12-1978

The effects of crossfostering pigs at birth on subsequent survival and performance

Mike C. Crider

To the Graduate Council:

I am submitting herewith a thesis written by Mike C. Crider entitled "The effects of crossfostering pigs at birth on subsequent survival and performance." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

E.R. Lidvall, Major Professor

We have read this thesis and recommend its acceptance:

D.O. Richardson, J.B. McLaren

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a thesis written by Mike C. Crider entitled "The Effects of Crossfostering Pigs at Birth on Subsequent Survival and Performance." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

E. R. Lidvall

E. R. Lidvall, Major Professor

We have read this thesis and recommend its acceptance:

J. B. McLaren

D. O. Richardson

Accepted for the Council:

L. Evans Roth

Vice Chancellor
Graduate Studies and Research

THE EFFECTS OF CROSSFOSTERING PIGS AT BIRTH ON SUBSEQUENT SURVIVAL AND PERFORMANCE

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Mike C. Crider

December 1978

ABSTRACT

Data from 144 crossbred Duroc, Hampshire, Yorkshire and Landrace litters were used to study effects of crossfostering pigs at birth on subsequent performance traits. There were 1,413 pig births from six farrowings during 1977 included in the study. Pigs were ear notched, weighed, needle teeth clipped and male pigs castrated on day one. Crossfostering was accomplished within 24 hours of birth. Two randomly selected litters of pigs were crossfostered as a group. The smallest one-half of the pigs by weight were placed with one sow and the largest one-half by weight with the other sow. The pigs were weaned at 5 weeks of age, weighed and placed in the nursery. The largest one-third of the pigs by weight were randomly assigned to four nursing pens, the middle third to four pens and the light-weight one-third to the remaining four pens. The pigs were weighed and moved as a pen of pigs to the finishing barns. Crossfostering reduced the variation within litters and enlarged variation among litters. The small crossfostered litter pigs were superior in uniformity of daily gain compared to small pigs from control litters. The smaller pigs (control and crossfostered) did not perform as well as larger pigs in terms of average daily gain. Average daily gain to weaning was shown to be an important factor in determining succeeding performance traits. Crossfostering appears advantageous in developing more uniformity in size and weight among pigs produced.

ACKNOWLEDGMENTS

The author wishes to thank the University of Tennessee College of Agriculture and Ames Plantation for providing assistance during the course of study.

The author wishes to express his deepest appreciation to the following:

To Professor E. R. Lidvall, major professor, for his knowledge in the area of swine management, guidance and friendship through the course of the study.

To Dr. D. O. Richardson, for serving on the graduate committee, for assistance concerning data analysis and for reviewing the manuscript.

To Dr. J. B. McLaren, for serving on the graduate committee, for assistance concerning data analysis and for reviewing the manuscript.

To the entire staff at Ames Plantation, especially the swine crew for their help in collecting data, feeding and care of the animals and their friendship.

To Roger Billingsley, Steve Damron, Doug Ellis, Jim Fain, Max Hawkins, Kim Kirnan and Steve Umberger for their assistance, support and friendship during the course of the study.

To Cathy Livingston for her help in the typing of this manuscript.

To Kim McNair for her understanding, encouragement and unending support.

To his parents, Justin and Joy Crider, for their love, unceasing encouragement and the many sacrifices which made higher education possible.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The number of pigs a sow farrows represents her fertility, that of the boar to which she was bred and the quality of management she has received. The number of pigs she raises, not the number she farrows, determines her economic value to the breeding herd and provides whatever profit she is to contribute to the operation.

At birth, each baby pig represents a potential market hog with an opportunity to yield a profit. Baby pig mortality represents a twofold loss of feed (fed to the sow) and potential profits. Management has relatively little influence on the hereditary and physiological capacity of a sow to produce pigs; however, it can play an important factor in the survival of pigs.

Approximately one-fourth of all pigs born die before they are five months old (Cox, 1962). The probability of survival of a baby pig farrowed alive is approximately 0.67 (Krider and Carroll, 1971). The extent of these losses varies from farm to farm, but most reports based on reasonable numbers of records suggest that the mortality rate among pigs farrowed alive is 20 to 30 percent. This loss is better appreciated if translated into pounds of feed. Fairbanks et al. (1945) showed that a sow eats an average of 70 to 100 pounds of feed during gestation for each pig she farrows. During lactation the feed requirement increases by 1-2 pounds per pig. For each dead pig found, approximately two bushels of corn is wasted beyond recovery. No swine grower would knowingly destroy that much feed. Yet, through a result of lack of planning, bad management, neglect or a combination of these, he becomes responsible for the waste of this feed.

The number and quality of pigs weaned is a combination of the number of pigs farrowed, heredity, death losses and quality of management. Management is the one factor which gives the producer the best opportunity to increase profits.

A major goal of the commercial swine producer is to maximize the number and weight of pigs weaned per sow per year. The production of uniform litters which are ready for market at the same age is of material economic importance. It is well recognized, however, that the individual pigs of a litter vary widely in weaning weight and that they grow at different rates. These differences are often primarily responsible for the lack of uniformity in the market weights of pigs.

Sows which regularly produce the greatest weight of pigs at weaning are the most profitable to the producer. Since the weight of litters at weaning is dependent upon the number of pigs weaned and the individual weight of the pigs at weaning, the producer, must maximize both (a) number of pigs weaned per litter and (b) weaning weight of the pigs.

McMeekan (1936) suggested that the number of pigs weaned is more important than weaning weight in producing heavy litters; however, both are important. Winters *et al*. (1947) showed that an increase of one pig in a litter increases the total weaning weight of the litter by 20 pounds. Weight of the litter at weaning has a definite relationship with subsequent rate of gain. Heavier weaned pigs retain their rapid rate of growth through to market. Lighter weaned pigs tend to grow more slowly throughout the growing period (Smith et al., 1939).

Therefore as the swine industry changes from pasture type production units to highly mechanized confinement operations, the average pork producer is under constant pressure to maximize production by increasing the pounds of pork produced per sow per year in the breeding herd. A partial solution to this pressure lies in the production of more and heavier pigs at weaning. The purpose of this study was to evaluate the effect of equalizing litters of pigs by weight and number at birth upon their subsequent livability, growth rate and uniformity.

CHAPTER II

LITERATURE REVIEW

I. FACTORS INFLUENCING PIG PERFORMANCE

Birth Weight

Mortality in small pigs is closely related to the strength of pigs at birth. Approximately 30 percent of weak pigs live to weaning, whereas 80 percent of the strong pigs survive according to Krider and Carroll (1971). Death losses come at an earlier age to weak pigs than to stronger pigs. Each day that a pig lives increases his chances for survival. Fredeen and Plank (1963) cited that preweaning mortality was 44 percent for pigs weighing 2.5 pounds or less at birth and 12 percent for pigs larger than 2.5 pounds. Their work showed total preweaning mortality to be 29 percent with 20 percent dying between birth and three weeks of age. Mortality between three weeks and weaning was about 9 percent.

Winters et al. (1947) illustrated that birth weight had a significant effect upon both survival and total weaning weight of the litter. An increase in survival rate increased the total weaning weight of the litter. A one pound increase in average birth weight increased total weaning weight 15.9 pounds. He pointed out that birth weight accounts for more of the variation in total weaning weight of the litter than did litter size. Since pig weight at birth is inversely related to weaned litter size (Fredeen and Plank, 1963), therefore larger litters would result in lighter weight pigs. This is in agreement with Revelle and Robison (1973) but disagrees with the work of Smith et al. (1939), which demonstrated that litter size had no influence on the pig's rate of gain.

The relationship between birth weight and subsequent rates of growth has made no distinction between differences in pigs within a litter or differences between litters (Winters et al., 1947). However, Husby (1933) pointed out that there were two categories of undersized pigs. There are litters of below-average pigs, and there are litters composed of both below-average pigs and normal size pigs. He suggested that pigs in the latter category would find their smallness a greater handicap than would pigs with litter-mates of equal size, provided that the lighter weight pigs of a litter below average were not due to some genetic or nutritional influence.

Mcbride (1963) and Wyeth and Mcbride (1964) found a correlation between the birth weight of pigs and the size of teat they accepted. Anterior teats were the preference of the majority of the pigs. These teats appear to be more acceptable to the pig due to their larger size and flow of milk as determined by Mcbride (1963). Pigs nursing anterior teats had an advantage in growth, presumably through more milk supply (Mcbride et al., 1965). Larger pigs that acquire the anterior teats have an advantage through the entire nursing period. Lodge and McDonald (1959) and Smith et al. (1939) showed that the heavier a pig is at weaning, the faster it will tend to grow in all stages. It appears advantageous to produce heavy weaning weights thus enabling pigs to grow well during the finishing period. This allows the swine producer to market his hogs more quickly at a lower production cost.

