EFFECT OF INCREASED FEED INTAKE DURING LATE GESTATION ON THE REPRODUCTIVE PERFORMANCE OF SWINE

By

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CHAPTER I

INTRODUCTION

Postnatal survival rate of pigs is not high, generally ranging from 70 to 90%. It is well established that postnatal viability and survival are influenced by birth weight in pigs (Vestal, 1936; Speer, 1970), in goats (Moulick and Syrstad, 1970) and in sheep (Karam, 1959; Shelton, 1964). Most observers have noted a lower mortality among young which are heavier at birth particularly in litter-bearing species where the heavier littermates have a greater chance of survival. It has been reported by Marthens et al. (1975) that not only is birth weight important per se but that weight for gestatimal age is important for survival and postnatal progress in human infants. Small for gestatimal age newborns have a significantly higher neonatal mortality than the term newborn of normal birth weight. Surviving small for gestatimal age infants exhibit a higher incidence of impairment of neurological functions as well as subsequent intellectual development. Swine exhibit a naturally occurring high incidence of small for gestatimal age newborns. It is not unusual to find littermates differing by as much as 200% in body weight at birth in this species. Dickerson et al. (1971) reported a decrease in brain cell number and size in small for gestatimal age pigs.

Good reproductive performance by the sow is one of the most economically important aspects of swine production. The maternal contribution to variability and birth weight of the offspring is of greater magnitude than the paternal contribution in several species of mammals. Lush et al. (1934) reported that about 47% of the variation in birth weights of pigs is accounted for by maternal environment, whereas sire differences account for only about 7% of the variability.

The majority of the weight gain, protein, calcium, and phosphorus is deposited in the fetus during the last 21 days of pregnancy (Mitchell et al., 1931). Recent studies (Boyd et al., 1978a; Seerley et al., 1978a, 1978b) suggest the possibility of increased energy storage in newborn progeny of sows fed increased energy during late gestation. Also, since birthweight is highly correlated with energy intake of the sow during gestation (Baker et al., 1969; Frobish et al., 1973; Libal and Wahlstrom, 1977), the level of nutrient intake during the last trimester of pregnancy should have a major effect on the pig's chances for survival. Numerous studies have been conducted to determine the influence of nutrition of the gestating sow on reproductive performance. The results of these trials have been varied due to different nutritional regimes, research techniques, number of experimental units and the inherent variability of the reproductive traits being studied.

The purpose of this study was to determine the effects of increasing the level of feed intake during late gestation on litter size, birthweight and survival of pigs and subsequent performance of pigs during the preweaning period.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this review is to investigate the effects of gestation diet on the reproductive performance of the sow. This includes the effect of dietary energy level and source on sow milk constituents, carcass composition and performance of the neonatal pig, the effect of dietary protein, the effect of varying the level and pattern of feed intake, and the effect of protein and energy deprivation.

Influence of Dietary Energy on the Reproductive Performance of the Gestating Sow

Effect of Various Levels and Sources of Energy Fed Throughout Gestation

The nutritional status of the sow during gestation may play an important role in achieving high reproductive performance. Several studies have been conducted to determine the effect of various dietary components on the reproductive performance of the sow. Dean and Tribble (1960) conducted a series of trials to study the effect of gestation energy level on the reproductive performance of sows and gilts. The control group of sows received a level of energy estimated to achieve the desired gestation weight gain recommended by the National Research Council while the other group of sows was fed an energy level of approximately two-thirds that of the control group throughout gestation and lactation. The limit-fed sows and gilts appeared to lose condition during gestation and lactation; however, they consistently farrowed and weaned larger litters than the control sows and gilts. Average weaning weight of pigs, however, favored the control sows.

In three trials conducted as 2X2 factorial arrangements with two protein levels (182 or 364 grams per day) and two energy levels (5,400 or 10,800 Kcal M. E. per day), Frobish et al. (1966) found increased sow gestation weight gain with increased energy in the gestation diet. No effects due to energy level were observed for the number of live pigs farrowed or weaned or for the weight of live pigs at birth and weaning.

In an attempt to determine the feasibility of reducing the energy intake of the gravid sow, Vermedahl et al. (1969) fed two levels of energy during gestation (4.4 or 7.3 Mcal M. E.) and two levels of feed intake during lactation (ad libitum or one percent of body weight plus .36 kg for each pig being nursed) in a 2X2 factorial arrangement of treatments. Reduction in gestation energy level resulted in a decrease in daily gain and condition of the gilt at parturition, litter size at farrowing, birthweight and 21-day weight of the off-spring but energy level during gestation had no significant effect on the number of live pigs at birth. These results are consistent with studies conducted by Elsley et al. (1968) in which litter size was not affected in gilts fed 8.3 or 5.2 Mcal of energy daily during gestation and 20.0 or 13.8 Mcal of energy daily during lactation.

Several experiments were conducted in which the gestation energy level was varied from 2.0 to 9.0 Mcal of metabolizable energy per day (Buitrago et al., 1970; Frobish et al., 1973; Buitrago et al., 1974b;

Libal and Wahlstrom, 1977). The results of these studies indicate that sow weight gain during gestation and pig birthweight increase linearly with increasing energy intake. The number of pigs farrowed, pigs weaned and pig weaning weights did not appear to be consistently affected by gestation energy level. The number of pigs weaned and pig weaning weight were reduced on the 3.0 Mcal energy level (Buitrago et al., 1970) and litter birth weight was decreased in gilts or sows fed the 2.0 Mcal energy level in studies conducted by Buitrago et al. (1974).

Increasing the energy intake of the sow or gilt throughout the entire gestation period appears to increase sow weight gain and individual pig birth weight but seems to have little effect on litter size at birth and weaning, number of live pigs born, or litter and individual pig weight at weaning.

Effects of Various Levels and Sources of Energy Fed at Different Times During the Gestation Period

Ovulation rate and embryonic mortality are two important factors that affect litter size in swine. Several workers have shown that an increase in energy intake prior to breeding improves ovulation rate (Robertson et al., 1951; Christian and Nofziger, 1952; Self, Grummer, and Casida, 1955; Zimmerman et al., 1960; Sorensen, Thomas, and Gossett, 1961) and that a continual high energy intake post-breeding results in a higher embryonic mortality (Robertson et al., 1951; Christian and Nofziger, 1952; Self et al., 1955; Gossett and Sorensen, 1959). Other work has shown that high energy intake affects neither ovulation rate nor embryo survival (Haines, Warnick, and Wallace, 1959; Goode, Warnick and

Wallace, 1960; Clawson et al., 1963; Lodge, Elsley, and MacPherson, 1966a; O'Grady, 1967; Elsley, MacPherson, and McDonald, 1968; Elsley et al., 1969; Vermedahl et al., 1969; Baker et al., 1969; Self et al., 1960; Frobish, Speer, and Hays, 1966; Lodge, 1969).

To determine the effect of varying the pattern of energy intake, Frobish (1970) conducted a trial feeding gilts either 3.2 or 6.0 Mcal metabolizable energy daily from either breeding to parturition or breeding to 76 days post-coitum at which time they received the opposite energy intake to parturition. Energy level or pattern of gestation feeding had no effect on birth or weaning weight of pigs. High energy intake during any portion of the gestation period significantly increased the number of live pigs farrowed and those gilts on a continuous high level of energy intake during gestation weaned significantly more pigs per litter than those on a low energy intake throughout gestation. Gilts receiving 6.0 Mcal daily throughout gestation or for the first two-thirds of gestation had significantly higher gestation gains than those receiving 3.2 Mcal M. E. daily.

Nutritional inadequacy is now thought to be a possible cause of many neonatal deaths and the possibility of an energy deficit for the neonatal pig is of vital concern since this limits growth and survival of the pig. Two studies in which either cornstarch or corn oil was added to the diet of gravid gilts to increase energy during the last five days of gestation (Seerley, et al., 1974; Friend, 1974) resulted in increased birth weights, survival rate of lightweight pigs and pig weight at weaning. However, the short prefarrowing treatment and manipulation of litters at birth makes it difficult to interpret the effect of prefarrowing treatment on pig survival.

In similar studies, Lindemann et al. (1980) compared a control corn-soy ration to the control ration plus 10% added fat fed from 109 days post-coitum to 14 days postpartum. No significant differences were found in the number of live pigs per litter, pig birth weight, or two-week pig weight or survival. These results, however, were not consistent with the results reported by Seerley et al. (1981) in which sows were fed 1.8 kg of 4% fat ration from breeding to day 109 of gestation and 1.8 kg daily of a ration supplemented with either 10% corn oil, 10% animal fat, or a control with no added fat fed from 109 days post-coitum to parturition. These same rations were full-fed throughout lactation. Improved survival and heavier pigs at 21 days of age were found in litters from lipid-fed sows compared to litters from sows fed no supplemental fat.

Okai et al. (1977) conducted a study comparing a low level of intake (2.0 kg daily) of a barley-soybean meal control diet to ad libitum intake of the control diet or diets containing 10% added sucrose or 10% added tallow to increase energy. Gestation treatments were started on day 109 post-coitum and continued until parturition. All sows received a standard 17% protein ration throughout lactation. Ad libitum-fed sows had significantly greater gestation weight gains than limit-fed sows. In addition, survival of pigs with less than 1.0 kg birthweight was significantly higher for sows consuming the control diet ad libitum. Level and source of energy did not affect the number or weight of pigs born or the number of pigs weaned. Pigs from sows receiving sucrose during gestation were significantly heavier at weaning than those from sows on other treatments.

In a 3X2 factorial arrangement of treatments, Boyd et al. (1978b) compared a gestation control ration (5,750 Kcal M. E./day) to the control ration plus tallow or cornstarch to provide 9,300 Kcal M. E. daily. Lactation treatments consisted of a control (3,034 Kcal M. E./kg) or control plus 20% tallow (3,843 Kcal M. E./kg) fed on an ad libitum basis for a 14-day period following parturition. Gestation treatment started on day 100 post-coitum. Reproductive performance of the sow was not affected by gestation treatment. These findings are in agreement with the results of a study by Pond et al. (1981) in which corn starch was added to the gestation diet from day 100 post-coitum to parturition to increase the energy content of the control diet from 6.0 Mcal M. E. daily to 12.0 Mcal M. E. daily. No effect on reproductive performance was observed due to the treatments applied.

In general, increasing energy intake of the gravid sow during late gestation has little effect on most reproductive traits; however, this increase may result in an increased birth and weaning weight of pigs in addition to an improved survival rate for pigs of less than 1.0 kg birth weight.

Influence of Dietary Energy Level and Source On Sow Milk Constituents and Carcass Composition of the Neonatal Pig

The vulnerability of the neonatal pig is well documented. Pigs are born with only approximately 1.5% body fat (Manners and McCrea, 1962) and deplete most of their glycogen reserves within 72 hours after birth (Seerley et al., 1978). The pig must, therefore, rely on early feed intake for survival. It has been postulated that increased fat content of the dam's milk and the content of stored energy in the neonatal pig may play a vital role in the survival of the pig.

The effect of prenatal growth retardation by nutritional stress on total weight and on cellular components or organs and tissues from the stunted progeny were studied by Buitrago et al. (1974a). Gilts were fed 2.2 or 8.0 Mcal of digestible energy per day in isonitrogenous diets throughout gestation. Average birthweight of pigs from sows on the low gestation energy intake was about 70% of that of progeny of sows fed a high gestation energy intake. Progeny of low energy intake dams showed significantly reduced levels of total DNA in the gastrocnemius muscle and reduction in muscular fat, liver glycogen, and blood serum protein. This suggests that a nutritional energy deficit during gestation might involve a reduction in all major nutritional elements for the fetus.

In the absence of information available concerning nutritional status during short, specific periods of gestation as it might affect the composition and viability of the newborn pig, Elliot and Lodge (1977) conducted a study in which sows were fed either .45 or 2.27 kg feed per day from day 100 of gestation until farrowing. Intake of vitamins and minerals were equal for both treatments. This short-term energy stress prior to farrowing had no effect on birth weight, muscle glycogen stores, or body composition of the newborn pigs; however, liver glycogen levels were significantly lower at birth in pigs from energy-stressed dams. This difference disappeared by six hours postpartum.

Glycogen is the major energy reserve of the newborn pig. Several studies of glycogen content of liver and skeletal muscles of pigs have shown an increase in the rate of glycogen deposition in fetal tissues during late gestation and a rapid rate of liver glycogen utilization within the first 12 to 18 hours of extra-uterine life (Mersmann et al., 1972; Stanton and Mueller, 1974; Widdowson and Crabb, 1976). To determine the pattern of glycogen deposition of the fetal pigs, Okai et al. (1978) conducted a study in which sows were fed 2.2 kg per day of a corn-soybean meal diet containing 14% crude protein during gestation. Pigs were surgically removed from sows at days ranging from day 44 to day 113 post-mating. The pattern of glycogen deposition indicated that liver and carcass glycogen levels were low in early gestation and increased rapidly in the last four weeks of gestation.

