this study showed little reduction in average daily gain when replacing barley for corn regardless whether supplementation was soybean meal or roasted soybeans. Roasted soybean supplementation reduced daily feed intake while barley increased daily intake. Feed efficiency was improved by supplementation with roasted soybeans.

Backfat thickness of the pigs fed the barley diets was reduced regardless of supplementation. When roasted soybeans replaced soybean meal in either the corn or barley diets backfat was increased. From the results of this growing-finishing study barley appears to be very competitive with corn when supplemented with either soybean meal or roasted soybeans.

[1]Murray Danielson is Professor of Animal Science, West Central Research Extension Center, North Platte, NE.



Effect of Trim, Chop Type and Cooking Method on Fat, Caloric and Cholesterol Content of Pork

J. B. Morgan, C. R. Calkins and R. W. Mandigo[1]

Consumers have changed their eating habits tremendously during the last two decades. Growing concern about cholesterol, source and amount of daily fat intake and caloric content have been cited as factors. Recent publicity about the composition of pork and pork products has been based on U.S.D.A. experiments using pork which was trimmed of subcutaneous fat after cooking. More frequently, separable fat is trimmed from pork retail cuts before cooking, thereby preventing any opportunity for fats melted by cooking temperatures to migrate into the lean. The purpose of this experiment was to more precisely estimate actual fat percentage, caloric and cholesterol content within pork trimmed before or after cookery by several household methods.

Materials and Methods

Seven pork carcasses were selected and five blade steaks, rib chops and top-loin chops were obtained from each and trimmed of all external fat. A second set of cuts, anatomically paired, were removed from the opposite side of each carcass and trimmed to 0.5 in. of subcutaneous fat. Paired cuts were assigned to one of four common household cooking methods: (1) braising - meat was browned for 3 min. in 3 tbsp. water in a preheated (350°F), oven-safe pan, covered and placed in a preheated (325°F) oven; (2) pan-frying -meat was fried in 1 tbsp. hydrogenated cooking oil in a preheated (375°F) pan; (3) roasting - meat was placed on an elevated roasting rack and cooked in a preheated (354°F)oven; (4) microwaving - meat was placed on a rack within a microwavable-safe container and covered. The fifth pair of cuts was retained for raw analysis. All meat samples were cooked to an internal temperature of 161° F. Cooked weight, cooking time, drip loss and fat loss were recorded during each cooking process. After cooking, all samples were dissected into knife-separable lean, bone and fat. Moisture, fat and protein were determined on the knife-separable lean component. Retention of fat within the knife-separable lean was calculated for all retail cuts. Cholesterol content of top-loin chop, knife-separable lean of both trim levels was quantitated.

Results and Discussion

Knife-separable lean from top-loin chops cooked with 0.5 in. subcutaneous fat trim contained greater percentages of extractable fat and more calories than chops cooked without subcutaneous fat, regardless of cooking method (Tables 1, 2). These data suggest that fat melted during cooking can migrate into the lean. Microwaved and roasted top-loin chops exhibited the

Table 1. Grams of fat in 3 ounces of cooked, knife-separable, pork lean as affected by cooking method and trim level.

	Top-loin chop			Rib chop			Blade steak		
	0.0[a]	0.5[b]	Percent difference	0.0	0.5	Percent difference	0.0	0.5	Percent difference
Braise	3.99	5.33	22.4	6.01	5.73	−4.9	9.47	9.57	1.1
Pan-Fry	4.34	5.77	24.8	5.38	6.91	22.2	8.88	10.66	16.7
Roast	3.79	5.11	34.9	6.17	8.00	29.7	10.24	9.91	−3.3
Microwave	4.49	6.80	34.0	5.60	6.49	13.7	9.25	8.68	−6.5

a = 0.0 in. subcutaneous fat trim prior to cooking.
b = 0.5 in. subcutaneous fat trim prior to cooking.

Table 2. Caloric content in 3 ounces of cooked, knife-separable, pork lean as affected by cooking method and trim level.

	Top loin chop			Rib chop			Blade steak		
	0.0[a]	0.5[b]	Percent difference	0.0	0.5	Percent difference	0.0	0.5	Percent difference
Braise	150.97	153.87	1.9	164.61	161.99	−1.6	181.08	185.04	2.1
Pan-Fry	156.37	170.01	8.0	161.66	171.27	5.6	180.90	205.33	11.9
Roast	137.89	150.93	8.6	163.90	176.48	7.1	188.60	186.20	−1.3
Microwave	172.13	185.64	7.3	168.35	177.60	5.2	189.99	182.19	−4.3

a = 0.0 in. subcutaneous fat trim prior to cooking.
b = 0.5 in. subcutaneous fat trim prior to cooking.

largest percentage difference in fat (Table 1), perhaps because of extremely high evaporative and drip losses generated during the cooking cycle. Rib chops displayed smaller, mostly non-significant differences in fat and caloric content of cooked lean. Very few significant differences in fat or caloric content were noted among blade steaks differing in external fat trim. The presence of seam fat and small fat deposits in the tail area of the rib chop and the abundance of seam fat within blade steaks probably masked any treatment effects. Results using the braising method of cooking indicated essentially no difference between trim level in caloric content for all retail cuts (Table 2). This may be due to moist heat cookery, which minimized both drip and evaporative losses and eliminated effects of trim level.

No differences in cholesterol content were observed between top-loin chops differing in external fat trim within cooking method (Table 3). This chop type was selected because it showed the greatest influence by trim level. Braised and microwaved chops displayed slightly higher values than roasting and pan-frying methods. These results suggest that cooking method may have a greater impact on cholesterol content of cooked pork than fat trim level before cooking.

Cooking promotes loss of water from meat. Fat and protein are lost, generally to a lesser extent. Nutrient retention indicates the decrease or increase in amount of nutrients retained within meat during cooking. Level of trim affected total nutrient retention of fat in pork lean (Table 4), as calculated by USDA procedures. Almost every retail cut containing 0.5 in. of fat trim before cooking exhibited a greater fat retention value than the 0.0 in. fat trim counterparts for all cooking treatments. This is likely a reflection of fat migrating into the lean during cook-

Table 3. Cholesterol Content (mg) of 3 ounces of cooked pork top-loin chop, knife separable, lean as affected by cooking method and trim level.

	Top loin chop		
	0.0[a]	0.5[b]	Percent difference
Braise	72.06	73.59	2.1
Pan-fry	69.26	69.52	0.4
Roast	68.08	67.70	−0.6
Microwave	73.76	77.53	4.9

a = 0.0 in subcutaneous fat prior to cooking.
b = 0.5 in. subcutaneous fat prior to cooking.

ing. Microwaving displayed the largest percentage difference between top-loin chops, possibly due to extreme moisture loss during the cooking process. Rib chops displayed the highest percentage fat retention values compared to other cut types. This can be explained by fat migrating into the lean from both the tail region of the chop as well as any external fat trim. Blade steaks responded similar to other cut types with the exception of microwaving. This could be a result of the short cooking period required for microwaved, blade steaks which generated the loss of moisture from the lean while seam fat was undercooked.

Conclusions

This study indicates eliminating subcutaneous fat trim before cooking reduces the amount of fat in the lean, which would decrease total calories consumed. There is no difference in cholesterol content of cooked lean between cuts containing different external fat trim levels before cooking. The cooking method used to prepare pork retail cuts appears to influence cholesterol retention. Previous fat and calorie information associated with pork retail products may be overstating actual nutrient consumption for those consumers who trim subcutaneous fat before cooking.

[1]J. B. Morgan is a graduate assistant, C. R. Calkins is an Associate Professor, and R. W. Mandigo is a Professor, Dept. of Animal Science.

Table 4. Total percent retention of fat in knife-separable, pork lean as affected by cooking method and trim level[a].

	Top loin chop			Rib chop			Blade steak		
	0.0[b]	0.5[c]	Percent difference	0.0	0.5	Percent difference	0.0	0.5	Percent difference
Braise	116.65	157.47	25.9	182.61	193.19	5.5	128.90	159.58	19.2
Pan-fry	120.21	166.98	28.0	156.04	215.88	27.7	113.31	152.67	25.6
Roast	109.85	147.31	25.4	194.11	282.29	31.2	135.33	167.95	19.4
Microwave	100.09	178.93	44.1	139.28	188.89	26.3	99.55	119.26	16.5

[a]=Retention values were calculated using raw sample=100%.
[b]=0.0 in. subcutaneous fat trim prior to cooking.
[c]=0.5 in. subcutaneous fat trim prior to cooking.

Dietary Protein and Farrowing Constipation

Edd Clemens[1]

Pork producers recognize that periods of abrupt nutritional alterations and environmental stress may be associated with various digestive disorders. These non-infectious disorders are often manifested as constipation, diarrhea, gas or bloody stools. Producers also note that farrowing constipation is a particularly frustrating disorder. Its unpredictable occurrence is accompanied by decreased milk production and extensive loss of piglets.