Litter Size

Litter size is one of the more economically important traits in swine production. At birth, litter size obviously establishes an upper limit on the number of pigs weaned but the latter is importantly conditioned by pre-weaning mortality (Fredeen and Plank, 1963). Considerable effort has been expended toward improving litter size at birth; however, it has not been altered substantially.

Fredeen and Plank (1963) showed that pigs in large litters were smaller and pigs in small litters were larger at weaning. This is in agreement with the work of Winters et al. (1947). Research work performed by Revelle and Robison (1973) indicated that nutritional and/or sociological stresses become a factor in the pigs growth as litter size rises above 12 pigs. The best maternal environment for physiological growth and maturity is a litter size below six (Revelle and Robison, 1973). Smith and Donald (1937) cited a litter size range of 7 to 11 pigs in which there was no difference in pig average weaning weight. Fredeen and Plank (1963) reported that post-weaning growth rates were reduced in litters of 10 or more weaned pigs. A higher percentage of pigs born die before weaning in large litters than in small litters (Winters et al., 1947). With the effects of survival and birth weight eliminated, Winters showed a 20.26 pound increase in the total 56-day weight of the litters in his work.

Revelle and Robison (1973) illustrated that pigs from large litters tended to mature more slowly due to greater stress present in their environment. Social and/or nutritional stresses were unimportant factors in litters of less than six pigs. To quote Falconer

(1955).

> . . . in assessing the optional litter size one must take into account not only the number of children produced but also the number of grandchildren: large litters mean more children but perhaps fewer grandchildren.

The research of Revelle and Robison (1973) and Smith and Donald (1937) showed that a range in litter size of approximately 6 to 12 and 7 to 11, respectively, produced no differences in weaning weight, and generally supports Falconer's theory.

It appears that standardizing the size of the litter should eliminate the effect of growth environment upon later reproduction. According to Revelle and Robison (1973) standardization will also facilitate accurate measures of milking ability assessed by litter weaning weight. The differences in number of pigs born alive are economically important and, if real, may be large enough to warrant such practices as litter standardization to allow increased production immediately through alteration of the environment and permanently through selection (Nelson and Robison, 1976).

Individual pig weaning weight is not dependent on litter size according to McMeekan (1936) nor does litter size exert an influence on rate of gain or weaning weight (Smith and Donald, 1937 and 1939). The relative influence of litter environment in determining rate of gain decreases from birth to 112 days, with the greatest decrease immediately following weaning (Baker <u>et al</u>., 1943). They illustrated the importance of litter environment in determining litter weight decreases of 49 percent at birth to 24 percent at 168 days. Apparently, pig weight at weaning is inversely related to weaned litter size and this relationship is influenced early in the pig's life.

The effect of litter size on milk production appears to be a possible mechanism by which litter size influences weaning weight. Skjervold and Standal (1946) reported that milk production of the sow depends on the number of pigs in the litter. This agrees with the earlier work of Smith and Donald (1937). However, Hammond (1926) pointed out that extremely fertile sows generally have a better milk supply than less productive sows.

Social Rank and Sex

The development of a "teat order" is the most interesting aspect of the early behavior of pigs (Mcbride, 1963). The significance of the teat order seems to be related to quiet and orderly feeding behavior and it is analogous to the social order that develops later. Teat order and social order are probably not directly related; however, both appear to be dependent upon such competitive factors as body weight and behavioral aggressiveness. Wyeth and Mcbride (1964) showed that larger pigs at birth were more successful at obtaining the anterior teats. Anterior teats were shown by Mcbride *et al.* (1965) to produce an advantage in growth (presumably through a more abundant milk supply). Within 24 hours after birth pigs display an aggressiveness in competition for teats. Generally teeth play is an important tool in this competition (Mcbride, 1963). Heavier and more aggressive pigs at birth obtained anterior teats which affected the social rank through influence on their three-week weight (Mcbride *et al.*, 1965). An aggressive, heavy pig at birth apparently has an advantage in establishing itself as a dominant member of the litter early in life.

Social rank is probably the result of such factors as physical conformity, previous experience, sex, genetic factors, environment and the identity of group members (Meese and Eubank, 1973). Fast-growing litters are less variable than slow-growing litters because they are not affected by unfavorable influences; whereas slow-growing litters may respond to stimuli in either a positive or negative direction (Smith and Donald, 1939). Mcbride and James (1964) observed a tendency for heavier pigs at weaning to have higher social rank. The correlations which they observed were generally higher in pens with greater variation in initial weight. This suggests that large differences in weight between pigs may be more decisive in determining social rank than is the weaning weight for each individual pig. Mcbride et al. (1965) concluded that 25 to 30 percent of the variation in social rank was attributable to differences in body weight at the time the social order was established.

The social dominance pattern appears clearly established before weaning and its development is complete by 8 weeks (Mcbride and James, 1964). Three-week weights affect social rank through the influence of birth weight and teat position (Mcbride et al., 1965). However, Lodge and McDonald (1959) showed that three-week weights were more important than birth weights in attempting to increase mean eight-week weaning weights. Mcbride et al. (1965) indicated that social rank has an important effect on eight-week weaning weights and, since social order persists through life, it would be expected to exert a continuing influence on growth.

Beilharz and Cox (1967) state that, on the average, males were dominant to females. The work of Meese and Eubank (1973) showed no significant correlation between social rank and sex. Contrary to the work of Beilharz and Cox (1967), they showed a slight excess of females in the three top social ranks. Males tended to be more aggressive in the studies of Mcbride and James (1964) and Meese and Eubank (1973); however, the most aggressive was not always the most dominant pig. Social orders of eight-week old pigs appeared less stable in groups of males than in female groups (Mcbride and James, 1964). Their work also shows weight differences between pigs to be more decisive in determining social rank than actual pig weight. Indications are that females may be able to physically adjust to larger weight differences allowing them a slight advantage in the social order. Although females may have a slight advantage in social order, Fredeen and Plank (1963) showed little variation accounted for in measures of growth rate between sexes.

Mothering Phase Factors

While the sire influences his offspring only through the genes he transmits, the dam affects her offspring through the environment provided as well as through the genes transmitted. The environmental effects of the dam are referred to as maternal influences. The uterine and postnatal environment as determined by milk production and mothering ability are factors which influence the contribution of the female through environment. Maternal performance should be considered in two parts: namely the reproductive phase and the mothering phase. Total milk production and age of lactating dam probably exhibit more influence on the mothering phase than other factors which could be considered.

If it is correct to assume that milk production is a major component of mothering ability influence, then milk production measures are useful in studying mothering phase maternal effects. Donald (1939) showed sow's milk production to be a most important factor in the growth of the nursing pig. Lodge and McDonald (1959) found that 77 percent of the between litter variance for eight-week weaning weight was due to creep consumption and 10 percent of the variance was due to differences in milk consumption. At 3 weeks of age, milk production accounted for 15 percent of the between litter variance. Milk production appears inadequate to explain differences between litter weight means where creep feed is available (Robison, 1972).

Skjervold and Standal (1964) also pointed out that individual pig weight at 3 weeks and gain from 3 to 5 weeks seem to depend little on milking and nursing ability of the sow. Ahlschwede and Robison (1971) showed maternal effects to be two or three times as large as genetic effects during the sixth week. After the eighth week genetic effects were greater than maternal influence according to Cox and Willham (1962). Hetzer (1942) found that the part played by permanent mothering and nursing ability tended to increase up to weaning, but decreased with increasing age of the pigs. Ahlschewede and Robison (1971), Robison (1972), Lodge and McDonald (1959) and Barber (1955) offer a reasonable explanation for these results. They state that pigs nursing sows that are producing little milk are driven to creep feed sooner than pigs nursing heavy milkers. The early supplemental feeding more than compensates for the additional milk. They concluded that pigs receiving only limited supplies of sow's milk may be encouraged to start eating creep feed at an earlier age and eat more feed during the last 5 weeks of lactation. The excess feed consumed then compensates for the lower milk intake.

The data of Donald (1939) suggests that when competition exists initial weight is important in determining final weight. Recently, the finding of Leece (1971) agrees with this observation. Using the "autosow" to rear pigs artifically Leece (1971) showed similar growth rate and feed efficiency for pigs weighing less than 1000 grams as compared to pigs weighing over 1000 grams. Thus, much of the difference in growth rate of different size pigs (at birth) appears to be due to competition and how well the mother sow is equipped for this competition, rather than their genetic ability for growth.