It has been suggested by Seerley et al. (1978b) that the neonatal pig may utilize certain fatty acids faster during starvation than other fatty acids. This is in agreement with studies reported by Wolfe et al. (1978) in which the oxidation of palmitate in liver homogenates of seven-day-old pigs was faster than the oxidation of stearate or myristate. It has also been reported by Carroll (1958) and Goransson (1965) that short-chain fatty acids appear to be oxidized more completely than long-chained fatty acids in the rat. In general, the ability of the neonatal pig to utilize different sources of fat is poorly understood. It is known that the quantity and quality of sow's milk can be altered by dietary fat supplementation (Willett and Maruyama, 1946; Salmon-Legagneur, 1946), but the benefit of this to the neonatal pig is unknown.

Several studies have been conducted comparing different sources of energy added to the ration of sows during late gestation and lactation. Anderson and Wahlstrom (1970) compared feeding for two levels of gestation gain and three levels of prefarrowing energy in a 2X3 factorial arrangement of treatments with gilts receiving either the standard gestation diet alone or the standard diet supplemented with sucrose or lard from day 104 of gestation until farrowing. Sucrose added 1.0 Mcal M. E.

daily while the supplemental lard added 2.0 Mcal M. E. daily. Gilts fed for lower gestation gain produced pigs with higher blood sugar, higher liver fat and lower liver glycogen. Pigs from gilts on the sucrose treatment had the highest rate of gain from birth to 72 hours while pigs from gilts fed lard had the lowest.

Three studies were conducted to compare the effect of feeding corn oil or corn starch to gestating sows (Seerley et al., 1974; Friend, 1974; Seerley et al., 1978b). In each experiment, either corn oil or corn starch was added to a basal ration for the last five days of gestation. In each study, the feeding of corn oil resulted in an increase in the total carcass lipids and the percent of linoleic acid in the carcass fat of neonatal pig. In addition, the percent fat and percent linoleic acid was increased in the colostrum and milk of the dam. Seerley et al. (1978b) also found an increase in total energy in the colostrum of sows fed corn oil. Carcass moisture, ash, and protein were not affected by dietary treatment.

Seerley et al. (1981) compared the effect of feeding corn oil, animal fat, or no fat to gestating sows for the last five days of gestation and found that pigs from sows fed lipids had more total glycogen in the carcass at birth than pigs from sows fed no fat. Feeding corn oil to the gestating sow had a significant effect on the percentages of fatty acids in the carcasses of neonatal pigs.

The effect of feeding animal fat to gestating sows was investigated earlier by Seerley et al. (1978a) when it was compared to corn starch as an energy source during the last ten days of gestation. Feeding animal fat increased the percent of total lipids and the percent of oleic acid while decreasing the percent of linoleic acid in the colostrum and milk of the sow. Seerley and Poole (1974) estimated that 35% of the fatty acids lost from a fasting newborn pig was oleic, whereas stearic and arachidonic acids were poorly utilized. Animal fat is high in oleic acid content and, therefore, should provide a different ratio of fatty acids to sows and pigs than carbohydrate energy sources.

The effect of feeding tallow to sows during the last two weeks of gestation was studied in four experiments in which tallow was compared to control rations and sucrose or corn starch (Okai et al., 1977, 1978; Boyd et al., 1978a, 1978b). Results of these studies are not in complete aggreement on the effect of supplemental tallow. Okai et al. (1 (1977 and 1978) report no effect of feeding tallow on liver or muscle glycogen content, proximate composition of colostrum, proximate carcass composition, or fatty acid content of the carcass lipids of the newborn pig. In contrast, Boyd et al. (1978a, 1978b) reported that pigs from sows fed tallow had a higher percentage of carcass lipids and a higher level of glycogen per gram of wet liver, however, these were not statistically significant. Boyd et al. (1978b) also reported that supplemental tallow in the gestation diet of sows increased the fat content of the sow's milk compared to the control and corn starch diets.

The energy reserves of the pig is meager at birth and is rapidly depleted without supplemental energy intake. Consequently, survival depends on milk intake soon after birth. The dietary feeding of the sow prior to parturition can affect the composition of colostrum, milk, and to some degree, the pig carcass. Feeding lipids prior to parturition can help to insure adequate energy for pigs prior to birth, slightly increase energy reserves, increase total lipids and changes in the percentages of fatty acids within the colostrum and milk of the sow.

These effects combined may lead to improved survival and subsequent growth of the neonatal pig.

Influence of Dietary Protein on the Reproductive Performance of the Gestating Sow

There appears to be general agreement that corn alone does not contribute sufficient protein of adequate quality to promote satisfactory reproductive performance. Ripple et al. (1965) showed that corn alone during the last half of gestation could not support gestation weight gain during winter months or litter gain the first two weeks of lactation equal to that of gilts fed 16% protein rations.

The deficiencies of corn alone can be corrected by replacing common corn with high-lysine corn, as was shown by Baker et al. (1971), where equal performance was obtained from gilts fed opaque-2 corn or 12, 16, and 20% corn-soybean meal diets. Baker et al. (1970b) demonstrated that corn deficiencies could also be overcome by adding soybean meal to the sow ration during the last five weeks of pregnancy.

In a review, Pond (1973) summarized the results of 12 trials in which protein levels of 5 to 12 percent had been fed to gilts or sows during gestation. The number or weight of pigs at birth was not affected by the sow's protein intake during gestation. In six trials, however, there were effects on litter size or weight at weaning.

Feeding trials (Boaz, 1961; Holden et al., 1968) have demonstrated that protein intakes lower than those recommended in national feeding standards result in satisfactory reproductive performance as measured by litter size and weight and regularity of breeding. Protein levels from near zero to 20% from both plant and animal sources were fed to gestating sows without detrimental effects. Lucas et al. (1966) reported no significant differences in total number of pigs born, number of live pigs born, birthweight, number and weight of pigs weaned and gestation weight gain between sows fed 1.82 kg daily of 8, 12, 16, or 20% protein gestation diets.

In support of these results, Greenhalgh et al. (1977) conducted an extensive series of coordinated trials on the protein requirements of sows. Treatments were arranged in a 4X2 factorial with gestation protein levels of 9, 11, 13, and 15% and lactation protein levels of 13 and 17%. Barley fortified with minerals and vitamins and with varying amounts of equal parts of soybean meal and fish meal were used to obtain the dietary protein levels. The diets were fed to first through fourth parity sows at seven centers at 2 kg/day during gestation and approximately 5.7 kg/day during lactation to produce 468 liters. Gestation diets had no consistent effect on pig numbers or weights at birth or weaning. There was also no direct treatment effect on the time required for rebreeding. The treatment combination of 9% protein during gestation and 13% protein during lactation gave the lowest weight of weaned pigs per litter. The combination of 11% protein during gestation and 13% protein during lactation was concluded to provide the lowest protein intake consistent with satisfactory performance.

In a similar study, Mahan and Mangan (1975) used 9, 13, and 17% protein levels for gestation and 12 or 18% protein during lactation to study the carry over effect of maternal tissue reserves from gestation to lactation. Sows were fed 1.82 kg daily during gestation and ad libitum during lactation. Progeny parturition data were similar for all three gestation diets. This data provides further support to previous data suggesting that gestation protein levels as low as 9% may be adequate.

Protein levels for gestating sows as low as 9% appear to be sufficient to produce adequate litter size and birth weight of pigs in several trials. The major effect of higher protein levels is to increase sow weight gain during pregnancy and improve lactation performance which may improve subsequent performance of pigs.

The Effect of Varying Level and Pattern of Feeding on the Reproductive Performance of Sows

To assess the effect of both prebreeding and late gestation level of feeding Mayrose et al. (1966) conducted a study in a 2X2 factorial arrangement of treatments with sows receiving either 2.72 or 1.82 kg of feed daily from 14 days prebreeding to 21 days postbreeding and either 2.72 or 1.82 kg of feed daily from 84 days postbreeding to farrowing. All animals were fed the low level of feed from day 21 through day 83 of gestation. Increasing sow intake at breeding significantly increased pig birth weight whereas increasing sow intake during the last one-third of pregnancy significantly increased sow weight but had no effect on the birth weight of pigs. Sows with a high intake at both breeding and during late gestation farrowed fewer pigs per litter.

Elsley (1968) discussed the influence of feeding level on the performance of pregnant sows. Sows fed 3.18, 2.39, or 1.59 kg of feed daily throughout gestation and 6.14 or 4.32 kg of feed daily throughout lactation increased body weight linearly as intake increased. Birthweight of pigs also increased linearly with increasing gestation intake which in turn led to higher weaning weights for pigs from sows on a high level of intake. Level of feed intake had no effect in the number of pigs born.

Two studies were conducted comparing two protein levels and three feeding patterns in a 2X3 factorial arrangement of treatments (Pike and Boaz, 1969; Pike, 1970). The feeding patterns consisted of feeding 3.6 kg per day from 0-49 days postbreeding, 2.7 kg from 49 to 63 days, and 1.8 kg of feed per day from 63 to 112 days postbreeding or increasing the feed intake from 1.8 kg to 3.6 kg daily during these same three periods of feeding a control of 2.7 kg daily throughout gestation. Protein levels were 19.5 and 10.5 percent. Sows were treated alike during lactation. Fertility and parturition results were unaffected by treatment. At three weeks of age, the size and weight of litters was significantly higher for sows on the high protein levels. In addition, sows on the high protein level weaned significantly more pigs and gained significantly more weight during pregnancy than sows on the low protein diets. Sows on the low to high pattern of feeding gained significantly more weight during gestation and had significantly heavier litters at birth than sows on the high to low pattern of feeding. When the treatments were repeated through the third pregnancy, nitrogen retention was higher for sows fed the high protein level. Intrauterine nitrogen deposition was not affected by treatment, however, extrauterine nitrogen deposition was significantly higher in sows fed the high protein level. Extrauterine nitrogen deposition appeared to enhance subsequent lactation performance. Protein utilization seems to be more efficient in late pregnancy suggesting that feeding higher levels of protein in late pregnancy should lead to greater efficiency over the whole pregnancy provided energy intake is sufficient.

No differences in litter performances were reported in two other studies in which sows received a constant daily feed intake of 2.1 or 1.8 kg or the same total amount of feed during gestation but in either a high-low or low-high feeding pattern (Solomon-Legagner, 1962; Adam, 1973).

Five other studies have been conducted all of which tend to support the contention that level and pattern of feeding during pregnancy does not influence the number of pigs farrowed or raised, but that it may influence birth weight and postnatal growth rate. Lodge et al. (1966a and 1966b) fed 1.36 or 2.72 kg daily to sows during gestation and compared their performance with a third group that were fed 1.36 kg daily during the first 2/3 and 2.72 kg daily during the remainder of pregnancy. Gilts were started on treatment at first breeding and continued through three successive gestation periods. During lactation gilts were fed 1.82 kg plus .36 kg per nursing pig. Gestation treatment had a significant effect on birth weight and three-week pig weight, but pig weights were similar at eight weeks of age. Significant sow gestation weight changes were found between treatments but showed no relation to litter weight at birth. There were no significant treatment effects on number of pigs farrowed or weaned in a similar study reported by O'Grady (1967). Feed intakes during pregnancy were 1.36 or 2.72 kg daily or 3.63 kg fed daily during the first and last 28-day period with 1.82 kg fed daily during mid gestation. During a five-week lactation period, gilts were fed 1.82 kg of feed plus .45 kg per nursing pig. Total energy intake during pregnancy had a significant effect on litter weight at birth and at weaning but pattern of energy intake did not affect birth or weaning weights.

In similar studies, Meade et al. (1966) fed gilts during the first and second 28-day periods and during the last half of gestation: 1.36, 1.82, and 2.27 kg; 1.82, 2.27, and 2.72 kg or 2.72 kilograms continuously throughout gestation while Cromwell et al. (1980) fed gilts 1.82 kg daily throughout pregnancy or 1.45 kg for the first 90 days followed by 3.27 kg daily to farrowing. Hillyer (1980) fed sows 2.4 kg daily throughout gestation or 2.4 kg from breeding to 90 days followed by 3.4 kg from 90 days to farrowing. Live pigs farrowed, birth and weaning weights and number of pigs weaned were not different among patterns of feeding.