The cause of farrowing constipation is unknown. However, if we accept the fact that the disorder is non-infectious, and review the management events associated with the disorder, we quickly note that two primary changes occur in the handling of the animal. The first is quite often an environmental change; that is the confinement of the sow, or gilt, to the farrowing unit. And, the second is nutritional; changing from the gestation diet to the lactation diet. The diet change usually involves marked increases in dietary energy and dietary protein intake. The question that one might ask is; are these efforts to enhance lactation and production by nutritional means a predisposing cause of farrowing constipation?

Recent studies have shown that changing the level of dietary protein markedly alters the structure of the large bowel in pigs. These structural alterations are associated with significant changes in the ability of the large bowel to absorb and secrete fluids and electrolytes. Since the gut contents, particularly the electrolytes (sodium, chloride, bicarbonates and fatty acids) are the driving force for intestinal water movement, it is easy to imagine how a slight modification in diet can adversely affect bowel movements. A similar effect has been found with dietary protein. When the protein content of the diet was increased, both the structure and the functional abilities of the pigs large intestine were altered.

The large intestine of pigs, as well as most mammals, allows for the fine adjustment of fluids and electrolyte maintenance within the system. This controls the consistency of the stool. Furthermore, we know the large bowel is sensitive to the level of dietary protein. That is, it becomes a protein sink, storing protein during periods of abundance and releasing them during shortages. As a result, the size of the bowel will increase with the addition of dietary protein. This is evident from the data presented in Table 1, and from the light micrographs in Figure 1 showing the obvious structural differences. As the level of dietary protein was increased the intestinal mass (or volume) increased, significantly lowering the surface area-to-volume ratio.

Table 1: Surface area-to-tissue volume ratio of the proximal and distal segment of the swine large intestince, when fed a 12% or a 20% crude protein diet.

Segment of Large Intestine	Surface-area-to-volume ratio: 12% Protein	20% Protein	Average Over Protein Levels
Proximal	508	314	308
Distal	755	367	549
Average of Segments	630	341	

As the volume of tissue changes, one would expect the movement of nutrients from the gut through the intestinal wall to be altered. Such is the case, as is seen in Table 2. Statistically significant differences between protein levels were found for the movement of sodium, bicarbonate and acetate ions.

While the difference in volume of fluid absorption between the two diets (approximately 2 milliliters per hour) appears to be small, the data represents only an 8-inch segment of intestine. When considering the entire large bowel, this would represent an approximate 20-fold increase in absorptive volume, which is further coupled with the 24-hour day. Thus, permitting for a considerable difference in the volume of fluid movement between the two diets.

Comparative studies in dogs have shown that the nutritional adaptation period for the large bowel when changing diets is seven to ten days. During the transition period both the structural component and the functional abilities of the large intestine are undergoing readaptation. If we consider present practices of feeding 4 lb. per day of a 12% protein diet during gestation, and the abrupt change to full feed of a 16% protein diet in the farrowing house, we may well expect the large bowel to become impacted. A gradual transition from the gestation diet to lactation diet should reduce the occurrence of farrowing constipation.

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[1]Edd Clemens, Professor, Department of Animal Science, University of Nebraska–Lincoln.

Table 2: Net electrolyte flux within the proximal and distal segment of the swine large intestine, when fed a 12% or a 20% crude protein diet.

Determinant	Net Intestinal Flux (mM/hr) — According to dietary protein content: 12%	20%	Difference	According to segment of Intestine: Proximal	Distal	Difference
Volatile fatty acid	1.4 + 0.1	1.7 + 0.1	NS	1.8 + 0.0	1.2 + 0.1	P < 0.01
Sodium	1.2 + 0.2	−0.9 + 0.4	P < 0.001	0.1 + 0.4	0.0 + 0.5	NS
Chloride	−0.1 + 0.0	−0.2 + 0.1	NS	−0.2 + 0.0	−0.2 + 0.0	NS
Bicarbonate	0.8 + 0.2	−0.1 + 0.1	P < 0.001	0.3 + 0.2	0.4 + 0.1	NS
Acetate	0.8 + 0.1	1.0 + 0.1	P < 0.02	1.1 + 0.1	0.6 + 0.0	P < 0.004
Propionate	0.4 + 0.0	0.2 + 0.0	NS	0.4 + 0.1	0.3 + 0.0	P < 0.07
Butyrate	0.2 + 0.0	0.2 + 0.0	NS	0.2 + 0.0	0.2 + 0.0	NS
Water	31 + 2	29 + 5	NS	34 + 6	26 + 3	NS

Water flux is expressed in milliliters per hour.
Data are expressed as the mean + SEM. NS = not significant (ie, P > 0.05).

Figure 1. Scanning electron micrographs of the cecum of pigs fed 12% versus 20% crude protein diets.

Cooler Nights For Weaned Pigs?

Michael C. Brumm and David P. Shelton[1]

A nursery for weaned pigs is one of the most heating-intensive buildings in a pork production system. Current recommendations call for air temperatures of 85° F at pig level at weaning, with temperature reductions of 3-4° F per week to a minimum of 70° F at 8 weeks of age.

Temperature reductions or thermostat set-backs during nighttime hours are used extensively to reduce residential heating costs. Under the right conditions, this practice could be used in pig nurseries without harming health or performance, reducing nursery pig production costs.

To explore this possibility, two experiments using a total of 896 pigs weaned at three to four weeks of age were conducted. Seven winter trials were conducted during a five year period.

The facility used was a two-room nursery at the Northeast Research and Extension Center at Concord. Each nursery room had comparable ventilation, heating, and manure handling systems. The two rooms were alternated between control and reduced temperature treatments from trial to trial. Sixty-four newly weaned pigs were used in each of the two treatments in each trial. Pigs were housed 8 per pen in 4 ft x 4 ft pens with open mesh partitions, 100 percent woven wire flooring, a 5-hole self-feeder and one nipple drinker.

All pigs were fed a commercial pelleted diet containing 18% crude protein, 1.15% lysine, 1515 kcal ME/lb and FOA-390 as the growth promoting feed additive.

In the first experiment, pigs were housed in one of two temperature treatments. Similar to current recommendations, the furnace thermostat in the room with the control treatment was set to maintain a temperature of 86° F during the first week post-weaning. Room temperatures were then decreased 3.6 F° per week. In the room with reduced nighttime temperatures (RNT), the thermostat was set to the same temperature as the control treatment during the day. During nighttime hours (7 PM to 7 AM) of the first week, thermostat settings were reduced to 77° F for the first three nights, then to 68° F for the next four nights. Nighttime temperature settings were then further reduced by 1.8 F° per week for the duration of each trial. Dual thermostats, controlled by a timeclock, were used. Three trials of this experiment were conducted.

In the second experiment, the control temperature treatment was the same as experiment 1. However, a modified reduced nighttime temperature scheme (MRNT) was investigated. During the first week post-weaning and during daytime hours for the remainder of each trial, the MRNT room was maintained the same as the control room. Starting with the second week in each trial, during nighttime hours (7 PM to 7 AM), thermostat settings were reduced approximately 10 F° from the daytime or recommended temperature. In this experiment, pigs were grown to market weight in partially slatted confinement facilities to evaluate any possible carry-over effects the nursery treatments might have had on growing finishing performance. Four trials of this experiment were conducted.

Results

Figure 1 is a plot of the hourly temperatures by week at pig height averaged across all trials of each experiment. While a definite daily temperature fluctuation was achieved for both the RNT and MRNT treatments, the rate of cooldown was dependent on outside air temperature, pig size and building mass. As the pigs grew, nighttime target temperatures were generally not reached until the early morning hours, if at all. The pigs were exposed to the coolest air temperatures for only a relatively short time period.

There was an improvement in overall average daily gain and average daily feed intake for RNT pigs compared to the control pigs in experiment 1 (Table 1). Since there was no difference in feed conversion between the two temperature regimes, the improved

Table 1: Summary of pig performance and utility use for Experiment 1—Three Trials.

Item	Control Temperature	Reduced Nighttime Temperature
No. of Pigs, initial	192	192
Weight, lb		
Initial	14.1	14.0
Final	39.5	41.0
ADG, lb	.73	.78
ADF, lb	1.12	1.21
F/G	1.55	1.58
Dead and Removed, no	1 (.5%)	5 (2.6%)
Utility cost[a]	$292.10	$273.37

[a]Propane = $.70/gal, Elec. = $.05/kwh.

gain for the RNT treatment is probably a reflection of the increased feed intake.

Utility (propane and electricity) savings were $0.62 per pig for the RNT treatment. However, much of the savings were offset by greater mortality.

In experiment 2, where the nighttime temperatures were not reduced until one week after weaning, MRNT pigs had increased gain and feed intake compared to the control pigs (Table 2). As in the first experiment, there was no difference in feed conversion between the two temperature treatments.

Utility savings for this experiment amounted to $0.30 per pig weaned in the reduced nighttime temperature treatment. However, in this experiment, there was little difference in death loss. The lack of differences in mortality between treatments in experiment 2 may be related to the need of the weaned pig for a constant warm air temperature until feed intake is sufficient to provide enough energy for both heat production and basic metabolism.

While piling and huddling were evident for both RNT and MRNT pigs, no particular health problems were noted. The time spent managing the rooms was similar for both treatments.