The number of pigs born increases with the increasing age of the sow (McMeekan, 1936). His work also showed no significant difference in the litter weaning weights of second, third, fourth, fifth, and sixth litter sows. Nordskog et al. (1944) reported that pigs from "sow mothers" were 4 pounds heavier at eight-week weaning than pigs reared by gilts. This advantage was shown to be maintained to approximately 168 days of age.

II. REVIEW OF PREVIOUS CROSSFOSTERING RESEARCH

The relative importance of sow and litter in determining the variation of the weight of nursing pigs has been investigated by means of paired litters farrowed at approximately the same time and divided into two groups of pigs. One group was left on its mother and the other transferred to the second sow in exchange for a similar group (Donald, 1939). Results from these litters indicate that an equal and significant amount of variation in the growth of pigs up to 3 weeks was found between litters as reared, suggesting that crossfostered pigs perform as well as pigs nursing their own mother. The weight of the pigs at 8 weeks was found to be influenced by the sow, but when adjusted for variation in weight at three weeks, showed the effect of litter as born no longer significant. Weight at the time of exchange showed an affect on 3 and 8-week weights. Fostered pigs did as well as pigs remaining with their genetic mother when given an equal chance. Donald (1939) concluded that the most important factor in the growth of nursing pigs is the milk production of sow.

Further work using foster mothers was not reported until that accomplished by Cox and Willham (1962). Their work was not designed to determine the value of foster sows, but rather to demonstrate the magnitude of maternal effects of swine. Their data on body weight at 154 days of age from 33 litters indicates that postnatal factors including mothering ability and pen environment was maximized at 42 days. Indications were that fostering, by itself, did not influence weight. However, Cox and Willham (1962) reported a crossfoster design as extremely useful in pigs as an approach to maternally influenced problems.

CHAPTER III

EXPERIMENTAL PROCEDURE

Data for this study were collected from January 1977 to June 1978 from the swine herd at Ames Plantation, Grand Junction, Tennessee.

I. EXPERIMENTAL ANIMALS

Approximately 24 gilts and sows were bred to farrow in each of six farrowings during 1977 in the confinement unit (system three) at Ames Plantation. A total of 144 litters were farrowed and they produced 1,413 pig births.

II. MATERIALS

The confinement unit included a 24-crate farrowing barn, 12-pen nursery and two finishing barns which had 12 pens each. Sows were bred and gestated in pasture lots.

The 24-crate farrowing barn was an environment controlled building. Each crate was 5 x 7 feet equipped with a cup waterer and feed bowl. Each crate had electrically heated concrete for pig comfort. The anterior 12 inches of each crate was equipped with one foot of one inch flat steel slats. The rear slat section of each crate was 30 inches in width. There were six types of slat material employed behind the sows consisting of aluminum, Behlen stainless steel, expanded metal, plastic, round rods and steel. These materials were randomly distributed throughout the barn.

The 12-pen nursery was a totally enclosed environment controlled unit with supplemental heat. One-half of the 8 x 8 foot pens were equipped with Behlen stainless steel slats and six of the pens had five inch concrete slats with one inch spacings. Water was provided by cut-type waterers and round feeders were centrally located in each pen.

Two modified open front curtain-sided barns were utilized to finish the hogs for market. Each building, 26 x 102 feet, had 12 pens measuring 8 x 20 feet equipped with eight-foot slats, a four-hole Smidley fenceline feeder, a cup-type waterer and a sprinkler for summer cooling. Finishing barn one was equipped with five inch concrete, wood and wood covered (a plastic material) slats, and finishing barn two had five inch concrete, plastic and aluminum slats with one inch slots. The slats were randomly distributed in each barn, respectively.

III. FEEDING AND MANAGEMENT

All pigs were identified (ear notched) and weighed to one-tenth pound at birth. Iron shots were administered, needle teeth clipped and male pigs castrated on day one. The pigs were given access to an 18 percent protein pelleted creep feed at approximately 10 days of age. Nursing sows were fed a 14 percent fortified protein ration (Table 1) at the rate of one pound of feed for each suckling pig plus 3 to 5 pounds additional for the sow.

The pigs were weaned at about 5 weeks of age, weighed and placed in the nursery. The heaviest one-third of the pigs by weight

TABLE 1

COMPOSITION OF RATIONS

	Breeding and Gestation	Lactation	Pig Nursery 15-35 lbs.	Pig Nursery 35-80 lbs.	Finish
Corn, lbs.	1575	1250	1220	1545	1640
SBM, lbs.	325	350	480	380	310
Alfalfa Meal, lbs.	----	100	----	----	----
Wheat bran, lbs.	----	200	----	----	----
Dried Whey, lbs.	----	----	200	----	----
Pre-mix, * lbs.	100	100	100	75	50
Total	2000	2000	2000	2000	2000

*Pre-mix contains vitamins, minerals and varying levels of antibiotic.

were randomly assigned to four nursing pens, the middle third to four pens and the light-weight one-third to the remaining four pens. The pigs were subsequently moved as a "pen of pigs" to the finishing barn. During the nursery period, pigs were fed a 16 percent protein ration (Table 1). After approximately 50 days in the nursery the pigs were weighed and transferred to one of the two finishing barns. Throughout the finishing phase pigs were fed a 16 percent protein ration (Table 1).

IV. CROSSFOSTERING

The farrowing period generally extends no longer than 2 weeks. At each farrowing the herdsman attempted to crossfoster pigs from 12 litters and the remaining litters were used as controls. Litters of pigs were allotted to crossfostering within 24 hours of birth using the following experimental guidelines:

1. Crossfostered litters must have been born within a 24 hour period.
2. Only two litters of pigs were crossfostered as a group.
3. The total number of pigs in crossfostered litters was divided equally between the two sows. For example, litters of 8 and 12 pigs were assigned 10 to each sow. The lightest one-half of the pigs by weight were placed with one sow and the heaviest half by weight with the other sow.
4. Pig weight groups (small and large groups) were randomly assigned to the sows. Sow breed, weight, condition or other factors were not given consideration in assignment of groups.

5. Sow and gilt litters were not crossfostered. Sow litters were considered to be those which previously had produced one or more litters of pigs.
6. A gilt or sow was in no case assigned more pigs than she had available functioning teats.

The standard Ames Plantation sow and litter rations, feeding practices and general management procedures (as previously mentioned) were employed in caring for the sows and pigs regardless of the experimental treatment.

V. METHODS OF ANALYSIS

The Statistical Analysis System (SAS) developed by Barr and Goodnight (1976) was utilized to determine if differences existed between control and crossfostered litters for various performance traits. The means procedure of SAS was utilized to produce simple descriptive statistics of the variables used to characterize animal performance.

The generalized Linear Models (GLM) procedure was utilized to determine the effect of crossfostering independently of age and breed of dam, breed of sire, sex of pig and season of farrowing. The underlying model that was used to describe the dependent variables was:

Y = u + crossfostered + breed of dam + age of dam +
breed of sire + sex + season of farrowing + error.

The dependent variables (Y) included percentages of live pigs, daily gain to weaning, weaning weight, daily gain in the nursery, final nursery weight, daily gain during finishing, final market weight and days to 230 pounds.

Duncan's multiple range test was utilized for mean separation when differences occurred among means.

Correlation analysis was used to determine the relationship among performance traits. This procedure measures the degree of linear association between two variables and does not imply a cause-effect relationship. A positive correlation suggests that as one variable increases the other increases. A negative correlation implies that as one variable increases the other decreases.

CHAPTER IV

RESULTS AND DISCUSSION

Data from six independent groups of crossbred Duroc, Yorkshire, Hampshire and Landrace pigs formed the basis for this study. The pigs were identified at birth with approximately half of the litters utilized as controls and the remaining half crossfostered. Pigs were weighed at birth, weaning, end of nursery phase and market age. Percentages of live pigs were calculated for each respective weighing.

I. DESCRIPTION OF THE PIGS

Table 2 contains the means and standard deviations for each weigh period and the gains during each respective period for all groups of pigs. Tables 3, 4, 5, 6, 7, and 8 contain the identical information for each individual group of pigs. Table 9 contains information concerning the control pigs and the two classes of crossfostered pigs combined.

Birth to Weaning

The average birth weight was basically the same (P>.05) for each class of pigs.