Two studies were conducted to determine the effect of pattern of feeding on the survival and development of embryos in early pregnancy. Heap et al. (1967) fed 1.36, 2.72, or 4.09 kg of meal to sows daily from the day following service until slaughter 28 days later. No relationship was found between the weight of sow at service and the number of corpora lutea or between number of compora lutea and number of normal embryos. Treatment did not affect the number of normal embryos, survival rate, weight, or crown-rump length of embryos. Shultz et al. (1966), however, found a decrease in embryo survival in gilts fed 1.81 kg daily compared to gilts receiving 3.63 kg daily from one estrus cycle before mating to slaughter at 25 days post-coitum.

Effect of Protein or Energy Deprivation on the Reproductive Performance of Gestating Sows

Birth and weaning weights can be reduced by severe feed restriction during gestation (Clauson et al., 1963; Baker et al., 1969; Frobish et al., 1973; Libal and Wahlstrom, 1977). Gilts fed 1.36 or 2.72 kg daily containing .14 or .54 kg protein were used to demonstrate that a low level of intake during gestation reduced birth weight but was, however, adequate for reproduction and apparently did not hinder lactation performance as indicated by equal weaning weights among treatments (Clawson et al., 1963).

In two studies utilizing protein-free diets fed to gilts during various segments of the gestation period (Pond et al., 1968, 1969), it was demonstrated that the pregnant gilt is able to use body reserves of protein and amino acids to meet the needs of the fetus for survival. However, the duration of protein deprivation has an important bearing on the long-term effects of progeny development.

The effects of restricted feed intake during gestation was reported by Baker et al. (1969). Gilts were fed .9, 1.4, 1.9, 2.4, or 3.0 kg/day of a diet designed to be adequate when fed at 1.9 kg/day. Gilts received this diet ad libitum during the three-week lactation period. Restricted intake resulted in reduced farrowing percentage and birth and weaning weight, however, the number of pigs farrowed or weaned was not affected.

Many factors affect the birth and weaning weight of pigs, including seasonal, climatic, and housing conditions as well as age and weight of the dam. Lodge and McDonald (1959) reported that at three weeks of age, birth weight and milk consumption accounted for only 6 and 15 percent of the between litter variance in pigs.

In general, the energy and protein nutrition of the gestating sow has a somewhat varied effect upon the reproductive traits, such as litter size and weight, pig weight and survival and rebreeding ability of the sow. Only during severe deficiency of either class of nutrients is birth weight reduced and only in the case of energy restrictions does litter size appear to be adversely affected. Milk production can be depressed by a deficiency of either protein or energy. The sow appears to be able to buffer the offspring against nutritional energy and protein deficiency by drawing on her own reserves to allow fetal survival. High levels of energy fed to the sow during gestation appear to increase sow weight gain during pregnancy and increase sow weight loss during lactation as well as increase pig birth weight. High levels of protein fed during gestation seem to have little effect on litter size or weight but may improve lactation performance. Varied response is obtained to feeding extra energy and protein at different times during the gestation period.

In a summary of 2,346 farrowings in five herds, the coefficients of variation were 27% for total and live pigs farrowed, and 32% for pigs weaned (Hays et al., 1969). With this high degree of variation within the reproductive traits, long-term studies involving large numbers of animals, a variety of approaches and the combined efforts of researchers will be required to assess the full impact of maternal nutrition during pregnancy on the growth and development of progeny.

CHAPTER III

MATERIALS AND METHODS

Experimental Design

Seventy-seven Yorkshire sows and 45 Yorkshire gilts were used in a study to determine the effect of increasing the level of nutrition during late gestation on subsequent productivity.

One hundred and twenty-two litters were produced between January 1980 and March 1981; however, only 108 litters had complete records at weaning time. A summary of the number of litters produced for each treatment by parity and farrowing season is presented in Table X (see Appendix). For these analyses, parity is divided into two categories, first parity gilts and all sows with parity greater than one.

Prior to breeding and throughout gestation, gilts and sows were fed a standard 14% crude protein corn-soybean meal ration (Table I). The specific feeding regime for each treatment through the entire gestation period is shown in Table II. Treatment consisted of a control level of feed intake of 1.82 kg per head per day (2.27 kg December - February) and a high level of feed intake of 3.18 kg per head per day (3.63 kg December to February) starting at 90 days of gestation and continuing until farrowing. After farrowing, sows were allowed to consume the 14% protein diet on an ad libitum basis throughout lactation. Creep feed (Table III) was provided to pigs at three weeks of age and continued

TABLE I

GESTATION-LACTATION DIETS FOR DEVELOPING GILTS AND SOWS

Ingredients	International Feed Number	Percents Composition (as fed basis)
Corn	4-02-935	81.11
Soybean Meal (44%)	5-04-604	15.48
Calcium Carbonate		1.06
Dicalcium Phosphate		1.60
Vitamin-trace mineral premix[a]		0.25
Salt		0.40
CTC 50		0.10
Calculated analysis		
Crude Protein (N X 6.25)		13.95
Calcium		0.84
Phosphorus		0.62
Metabolizable energy (Mcal/kg)		3.18

[a]Vitamin-trace mineral premix supplied 1,760 mg riboflavin; 8,800 mg pantothenic acid; 8,800 mg niacin; 8.8 mg Vitamin B_{12}; 176,000 mg choline chloride; 1,760,000 I.U. Vitamin A; 176,000 I.U. Vitamin D_3; 4,400 I.U. Vitamin E; 440 mg menadione dimethyl-primidinal bisulfite; 39.6 mg selenium; 299.2 mg Iodine; 19.8 g Iron; 11 g Manganese; 2.2 g Copper and 39.6 Zinc per kilogram of premix.

TABLE II

FEED INTAKE FOR EACH TREATMENT (KG)

	Treatment[a]			
	1		2	
	Gilt	Sow	Gilt	Sow
Prior to Breeding	2.27	1.82	2.27	1.82
After Breeding (day 1-90)	1.82	1.82	1.82	1.82
90 Days (gestation to farrowing)	1.82	1.82	3.18	3.18

[a]Feed increased .454 additional kilograms during the months of December through February.

TABLE III

CREEP RATION

Ingredient	International Feed Number	Percent Composition (as fed basis)
Ground shell corn	4-02-935	58.45
Ground oats	4-03-309	5.00
Soybean meal	5-04-604	23.03
Whey, dried	4-01-182	10.00
Salt		.25
Defluorinated phosphate		1.28
Calcium carbonate		1.00
Vitamin, TM premia		.75
ASP - 250		.25
Calculated analysis		
Crude Protein		17.21
Calcium		.99
Phosphorus		.63
Lysine		.93
Metabolizable energy (Mcal/kg)		3.11

[a]Vitamin trace mineral premix supplied 1760 mg riboflavin; 8,800 mg pantothenic acid; 8,800 mg Niacin; 8.8 mg Vitamin B_{12}; 176,000 mg Choline Chloride; 1,760,000 I.U. Vitamin A; 176,000 I.U. Vitamin D_3; 4,400 I.U. Vitamin E; 44 mg Menadiane dimethyl-primidinol bisulfite; 39.6 mg Selenium; 299.2 mg Iodine; 19.8 g Iron; 11 g manganese; 2.2 g Copper; and 39.6 g Zinc per kilogram of premix.

until weaning at six weeks of age. After weaning, all sows were returned to the prebreeding level of feed intake (1.82 kg/head/day) and rebred.

Husbandry and Data Collection

Gilts and sows were maintained in dirt lots throughout the breeding and early gestation periods. Pens were equipped with individual feeding stalls such that gilts and sows could be individually hand fed once daily in the morning. Nipple waterers were provided to allow access to water ad libitum. Shelter was provided in each lot in the form of 7.32 X 3.66 m houses equipped with foggers for cooling during periods of high temperature. Straw was provided within the houses for bedding during periods of cold temperature. Gilts and sows were each bred twice by artificial insemination during the estrus period. After breeding all sows and gilts were weighed and an average backfat thickness was determined by ultrasonic probe of the first rib, last rib, and the last lumbar vertebrae. At 90 days of gestation, sows and gilts were randomly allotted to gestation treatment, weighed and average backfat was again determined by ultrasonic probe. At approximately 110 days of gestation, gilts and sows were weighed and moved to a farrowing house and kept in 1.83 by 2.13 meter farrowing crates until 21 days after farrowing. Heat lamps were provided within the farrowing crates to supply supplemental heat to pigs. Sows were weighed within 24 hours after farrowing. Individual pig weights (alive and dead) were taken as soon after farrowing as possible. In addition, pigs were ear notched, needle teeth clipped and given iron shots at this time. Pigs were allowed to nurse free choice and had access to fresh water at all times.

At 21 days postfarrowing, sows and litters were weighed and moved to nursury pens where pigs were allowed access to creep feed and nipple waters ad libitum. Nursury pens were 1.83 m wide by 10.36 m long with concrete floors and shelter provided for both sows and pigs. Foggers were provided for cooling during summer as well as bedding and heat lamps for warmth during winter months. At 42 days postfarrowing, pigs were individually weighed and weaned. Sows were weighed and returned to dirt lots for rebreeding.

Additional measurements included the total and live pigs at birth, 21 days and at weaning; feed consumption of sows from parturition to day 21 of lactation; consumption of creep feed by the baby pigs from three weeks until weaning; and the number of days to the first estrus of the sow after weaning.

Statistical Analysis

The effect of increased nutrition during late gestation on pig weight at birth, 21 days and weaning and on sow performance as measured by litter size at birth, 21 and 42 days, litter weight at birth, 21 and 42 days, sow weight and weight change during gestation and lactation, litter survival and the number of days to first estrus after weaning was analyzed by least squares procedures. The linear model considered was $Yijkl = \mu + Ti + Pj + Fk + TPij + TFik + PFjk + TPFijk + eijkl$ where $Yijkl$ is the observation, μ is a common constant, Ti is the effect of the ith treatment, Pj is the effect of the jth parity, Fk is the effect of the kth farrowing season, $TPij$ is the interaction of the ith treatment and the jth parity, $TFik$ is the interaction of the ith treatment and the kth farrcwing season, $PFjk$ is the interaction of the jth parity and the kth farrowing season, $TPFijk$ is the interaction of the ith treatment and the jth parity and the kth farrowing season and eijkl is the random error specific for each observation. In addition, individual pig and litter weight at birth, 21 and 42 days were analyzed with the above model including litter size at birth as a covariate. Litter weight at 21 and 42 days were also analyzed with the above model including litter size at birth and number of live pigs born as covariates.

All sow performance traits subsequent to 90 days of gestation were analyzed with the above model, including sow weight change from breeding to 90 days gestation as a covariate. Only adjusted means for sow weight at 110 days of gestation, farrowing, 21 days postfarrowing, 42 days postfarrowing, and sow weight change from breeding to weaning are reported because the adjustment for sow weight change from breeding to 90 days of gestation did not affect the results obtained for other sow performance traits.

To determine how the treatments applied may affect the performance of sows in different physical condition, sow weight and backfat thickness at 90 days gestation as well as the interactions of these two traits with the treatments applied were included as covariates in the above model. The only traits in which the results were affected by these adjustments were sow weight at farrowing, sow weight change from 110 days gestation to farrowing, litter birthweight, and the number of live pigs born; therefore, these are the only means reported in which these adjustments were made.

Means reported are least square means and the significant differences between means were determined by a t-test.

CHAPTER IV

RESULTS AND DISCUSSION

Treatment Effects

Gilt and sow weights at the various stages of gestation and lactation as well as sow weight changes are presented in Table IV. Sow weights at breeding, 90 days of gestation, 110 days of gestation, farrowing, 21 days postfarrowing and weaning at 42 days postfarrowing were not significantly different between treatments. Gilts and sows allotted to the high intake treatment showed significantly higher gain ($P<.05$) from breeding to 90-days gestation. Both groups were treated alike during this period. Adjusting for the faster growth rate by covariate analysis did not significantly alter any of the results obtained. Pike and Boaz (1969) and Pike (1970) reported increased sow weight gain with increasing feed intake during late gestation. Elsley (1968) reported a linear increase in sow gestation weight gain as sow gestation feed intake increased from 1.59 to 3.18 kg per sow per day. In this study, the total gestation weight gain was low for both treatments which may account for the absence of a significantly higher gestation weight gain on the high intake treatment.