The lack of an effect due to nursery temperature treatment on subsequent grower-finisher performance in experiment 2 (Table 2) demonstrates that no detrimental carry-over effect was observed.

Lowering nighttime room air temperatures in pig nurseries offers the potential to reduce energy costs while positively influencing weaned pig performance. Except for the mechanics and equipment needed for the temperature changes, no special or extra management inputs need to be employed for this technique.

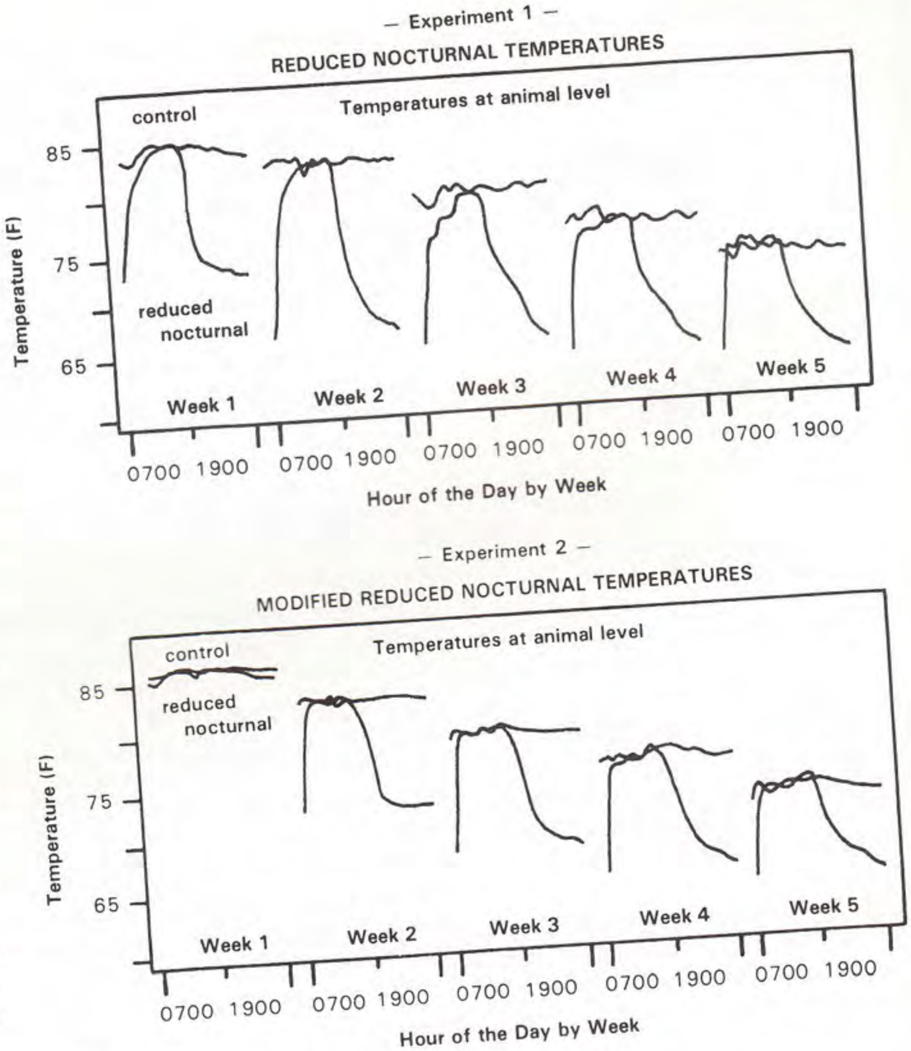

Figure 1. Temperatures in pig zone.

Table 2. Summary of pig performance and utility use for Experiment 2—Four Trials.

	Control Temperature	Modified Reduced Nighttime Temperature
No. of pigs, initial	256	256
Nursery performance		
Weight, lb		
Initial	14.7	14.7
Final	39.4	40.5
ADG, lb	.75	.79
ADF, lb	1.17	1.25
F/G	1.57	1.61
Dead and Removed, no	9 (3.5%)	6 (2.3%)
Utility cost[a]	$492.27	$415.72
Grower-Finish Performance		
ADG	1.52	1.52
ADF	4.91	4.88
F/G	3.23	3.23

[a]Propane = $.70/gal, Elec = $.05/kwh.

Recommendations

Producers considering the use of reduced nighttime temperatures in nurseries are urged to observe four precautions:

1) Good nursery facilities are required. The desired sleeping area should be draft-free. Adequate moisture control is

needed.

2) Do not reduce nighttime temperatures until the newly weaned pigs are all eating aggressively.
3) Turn down the furnace thermostat no more than 10° F from the recommended daytime setting.
4) Observe pigs carefully. At any sign of ill health or reduced performance, return to the recommended constant warm temperature.

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[1]Michael C. Brumm, Associate Professor and David P. Shelton, Associate Professor, Northeast Research & Extension Center, Concord, NE.

Choosing Economic Levels Of Protein for Pigs

Larry L. Bitney and Duane E. Reese[1]

Should the protein level in swine diets be adjusted if corn and protein supplement prices change? What are the critical price levels for considering a change? What affect will a change in diet protein level have on the quality of your hogs? The objective of this article is to give pork producers guidelines for answering these questions, and for selecting protein levels for their swine diets.

Performance Data

The results of studies on the effect of different levels of protein in the diet of growing-finishing pigs on average daily gain and feed conversion were reviewed. Data from recent feeding experiments were combined with those used in an earlier study. (See Neb. Swine Rpt. EC74-219, page 3-4). Two weight ranges were established for this study, 40 to 110 pounds and 110 to 220 pounds. Weighted averages of performance data from experiments are summarized in Table 1.

Economic Analysis

Break even charts were developed, using data from Table 1. These charts, which are presented in Figure 1, show the most economical diet protein level, given a set of corn and soybean meal prices. One chart is for 40-110 pound pigs, and one is for 110-220 pound pigs.

An example of how to use Figure 1 is shown below:

Pigs are in the 40-110 pound weight range

The on-farm price of corn is $1.75 per bushel

The on-farm price of soybean meal is $150 per ton

A dotted line is drawn across the chart at a corn price of $1.75, until it meets the vertical line on the chart indicating a soybean meal price of $150. (Point "a") This point lies in area of the chart which is labeled "16%", indicating that a 16% protein diet is most economical in this situation.

Individual producers can follow this process, using their corn and soybean meal prices to determine the most economical diet protein level for their hogs. Producers using milo instead of corn can use the charts by converting the price of milo to a bushel basis. Also, producers are advised to choose their preferred type of soybean meal (44% or dehulled) and proceed to use the charts.

It should be noted that gilts intended for later use in a breeding herd should be fed at least a 14% protein diet. Feeding protein levels below 14 percent may affect their subsequent performance in the breeding herd.

Since it may require some effort to switch protein levels in a given swine diet, a producer may want to explore the sensitivity of the protein level to price changes. Using the above example, if soybean meal remains at $150/ton, how much could the corn price change before a producer would change diets? The line which indicates $150/ton soybean meal crosses the break even line between the 14 percent and 16 percent diets (point "b") at a corn price of approximately $1.35/Bu., and the break even line between the 16 percent and 18 percent diets (Point "c") at a corn price of approximately $3.75/Bu. Thus, a producer who has a soybean meal price of $150/ton locked in would continue to feed the 16% diet as long as the corn price remained within the range of $1.35 to $3.75

Table 1. Average daily gain and feed per pound as affected by weight of pig and protein level of diet.[a]

Weight Range lb.	Protein Level in Diet	Avg. Daily Gain, lb.	Feed/Gain
40 - 110	12	1.27	3.16
	14	1.40	2.60
	16	1.49	2.50
	18	1.51	2.50
110 - 220	12	1.52	3.78
	14	1.66	3.42
	16	1.67	3.25

[a]Weighted averages from over 20 experiments

per bushel. A similar method could be used to establish a price range for soybean meal, if the corn price were constant.

If a producer's corn and soybean meal prices fall on the break even line, such as point "b", the following actions might be considered:

1) Consider feeding the higher protein diet (16% in this example) while the pigs are small, and start feeding the lower protein diet when they reach the upper part of the weight range;

2) Consider feeding a ration with a protein level which is in between the two (15% in this example since point "b" is on the break even line between the 16% and 14% diets).

Effect of Non-feed Costs

Feed per pound of gain and average daily gain are the two primary factors influencing the choice of a diet protein level, from a cost standpoint. The effect of a reduction in feed per pound of gain is realized directly. If it takes less total feed to achieve a given weight gain on an animal, a producer can afford to pay more per pound for the diet.

The effect of an increase in average daily gain is realized indirectly, through a reduction in non-feed costs. If a higher protein diet results in an animal taking fewer days to achieve a given amount of gain, some non-feed costs are reduced. The amount of reduction depends on an individual producer's situation.

The question is—which non-feed costs are decreased if a group of pigs takes a week less to reach market weight? The cost of utilities, feed processing, repairs due to use, labor, and interest on operating costs will decrease. These costs were assumed to be 6.8 cents/day in developing the charts in Figure 1.