The percentage of pigs weaned was approximately the same (P>.05) for the control and both classes of crossfostered litters. However, there was considerable variation among the different groups. In group 1, 78 percent of the crossfostered pigs nursing their genetic dams reached weaning as compared to 63 and 61 percent, respectively, for the

TABLE 2

PERFORMANCE MEANS AND STANDARD DEVIATIONS FROM BIRTH TO MARKET FOR CONTROL, CROSSFOSTERED NURSING GENETIC DAM AND CROSSFOSTERED NURSING FOSTER DAM PIGS

		Crossfostered Pigs	
	Control	Genetic Dam	Foster Dam
Birth-weaning:			
No. born alive	732	377	304
No. weaned	566	284	242
Percent weaned	77	75	80
Avg. birth wt., lbs.	3.2 ± .78	3.2 ± .83	3.3 ± .70
Avg. wean wt., lbs.	17.5 ± 6.0b	18.4 ± 5.6a	17.6 ± 5.5ab
ADG to weaning, lbs.	.39± .13	.40± .12	.38± .13
Nursery phase:			
No. alive	546	271	236
Percent alive	75	72	78
Avg. final nursery wt., lbs.	63.2 ± 17.2b	66.0 ± 16.0a	64.5 ± 17.2ab
ADG in nursery, lbs.	.88± .25	.90± .24	.88± .25
Growing-finishing phase:			
No. marketed	539	269	235
Percent marketed	74	71	77
Avg. final market wt., lbs.	219± 20	219± 20	217± 20
ADG in finishing, lbs.	1.58± .21	1.56± .21	1.56± .19
Days to 230 lbs.[1]	201± 22	202± 22	204± 22

Note: Means in the same row superscripted with different letters are different (P<.05).

[1]Standard deviations are extremely high, but days is adjusted to 230 lbs. on all pigs, regardless of their market weight.

TABLE 3

PERFORMANCE MEANS AND STANDARD DEVIATIONS FROM BIRTH TO MARKET FOR CONTROL, CROSSFOSTERED NURSING GENETIC DAM AND CROSSFOSTERED NURSING FOSTER DAM PIGS IN GROUP I

	Control	Crossfostered Pigs	
		Genetic Dam	Foster Dam
Birth-weaning:			
No. born alive	164	37	31
No. weaned	103	29	19
Percent weaned	63b	78a	61b
Avg. birth wt., lbs.	2.6 ± .36	3.2 ± .79	3.2 ± .81
Avg. wean wt., lbs.	13.9 ± 5.5b	15.1 ± 5.1ab	16.2 ± 4.9a
ADG to weaning, lbs.	.33± .14	.32± .11	.34± .12
Nursery phase:			
No. alive	93	26	19
Percent alive	57b	70a	61b
Avg. final nursery wt., lbs.	60.3 ±17.4b	69.8 ±15.5a	65.7 ± .8ab
ADG in nursery, lbs.	.84± .24b	.97± .23	.89± .27ab
Growing-finishing phase:			
No. marketed	90	25	19
Percent marketed	55b	68a	61b
Avg. final market wt., lbs.	212±19b	223±17a	214±17ab
ADG in finishing, lbs.	1.47± .15ab	1.49± .19a	1.44± .13b
Days to 230 lbs.	210±21	205±21	214±21

Note: Means in the same row superscripted with different letters are different (P<.05).

TABLE 4

PERFORMANCE MEANS AND STANDARD DEVIATIONS FROM BIRTH TO MARKET FOR CONTROL, CROSSFOSTERED NURSING GENETIC DAM AND CROSSFOSTERED NURSING FOSTER DAM PIGS IN GROUP 2

		Crossfostered Pigs	
	Control	Genetic Dam	Foster Dam
Birth-weaning:			
No. born alive	130	75	51
No. weaned	92	60	43
Percent weaned	71b	80ab	84a
Avg. birth wt., lbs.	3.3 ± .76	3.2 ± .93	3.3 ± .70
Avg. wean wt., lbs.	22.3 ± 6.8	22.6 ± 6.4	20.7 ± 5.7
ADG to weaning, lbs.	.46 ± .16	.47± .13	.43± .14
Nursery phase:			
No. alive	91	56	42
Percent alive	70b	75b	82a
Avg. final nursery wt., lbs.	72.8 ±16.6ab	74.3 ±14.7a	67.7 ±15.2b
ADG in nursery, lbs.	1.01± .23	1.02± .23	.94± .23
Growing-finishing phase:			
No. marketed	89	56	42
Percent marketed	68c	75b	82a
Avg. final market wt., lbs.	214±21	215±22	210±18
ADG in finishing, lbs.	1.44± .16	1.45± .18	1.44± .14
Days to 230 lbs.	207±21	206±21	210±19

Note: Means in the same row superscripted with different letters are different (P<.05).

TABLE 5

PERFORMANCE MEANS AND STANDARD DEVIATIONS FROM BIRTH TO MARKET FOR CONTROL, CROSSFOSTERED NURSING GENETIC DAM AND CROSSFOSTERED NURSING FOSTER DAM PIGS IN GROUP 3

		Crossfostered Pigs	
	Control	Genetic Dam	Foster Dam
Birth-weaning:			
No. Born alive	120	73	53
No. weaned	93	60	51
Percent weaned	78^{b}	82^{b}	96^{a}
Avg. birth wt., lbs.	3.3 ± .81	3.1 ± .96	3.4 ± .75
Avg. wean wt., lbs.	17.2 ± 5.7^{a}	17.1 ± 4.0	15.0 ± 4.7^{b}
ADG to weaning, lbs.	.40± .13^{a}	.40± .09^{a}	.35± .12^{b}
Nursery phase:			
No. alive	89	58	48
Percent alive	74^{b}	79^{b}	91^{a}
Avg. final nursery wt., lbs.	51.2 ±17.4^{b}	56.2 ±11.2^{a}	50.4 ±14.5^{b}
ADG in nursery, lbs.	.69± .26^{b}	.79± .19^{a}	.71± .24^{b}
Growing-finishing phase:			
No. marketed	89	58	48
Percent marketed	74^{b}	79^{b}	91^{a}
Avg. final market wt., lbs.	221±22	223±17	217±18
ADG in finishing, lbs.	1.72± .18	1.71± .19	1.66± .16
Days to 230 lbs.	194±21	192±19	198±19

Note: Means in the same row superscripted with different letters are different (P<.05).

TABLE 6

PERFORMANCE MEANS AND STANDARD DEVIATIONS FROM BIRTH TO MARKET FOR CONTROL, CROSSFOSTERED NURSING GENETIC DAM AND CROSSFOSTERED NURSING FOSTER DAM PIGS IN GROUP 4

	Control	Crossfostered Pigs	
		Genetic Dam	Foster Dam
Birth-weaning:			
No. born alive	118	42	50
No. weaned	96	32	38
Percent weaned	81	76	76
Avg. birth wt., lbs.	3.4 ± .72	3.7 ± .66	3.5 ± .65
Avg. wean wt., lbs.	17.2 ± 5.2b	21.1 ± 4.9a	20.4 ± 5.5a
ADG to weaning, lbs.	.35± .11b	.42± .11a	.40± .11a
Nursery phase:			
No. alive	95	32	38
Percent alive	81	76	76
Avg. final nursery wt., lbs.	64.8 ±13.6b	72.9 ±14.2a	71.7 ±15.5a
ADG in nursery, lbs.	.97± .20b	1.06± .229	1.05± .23a
Growing-finishing phase:			
No. marketed	93	32	38
Percent marketed	79	76	76
Avg. final market wt., lbs.	231±17	235±14	231±21
ADG in finishing, lbs.	1.77± .19	1.74± .15	1.70± .22
Days to 230 lbs.	185±18	184±14	190±24

Note: Means in the same row superscripted with different letters are different ($P<.05$).

TABLE 7

PERFORMANCE MEANS AND STANDARD DEVIATIONS FROM BIRTH TO MARKET FOR CONTROL, CROSSFOSTERED NURSING GENETIC DAM AND CROSSFOSTERED NURSING FOSTER DAM PIGS IN GROUP 5

		Crossfostered Pigs	
	Control	Genetic Dam	Foster Dam
Birth-weaning:			
No. born alive	128	65	46
No. weaned	115	44	34
Percent weaned	90a	68b	74b
Avg. birth wt., lbs.	3.5 ± .87	3.1 ± .71	3.2 ± .67
Avg. wean wt., lbs.	17.5 ± 4.1	17.6 ± 4.6	16.2 ± 4.5
ADG to weaning, lbs.	.39± .11	.39± .12	.35± .12
Nursery phase:			
No. alive	114	42	33
Percent alive	89a	65c	72b
Avg. final nursery wt., lbs.	61.5 ±12.3	59.8 ±13.4	60.3 ±11.0
ADG in nursery, lbs.	.88± .19	.85± .21	.89± .17
Growing-finishing phase:			
No. marketed	114	40	29
Percent marketed	89a	62b	63b
Avg. final market wt., lbs.	218±18	214±19	213±18
ADG in finishing, lbs.	1.55± .18	1.50± .17	1.50± .15
Days to 230 lbs.	201±21	207±21	208±20

Note: Means in the same row superscripted with different letters are different (P<.05).