Sows on the high intake treatment lost significantly more weight ($P<.10$) during the first 21 days of lactation than those on the control diet, however, no difference in weight change from 21 days postfarrowing

TABLE IV

LEAST SQUARE MEANS FOR SOW WEIGHT AND WEIGHT CHANGE FOR EACH TREATMENT

Trait	Control	High Intake
No. Sows	60	62
Sow Weight, kg:		
Breeding	176.6 ± 4.7	170.7 ± 3.7
90-day gestation	197.2 ± 4.8	200.2 ± 3.8
90-day change	20.7 ± 3.5[a]	29.6 ± 2.7[b]
110-day gestation	206.3 ± 5.1	211.4 ± 4.0
Adjusted for 90-day change	208.4 ± 4.9	209.6 ± 3.9
90-110-day change	9.0 ± 2.1	11.1 ± 1.6
Post farrow (within 24 hours)	193.6 ± 4.9	198.6 ± 3.8
Adjusted for 90-day change	195.6 ± 4.7	197.0 ± 3.7
110-day post farrow change	-12.8 ± 1.9	-12.7 ± 1.5
21-day post farrow	185.3 ± 4.8	184.1 ± 3.8
Adjusted for 90-day change	186.7 ± 4.8	183.1 ± 3.8
Post farrow - 21-day change	-8.6 ± 2.5[c]	-14.3 ± 2.0[d]
42-day post farrow (weaning)	189.9 ± 5.2	189.0 ± 3.8
Adjusted for 90-day change	190.3 ± 5.2	188.7 ± 3.9
21-42-day change	4.5 ± 2.5	5.9 ± 1.9
Breeding to weaning change	12.9 ± 4.9	20.0 ± 3.6
Adjusted for 90-day change	14.9 ± 4.5	18.2 ± 3.3

[a,b]Means in the same row differ significantly (P<.05)
[c,d]Means in the same row differ significantly (P<.10)

to 42 days postfarrowing was observed between treatments (P>.65). Overall weight change from breeding to weaning at 42 days postfarrowing was not significantly different between treatments (P>.24).

Greater weight loss during the first 21 days of lactation shown by sows on the high intake treatment is in agreement with results reported by Lodge et al. (1966b) and Meade et al. (1966). Lodge et al. (1966b) and Meade et al. (1966) also reported that no apparent relationship existed between sow lactation weight change and litter weight at 21 days postfarrowing.

The effects of gestation treatment on litter size, litter weight and pig survival are presented in Table V. No significant effect due to treatment was observed for litter size, litter weight, or pig survival at birth, 21 or 42 days postfarrowing although litter size was 0.53 pigs higher at 42 days and survival to 42 days was 9.4% higher for pigs from sows on the high intake treatment. Survival rate from 21 to 42 days postfarrowing was 10.7% higher for pigs from sows on the high intake treatment, however, this was not statistically significant. Adjusting the data for the total number of pigs born or the total number of pigs born and the number of live pigs born by covariate analysis did not affect the observed results.

Several authors have reported that increasing feed intake during late gestation results in no improvement in litter weight at birth or weaning (Solmon-Legagneur, 1962; Meade et al., 1966; Adams, 1973), litter size at birth (Solmon-Legagneur, 1962; Lodge et al., 1966; Meade et al., 1966; and O'Grady, 1967) or litter size at weaning (Meade et al., 1966; and O'Grady, 1967). In contrast, Lodge et al. (1966) and O'Grady (1967) reported increased litter weight at birth and weaning with

TABLE V

LEAST SQUARE MEANS FOR LITTER SIZE, WEIGHT, AND SURVIVAL FOR EACH TREATMENT

Trait	Treatment	
	Control	High Intake
No. Litters	60	62
Litter Size		
Total pigs at birth	10.5 ± .6	10.0 ± .5
Live pigs at birth	9.1 ± .6	8.1 ± .4
Live pigs at 21 days	8.0 ± .6	7.8 ± .5
Live pigs at 42 days (weaning)	6.9 ± .7	7.4 ± .5
Litter weight, kg:		
Birth	13.5 ± .8	13.5 ± .7
Adjusted for total pigs born	13.3 ± .5	13.9 ± .4
21-days	41.7 ± 2.7	42.3 ± 2.1
Adjusted for total pigs born	41.5 ± 2.4	42.8 ± 1.9
Adjusted for total and live pigs born	41.5 ± 2.2	42.8 ± 1.8
42-days (weaning)	78.7 ± 5.4	78.3 ± 3.9
Adjusted for total pigs born	79.0 ± 5.1	79.0 ± 3.6
Adjusted for total and live pigs born	78.7 ± 4.6	78.8 ± 3.3
Pig Survival[a], %		
Birth	87.7 ± 3.2	89.0 ± 2.5
21-days	88.1 ± 4.4	89.8 ± 3.5
42-days (weaning)	75.6 ± 6.0	85.0 ± 4.7
21-42 days	83.8 ± 5.6	94.5 ± 4.4

[a]Survival rate calculated as follows: Birth = number born alive ÷ Total pigs born; 21 days = number of pigs alive at 21 days ÷ number born alive; 42 days = number of pigs alive at 42 days ÷ number born alive; 21-42 days = number of pigs alive at 42 days ÷ number of pigs alive at 21 days.

increased feed intake. The results of this study are in agreement with those reporting no improvement in litter size and weight at birth or weaning for sows receiving increased feed intake during gestation.

Differences Due to Season and Age of Dam

The effects of parity of the dam on weight and weight change and on litter size, litter weight, and pig survival are presented in Tables VI and VII. Sows were significantly heavier than gilts ($P<.0001$) for each of the observed weights during gestation and lactation. No differences between gilts and sows were observed for weight changes between breeding and 90 days gestation, 90 days gestation and farrowing or farrowing and 21 days postfarrowing; however, sows gained more weight ($P<.001$) than gilts from 21 days postfarrowing to 42 days postfarrowing which resulted in sows gaining more weight ($P<.01$) than gilts over the entire gestation-lactation period.

Sows farrowed more pigs at birth ($P<.10$) than gilts which resulted in a higher birth weight ($P<.10$) for litters from sows than litters from gilts. This difference in litter birthweight disappears, however, when birthweight is adjusted for litter size by covariate analysis. No differences between parities were observed for the number of live pigs born, number of live pigs at 21 days, number of live pigs at 42 days, litter weight at 21 and 42 days or survival of pigs at birth, 21 and 42 days. Adjusting the litter weight at 21 and 42 days for the number of total pigs born or the number of total pigs born and the number of live pigs born, by covariate analysis, did not result in significant differences between parities.

Significant farrowing season differences were found in sow feed

TABLE VI

LEAST SQUARE MEANS FOR SOW WEIGHT AND WEIGHT CHANGE FOR EACH PARITY

Trait	Gilt	Sow[a]
No. Dams	45	77
Sow Weight, kg:		
Breeding	157.2 ± 4.8[d]	190.0 ± 3.6[e]
90-day gestation	182.0 ± 5.0[d]	215.5 ± 3.7[e]
90-day change	24.8 ± 3.6	25.4 ± 2.6
110-day gestation	190.6 ± 5.2[d]	227.0 ± 3.9[e]
90-110 day change	8.6 ± 2.1	11.5 ± 1.6
Post farrow (within 24 hours)	177.7 ± 5.0[d]	214.6 ± 3.7[e]
110-day post farrow change	-13.1 ± 1.9	-12.4 ± 1.4
21-day lactation	165.6 ± 5.0[d]	203.8 ± 3.7[e]
Post farrow - 21-day change	-12.2 ± 2.6	-10.8 ± 1.9
42-day lactation (weaning)	164.2 ± 5.4[d]	214.7 ± 3.6[e]
21-42 day change	-.5 ± 2.6[d]	11.0 ± 1.7[e]
Breeding to weaning change	8.1 ± 5.0[b]	24.7 ± 3.4[c]

[a]Parity 2 includes all sows parity greater than one.
[b,c]Means in the same row differ significantly (P<.01).
[d,e]Means in the same row differ significantly (P<.001).

TABLE VII

LEAST SQUARE MEANS FOR LITTER SIZE, WEIGHT,
AND SURVIVAL FOR EACH PARITY

Trait	Gilt	Sow[a]
No. Litters	45	77
Litter Size		
Total pigs at birth	9.6 ± .7[c]	11.0 ± .5[d]
Live pigs at birth	8.5 ± .6	9.5 ± .4
Live pigs at 21 days	7.6 ± .6	8.2 ± .4
Live pigs at 42 days (weaning)	6.6 ± .7	7.7 ± .5
		±
Litter Weight, kg:		
Birth	12.5 ± .9[c]	14.5 ± .6[d]
Adjusted for total pigs born	13.4 ± .5	13.8 ± .3
21 days	40.7 ± 2.7	43.3 ± 2.0
Adjusted for total pigs born	42.2 ± 2.5	42.2 ± 1.8
Adjusted for total and live pigs born	42.1 ± 2.3	42.2 ± 1.7
42 days (weaning)	74.9 ± 5.5	82.2 ± 3.7
Adjusted for total pigs born	77.6 ± 5.2	80.4 ± 3.5
Adjusted for total and live pigs born	77.0 ± 4.8	80.5 ± 3.2
Litter Survival[b], %		
Birth	89.5 ± 3.3	87.2 ± 2.4
21 days	89.6 ± 4.6	88.4 ± 3.4
42 days (weaning)	77.9 ± 6.2	82.8 ± 4.5
21-42 days	85.4 ± 5.8	93.0 ± 4.3

[a]Parity 2 includes all sows parity greater than one.

[b]Survival calculated as follows: birth = number born alive ÷ total pigs born; 21 days = number alive at 21 days ÷ number born alive; 42 days = number alive at 42 days ÷ number born alive; 21-42 days = number alive at 42 days ÷ number alive at 21 days.

[c,d]Means in the same row with different superscripts differ significantly (P<.10).

intake from farrowing to 21 days postfarrowing, creep feed intake from 21 days postfarrowing to weaning at 42 days postfarrowing and litter weight at 21 and 42 days postfarrowing (Table VIII). Sow feed intake was higher in the January - March ($P<.001$) and October - December ($P<.05$) farrowing seasons than in the July - September farrowing season. Sow intake was also higher ($P<.05$) in the January - March farrowing season than in the April - June farrowing season. Creep feed intake was higher during the January - March season ($P<.01$), July - September season ($P<.05$) and the October - December season ($P<.10$) than during the April - June farrowing season.

Litter birthweight was affected by farrowing season (Table VIII) only when birthweight was adjusted, by covariate analysis, for the total number of pigs born per litter. Adjusted birthweight was higher in the January - March ($P<.05$) and the April - June ($P<.01$) farrowing seasons than in the July - September farrowing season. Litter weights at 21 and 42 days postfarrowing were heavier during the April - June and October - December farrowing seasons than during the January - March and July - September farrowing seasons in both the adjusted and unadjusted analysis.

Significant differences were observed in individual pig weight at birth, 21 and 42 days postfarrowing due to treatment by parity by farrowing season interactions (Table IX). Birthweights appear to be higher in litters from both sows and gilts on the high intake treatment during the colder seasons (October - March). Adjusting for the total number of pigs born per litter did not affect the results for pig birth, 21 and 42 day weight.

Environmental sources of variation account for much of the variation observed in the individual sow productivity traits (Lush and Molln,

TABLE VIII

LEAST SQUARE MEANS FOR SOW FEED CONSUMPTION, CREEP FEED CONSUMPTION AND LITTER WEIGHT FOR EACH FARROWING SEASON

Trait	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec
No. Litters	73	16	18	15
Sow Feed Intake[a], kg:	178.6 ± 6.3^{e}	143.4 ± 15.5^{cd}	132.5 ± 11.4^{c}	170.2 ± 13.0^{de}
Creep Feed Intake[b], kg:	16.5 ± 1.3^{d}	7.3 ± 2.9^{c}	15.4 ± 2.1^{d}	15.3 ± 2.9^{cd}
Litter Weight, kg:				
Birth	13.7 ± .5	14.8 ± 1.4	12.2 ± 1.0	13.5 ± 1.1
Adjusted for total pigs born	13.7 ± .3^{d}	14.9 ± .7^{d}	12.4 ± .6^{c}	13.5 ± .6^{cd}
21 days	38.6 ± 1.7^{c}	47.3 ± 4.4^{d}	35.1 ± 3.2^{c}	47.0 ± 3.7^{d}
Adjusted for total pigs born	38.7 ± 1.6^{c}	47.4 ± 4.0^{d}	35.5 ± 2.9^{c}	46.9 ± 3.3^{d}
42 days (weaning)	67.6 ± 3.4^{c}	87.6 ± 8.0^{d}	71.7 ± 6.1^{cd}	87.1 ± 8.0^{d}
Adjusted for total pigs born	68.1 ± 3.2^{c}	87.8 ± 7.5^{d}	72.1 ± 5.7^{cd}	87.8 ± 7.5^{d}

[a] Sow feed consumption from farrowing to 21 days lactation.
[b] Creep feed consumption from 21-42 days post farrowing.
[cde] Means in the same row with different superscripts differ significantly (P<.05).