But what about other cost items? While there may be agreement that veterinary and medicine, marketing, and death loss costs will most likely not decrease if it takes a few days less to finish a group of pigs, other items may be debatable. What about building and equipment costs? In the short run, buildings and equipment are probably more of a physical limitation. A producer who has another group of hogs waiting for a finishing pen may not be able to switch to a lower protein, slower gaining diet, even if it would be more economical. It is unlikely that the cost savings from switching protein levels would outweigh the reduction in income from selling

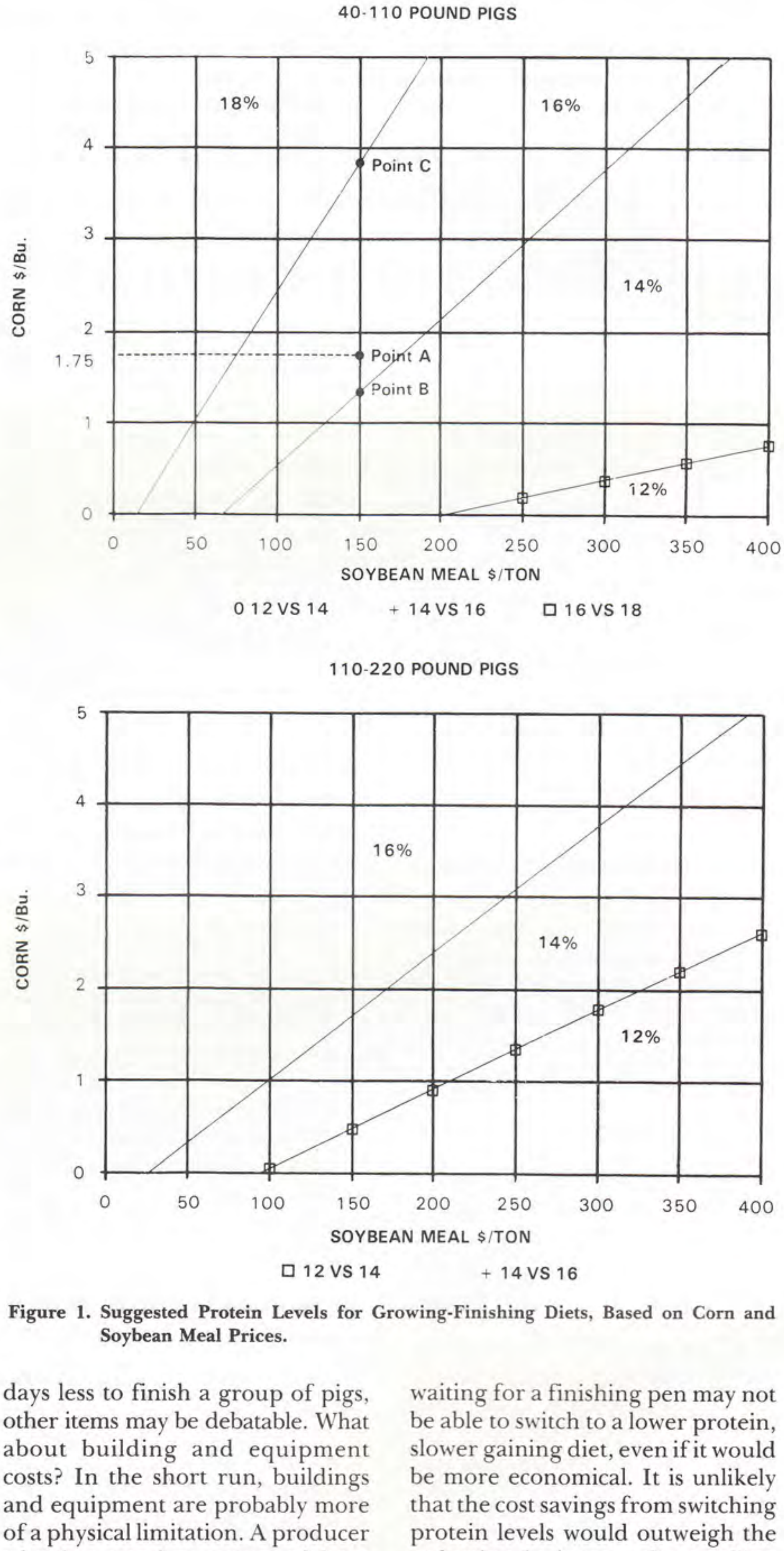

Figure 1. Suggested Protein Levels for Growing-Finishing Diets, Based on Corn and Soybean Meal Prices.

the hogs at a lighter weight. If a corn and soybean meal price situation indicated that a producer should switch to a higher protein level, which would result in a group of pigs finishing sooner, the building would probably just sit idle for a few days. Thus, the producer's annual building and equipment costs would not be affected by the switch in diet protein levels.

Building and equipment costs might be a long-run consideration, however. Decisions regarding the size of facility to build, or which production schedule to choose could be affected by the expected length of time it will take to finish each group of pigs. But, if a facility and production schedule were designed around a shorter finishing period, there would be no flexibility to shift to lower protein diets, if the corn and soybean meal price relationship changed. This merely reinforces the argument for not considering building and equipment costs in Figure 1, which is intended as a guide in making short run adjustments in diet protein level as corn and soybean meal prices change.

Effect on Carcass Merit

The discussion to this point has focused on production costs. A change in diet protein level could also influence income, through differences in carcass merit. Whether income is affected depends on the method by which a producer sells hogs. Producers selling on a live weight basis probably will not realize any difference in income from a change in diet protein level. However, producers who sell hogs on a carcass merit basis may realize more income from hogs which are fed higher protein diets.

A study was completed recently at the University of Nebraska to determine how diet protein level affects carcass quality in barrows and gilts (Table 2). The data indicate that 10th rib backfat depth decreases and loin eye area increases as the diet protein level increases. It is important to note that improvements in carcass quality for each incremental increase in diet protein level diminish at higher protein levels.

Table 2. Effect of protein level on carcass characteristics in barrows and gilts[a]

Item	Protein Level, %			
	12	14	16	18
10th Rib backfat, in.[b]	1.35	1.25	1.18	1.14
Loin eye area, sq. in.[b]	4.02	4.47	4.76	4.91

[a]Journal of American Science, 63 (Suppl.1):119, 1986
[b]Predicted at 230 lb live wt.

These results indicate that producers selling hogs on a carcass merit system may not maximize profit when feeding a lower protein level that minimizes feed cost. For example, cost of production may be reduced by switching to lower protein diets, but fewer dollars above all costs may be generated because of a decrease in carcass quality. Also, as indicated earlier, carcass quality continues to improve slightly as percent protein in the diet increases. Depending on the value placed on a higher quality carcass, greater overall returns may be achieved by feeding protein levels above that which would minimize cost of production.

Since the major factor influencing level of profit on swine farms continues to be cost of production, producers are advised to evaluate their situation by using Figure 1. If the point reached on the figure is on or close to a break-even line, a producer might consider feeding the higher protein level if more income can be realized from the sale of a better quality carcass.

Management Considerations

In addition to the factors already discussed, producers should consider the following points in evaluating diet protein levels.

(1) Pigs which are fed a lower protein diet will generally take longer to reach market weight. The maximum difference in length of time for the gain from 40 to 220 pounds resulting from probable choices in protein levels shown in Table 1 is nine days. In addition to the considerations discussed in the section dealing with non-feed costs above, the time required to reach market weight becomes important when:

(a) the hog market is trending upward or downward;

(b) rigid production schedules must be met;

(c) rapid turnover is necessary; and

(d) maximum weight gain per facility unit is desired.

(2) The question of total profitability, or whether or not a producer should feed hogs has not been addressed here. This analysis assumes a producer has made the decision to feed hogs and it shows the most economical level of protein to feed.

(3) Does the hog price affect the choice of protein level? It does only if the protein level affects the number of hogs a producer markets per year, or the weight at which they are marketed. The effects of an uptrending or downtrending market have already been mentioned.

Producers who have enough slack in their production systems to hold hogs up to a week longer than normal, could adjust protein levels within the relevant ranges of Figure 1 and still market the same number of hogs for a lower cost. The analysis in Figure 1 is aimed at the producer in this situation. Thus, market hog price is not considered as a factor in the analysis.

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Hominy Feed--An Important Corn By-Product for Growing-Finishing Swine

E. R. Peo, Jr., J. D. Hancock and A. J. Lewis[1]

We should feel particularly blessed that "Mother Nature" has provided us with an animal that can consume a by-product not usable by humans and convert it into a succulent, nutritious, healthful human food called pork. Such has been important in the past, is important now and may be of even greater importance in the future as more and more by-products become available from expanded use of cereal grains and other feedstuffs for human food and industrial purposes.

One by-product of the corn milling industry that has been around for a long time, but has not been used extensively by pork producers is hominy feed. Research on the feeding value of hominy feed for pork has been limited and thus, inadequate knowledge about hominy feed may be the reason why pork producers have been somewhat reluctant to use this by-product. Too, an abundance of feed grains has tended to make by-products less attractive even though economics say they should be considered and used if the price is right.