TABLE 8

PERFORMANCE MEANS AND STANDARD DEVIATIONS FROM BIRTH TO MARKET FOR CONTROL, CROSSFOSTERED NURSING GENETIC DAM AND CROSSFOSTERED NURSING FOSTER DAM PIGS IN GROUP 6

	Control	Crossfostered Pigs	
		Genetic Dam	Foster Dam
Birth-weaning:			
No. born alive	72	85	73
No. weaned	67	59	57
Percent weaned	93a	69c	78b
Avg. birth wt., lbs.	3.4 ± .77	2.9 ± .69	3.4 ± .67
Avg. wean wt., lbs.	18.0 ±5.2a	16.2 ±4.2b	17.2 ±5.2ab
ADG to weaning, lbs.	.40± .12a	.36± .11b	.38± .14ab
Nursery phase:			
No. alive	66	57	56
Percent alive	92a	67c	77b
Avg. final nursery wt., lbs.	71.8 ±17.7	66.7 ± 17.8	71.1 ±17.1
ADG in nursery, lbs.	.88± .24	.83± .25	.88± .22
Growing-finishing phase:			
No. marketed	64	57	56
Percent marketed	89a	67c	77b
Avg. final market wt., lbs.	218± 22a	211± 19b	215± 19ab
ADG in finishing, lbs.	1.55± .16a	1.48± .16b	1.52± .13ab
Days to 230 lbs.	207± 23a	215± 21b	210± 21ab

Note: Means in the same row superscripted with different letters are different (P<.05).

TABLE 9

PERFORMANCE MEANS AND STANDARD DEVIATIONS FROM BIRTH TO MARKET FOR CONTROL AND CROSSFOSTERED LITTERS

	Control	Crossfostered
Birth-weaning:		
No. born alive	732	681
No. weaned	566	526
Percent weaned	77	77
Avg. birth wt., lbs.	3.18 ± .78	3.24 ± .78
Avg. wean wt., lbs.	17.5 ± 6.0	18.0 ± 5.6
ADG to weaning, lbs.	.39 ± .13	.39 ± .12
Nursery phase:		
No. alive	546	507
Percent alive	75	75
Avg. final nursery wt., lbs.	63.2 ± 17.2b	65.3 ± 16.6a
ADG in nursery, lbs.	.88± .25	.89 ± .24
Growing-finishing phase:		
No. marketed	539	504
Percent marketed	74	74
Avg. final market wt., lbs.	215± 27	213 ± 28
ADG in finishing, lbs.	1.55± .24a	1.53 ± .24b
Days to 230 lbs.	207± 36	212 ± 58

Note: Means in the same row superscripted with different letters are different (P<.05).

control pigs and crossfostered pigs nursing foster sows. Groups 2 and 3 weaned a higher percentage of crossfostered pigs nursing foster dams (84 and 96 percent, respectively). The control litters resulted in 71 and 78 percent weaned pigs and crossfostered pigs nursing genetic dams resulted in 80 and 82 percent weaned pigs for their respective groups. In groups 5 and 6, 90 and 93 percent of the control pigs were weaned compared to 68 and 69 percent of the crossfostered pigs nursing genetic dams, and 74 and 78 percent of the crossfostered pigs nursing foster dams.

Average weaning weight was higher ($P<.05$) for crossfostered pigs nursing their genetic dams than were weaning weights of the controls or pigs nursing foster dams (Table 2, page 22). However, gain from birth to weaning showed no significant differences among the three classes of pigs. Group 4 showed the two classes of crossfostered pigs to be superior to the controls in weaning weight and daily gain to weaning ($P<.05$).

Nursery Phase

The percentage of pigs alive at the end of the nursery phase (of those born alive) was not different ($P>.05$) among the three classes of pigs. However, groups 1, 2, and 3 resulted in more crossfostered pigs leaving the nursery alive ($P<.05$), while groups 4, 5, and 6 had a higher percentage ($P<.05$) of control pigs alive at the end of the nursery phase.

Final nursery weight and average daily gain in the nursery favored crossfostered pigs nursing their genetic dams ($P<.05$).

Crossfostered pigs nursing foster dams had slightly higher final nursery weights (P>.05) than did the control pigs. However, ADG during the nursery phase was not significantly different for the three classes of pigs. In groups 1, 3, and 4 the two classes of crossfostered pigs were superior in both final nursery weight and daily gain during the nursery phase (P<.05). To the contrary, in groups 2 and 6, the control pigs had an advantage in these respective traits (P<.05).

Finishing Phase

There were no essential differences in the percentage of pigs to reach market weight between the control and crossfostered pigs (P>.05). However, considerable variation existed among the groups. Groups 1, 2, and 3 marketed a higher percentage (P<.05) of crossfostered pigs, while groups 4, 5, and 6 marketed a higher percentage (P<.05) of control pigs.

No differences (P>.05) existed among the three classes of pigs for ADG during finishing, final market weight or days to 230 pounds. The control pigs did reach 230 pounds in 201 days compared to 202 and 204 days, respectively, for the crossfostered pigs nursing their genetic dams and crossfostered pigs nursing foster dams. There were numerous differences among the six groups; however, only group 6 showed the control pigs to be superior (P<.05) for all three finishing performance traits measured.

II. RELATIONSHIPS AMONG PERFORMANCE TRAITS MEASURED

Correlation coefficients were calculated among the performance traits measured for all pigs in the study. This value suggests the degree of association that exists between two variables. This procedure allows for the identification of possible effects which earlier traits may exert on succeeding traits. Results for the correlation analysis are found in Table 10.

Birth weight did not show a high relationship with the subsequent performance traits measured. However, birth weight and weaning weight possessed a correlation of .31.

Average daily gain to weaning was highly correlated with weaning weight (.94). Correlation coefficients of .46, .65, .45 and .47 were found between average daily gain to weaning and nursery gain, final nursery weight, gain during the finishing phase and market weight, respectively. Weaning weight was moderately correlated with nursery gain and final market weight (.56 and .50, respectively). Pig weight at the end of the nursery phase and weaning weight had a correlation coefficient of .73. However, weaning weight was not as strongly correlated with nursery gain.

Average daily gain in the nursery and final nursery weight was correlated with final market weight, .64 and .60, respectively. However, each showed only a slight relationship with average daily gain during the finishing period.

Final market weight had a strong negative association (-.86) with days to 230 pounds. Finishing period gain had a -.76 correlation

TABLE 10

CORRELATION COEFFICIENTS AMONG PERFORMANCE TRAITS FOR THE PIGS

	Birth Weight	Gain to Weaning	Wean Weight	Gain in Nursery	Final Nursery Weight	Gain During Finishing	Final Market Weight	Days to 230 pounds
Birth Weight*	1.0000	.2112	.3050	.1858	.2187	.2071	.2352	-.1945
Gain to Weaning		1.0000	.9352	.4518	.6522	.4518	.4686	-.3888
Wean Weight			1.0000	.5597	.7318	.1811	.5005	-.3752
Gain in Nursery				1.0000	.9272	.2172	.6388	-.4881
Final Nursery Weight					1.0000	.1772	.6009	-.4650
Gain During Finishing						1.0000	.8371	-.7585
Final Market Weight							1.0000	-.8610
Days to 230 pounds								1.0000

*All correlations were significant (P<.01).

with days to 230 pounds. Nursery gain and final nursery weight were found to have correlation coefficients of -.49 and -.47, respectively, with days to 230 pounds; thus suggesting that pig performance during the nursery phase may account for considerable variation in days to market.

III. DEFINING PERFORMANCE TRAITS USING SELECTED VARIABLES

Multiple regression analysis was used to illustrate variation in the performance traits measured. Influencing factors were evaluated by fitting models of the independent performance traits and regressing each on the selected variables. The results of this procedure are shown in Table 11.

The r-square model describing birth weight accounts for .12 of the variation. Partial F-values for breed of dam, breed of sire, sex and group were significant (P<.05) in this model.

R-square values for average daily gain to weaning and weaning weight were .13 and .24, respectively. All effects were significant (P<.05) for average daily gain to weaning except sex. Crossfostering and sex were the only effects not accounting for a significant variation in weaning weight (P>.05).

Models predicting variation for nursery gain and final nursery weight accounted for .28 and .29, respectively, of the variation present in these two traits. All effects were significant (P<.05) except crossfostering the pigs.

R-square values of .34, .19 and .13 were found for average daily gain during finishing, final market weight and days to 230 pounds.