TABLE IX

LEAST SQUARE MEANS FOR INDIVIDUAL PIG WEIGHT AT BIRTH, TWENTY-ONE DAYS AND FORTY-TWO DAYS FOR EACH TREATMENT, PARITY AND FARROWING SEASON

Trt	Parity	Farrowing Season	Pig Birth Weight (kg)		Pig 21-Day Weight (kg)		Pig 42-Day Weight (kg)	
Control	Gilt	Jan-Mar	1.2	.0	5.1	.1	9.5	.3
Control	Gilt	Apr-Jun	1.5	.1	5.2	.4	8.7	.7
Control	Gilt	Jul-Sept	1.3	.0	4.8	.2	9.9	.5
Control	Gilt	Oct-Dec	1.2	.1	5.1	.3	10.5	.8
High In.	Gilt	Jan-Mar	1.4	.0	4.8	.1	8.3	.3
High In.	Gilt	Apr-Jun	1.4	.1	5.6	.3	11.0	.5
High In.	Gilt	Jul-Sept	1.3	.1	5.5	.2	10.3	.4
High In.	Gilt	Oct-Dec	1.1	.1	5.7	.2	10.0	.5
Control	Sow	Jan-Mar	1.4	.0	5.4	.1	9.8	.2
Control	Sow	Apr-Jun	1.4	.1	5.5	.2	11.0	.3
Control	Sow	Jul-Sept	1.1	.1	4.3	.2	9.9	.5
Control	Sow	Oct-Dec	1.3	.1	5.7	.1	10.8	.5
High In.	Sow	Jan-Mar	1.4	.0	5.7	.1	10.3	.2
High In.	Sow	Apr-Jun	1.5	.1	5.6	.2	10.9	.4
High In.	Sow	Jul-Sept	1.1	.0	4.0	.2	8.8	.4
High In.	Sow	Oct-Dec	1.5	.0	6.1	.2	12.1	.4

1942; Omtvedt et al., 1966). The general trend in this study was for lighter birthweights in litters farrowing in July - September than for litters farrowed in the other three seasons. Weaning weight for litters farrowed in the January - March season were lower than those for litters farrowed in the other three seasons. Litter size at birth and weaning were equal for each season. These results are not in complete agreement with those reported by Johnson and Omtvedt (1973, 1975) in which spring-born litters were found to be heavier at birth and weaning than fall-born litters. Unusually high ambient temperatures during the June, July, and August months may account for some of the differences in this study.

The low feed intake from farrowing to 21 days postfarrowing for sows farrowing during the April - June and July - September farrowing seasons and the low creep feed intake from 21 to 42 days postfarrowing that was apparent for pigs born during the April - June season were not expected as sows were housed within a farrowing unit and not exposed to extremes in temperature during this time.

Sows were heavier than gilts as expected for all weights taken during the reproductive cycle. Smaller litters for first parity gilts at both birth and weaning along with lower death losses at birth and 21 days are generally consistent with reports in the literature (Stewart, 1945a; Omtvedt et al., 1966; Smith and Mclaren, 1967). It should be noted here that for these data, litters from second parity sows and greater were combined to form the second parity in this analysis.

Differences Due to Condition of Dam

The condition of the sow or gilt, prior to the start of treatments, as determined by weight and backfat thickness at 90 days of gestation, was examined by using weight and backfat at 90 days of gestation as a covariate. The condition of the sow or gilt influenced the effect of treatment on the postfarrowing sow weight, sow weight change from 110 days of gestation to farrowing, number of pigs born alive, litter birth weight, and individual pig birth weight. Where significant differential effects due to condition of the sow were observed, plots were made to illustrate these effects. Sow condition did not account for a significant difference in treatment effect for sow weight at 21 or 42 days postfarrowing, sow weight change from farrowing to 21 or 42 days postfarrowing litter size at 21 or 42 days, litter weight at 21 or 42 days, individual pig weight at 21 or 42 days or pig survival at birth, 21 or 42 days.

The effect of the control and the high intake treatments on sow postfarrowing weight was influenced by sow weight and backfat at 90 days of gestation (Figures 1 and 2, respectively). For a given backfat at 90 days of gestation, sow postfarrowing weight increased with increasing sow weight at 90 days of gestation for both treatments. For a given sow weight at 90 days of gestation, the change in sow postfarrowing weight as backfat at 90 days of gestation increased was different ($P<.05$) for each treatment. In sows and gilts on the control treatment, sow postfarrowing weight increased with increasing backfat at 90 days of gestation (Figure 1) while on the high intake treatment, sow postfarrowing weight decreased with increasing backfat at 90 days of gestation (Figure 2). This suggests that increasing the level of intake of sows and gilts during the last one-third of pregnancy may result in the leaner sows at 90 days of gestation gaining more weight from 90 days of gestation to farrowing than sows that are fatter at 90 days of gestation.

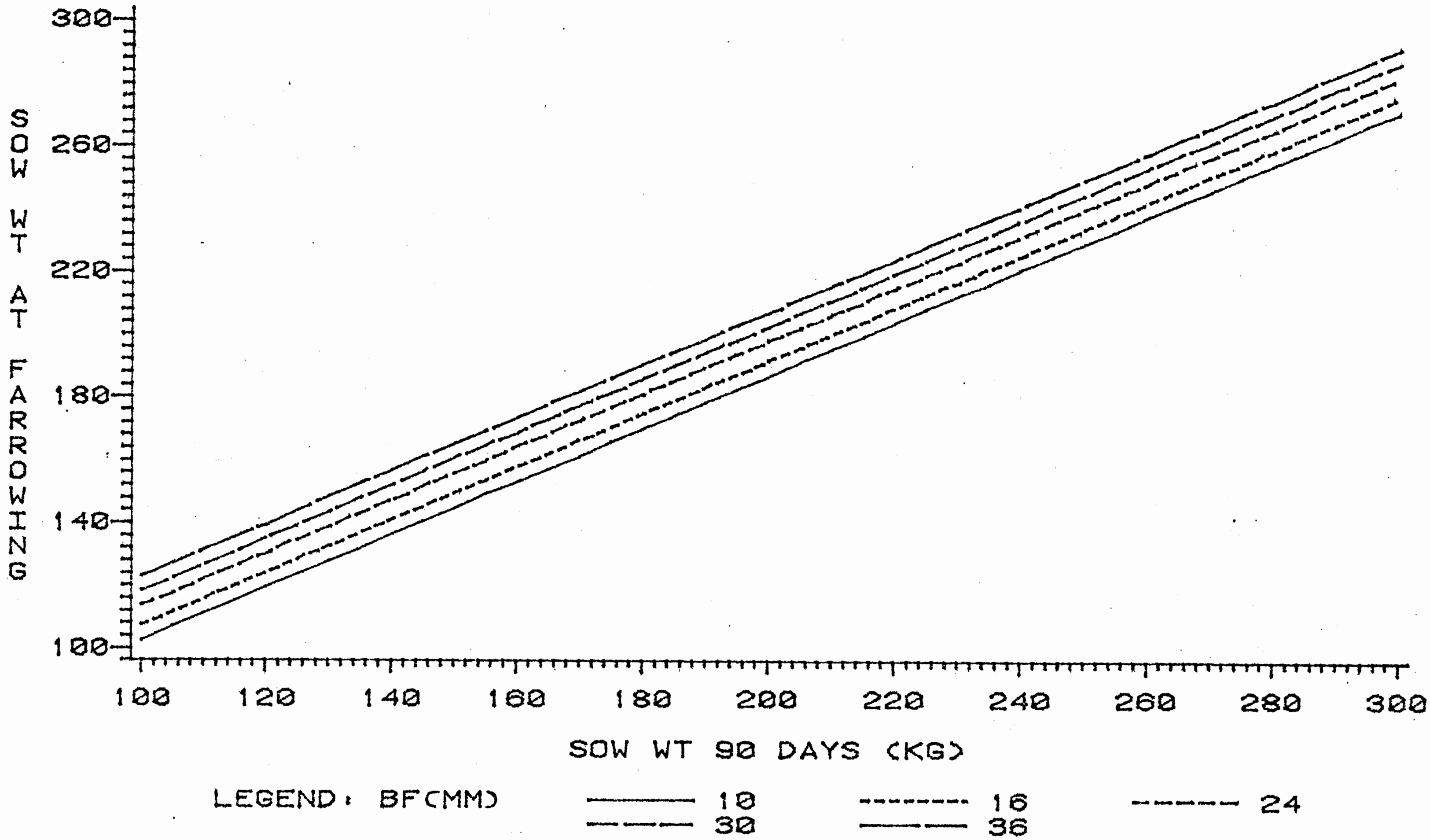

Figure 1. Predicted Sow Weight (kg) at Farrowing for the Control Treatment at Various Sow Weights and Backfats at 90 Days of Gestation

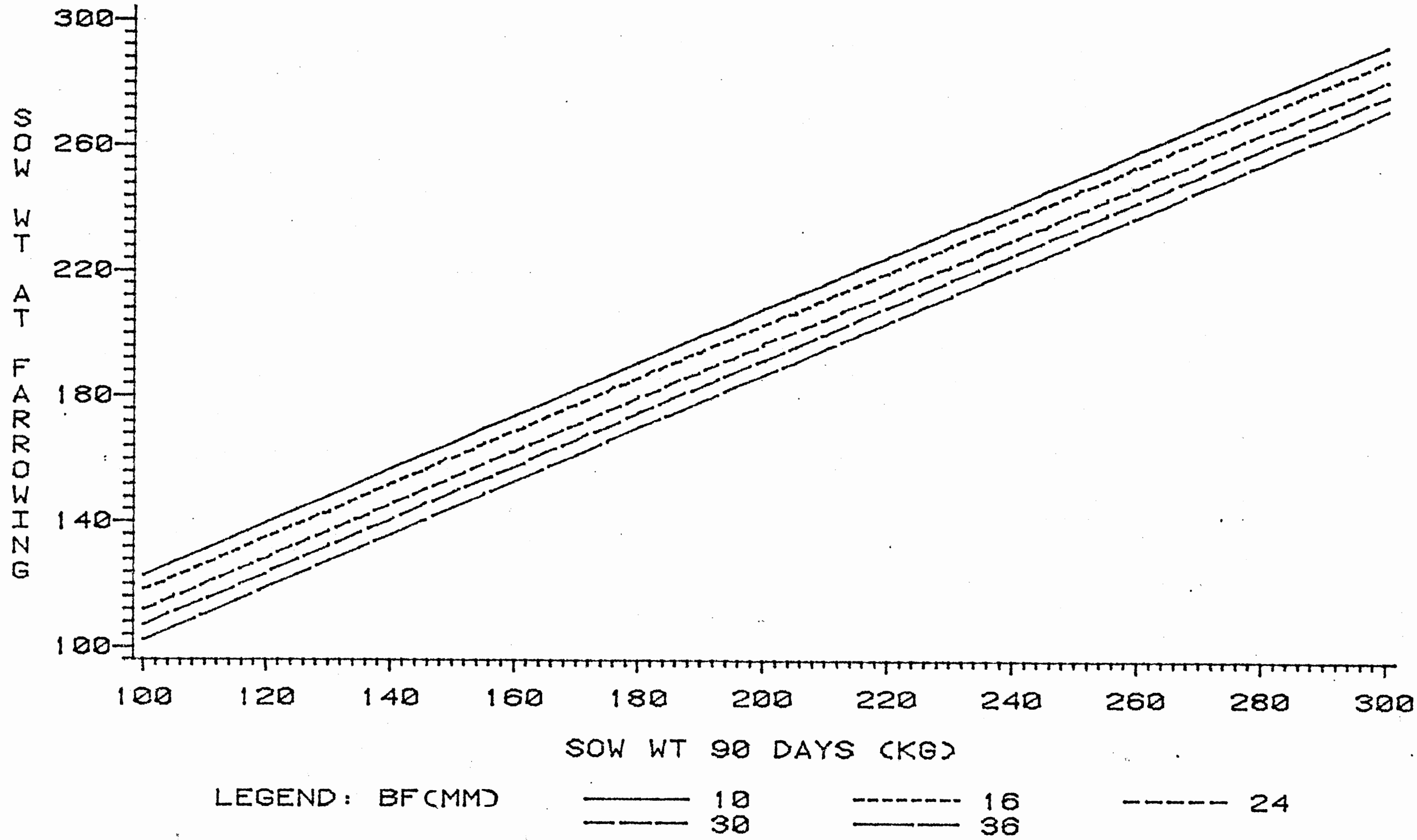

Figure 2. Predicted Sow Weight (kg) at Farrowing for the High Intake Treatment at Various Sow Weights and Backfats at 90 Days of Gestation

For a given backfat at 90 days of gestation, the difference between sow weight at 110 days of gestation and postfarrowing sow weight changed in a similar manner with increasing sow weight at 90 days of gestation for each treatment. For a given sow weight at 90 days of gestation, the difference between 110-day (gestation) weight and postfarrowing weight as backfat at 90 days of gestation increased was different ($P<.05$) for each treatment. On the control treatment, sows and gilts tended to either gain more or lose less weight from 110 days of gestation to farrowing with increasing backfat at 90 days of gestation (Figure 3) while on the high intake treatment sows and gilts tended to either gain less or lose more weight from 110 days of gestation to farrowing with increasing backfat at 90 days of gestation (Figure 4). This suggests that increasing the feed intake of sows and gilts during the last one-third of pregnancy may result in the leaner sows and gilts at 90 days of gestation either gaining more or loosing less weight from 110 days of gestation to farrowing than sows and gilts that are fatter at 90 days of gestation.