"Hominy feed" by the feed industry definition is "the mix of bran, germ and part of the starch of white or yellow corn kernels produced in the manufacture of pearl hominy, grits or table meal. It must contain not less than 4 percent crude fat". The composition of hominy feed compared to corn is shown in Table 1. Except for energy and sulfur amino acids, hominy feed has greater nutrient content than corn. This fact, makes hominy feed attractive as a feed ingredient and often the computer will select hominy feed in place of corn in least-cost swine diet formulation.

DRY CORN MILLING FLOW

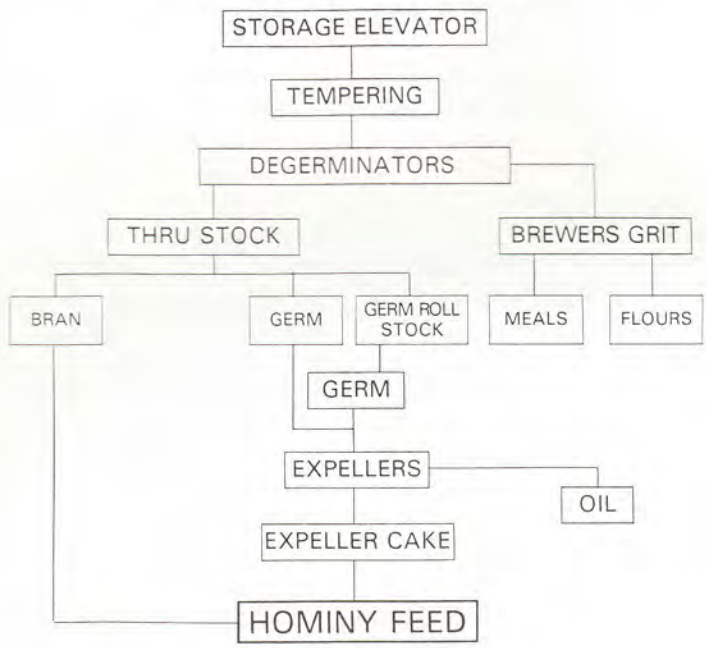

Table 1. Nutrient Content[a]

	Corn	Hominey feed
Metabolizable energy, kcal/lb	1,555	1,505
Nutrient, %		
Protein	8.5	10.6
Calcium	0.03	0.06
Phosphorus	0.28	0.52
Lysine	0.25	0.36
Tryptophan	0.09	0.13
Threonine	0.36	0.40
Sulfur amino acids	0.40	0.28
Fat (ether extract)	3.6	5.7

[a]Source: 1987 NRC composition tables.

Based on its nutrient composition, hominy feed should be an excellent feed, but surprisingly little research has been conducted to determine its value for pigs. One study conducted in Kentucky showed that finishing pigs fed corn diets gained 2.5 percent faster on 2.7 percent less feed per unit of gain than those fed an expeller type hominy feed (see Table 2). No research with younger pigs has been reported. Thus, we at the Nebraska Station conducted an experiment to determine the effects of pound for pound replacement of 0, 50 or 100 percent of dietary corn with solvent or expeller extracted hominy feed (two methods used to remove corn oil) on gains, feed conversion and carcass traits of growing-finishing pigs. The solvent extracted hominy feed we used was guaranteed to have 1.2 percent fat, considerably less than the definition specifies; the expeller extracted hominy feed 4 percent fat.

The pigs used in our study started on test at 66 lb body weight and were fed a 16% protein diet to 120 lb and a 14% protein diet from 120 lb to market weight. Composition of the experimental diets is shown in Table 3. Both the solvent extracted and expeller extracted hominy feeds were substituted for approximately 50 percent or 100 percent of the corn to determine the replacement value of the hominy feeds in swine diets.

The results of the study are shown in Table 4. Pigs fed the corn diets gained faster than those fed hominy feed with the greatest difference occurring between the pigs fed the corn diet (1.80 lb/day) and those fed the diet in which expeller extracted hominy feed completely replaced the corn (1.74 lb) day. The 100 percent replacement of corn with hominy feed resulted in a 5.7 percent reduction in feed intake. Feed conversion was improved 2 percent when hominy feed was substituted for 100 percent of the corn. The reduced gain, but improved feed efficiency, tend to offset each other. Thus, from a total performance standpoint, hominy feed seems to be about equal to corn for growing-finishing pigs.

Of the carcass traits, only dressing percent was affected by feeding hominy feed. Percentage of lean in the carcass was similar regardless of treatment. The lack of major effects on carcass traits would also indicate that hominy feed is equivalent to corn for growing-finishing swine.

When using hominy feed, it can be substituted pound for pound for corn or one can take advantage of the extra nutrients in hominy feed and reduce feed costs by balancing diets on the basis of nutrient content. For example, there is about 25 percent more protein, 44 percent more lysine and 86 percent more phosphorus in hominy feed than in corn (see Table 1). As far as we know, these nutrients from hominy feed are as available to the pig as they are from unprocessed corn. In fact, current studies at Nebraska indicate that the phosphorus in hominy feed has the same availability as the phosphorus in corn.

Handling and feeding of hominy feed creates some problems. Hominy feed comes in meal-form. The expeller extracted meals do not flow out of storage bins or feed down in self-feeders as easily as ground corn. There are fewer problems in this regard with the solvent-extracted hominy feed because it contains less fat. These minor problems are manageable and should not limit consideration of hominy feed for diets. Hominy feed is abundantly available in Eastern Nebraska. It is a good by-product of the corn milling industry and should be used in swine feeding programs when in todays world the computer says the "price is right".

Table 2. Hominy vs Corn for Finishing Pigs.

Diet:[b]	Corn-Soy	Hominy-Soy
No. Pigs[c]	15	15
Daily gain, lb	2.03	1.98
Daily feed, lb	7.42	7.42
Feed/gain	3.65	3.75

[a]Cromwell et al., Exp. 8103, University of Kentucky, Princeton Station.
[b]Diets consisted of 83% corn or hominy feed and 14.5% dehulled soybean meal and fortified with minerals and vitamins.
[c]Initial and final weights were 132 and 213 lb, respectively.

Table 3. Hominy Feed for G-F Pigs (Neb. Exp. 86403).

	Diet and amounts[a]				
Ingredient	100% C	50% HFS	100% HFS	50% HFE	100% HFE
Ground corn (C)	76.00	38.5	---	38.5	---
Hominy feed, sol (HFS)[b,d]	---	38.5	78.2	---	---
Hominy feed, exp (HFE)[c,d]	---	---	---	38.5	78.2
Soybean meal (44%)	20.80	19.8	18.6	19.8	18.6
Dicalcium phosphate	0.85	0.85	0.85	0.85	0.85
Limestone	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
Trace minerals	0.05	0.05	0.05	0.05	0.05
Selenium mix	0.05	0.05	0.05	0.05	0.05
Vitamin mix	1.00	1.00	1.00	1.00	1.00

[a]16% protein from 66 to 120 lb; 14% protein from 120 to 220 lb (Neb. Exp. 86403). [b]HFS = Solvent extracted hominy feed.
[c]HFE = Expeller extracted hominy feed.
[d]Hominy feeds were supplied gratuitously by Lauhoff Grain Co., Danville, IL.

Table 4. Hominy Feed for Growing-Finishing Pigs[a] (Neb. Exp. 86403).

	Treatments				
Criterion	100% Corn	50% HFS	50% HFE	100% HFS	100% HFE
Gain, lb/day[b]	1.76	1.76	1.76	1.74	
1.80					
Avg daily feed intake, lb[c]	5.79	5.70	5.71	5.54	5.45
Feed/gain[d]	3.21	3.24	3.26	3.16	3.13
Dressing percentage[e]	72.6	72.1	71.9	72.7	73.0
Backfat, inches	1.38	1.42	1.36	1.36	1.40
Carcass lean, %	53.2	52.8	53.4	53.4	52.9

[a]Data based on 4 pens of 8 pigs/pen; initial wt. 66 lb.
[b]Corn vs hominy feed (P<.11).
[c]Level of hominy feed (P<.12).
[d]Level of hominy feed (P<.10).
[e]Level of hominy feed (P<.02).