TABLE 11

R-SQUARE VALUES AND PARTIAL F RATIOS FOR INDEPENDENT VARIABLES REGRESSED ON PIG PERFORMANCE TRAITS

	Cross-fostering	Breed of Dam	Age of Sow	Breed of Sire	Sex	Group	R^2-Values
Birth Weight*	------	10.65[a]	1.72	16.50[a]	10.05[a]	17.21[a]	.1228
Gain to Weaning**	3.04[a]	3.81[a]	4.96[a]	3.24[a]	0.76	11.33[a]	.1301
Wean weight**	1.77	3.18[a]	8.81[a]	5.28[a]	1.60	27.78[a]	.2426
Gain in Nursery**	0.25	2.72[a]	9.86[a]	12.47[a]	5.02[a]	14.44[a]	.2818
Final Nursery Weight**	0.46	3.98[a]	11.05[a]	12.95[a]	4.08[a]	21.46[a]	.2932
Gain During Finishing**	2.47[b]	1.57	2.68[a]	2.21[b]	92.34[a]	57.92[a]	.3442
Final Market Weight**	1.67	2.94[a]	6.41[a]	6.55[a]	46.01[a]	23.34[a]	.1905
Days to 230 pounds**	3.05[a]	2.74[a]	6.67[a]	3.62[a]	26.14[a]	14.48[a]	.1338

*Model contained variables for breed of dam, age of sow, breed of sire, sex and group.

**Models contained variables for crossfostering, breed of dam, age of sow, breed of sire, sex and group.

[a]All partial F values are significant at the .05 level.

[b]All partial F values are significant at the .10 level.

Breed of dam was not significant in the model for finishing period gain. All other effects were highly significant (P<.05) in this model with the exception of crossfostering which was significant (P<.10). All partial F-values accounted for variation (P<.05) for final market weight with the exception of crossfostering. Days to 230 pounds was explained (P<.05) by all the variables present in the model.

IV. AGE OF SOW EFFECTS ON PIGS FROM CONTROL AND CROSSFOSTERED LITTERS

Least squares means were used to compare the performance traits of control and crossfostered pigs within sow age (number of litters produced) groups. Significant differences between the means were determined by Kramer's adjustment to Duncan's multiple range test. The results of this analysis are contained in Tables 12 and 13.

There were no observed differences (P>.05) between control and crossfostered litters of pigs farrowed from gilts for the traits measured. However, pigs from control litters did show a small insignificant advantage in the traits studied.

Crossfostered litters of pigs from second litter sows were .29 pounds heavier at birth (P<.05) than were the controls. The crossfostered litters of pigs maintained this advantage through weaning (P<.05). However, the control litter pigs had a .06 pounds higher average daily gain (P>.05) in the nursery. This suggests the possibility that crossfostered litters may have been nursing higher milk producing sows and that the pigs from control litters made some compensatory gain in the nursery.

TABLE 12

LEAST SQUARES MEANS FOR AGE OF DAM EFFECTS ON CONTROL AND CROSSFOSTERED PIGS FROM BIRTH TO FINAL NURSERY WEIGHT

	Birth Weight	ADG to Weaning	Weaning Weight	ADG in Nursery	Final Nursery Weight
1st litter gilts					
Controls	2.96 ± .12	.35 ± .03	15.6 ± 1.1	.69 ± .05	52.4 ± 3.2
Crossfostered	3.14 ± .16	.31 ± .03	13.8 ± 1.2	.65 ± .05	48.3 ± 3.6
2nd litter sows					
Controls	2.95 ± .09b	.37 ± .02b	16.4 ± .7b	.89 ± .03	64.1 ± 2.1
Crossfostered	3.24 ± .11a	.45 ± .02a	18.6 ± 1.0a	.83 ± .04	63.7 ± 2.8
3rd litter sows					
Controls	3.27 ± .09a	.41 ± .02	18.4 ± .7	.93 ± .03	68.0 ± 2.0
Crossfostered	3.02 ± .11b	.39 ± .02	17.9 ± 1.0	.94 ± .04	67.0 ± 2.8
4th litter sows					
Controls	3.05 ± .08	.41 ± .02	18.1 ± .6	.94 ± .03b	67.5 ± 1.9b
Crossfostered	3.12 ± .08	.42 ± .02	19.3 ± .6	1.00 ± .03a	72.9 ± 1.9a
5th litter sows					
Controls	3.20 ± .09	.44 ± .02	20.4 ± .7	.95 ± .03	70.9 ± 2.0
Crossfostered	3.29 ± .08	.42 ± .01	19.8 ± .6	.99 ± .03	72.3 ± 1.8
6th litter sows					
Controls	3.53 ± .09a	.47 ± .02a	22.0 ± .7a	1.04 ± .03a	76.8 ± 2.0a
Crossfostered	2.95 ± .08b	.41 ± .02b	19.2 ± .7b	.94 ± .03b	69.3 ± 2.0b
7th litter sows					
Controls	2.97 ± .15	.40 ± .02	17.9 ± 1.0	.86 ± .04	63.3 ± 3.0
Crossfostered	3.10 ± .12	.38 ± .03	17.3 ± 1.1	.92 ± .04	66.2 ± 3.1

Note: Means superscripted with different letters are different ($P<.05$).

TABLE 13

MARKET DATA LEAST SQUARES MEANS FOR AGE OF DAM EFFECTS ON CONTROL AND CROSSFOSTERED PIGS

	ADG in Finishing	Final Market Weight	Days to 230 pounds
1st litter gilts			
Controls	1.46 ± .05	198 ± 6	241 ± 10
Crossfostered	1.46 ± .05	192 ± 6	261 ± 11
2nd litter sows			
Controls	1.58 ± .03	217 ± 4	202 ± 7
Crossfostered	1.63 ± .04	220 ± 5	202 ± 9
3rd litter sows			
Controls	1.57 ± .03	220 ± 3	202 ± 6b
Crossfostered	1.52 ± .04	216 ± 5	223 ± 9a
4th litter sows			
Controls	1.60 ± .03	223 ± 3	193 ± 6
Crossfostered	1.57 ± .03	225 ± 3	196 ± 6
5th litter sows			
Controls	1.62 ± .03	227 ± 4	195 ± 6
Crossfostered	1.58 ± .02	225 ± 3	196 ± 6
6th litter sows			
Controls	1.58 ± .03	227 ± 3a	193 ± 6
Crossfostered	1.55 ± .03	219 ± 3b	202 ± 6
7th litter sows			
Controls	1.64 ± .04	220 ± 5	196 ± 10
Crossfostered	1.56 ± .04	217 ± 5	201 ± 10

Note: Means superscripted with different letters are different (P<.05).

Control pigs produced from third litter sows had an advantage (P<.05) in birth weight; however, this added weight failed to result in a significant advantage in the succeeding traits measured.

Pigs from control and crossfostered litters showed no differences in measured traits through weaning (P>.05) for fourth litter sows. This may imply that crossfostering was equally divided among high and low milk producing sows. Litters of crossfostered pigs had a higher average daily gain of .06 pounds per day (P<.05) in the nursery and were 5.4 pounds heavier (P<.05) at final nursery weight. No differences (P>.05) were observed in the following periods between these groups of pigs.

The pigs produced from fifth and seventh litter sows were extremely close (P>.05) between control and crossfostering for all traits measured. The control pigs were smaller at birth (P>.05), but performed slightly better up to weaning (P>.05). However, the crossfostered pigs made higher daily gains (P>.05) in the nursery and were heavier entering the finishing barn.

The pigs from sixth litter sows showed the most drastic difference (P<.05) in birth weight, weighing 3.53 and 2.95 pounds for control and crossfostered pigs, respectively. The control litter pigs continued their superior performance (P<.05) in all measured traits until the finishing phase.

V. EFFECTS OF BREED DAM ON PIGS FROM CONTROL AND CROSSFOSTERED LITTERS

The effects of breed of dam upon crossfostering was accounted for by examining least squares means between control and crossfostered litters. Since all sows were crossbreeds, the breed of dam was determined to be the breed of her sire. Results for this analysis are presented in Tables 14 and 15.

The control pigs from Duroc sows were superior to crossfostered pigs in average daily gain to weaning ($P<.05$) and weaning weight ($P<.05$). There were no differences ($P>.05$) found in nursery gain or final nursery weight between litter of control and crossfostered pigs from Duroc sows. However, control pigs from Duroc sows did gain faster ($P<.05$) in the finishing barn and went to market earlier at heavier weights ($P<.05$).

There were no differences ($P>.05$) between control and crossfostered litter pigs from Hampshire sows. Crossfostered pigs from Yorkshire sows showed a higher ($P<.05$) average daily gain to weaning, but there were no differences ($P>.05$) in other traits measured.

Litters of crossfostered pigs from Landrace sows had higher birth weights ($P<.05$) than did control pigs (3.44 and 3.26 pounds, respectively). However, no other differences were observed between control and crossfostered litter pigs from Landrace sows. It should be noted there were only 74 pigs in the trial representing Landrace sows.