The increased weight gain from 90 days of gestation to farrowing (Figure 2) along with the decreased weight loss at farrowing (Figure 4) for leaner sows and gilts fed high levels of intake for the last one-third of pregnancy could result in an increase in body energy reserves at the time of farrowing for those sows and gilts that are leaner at 90 days of gestation.

For a given weight at 90 days of gestation, the effect on the predicted number of live pigs born was similar as backfat at 90 days of gestation increased for each treatment. For a given backfat at 90 days of gestation, the predicted number of live pigs born as sow weight at 90

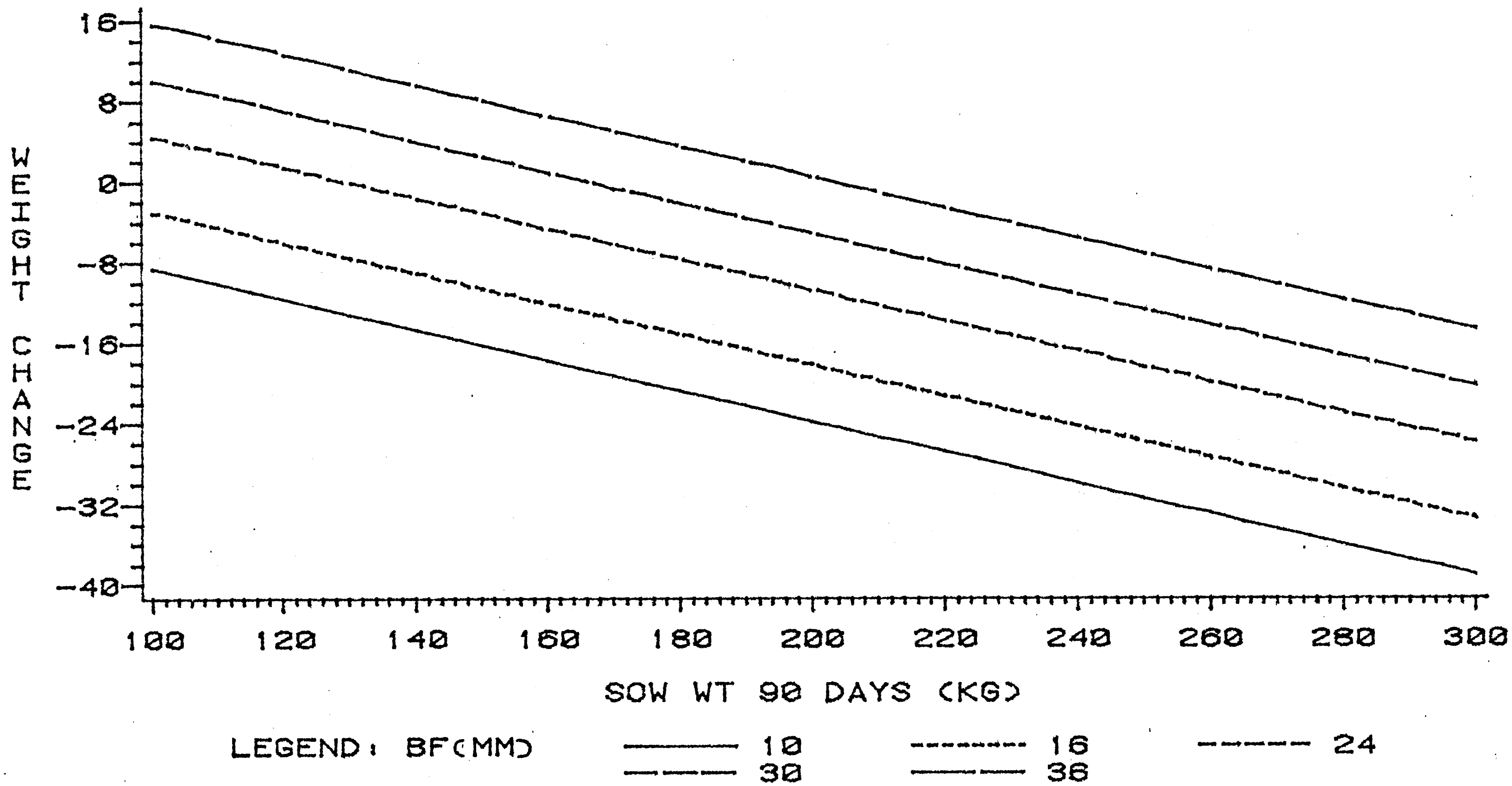

Figure 3. Predicted Sow Weight Change (kg) from 110 Days of Gestation to Farrowing, for the Control Treatment at Various Sow Weights and Backfats at 90 Days of Gestation

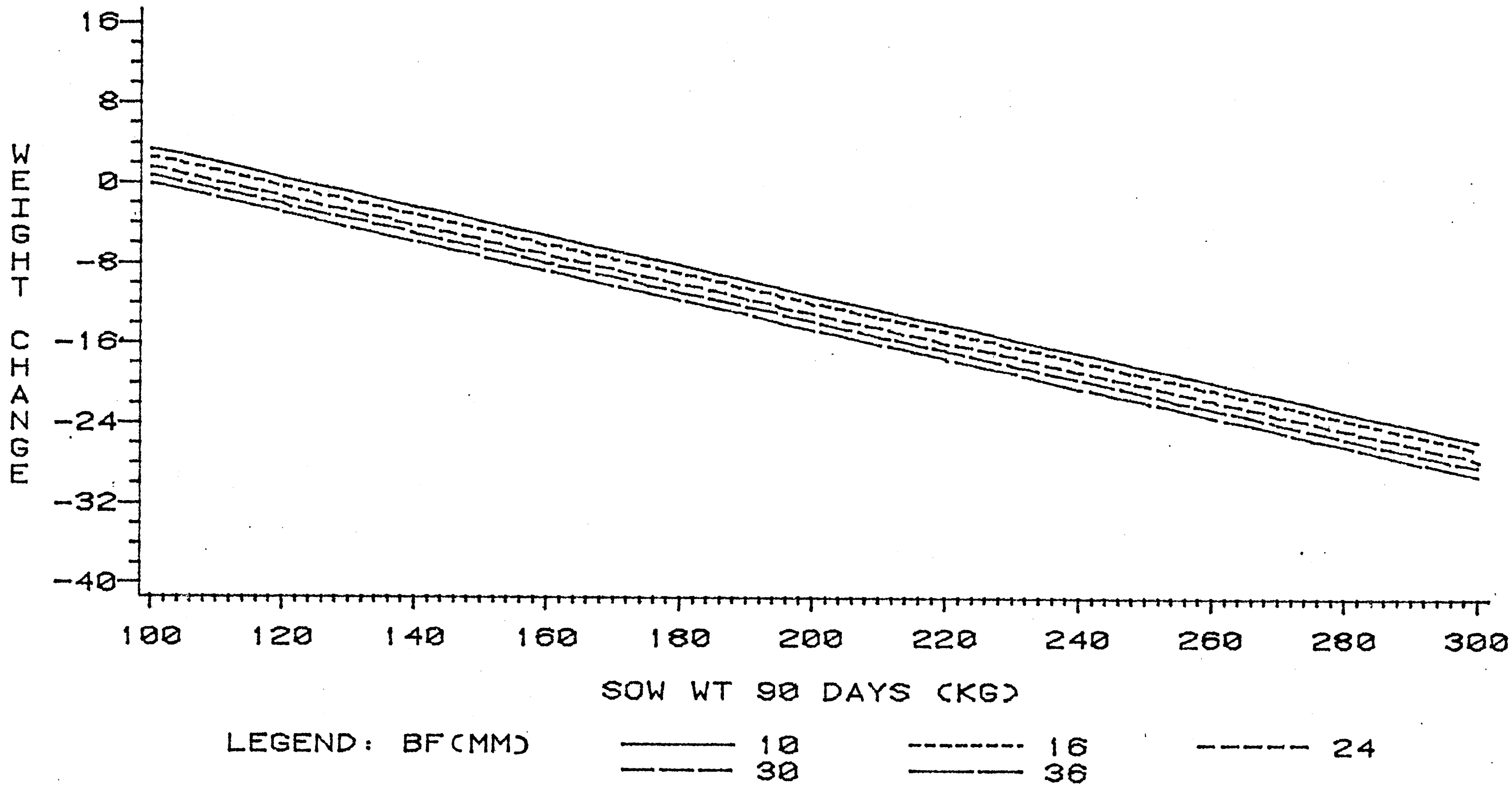

Figure 4. Predicted Sow Weight Change (kg), from 110 Days of Gestation to Farrowing, for the High Intake Treatment at Various Sow Weights and Backfats at 90 Days of Gestation

days of gestation increased was different ($P < .10$) for each treatment. On the control treatment, the predicted number of live pigs born was low for light weight sows and gilts, at 90 days of gestation and increased with increasing sow weight at 90 days of gestation (Figure 5) while on the high intake treatment, the predicted number of live pigs born was intermediate for lightweight sows and gilts at 90 days of gestation and remained relatively unchanged as sow weight at 90 days of gestation increased (Figure 6). This suggests that increasing the feed intake of sows and gilts during the last one-third of pregnancy may result in an increase in the number of live pigs born for lightweight sows and gilts but not for heavier sows and gilts.

For a given weight at 90 days of gestation, the effect on litter birthweight as backfat at 90 days of gestation increased was similar for each treatment. For a given backfat at 90 days of gestation, the litter birthweight as sow weight at 90 days of gestation increased was different ($P < .05$) for each treatment. On the control treatment the predicted litter birthweight was low for lightweight sows and gilts at 90 days of gestation and increased as sow weight at 90 days of gestation increased (Figure 7) while on the high intake treatment the predicted litter birthweight was intermediate for lightweight sows and gilts at 90 days of gestation and remained relatively unchanged as sow weight at 90 days of gestation increased (Figure 8). This suggests that high levels of feed intake during the last one-third of gestation may result in heavier litters at birth from lightweight sows and gilts.

Sow weight and backfat thickness at 90 days of gestation were used as indicators of sow condition at the time the treatments were applied to measure the effect of treatment on sows of varying physical condition.