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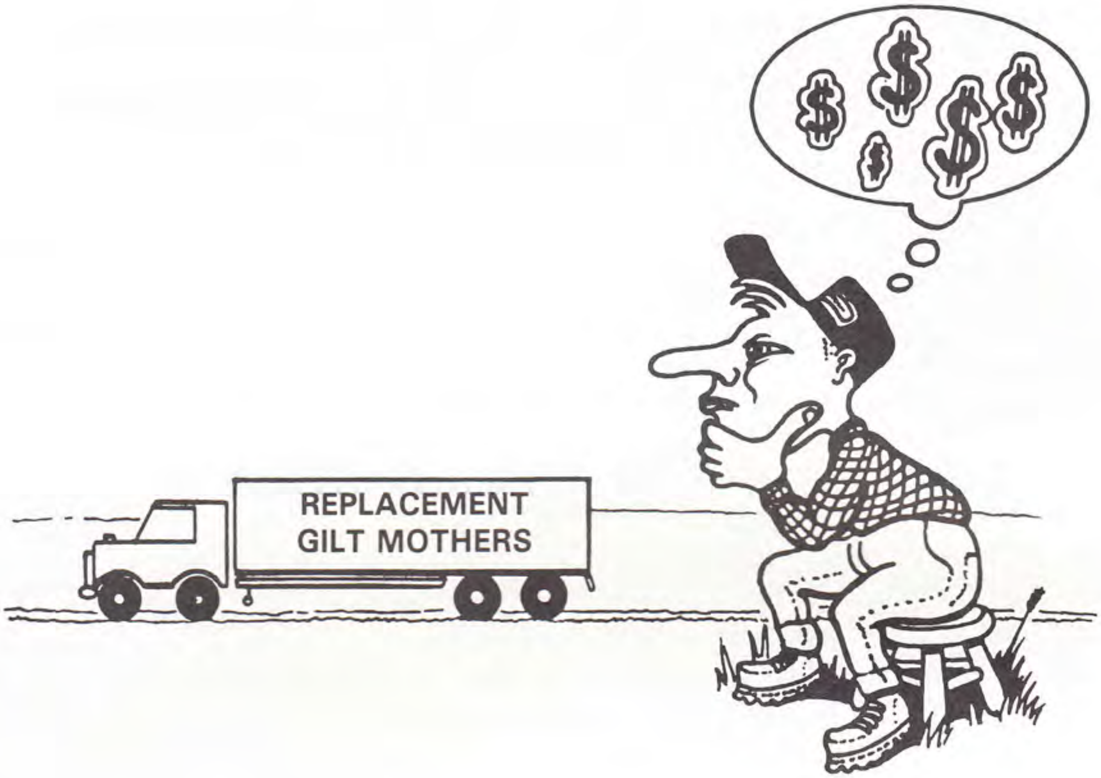

Home-Raised Replacement Gilts From Purchased Sows

William T. Ahlschwede[1]

Pork producers continue to adopt terminal crossbreeding systems. With terminal systems, replacement gilts are not kept from the market crosses. Special gilt-producing matings are required. However, many producers find it difficult to maintain the small breeding groups necessary to produce replacement gilts for terminal crossing. One option which has received considerable attention is buying replacement gilts. A second intermediate option of purchasing the mothers of replacement gilts deserves consideration.

Last year we reported that purchasing replacement gilts was feasible providing that the gilts were productive, that the price was reasonable and that sow retention rates were high. When replacement gilts are purchased, the profits generated through market hog production are shared with the producer of the gilts through the purchase price. The labors are divided, as are the profits. Purchasing the mothers of replacement gilts might provide commercial pork producers an opportunity to keep a larger share of the profits generated, while receiving many of the production benefits of purchased gilts.

The difficulties in raising replacement gilts for terminal crosses are of two general types. The first is one of economies of size. In small herds, few sows would be bred to produce gilts. Owning boars of high genetic merit of the maternal breeds with only a few sows to breed increases the costs per litter. In small herds, higher proportions of matings for replacement gilts would be required to assure having replacements when they were needed. A second type of difficulty is the inconvenience of having purebred and crossbred females in the sow herd. If one sought to raise Yorkshire-Landrace F1's, either purebred Yorkshire or purebred Landrace sows would be required. When 85-90 percent of the sows are Yorkshire-Landrace F1 crosses, the purebred sows cause operational problems. This is because the purebred sows do not breed as easily, have shorter lives in the herd, are poorer mothers and are more difficult to manage than their crossbred daughters. These problems are avoided with purchased gilts. These problems can be re-

Table 1. Expected Production and Profit from 100 Litters with Six Crossbreeding Systems.

Mating System Sire	Dam	Proportion matings in system	Percent offspring heterosis	Pigs marketed per litter	Conception rate %	Days to market	Fat thickness	Growing-finishing F/G	Net per 100 litters
Three breed rotation									
HAMP	ROT	33.3	85.7	8.56	80	169	1.10	3.26	$7,594.45
DUROC	ROT	33.4	85.7	7.96	83	165	1.16	3.27	$5,129.22
YORK	ROT	33.3	85.7	8.02	85	166	1.19	3.28	$5,060.88
System average, weighted by proportion matings in system									$5,927.38
L, Y based rotaterminal									
YORK	L,Y,L . . .	5	66.7	9.10	.72	170	1.23	3.32	$7,348.93
H × D	Y,L,Y . . .	45	100	9.08	.87	165	1.18	3.27	$9,105.79
LANDRACE	Y,L,Y . . .	5	66.7	9.34	.73	171	1.25	3.34	$7,829.86
H × D	L,Y,L . . .	45	100	9.11	.86	166	1.19	3.28	$9,006.45
System average, weighted by proportion matings in system									$8,909.45
Four breed terminal, L × Y sow									
YORK	YORK	2	0	7.78	72	177	1.20	3.35	$2,396.78
LAND	YORK	8	100	8.08	72	166	1.25	3.31	$5,157.64
H × D	L × Y	90	100	9.55	87	166	1.19	3.28	$10,727.80
System average, weighted by proportion matings in system									$10,115.57
Four breed terminal, Y × HL sow									
LAND	LAND	1	0	8.40	69	180	1.25	3.40	$3,304.83
HAMP	LAND	3	100	8.30	69	169	1.15	3.28	$5,503.97
YORK	H × L	9	100	8.67	80	167	1.19	3.28	$7,146.55
H × D	Y × HL	87	87.5	8.99	89	167	1.15	3.27	$9,023.74
System average, weighted by proportion matings in system									$8,692.01
Four breed terminal, Y × DL sow									
LAND	LAND	1	0	8.40	69	180	1.25	3.40	$3,304.83
DUROC	LAND	3	100	8.30	69	164	1.25	3.30	$4,724.37
YORK	D × L	9	100	8.94	80	164	1.24	3.29	$7,707.39
HAMP	Y × DL	87	100	9.18	78	167	1.13	3.26	$9,626.39
System average, weighted by proportion matings in system									$9,243.40
Five breed terminal, Y × CL sow									
LAND	LAND	1	0	8.40	69	180	1.25	3.40	$3,304.83
CHESTER	LAND	3	100	8.37	69	170	1.30	3.36	$3,681.49
YORK	C × L	9	100	9.48	80	167	1.26	3.32	$8,875.32
H × D	Y × CL	87	100	9.44	89	166	1.19	3.28	$10,240.10
System average, weighted by proportion matings in system									$9,851.16

Economic projections based on unit farrowing 100 litters at a base cost of $300 per litter.
Base conception rate of 80%, herd cost adjusted by $28 per sow above or below 80%.
Base litter size marketed was 7.5 pigs, litter cost adjusted by $8 per pig above or below base.
Base age to market at 220 pounds was 180 days. Non-feed costs of $14 per pig, adjusted by $0.05 per day above or below base.
Feed for growing-finishing charged at $140 per ton.
Hogs were marketed at 220 pounds at a base price of $45/cwt. with 1.15 in. last rib fat thickness.
Premiums and discount based on fat thickness were 1% for each 0.1 in. below or above base value.

duced with purchased sow mothers.

Table 1 shows Crossbreeding Systems Analysis results for the traditional three breed rotation cross of Hampshire, Duroc and Yorkshire, and various terminal crossbreeding systems. The first three systems, the three-breed rotation, the rotaterminal based on Yorkshire-Landrace sows and the terminal cross using Yorkshire-Landrace F1 sows, were the basis of last year's evaluation of the practice of purchasing replacement gilts. That analysis showed that one could expect profits with purchased F1 gilts similar to that experienced with the rotaterminal. Nearly half of the combinations of gilt purchase price and replacement rate projected profits for 100 litters equal to or greater than the expected $8,909 profit from the rotaterminal.

In the sections of Table 1 dealing with four breed terminal and five breed terminal crossbreeding systems, each line represents a type of mating. Female offspring produced by matings in a given line are used as the females in the mating in the next line. In the mating system titled "Four breed terminal, L x Y sow", the first line describes purebred Yorkshire matings. The second line describes matings of Yorkshire gilts produced in the matings on the first line to Landrace boars. The third line in the system is the terminal matings, L x Y F1 females mated to Hampshire x Duroc F1 boars. Each of the terminal mating systems are show in a similar manner.

Each of the terminal crossbreeding systems shown in Table 1 can be operated with purchased mothers of gilts. The last two lines in each system would be used. Matings producing replacement gilts for the terminal crosses, shown in the next to bottom line of the system would be made with purchased gilts. In the first terminal system in Table 1, one would buy Yorkshire gilts. These gilts would be bred to Landrace boars to produce replacement gilts for terminal crossing. This would eliminate the need for the matings between Yorkshire boars and Yorkshire gilts, the smallest breeding group in the system.

Table 2 shows the expected economic outcome for 100 litters of each of the terminal systems shown in Table 1 operated with purchased mothers of replacement gilts. Ten of the 100 litters are used for replacement gilt production. The replacement rate was used to calculate the number of gilts purchased per 100 litters farrowed. It was based on the conception rate of the matings involving purchased females. The values shown in the body of Table 2 are the returns (Table 1) from 10 gilt producing litters and 90 terminal litters less the cost of the purchased females. The cost of the purchased females is the number of litters (10) times the replacement rate times the sow purchase price shown at the head of each column. The columns of the table represent various prices of the purchased gilts, as a premium above the value of a 220 lb market hog. It is assumed that the operation is large enough that the boar siring replacement gilts is fully used.