VI. DIFFERENCES BETWEEN PIGS NURSING GENETIC DAMS AND PIGS NURSING FOSTER DAMS

Least squares means were determined for pigs nursing genetic dams (in control and crossfostered litters) and pigs nursing foster dams. The results of this analysis are shown in Table 16.

TABLE 14

LEAST SQUARES MEANS FOR BREED OF DAM EFFECTS BETWEEN CONTROL AND CROSSFOSTERED PIGS FROM BIRTH TO FINAL NURSERY WEIGHT

	Birth Weight	ADG to Weaning	Weaning Weight	ADG in Nursery	Final Nursery Weight
Duroc*					
Controls	3.23 ± .06	.39 ± .01a	17.5 ± .5a	.87 ± .02	63.2 ± 1.4
Crossfostered	3.16 ± .06	.34 ± .01b	16.1 ± .5b	.84 ± .02	60.9 ± 1.4
Hampshire*					
Controls	3.21 ± .07	.41 ± .01	18.5 ± .5	.90 ± .02	65.9 ± 1.5
Crossfostered	3.21 ± .07	.39 ± .01	18.2 ± .6	.93 ± .02	67.2 ± 1.6
Yorkshire*					
Controls	2.93 ± .07	.37 ± .01b	17.1 ± .6	.88 ± .02	63.1 ± 1.6
Crossfostered	2.90 ± .09	.40 ± .02a	17.9 ± .7	.91 ± .03	66.1 ± 1.9
Landrace*					
Controls	3.26 ± .13b	.42 ± .03	18.5 ±1.1	.96 ± .05	68.5 ± 3.1
Crossfostered	3.44 ± .15a	.44 ± .03	19.1 ±1.1	.90 ± .05	65.8 ± 3.3

*Breed of dam determined by breed of her sire.

Note: Means superscripted with different letters denotes significance ($P<.05$).

TABLE 15

LEAST SQUARES MEANS FOR BREED OF DAM EFFECTS BETWEEN CONTROL AND CROSSFOSTERED PIGS DURING THE FINISHING PERIOD

	ADG in Finishing	Final Market Weight	Days to 230 lbs.
Duroc*			
Controls	1.56 ± .02a	215 ± 2a	208 ± 5b
Crossfostered	1.49 ± .02b	207 ± 2b	223 ± 4b
Hampshire*			
Controls	1.56 ± .02	217 ± 3	210 ± 5
Crossfostered	1.55 ± .02	217 ± 3	214 ± 5
Yorkshire*			
Controls	1.55 ± .02	214 ± 3	211 ± 5
Crossfostered	1.56 ± .03	217 ± 3	208 ± 6
Landrace*			
Controls	1.61 ± .04	227 ± 5	186 ± 10
Crossfostered	1.63 ± .05	224 ± 6	191 ± 10

*Breed of dam determined by breed of her sire.

Note: Means superscripted with different letters denotes significance ($P<.05$).

TABLE 16

LEAST SQUARES MEANS COMPARING PIGS NURSING GENETIC DAMS AND PIGS NURSING FOSTER DAMS

	Pigs Nursing Genetic Dam	Pigs Nursing Foster Dam
Birth-weaning:		
No. born alive	1109	304
No. weaned	850	242
Percent weaned	77	80
Avg. birth wt., lbs.	3.07 ± .05b	3.21 ± .07a
Avg. wean wt., lbs.	18.4 ± .4 a	17.8 ± .5 b
ADG to weaning, lbs.	.41 ± .01a	.39 ± .01b
Nursery phase:		
No. alive	817	236
Percent alive	74	78
Avg. final nursery wt., lbs.	66.2 ± 1.3	65.2 ± 1.6
ADG in nursery, lbs.	.90 ± .02	.89 ± .02
Growing-finishing phase:		
No. marketed	808	235
Percent marketed	73	77
Avg. final market wt., lbs.	218 ± 2	216 ± 3
ADG in finishing, lbs.	1.57 ± .02	1.55 ± .02
Days to 230 lbs.	206 ± 4	210 ± 5

Note: Means superscripted with different letters denotes significance (P<.05).

Pigs nursing foster dams had higher birth weights (P<.05) than did pigs nursing genetic dams. This was due to random allotment of the litters to crossfostering. The pigs nursing genetic dams gained faster (P<.05) and were heavier at weaning (P<.05) than pigs nursing foster dams. There were no other significant differences; however, pigs nursing genetic dams were slightly higher (P>.05) for all performance traits measured.

A higher percentage of crossfostered pigs were alive at weaning, end of the nursery period and at market than were pigs nursing genetic dams. This suggests that crossfostering pigs to achieve more uniformity among litters created an environment with less stress, allowing the pig a better chance for survival.

VII. DIFFERENCES AMONG AND WITHIN LITTERS OF CONTROL AND CROSSFOSTERED PIGS

Variance components were calculated for control and crossfostered litters of pigs to determine the variation between performance traits among and within litters. The results of this analysis are shown in Table 17.

The birth weights of control pigs were less variable among litters (P<.01) than were birth weights of crossfostered litter pigs. The control pigs displayed much greater variation in birth weight within litters (P<.01) than did the crossfostered pigs. This indicates that crossfostering of pigs made for greater uniformity within litters; however, greater differences existed among the litters.

TABLE 17

VARIANCE COMPONENTS AND F-VALUES FOR PERFORMANCE TRAITS AMONG AND WITHIN LITTERS OF CONTROL AND CROSSFOSTERED PIGS

	Control σ^2	Crossfostered σ^2	F-Value
Birth weight			
among	.2691	.3562	1.32**
within	.3235	.1374	2.35**
Daily gain to weaning			
among	.0052	.0043	1.21**
within	.0103	.0093	1.11**
Weaning weight			
among	15.89	11.57	1.37**
within	15.75	14.63	1.08**
Daily gain in nursery			
among	.0260	.0263	1.01**
within	.0274	.0256	1.07**
Nursery weight			
among	135.28	132.58	1.02**
within	123.88	113.14	1.09**
Daily gain during finishing			
among	.0174	.0123	1.41**
within	.0256	.0270	1.05**
Market weight			
among	96.95	84.75	1.14*
within	322.08	311.10	1.04*
Days to 230 pounds			
among	110.69	124.42	1.12*
within	395.19	365.06	1.08*

**$P<.01$.

Crossfostered pigs showed less variation in daily gains to weaning ($P<.01$) than did control pigs. These daily gains (among and within litters) resulted in a more uniform ($P<.01$) group of weaning weights for crossfostered litter pigs.

Control pigs had less variation among litters ($P<.01$) for daily gain in the nursery. The within litter variation for daily gain in the nursery was smaller for crossfostered pigs ($P<.01$). However, final nursery weights were more uniform for the crossfostered pigs ($P<.01$), both among and within litters. The uniformity within litters is logically explained by more uniformity of nursery daily gains and smaller differences in weaning weights. However, uniformity of nursery weights among litters is probably due to the more narrow range of previous weaning weights, rather than the daily gain in the nursery.

Litters of crossfostered pigs showed less variation among litters ($P<.01$) and greater variation within litters ($P<.01$) than did the control pigs in daily finishing gain. Average daily gain in the finishing barn was not the only factor influencing final market weight as indicated by the greater uniformity of crossfostered pigs ($P<.01$) within and among litters for final market weights.

The variation of crossfostered pigs was larger ($P<.01$) among litters to an adjusted weight of 230 pounds than was variation among control litters. However, within litters the crossfostered pigs were more uniform ($P<.01$) at an adjusted 230 pound market weight.

The results of this analysis suggest that variation is neither created nor destroyed during the growing period of the pig. However, results of this experiment indicate that variation is removed from within crossfostered litters and replaced among the litters in nearly all performance traits measured. The variance components suggest that the performance of smaller pigs in crossfostered litters was superior to smaller pigs in control litters. Variance among litters was larger (P<.01) than variance within litters for control pigs and variance was smaller among litters (P<.01) than variance within litters for crossfostered pigs. This suggests that through weaning, the smaller pigs of crossfostered litters were equal but more uniform in daily gain than were smaller control litter pigs. However, smaller pigs for both crossfostered and control litters did not perform as well in terms of average daily gains as did the larger pigs in this experiment.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Results of this study led to the following conclusions and recommendations:

1. A greater percentage of pigs nursing foster dams reached weaning and subsequently reached market than did pigs nursing genetic dams.
2. Pigs nursing genetic dams tend to grow more rapidly than pigs nursing foster dams, thus producing heavier market weights in fewer days.
3. Crossfostering reduces variation within litters and enlarges variation among litters.
4. Small pigs in crossfostered litters were superior in uniformity of daily gain compared to small pigs from control litters.