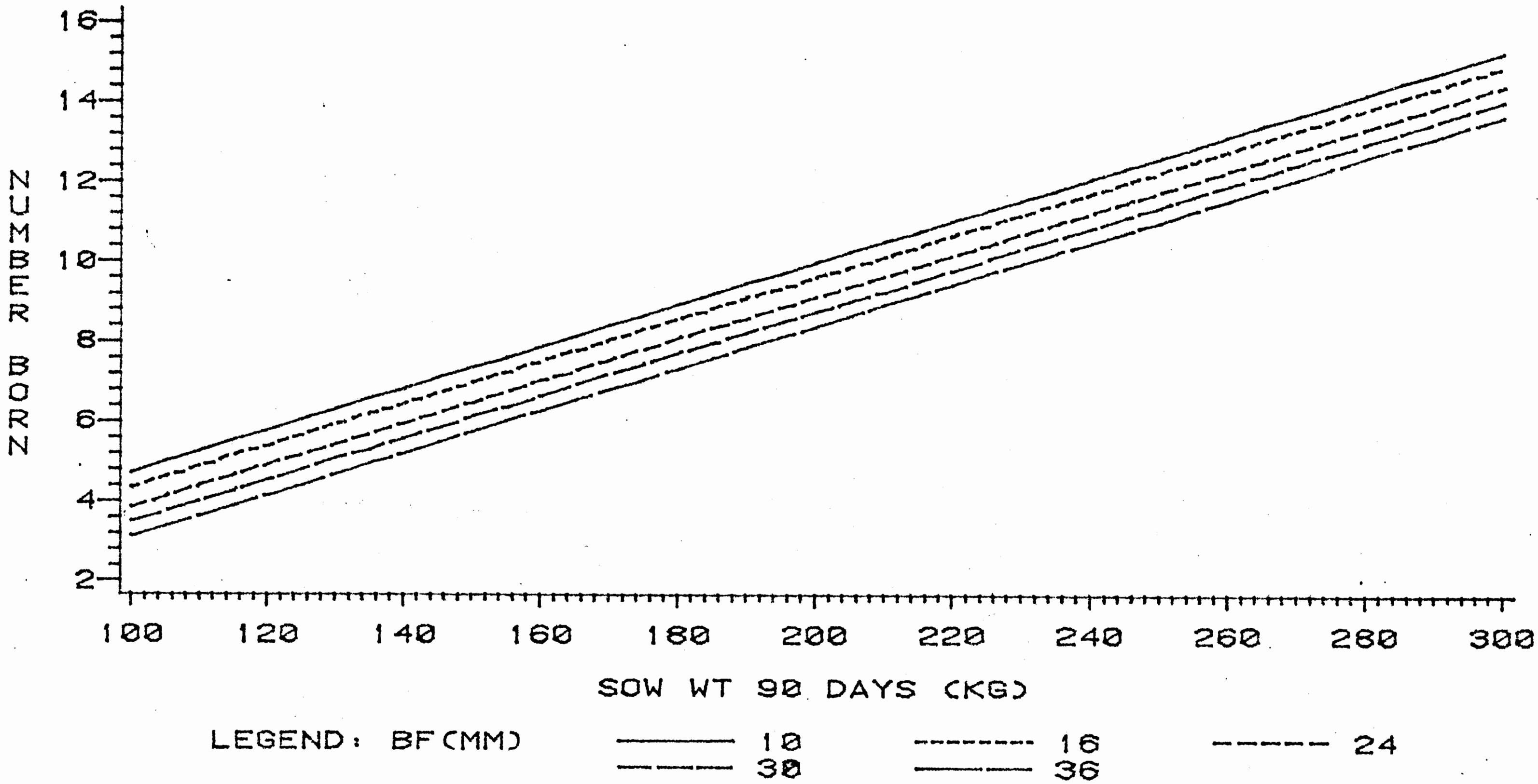

Figure 5. Predicted Number of Live Pigs Born for the Control Treatment at Various Sow Weights and Backfats at 90 Days of Gestation

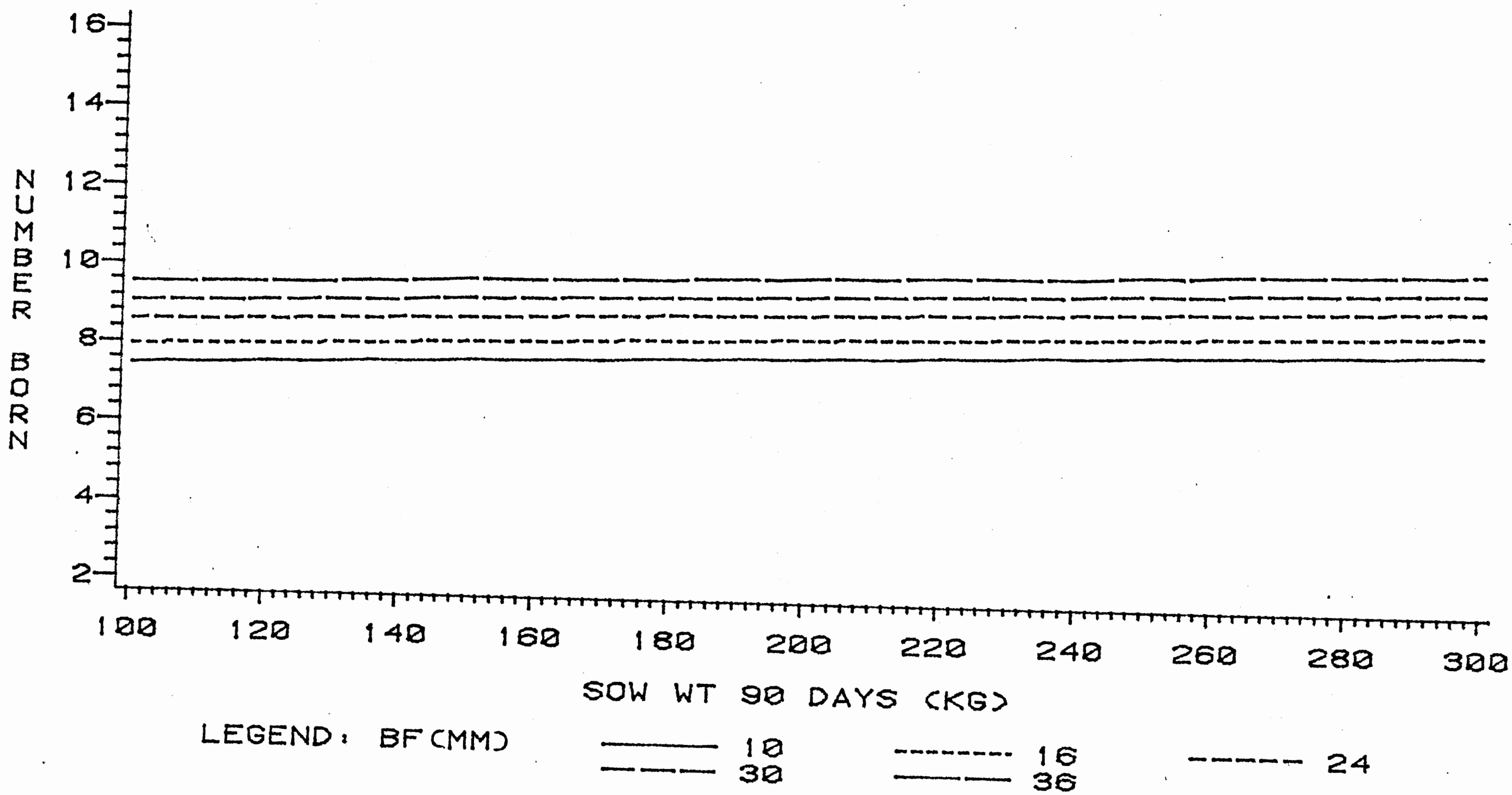

Figure 6. Predicted Number of Live Pigs Born for the High Intake Treatment at Various Sow Weights and Backfats at 90 Days of Gestation

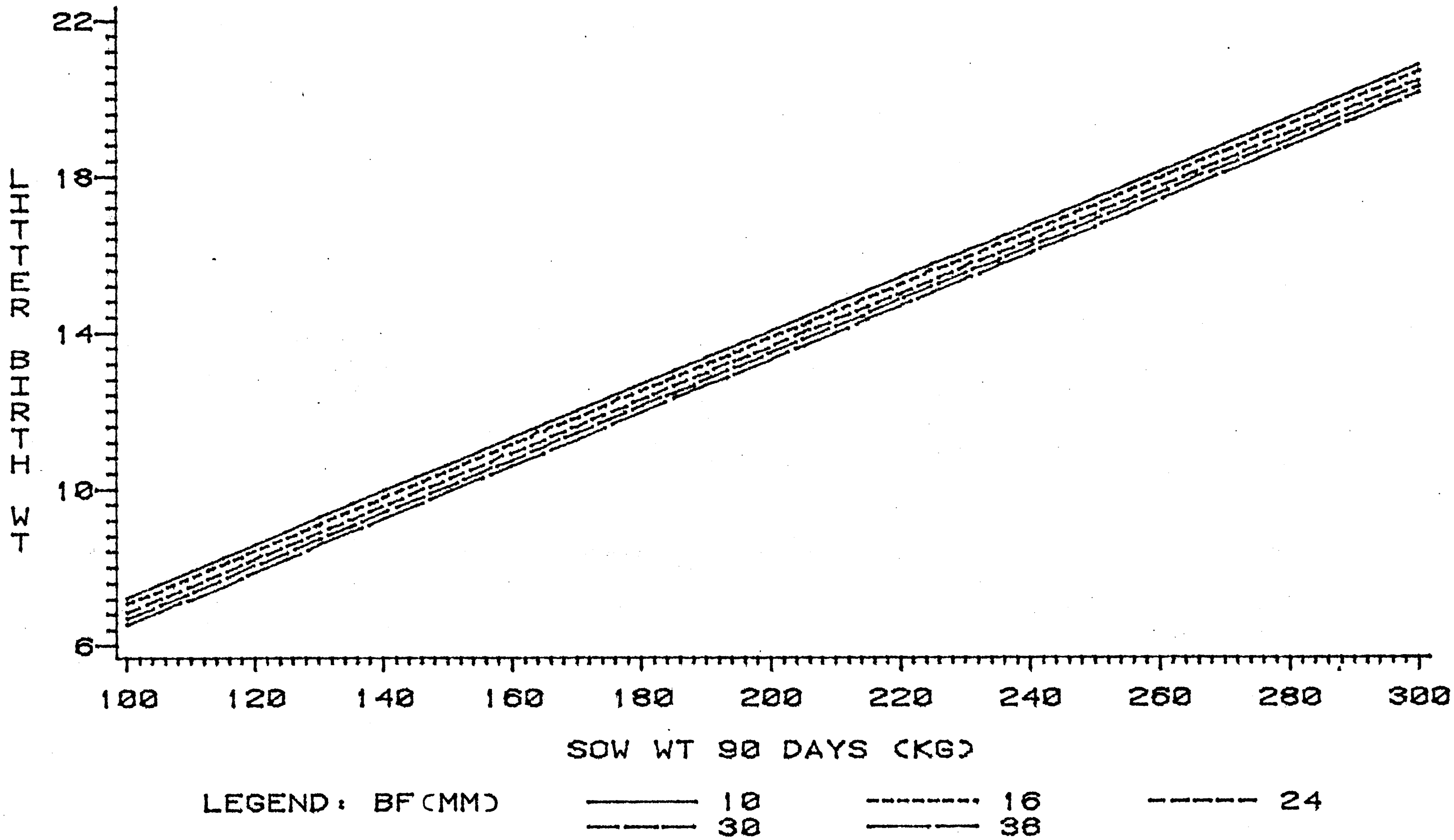

Figure 7. Predicted Litter Birth Weight (kg) for the Control Treatment at Various Sow Weights and Backfats at 90 Days of Gestation

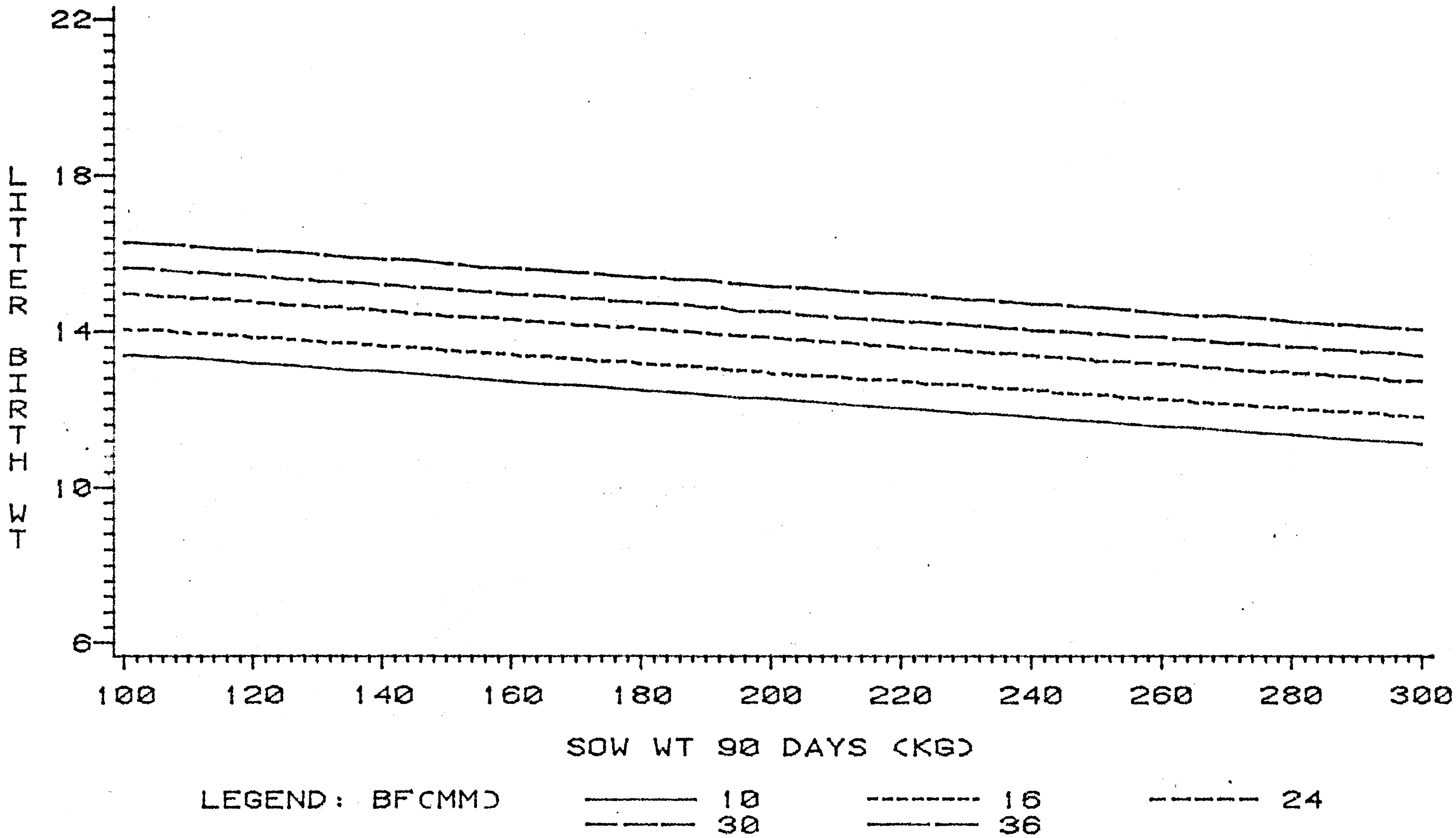

Figure 8. Predicted Litter Birth Weight (kg) for the High Intake Treatment at Various Sow Weights and Backfats at 90 Days of Gestation

Response differed between treatments as average backfat thickness at 90 days of gestation increased for postfarrowing sow weight and weight change from 110 days of gestation to farrowing. Response differed between treatments as sow weight at 90 days of gestation increased for the reproductive traits littersize, litter birthweight, and individual pig bir weight. It should be noted at this time that parity two includes sows of parity 2, 3, and 4 and that the parity of the sow may have accounted for a part of the variation due to sow weight, however, it is assumed here that sows from each parity were equally distributed across treatments by the randomization process.