The first line in Table 2 show the results of Mating System 3 using

Table 2. Expected Profit from 100 litters when the mothers of replacement gilts are purchased.

Type female purchased	replacement rate [a]	SOW PURCHASE PRICE PREMIUM PER GILT OVER MARKET HOG VALUE $100	$150	$200	$250	$300
Yorkshire	28%	$9,890.78	$9,750.78	$9,610.78	$9,470.78	$9,330.78
H × L	20%	$8,636.02	$8,536.02	$8,436.02	$8,336.02	$8,236.02
D × L	20%	$9,234.49	$9,134.49	$9,034.49	$8,934.49	$8,834.49
C × L	20%	$9,903.62	$9,803.62	$9,703.62	$9,603.62	$9,503.62

[a] Replacement rate for the purchased females.
Assumes 10% of the matings produce replacement gilts.

expected returns per 100 litters is quite good relative to the first three systems in Table 1, purchasing Yorkshire gilts for F1 replacement gilt production does not solve problems associated with managing purebred Yorkshire sows and F1 Landrace-Yorkshire sows in the same production unit.

The results of similar calculations from the three other terminal systems in Table 1 are also shown in Table 2. These all used crossbred sows as the gilt mother. In each case, Yorkshire boars are mated to the purchased females to produce the replacement gilts for terminal crosses. In the second line, the purchased females are Hampshire x Landrace F1 crosses. The terminal sire is a Hampshire x Duroc cross. In the third line, Duroc-Landrace F1 females are purchased. A Hampshire boar is used to sire market hogs. Line 4 uses purchased Chester White-Landrace F1 females to produce replacement gilts. A Hampshire-Duroc F1 boar is used to sire market hogs.

These three systems would be expected to be easier to operate than the Yorkshire sow-based system. The purchased sow mothers are crossbreds, expected to be productive and similar in management requirements to their daughters. The projections assume that the sire of replacement gilts has ample females to breed. In smaller herds, the cost of the partially occupied boar would need to be considered.

Large differences are apparent in Table 2 among the four schemes. The fourth system, using purchased C x L females to produce replacement gilts looks particularly favorable. It surpasses the Yorkshire sow mother system because of the increased productivity of the females producing the replacement gilts. They raise larger litters and have higher conception rates, reducing the number of gilts to be purchased. The system using D x L purchased gilt mothers surpasses the rotaterminal in Table 1 in expected returns at most gilt purchase prices. In contrast, the system using purchased H x L sows does not exceed the returns of the rotaterminal at any purchase price. The advantage of the D x L system over the H x L system comes from larger litter sizes and leaner market hogs.

The results reported in Table 2 indicate that purchasing the mother of replacement gilts for terminal crossbreeding is a feasible practice. All of the systems studied surpass the expected profit of $5,927 for the three breed rotation by a significant margin, as judged by expected economic return from 100 litters. Three of the four systems offer returns superior to the rotaterminal based on Landrace-Yorkshire sows. The systems based on Yorkshire and C x L sow mothers yield higher returns than expected when all gilts are purchased (L x Y F1's).

The effect of gilt purchase price is not large, as indicated in Table 2, when only the mothers of replacement gilts are purchased. Since few gilts are purchased, the purchase price is relatively less important than when all replace-purchased sow mothers. While the ments are purchased. However, when productivity of the system is not high, as with the H x L sow system, the gilts are too expensive at any price. The expected return of $8,636 with the H x L system with the least expensive sows is less than with the D x L system ($8,834) at the most expensive sow option, and less than expected with the rotaterminal ($8,909). One would conclude that it is only worth buying into superior systems.

The effectiveness of this approach relies heavily upon purchasing good boars to sire the replacement gilts. These boars sire all of the replacement females. In addition to siring gilts which farrow and wean large litters of fast-growing, lean pigs, the boars play a major role in the soundness and longevity of the sow herd. Suppliers of the boars to sire replacement gilts should be sought who place selection emphasis on performance tests of both sow and pig performance and who produce sound functional pigs under conditions similar to those the gilts will experience.

When all replacement gilts are purchased, both the purchase price and replacement rate are critical factors in determining feasibility. These are less critical when only the mothers of gilts are purchased. When all gilts are purchased, the responsibility for selecting the sire of the gilts and for producing sound functional gilts is transferred to the gilt producer. Part of the purchase price is in recognition of this task.

The practice of buying the mothers of replacement gilts allows commercial pork producers to accrue the benefits of terminal crossbreeding systems using home-raised gilts, while avoiding some of the hassle associated with replacement gilt production. These systems require two types of boars, one for gilt production and one for market hog production. The three breed rotation and the rotaterminal require three types of boar. Only one type of boar is required if all gilts are purchased. Hence, these systems, particularly those based on crossbred sow mothers are easier to operate than other systems with home raised replacement gilts.

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New Feed Additive *Ractopamine* Increases Feed Efficiency and Carcass Leanness in Finishing Pigs

J. D. Hancock, E. R. Peo, Jr. and A. J. Lewis[1]

At present a great deal of interest and excitement is being generated by developments in the use of porcine growth hormone and other substances known as repartitioning agents for finishing pigs. Research from Penn State and Cornell Universities indicates marked increases in average daily gain (15 to 20%), feed efficiency (25 to 30%) and carcass leanness (25 to 30%) of finishing pigs given porcine growth hormone. Since growth hormone is a protein molecule which would be destroyed by digestive enzymes if consumed in the feed, it must be injected daily to obtain the above responses. Thus, until a more convenient method of administration becomes available, the use of growth hormone in commercial swine operations does not seem to be practical.

As an alternative, several commercial companies are investigating the use in finishing pigs of a class of repartitioning agents known as β-agonists. These β-agonists direct nutrients away from storage as fat and into the deposition of lean tissue. β-agonists are small, relatively simple compounds that are similar in structure to some of the amino acids and epinephrine (adrenaline). Unlike growth hormone these small molecules are not destroyed by digestive enzymes and maintain their activity when consumed in the feed.

Table 1. Effects of Feeding β-agonists to Finishing Pigs.

Compound	Avg daily gain	Feed intake	Feed efficiency	Avg backfat thickness	10th rib fat depth	Loin eye area	Dressing %
Cimaterol							
American Cyanamid Co. (1984)	↓	NS[a]	NS	↓10%	↓13%	↑10%	NR[b]
Auburn U. (1985)	NS	↓8%	NS	↓11%	↓21%	↑ 8%	NR
U. of Illinois (1985)	NS	↓9%	↑12%	↓12%	↓17%	↑12%	↑ 1%
U. of Minnesota (1986)	NS	↓8%	NS	↓ 9%	↓14%	↑ 9%	NS
U. of Florida (1987)	↑4%	NS	NS	NR	↓12%	↑ 8%	NS
U. of Kentucky (1987)	↑3%	NR	↑ 5%	NR	↓15%	↑12%	↑ 1%
Clenbuterol							
American Cyanamid Co. (1984)	NS	NR	NS	↓11%	↓ 7%	↑11%	NS

[a]Not significant.
[b]Not reported.

Several experiments have been conducted to evaluate the use of two β-agonists (cimaterol and clenbuterol) in the diets of finishing swine (table 1). Increases of 10 percent in loin eye area and decreases of 11 percent in average backfat thickness are common. However, improvements in rate and efficiency of gain have not been consistent.

We recently conducted an experiment to evaluate the effects of dietary levels of another β-agonist called ractopamine on the performance and carcass traits of finishing pigs. There are reports that ractopamine will consistently improve rate of gain, efficiency of gain and carcass yield, as well as having marked effects on carcass lean content. Our experiment was conducted with 192 finishing pigs from 143 to 229 pounds. The pigs were fed a 16 percent crude protein corn-soybean meal diet that contained .65 percent calcium and .50 percent phosphorus. These nutrient levels are above the requirements of finishing pigs, but were chosen so that if there was any reduction in feed intake, this would not lead to inadequate daily intakes of protein, vitamins or minerals. Furthermore, where there is "repartitioning" of nutrients from fat to lean, there is probably a need for higher levels of dietary crude protein.

The effects of dietary levels of ractopamine on finishing pig performance are presented in table 2. Adding ractopamine to the diet did not significantly increase average daily gain, although the pigs fed diets containing 2.5, 5, 10, 20 and 30 ppm ractopamine gained on the average, 8 percent faster than pigs fed the control diet. Feed intake decreased by 9 percent and feed efficiency was improved by 15 percent as dietary level of ractopamine increased from 0 to 30 ppm.

The effects of ractopamine on carcass traits are presented in Table 3. Dressing percentage was increased slightly, and carcass length was decreased somewhat as level of ractopamine in the diet was increased from 0 to 30 ppm. Average backfat thickness, 10th rib fat thickness and leaf fat weight were decreased by 9, 14 and 23 percent, respectively, whereas loin eye area, muscling score and percentage carcass lean increased by 20, 28 and 6 percent, respectively, when 30 ppm ractopamine was added to the diet. Several subjective measures of meat quality (i.e., muscle color, firmness and marbling) were not affected by dietary level of ractopamine.