5. The smaller pigs (control and crossfostered) did not perform as well as the larger pigs in terms of average daily gain.
6. Correlation analysis labeled average daily gain to weaning as an important factor in determing succeeding performance traits.
7. Multiple regression analysis showed age and breed of dam to be important factors in determining growth of the pigs through the nursery phase.
8. There were no age differences of dam found between control and crossfostered litter pigs.
9. Duroc sows did not respond as well to having their pigs crossfostered as did the Landrace, Yorkshire, and Hampshire sows.
10. The results of this study are, at best, mildly encouraging. It is entirely possible, however, that the experimental design in itself has limited the scope and magnitude of the advantages which may occur under practical sow and litter management. Large commercial pork production units farrowing hundreds of sows yearly may be in position to crossfoster pigs among several litters. This would allow pigs to be more uniform in size and weight than was possible within the design of this experiment. In addition, this study did not allow time to observe the results of gilts selected from crossfostered litters.

CHAPTER V

SUMMARY

Data from 144 crossbred Duroc, Hampshire, Yorkshire and Landrace litters were used to study effects of crossfostering pigs at birth on subsequent performance traits. Analyses were run to determine which variables accounted for the greatest amount of variance in the performance traits measured. In addition, correlations were determined to associate the traits measured. The explanation of differences between control and crossfostered litter pigs within age and breed of dam were determined by least squares means produced from least squares analysis. Then, pigs nursing genetic dams were compared to pigs nursing foster dams by comparison of least squares means. Means and least squares means used in the study were tested for significance using Kramer's adjustment for unequal class numbers.

There were 1,413 pig births from six farrowings at Ames Plantation during 1977 included in this study. The pigs were ear notched, weighed, needle teeth clipped and male pigs castrated on day one. Crossfostering was accomplished within 24 hours of birth. Two randomly selected litters of pigs were crossfostered as a group. The smallest one-half of the pigs by weight were placed with one sow and the largest half by weight with the other sow. The pig weight groups were randomly assigned to the sows. Sow and gilt litters were not crossfostered.

The pigs were given access to an 18 percent protein pelleted creep feed at approximately 10 days of age. Nursing sows are fed 3 to 5 pounds of a 14 percent fortified protein ration plus 1 pound additional for each pig per day.

The pigs were weaned at about 5 weeks of age, weighed and placed in the nursery. The largest one-third of the pigs by weight were randomly assigned to four nursing pens, the middle third to four pens and the light-weight one-third to the remaining four pens. The pigs were subsequently moved as a "pen of pigs" to the finishing barns. Pigs were fed a 16 percent protein ration in the nursery and finishing barns. The pigs were weighed at weaning, upon leaving the nursery and at market weight.

The analysis showed a greater percentage of pigs nursing foster dams reached weaning and subsequently reached market than did pigs nursing genetic dams. However, pigs nursing genetic dams tended to grow faster than pigs nursing foster dams, thus producing heavier market weights in fewer days.

Average daily gain to weaning was shown to be extremely important in determining succeeding performance traits.

Age and breed of dam were determined to be important factors in pig growth up to and through the nursery phase. There were no age differences of dam found between control and crossfostered litter pigs. The pigs produced from Duroc sows did not respond as well to crossfostering as did the pigs from Landrace, Yorkshire and Hampshire dams.

BIBLIOGRAPHY

BIBLIOGRAPHY

Ahlschwede, W. T. and O. W. Robison. 1971. Prenatal and postnatal influences on growth and backfat in swine. J. Anim. Sci. 32:10.

Ahlschwede, W. T. and O. W. Robison. 1971. Maternal effects on weights and backfat of swine. J. Anim. Sci. 33:1206.

Baker, M. L., L. N. Hazel and C. F. Reinmiller. 1943. The relative importance of heredity and environment in the growth of pigs at different ages. J. Anim. Sci. 2:3.

Barber, R. S., R. Braude and K. G. Mitchell. 1955. Studies on milk production of large white pigs. J. Agr. Sci. 46:97.

Beilharz, R. G. and D. F. Cox. 1967. Social dominance in swine. Anim. Behav. 15:117-122.

Cox, D. F. 1962. Description and measurement of rates of early mortality in the pig. Research Bulletin 500, pp. 339-347.

Cox, D. F. and R. L. Willham. 1962. Systematic fostering experiments in swine. J. Anim. Sci. 21:366-368.

Donald, H. P. 1939. The relative importance of sow and litter during the growth of suckling pigs: A comparison of fostered with normally reared pigs. Empire J. Exp. Agr. 7:32.

Fairbanks, B. W., J. L. Krider, and W. E. Carroll. 1945. Effect of diet on gestation-lactation performance of sows. J. Anim. Sci., 4:410-419.

Falconer, D. S. 1955. Symposium on mammalian genetics and reproduction: The genetics of litter size in mice. J. Cell Comp. Physiol. 56:153.

Fredeen, H. T. and R. N. Plank. 1963. Litter size and pre- and post-weaning performance in swine. Can. J. Anim. Sci. 43:135.

Hammond, J. Pig. Breed. Ann. (1926), 6, 73 (cited from Smith and Donald. 1937. J. Agri. Sci. 27:485-502).

Heltzer, H. O. 1942. Differences in mothering and nursing ability of sows as a cause of differences in some weights of their pigs. J. Anim. Sci. 1:70 (Abstract).

Husby, M. (1933). Meld. Norg. Landbrttoisk. 35, 92 (cited from Smith et al., 1939. J. Agri. Sci. 29:274-294).

Krider, J. L. and W. E. Carroll. 1960. Swine Production. Revised 1971, Fourth Edition. McGraw-Hill Book Co., New York.

Lecce, J. G. 1971. Disadvantaged piglets reared artificially. J. Anim. Sci. 32:384.

Lodge, G. A. and I. McDonald. 1959. The relative influence of birth weight, milk consumption and supplementary food consumption upon the growth rates of suckling piglets. Anim. Prod. 1:139.

McBride, G. 1963. The "teat order" and communication in young pigs. Anim. Behav. 11:53-56.

McBride, G. and J. W. James. 1964. Social behavior of domesticated animals. IV. Growing pigs. Anim. Prod. 6:129-139.

McBride, G., J. W. James and G. S. F. Wyeth. 1965. Social behaviour of domestic animals. VII. Variation in weaning weight in pigs. Anim. Prod. 7:67-74.

McMeekan, C. P. 1936. Critical study of important factors in successful pig-keeping. New Zeal. J. Agri. 52:278-289.

Meese, G. B. and R. Ewbank. 1973. The establishment and nature of the dominance hierarchy in the domesticated pig. Anim. Behav. 21:326-334.

Nelson, R. E. and O. W. Robison. 1976. Effects of postnatal maternal environment on reproduction of gilts. J. Anim. Sci. 43:71-77.

Nordskog, A. W., R. E. Comstock and L. M. Winters. 1944. Heredity and environmental factors affecting growth rate in swine. J. Anim. Sci. 3:257.

Revelle, T. J. and O. W. Robison. 1973. An explanation for the low heritability of litter size in swine. J. Anim. Sci. 37:668-675.

Robison, O. W. 1972. The role of maternal effects in animal breeding: V. Maternal effects in swine. J. Anim. Sci. 35:1303.

Skjervold, Harald and Nils Standal. 1964. The influence of prenatal and postnatal pretesting environment on pig testing results: A cross-nursing study on pigs. Acta. Agr. Scand. 14:52.

Smith, A. D. Buchanan and H. P. Donald. 1937. Weaning weight of pigs and litter sampling with reference to litter size. J. Agri. Sci. 27:485-502.

Smith, A. D. Buchanan and H. P. Donald. 1939. Analysis of post-weaning growth in pigs. J. Agri. Sci. 29:274-294.

Winters, L. M., J. N. Cummings and H. A. Stewart. 1947. A study of factors affecting survival from birth to weaning and total weaning weight of the litter in swine. J. Anim. Sci. 6:288.

Wyeth, G. S. F. and G. McBride. 1964. Social behavior of domestic animals. V. A note on suckling behaviour in young pigs. Anim. Prod. 6:245.

VITA

Mike C. Crider, son of Justin Clinton Crider and Joy (Enochs) Crider, was born at Milan, Tennessee on July 7, 1954. He lived in Clarksburg, Tennessee until 18 years of age, when he graduated from Clarksburg High School in 1972. After graduation, he attended the University of Tennessee at Martin. He graduated in June 1976 with the Bachelor of Science degree in Agriculture. He then attended the University of Tennessee at Knoxville, beginning in September 1976, and received his Master of Science degree in Animal Science in December 1978.