The results of our experiment and those of others clearly demonstrate that ractopamine increases the performance and carcass merit of finishing pigs. Most of the response to ractopamine was achieved with dietary levels of 10 to 20 ppm. The decrease in fat measurements and increase in carcass lean content that resulted from feeding ractopamine are similar to those obtained from feeding other β-agonists. However, ractopamine seems to have a more consistent effect on feed efficiency than other β-agonists. Feeding β-agonists seems to produce less of a response in daily gain, feed efficiency and carcass leanness than that obtained with daily injections of porcine growth hormone. Therefore, any decision to use either a β-agonist or growth hormone will depend on cost of the product relative to economic return to the producer, the availability of the products and ease of administration.

At the present time, the Food and Drug Administration **has not** approved any of these products for use in swine. Although their future looks bright, it will probably be 2 to 3 years before any of these compounds become commercially available.

Table 2. Effects of Ractopamine on Finishing Pig Performance (Neb. Exp. 85411)[a]

	Ractopamine, ppm						
Item	0	2.5	5	10	20	30	C.V.[b]
Avg daily gain, lb[c]	1.44	1.57	1.59	1.52	1.55	1.53	6.9
Avg daily feed intake, lb[d]	6.61	6.51	6.63	6.19	6.14	5.99	5.3
Feed to gain ratio[d,e]	4.62	4.15	4.20	4.08	3.97	3.94	5.9

[a]Each value represents 4 pens with 8 pigs/pen; initial wt. of 143 lb, final wt. of 229 lb.
[b]Coefficient of variation, %.
[c]No treatment effect (P>.12).
[d]Linear effect (P<.005).
[e]Quadratic effect (P<.08).

Table 3. Effects of Ractopamine on Carcass Merit (Neb. Exp. 85411)[a]

	Ractopamine, ppm						
Item	0	2.5	5	10	20	30	C.V.[b]
Dressing percentage[c]	74.7	74.6	74.5	75.3	75.6	.6	
Carcass length, in[c,d]	31.5	31.4	31.2	31.1	30.7	30.6	.7
Avg backfat thickness, in[c,d]	1.27	1.24	1.22	1.18	1.15	1.16	3.7
10th rib fat thickness, in[c]	1.01	.91	.94	.94	.86	.87	5.0
Leaf fat weight, lb[c,d]	4.3	3.7	3.8	3.2	3.2	3.3	10.2
Loin eye area, sq in[c]	5.0	5.6	5.4	5.7	5.9	6.0	4.3
Muscling score[c,d]	3.2	3.6	3.7	3.9	4.1	4.1	5.8
Percentage carcass lean[c,d,e]	54.3	56.5	55.9	56.5	57.5	57.8	1.5

[a]Each value represents 4 pens with 8 pigs/pen.
[b]Coefficient of variation, %.
[c]Linear effect (P<.002).
[d]Quadratic effect (*<.10).
[e]Calculated using a National Swine Improvement Federation formula (USDA, 1981).

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Biotin For Sows

Austin J. Lewis and Daniel A. Burosh[1]

Biotin is a water-soluble vitamin that pigs require during all stages of their life cycle. Pigs need biotin for a wide range of functions that involve the use of energy, proteins and nucleic acids. Acute biotin deficiencies have been created experimentally. The deficiency signs include excessive hair loss, skin ulcerations and dermatitis, watery secretions around the eyes, inflammation of the mucous membranes of the mouth, cracking of the hooves, and cracking and bleeding of the foot pads. These signs are accompanied by poor performance in growing pigs and poor reproduction in sows. Under normal field conditions, however, clear-cut biotin deficiencies are rarely seen, and any marginal subclinical deficiencies of biotin that may be present are difficult to detect.

Fortunately, the biotin needs of pigs are relatively low and biotin is present in most common feedstuffs in ample quantities. Thus, there is usually no need to add supplemental biotin to the diets of nursery or growing-finishing pigs.

Do Sows Need Supplemental Biotin?

For sows the picture is less clear, and the need for supplemental biotin in sow diets is controversial. Although no one has produced a clear experimental deficiency in sows, there have been several reports during the last decade of beneficial effects of supplemental biotin in sow diets. Improvements in reproductive performance such as increases in conception rate, numbers of pigs born and weaned, and litter weaning weight, and decreases in the number of days from weaning to estrus have been described. Other experiments have failed to show a benefit from supplemental biotin.

Many factors contribute to the inconsistent results that have been obtained in sow experiments. These factors include:

a. a wide variation in the amount of biotin found in natural feedstuffs (e.g., protein supplements such as soybean meal, cottonseed meal and peanut meal have higher contents than cereal grains such as corn, milo, barley and wheat).
b. a wide variation in the bioavailability of biotin in natural feedstuffs (e.g., the biotin in corn seems to be completely available, whereas only half of the biotin in milo, barley and wheat is available).
c. a wide variation in the amount of biotin that is available to sows from synthesis by microorganisms in the gastrointestinal tract (e.g., microbial contributions can be substantial, but may be limited if antibiotics are fed and if sows are confined and have limited contact with manure).
d. a wide variation in the inclusion in certain feedstuffs with relatively high biotin contents (e.g., alfalfa).

Cooperative Experiment Planned

To obtain more information about the need for supplemental biotin in sow diets, the member stations of the North Central Regional Committee on Swine Nutrition (NCR-42 Committee) planned a cooperative experiment. They hoped that by conducting a similar experiment at several places throughout the region, and combining the results they could answer the question of whether sows fed diets common to this region need supplemental biotin.

The Nebraska station participated in the project, and the results that are presented in this article contain our findings. Combined data from the contributing stations will be available within a year.

Experimental Design

The experiment consisted of two dietary treatments: the first a corn-soybean meal control diet (14% crude protein), and the second the same as the control but with 300 mg/ton of added biotin. Twenty-four gilts were assigned to each of these diets at the time of their first breeding. They were fed their respective diet throughout three gestation and lactation cycles (parities). Thus, each sow received the same diet from the time that she was bred as a gilt until she weaned her third litter. During gestation sows were fed 4 lb/day (5 lb/day in winter). During lactation they were allowed *ad libitum* access to feed. Any sow that failed to conceive, aborted or developed other problems was removed from the experiment.

Findings

Of the 24 sows assigned to each treatment, 20 of those fed the control diet completed three parities, while only 13 of those fed the diet with added biotin completed three parities. The primary reason for sows not completing three parities was that they were not pregnant when they were moved to the farrowing house at day 109 of gestation. Thus, they either did not conceive at breeding or aborted during pregnancy. The rather large difference between the two treatments was unexpected. Other experiments have not found a negative effect of biotin on conception rate. It is difficult to understand how the supplemental biotin could have been responsible for the effect that we observed. Thus, at present we believe that the reduced number of biotin-supplemented sows completing three parities was a chance occurrence, but it is important to keep this observation in mind.

Sow weight changes during gestation, at farrowing and during lactation were similar for the two treatments, and did not appear to be influenced by biotin supplementation. Similarly, the feed intakes during lactation and the interval between weaning and estrus were essentially the same for the two groups of sows.

Biotin supplementation did appear to exert a positive effect on the number of pigs born and weaned. Sows fed supplemental biotin had approximately 0.7 more live pigs at birth and 0.6 more live pigs at weaning. Pigs from biotin-supplemented sows were somewhat lighter than their control counterparts, but this is probably a refection of the greater numbers. The total litter weaning weights were essentially the same for the two treatments.

Table 1. Reproductive Performance of Sows fed Biotin during Gestation and Lactation (Nebraska Experiment 85413).

	Control	Biotin[a]
Number of litters[b]	64	46
Average parity	1.95	1.87
Sow weights (lb):		
At breeding	325	322
At day 109 of gestation	434	430
Gestation weight change	109	108
At farrowing	408	398
Farrowing weight change	−26	−32
At day 21 of lactation	384	374
Lactation weight change	−24	−24
Lactation feed intake (lb)	10.5	10.1
Weaning to estrus interval (days)	7.7	7.2
Pig numbers and weights (lb)		
Pigs born alive	10.23	10.91
Average weight of pigs born alive	3.13	3.04
Pigs born total	10.95	11.37
Average weight of total pigs born	3.09	3.02
Pigs at 21 days	9.09	9.65
Average weight of pigs at 21 days	12.84	12.19

[a]Diet contained supplemental biotin (300 mg biotin per ton of feed)

[b]Numbers of sows starting first parity and completing three parities were: control group, 24 and 20; biotin group, 24 and 13.

Conclusion

Our results indicate that biotin supplementation may increase the number of pigs born alive and weaned. If this trend continues when all of the data from the other Experiment Stations are in, then biotin supplementation of diets commonly used in the Corn Belt would seem advisable. However, it costs approximately $1.50/ton to supplement sow diets with 300 mg of biotin, and this added cost needs to be considered when evaluating any improvements in reproductive performance. It is possible that supplementation with either 100 or 200 mg/ton (costing $0.50 to $1.00) may be as effective as supplementation with 300 mg/ton.

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