The predicted increase in the number of live pigs born and litter birthweight as sow weight at 90 days of gestation increased on the control treatment (Figures 5 and 7) are in agreement with results reported by other workers (Stewart, 1945a and Omtvedt et al., 1965) in which litter size and weight increased as sow weight at breeding increased. In addition, Young et al. (1974) reported that as sow weight at breeding increased, the number of embryos at 30 days of gestation increased for two and three breed cross embryos. In contrast, Varley and Cole (1978) found no significant relationship between sow weight and litter size.

Sow weight did not appear to affect the number of live pigs born or litter birthweight (Figures 6 and 8) for sows on the high intake treatment in this study. Lightweight sows on the high intake treatment are predicted to have more live pigs born and heavier litters than lightweight sows on the control treatment whereas heavier sows on the high intake treatment are predicted to have less live pigs born and lighter litters than heavyweight sows on the control treatment (Figures 5, 6, 7, and 8). This indicates that increasing the feed intake of lightweight sows during late gestation could increase productivity by increasing the number of live pigs born and thus increasing litter weight at birth. Increasing the feed intake of heavyweight sows would be of no benefit as this may lead to a reduction in the number of live pigs born.

In a review of the effects of maternal protein and energy nutrition during pregnancy, Pond (1973) reported that the sow is able to draw upon her own reserves to allow fetal survival. This could explain, in part, why lightweight sows that may not have large energy reserves may benefit from extra feed intake and heavyweight sows with adequate reserves may not benefit from the extra intake.

In this study, no apparent advantage was gained, in littersize, litter weight, pig weight, and pig survivability at birth or weaning, by increasing the feed intake of the dam during the last 24 days of gestation. It appears that some advantage could be gained by increasing the late gestation feed intake of lightweight sows and gilts. However, a more detailed study in this area is necessary to determine if this effect is real and if so, would the resulting increase in production offset the increased cost of management, labor, and feed, resulting from this practice. With the high degree of variation associated with the reproductive traits in swine, large studies with many animals are necessary to accurately determine the real effect of nutritional treatment during gestation.

CHAPTER V

SUMMARY

The effects of increasing the feed intake of sows during late gestation were studied in a trial utilizing 77 Yorkshire sows and 45 Yorkshire gilts. Treatments included a control level of feed intake (1.82 kg/head/day) fed throughout gestation and a high level of feed intake (3.18 kg/head/day) from 90 days of gestation to farrowing. Sows and gilts were maintained on dirt lots from breeding to 110 days of gestation, at which time they were moved to the farrowing house and remained in farrowing crates until 21 days postfarrowing. At 21 days postfarrowing, sows and litters were moved to sheltered nursery pens where they remained until weaning at 42 days postfarrowing. After weaning, sows were returned to the gestation lots and rebred when possible on the first estrus. Water was offered to both sows and pigs on an ad libitum basis throughout the lactation period. At weaning, sows were returned to a prebreeding level of intake (1.82 kg/head/day). Creep feed was offered to pigs ad libitum from 21 to 42 days postfarrowing.

Measurements taken included: 1) backfat probe of gilts and sows at breeding and at 90 days of gestation; 2) gilt and sow weight at breeding, 90 and 110 days of gestation as well as within 24 hours after farrowing, on day 21 of lactation and at weaning on day 42; 3) individual pig weight at birth (live and dead pigs), 21 and 42 days postfarrowing; 4) total and live pigs at birth 21 and 42 days; 5) feed consumption of

sows from parturition to day 21; 5) consumption of creep feed by pigs from 21 to 42 days of age; and 7) the number of days to first estrus after weaning.

No statistically significant treatment differences were observed for littersize, litter weight, sow weight, sow feed consumption, creep feed consumption, days to first estrus after weaning or pig survival. Significant ($P<.01$) parity differences were observed for all sow and gilt weights recorded and for sow weight changes from 21 to 42 days post-farrowing and from breeding to weaning. Significant ($P<.05$) farrowing season differences were observed for 21 and 42 day litter weights as well as creep feed consumption from 21 days postfarrowing to weaning, and sow feed consumption from parturition to 21 days postfarrowing. Highly significant treatment by parity by farrowing season interactions were observed for individual pig birth, 21, and 42 day weight.

Condition of the sow prior to treatment may be important in determining the effect of treatment on reproductive traits. Based on prediction estimates there appears to be a tendency for lightweight sows (<200 kg) to benefit from the high intake treatment more than heavier weight sows (>200 kg).

LITERATURE CITED

Adam, J. L. 1973. Effects on sow and litter performance of patterns of feeding in gestation area of boar breed. N.Z.J. Exp. Agri. 1:281.

Anderson, R. H. and R. C. Wahlstrom. 1970. Effects of energy intake and Dichlorvos during gestation on reproductive performance of gilts and some chemical characteristics of the offspring. J. Anim. Sci. 31:907.

Baker, D. H., D. E. Becker, A. H. Jenson, and B. G. Harmon. 1970a. Protein source and level for pregnant gilts: A comparison of corn, Opaque-2 corn, and corn-soybean meal diets. J. Anim. Sci. 30:364.

Baker, D. H., D. E. Becker, D. H. Jenson, and B. G. Harmon. 1970b. Reproductive performance and progeny development in swine as influenced by protein restriction during various portions of gestation. J. Anim. Sci. 31:526.

Baker, D. H., D. E. Becker, H. W. Norton, C. E. Sasse, A. H. Jensen, and B. G. Harmon. 1969. Reproductive performance and progeny development in swine as influenced by feed intake during pregnancy. J. Nutr. 97:489.

Boaz, T. G. 1962. The significance of level of protein in the nutrition of the pregnant sow. Vet. Rec. 74:1482.

Boyd, R. D., B. D. Moser, E. R. Peo, Jr., and P. S. Cunningham. 1978a. Effect of energy source prior to parturition and during lactation on tissue lipid, liver glycogen, and plasma levels of some metabolites in the newborn pig. J. Anim. Sci. 47:874.

Boyd, R. D., B. D. Moser, E. R. Peo, Jr., and P. S. Cunningham. 1978b. Effect of energy source prior to parturition and during lactation on piglet survival and growth and on milk lipids. J. Anim. Sci. 47:883.

Buitrago, J., J. H. Maner, and J. T. Gallo. 1970. Effect of gestation energy level on reproductive performance. J. Anim. Sci. 31:197 (Abstr.)

Buitrago, J. A., J. H. Manar, J. T. Gallo, and W. G. Pond. 1974b. Effect of dietary energy in gestation on reproductive performance of gilts. J. Anim. Sci. 39:47.

Buitrago, J. A., E. F. Walker, Jr., W. I. Snyder, and W. G. Pond. 1974a. Blood and tissue traits in pigs at birth and at 3 weeks from gilts fed low or high energy diets during gestation. J. Anim. Sci. 38:766.

Carrul, K. K. 1958. Digestibility of individual fatty acids in the rat. J. Nutr. 64:399.

Christian, R. E. and J. C. Nofziger. 1952. Puberty and other reproductive phenomena in gilts as affected by plane of nutrition. J. Anim. Sci. 11:789 (Abstr.)

Clawson, A. J., H. L. Richards, G. Matrone, and E. R. Barrick. 1963. Influence of level of total nutrient and protein intake on reproductive performance in swine. J. Anim. Sci. 22:662.

Cromwell, G. L., T. S. Stahly, and J. R. Overfield. 1980. Evaluation of a constant vs stepwise feeding pattern for pregnant sows. Am. Soc. Anim. Sci. Annual Meeting, Abstract No. 217, p. 194.

Dean, B. T. and L. F. Tribble. 1960. Effect of level of energy intake during gestation on condition and performance of swine. J. Anim. Sci. 19:1257 (Abstr.)

Dickerson, J. W. T., A. Merat, and E. M. Widdowson. 1971. Intrauterine growth retardation in the pig. Biol. Neonate 19:354.

Elliot, J. F. and G. A. Lodge. 1977. Body composition and glycogen reserves in the neonatal pig during the first 96 hours postpartum. Can. J. Anim. Sci. 57:141.

Elsley, F. W. H. 1968. The influence of feeding level upon the reproductive performance of pregnant sows. Vet Rec. 83:93.

Elsley, R. W. H., M. Bannerman, E. V. J. Bathurst, A. G. Bracewell, J. M. M. Cunningham, T. L. Dodsworth, P. A. Dodds, T. J. Forbes, and R. Laird. 1969. The effect of level of feed intake in pregnancy and lactation upon the productivity of sows. Anim. Prod. 11:225.

Elsley, F. W. H., R. M. MacPherson, and I. McDonald. 1968. The influence of intake of dietary energy in pregnancy and lactation upon sow productivity. J. Agr. Sci. 71:215.

Friend, D. W. 1974. Effect on the performance of pigs from birth to market weight of adding fat to the lactation diet of their dams. J. Anim. Sci. 39:1073.

Frobish, L. T. 1970. Effect of energy intake on reproductive performance and estrous synchronization of gilts. J. Anim. Sci. 31:486.

Frobish, L. T., V. C. Speer, and V. W. Hays. 1966. Effect of protein and energy intake on reproductive performance in swine. J. Anim. Sci. 25:729.

Frobish, L. T., N. C. Steele, and R. J. Davey. 1973. Long-term effects of energy intake on reproductive performance of swine. J. Anim. Sci. 36:293.

Goode, L., A. C. Warnick, and H. D. Wallace. 1960. Effect of energy level on reproductive performance of gilts. J. Anim. Sci. 19:643 (Abstr)

Goransson, G. 1965. The metabolism of fatty acids in the rat. III. Arachidic acid. Acta Physiol. Scand. 63:423.

Gossett, J. W. and A. M. Sorensen, Jr. 1959. The effects of two levels of energy and seasons on reproductive phenomena of gilts. J. Anim. Sci. 18:40.

Greenhalgh, J. F. D., F. W. H. Elsley, D. A. Grubb, A. L. Lightfoot, D. W. Sau., P. Smith, N. Walker, D. Williams, and M. L. Yeo. 1977. Coordinated trials on the protein requirements of sows. I. A comparison of four levels of dietary protein in gestation and two in lactation. Anim. Prod. 24:307.

Haines, G. E., A. C. Warnick, and H. D. Wallace. 1959. The effect of two levels of energy intake on reproductive phenomena in Duroc Jersey gilts. J. Anim. Sci. 18:347.

Hays, V. W., D. D. Kratzer, V. C. Speer, R. J. Bunch, and G. L. Cromwell. 1969. Variability in litter size and birthweight of pig as it relates to needed replications. J. Anim. Sci. 29:136 (Abstr.)

Heap, F. C., G. A. Lodge, and G. E. Lamming. 1967. The influence of plane of nutrition in early pregnancy on the survival and development of embryos in the sow. J. Reprod. Fertil. 13:269.

Hillyer, G. M. 1980. The effect of increasing feed level to sows and gilts in late pregnancy on subsequent litter size, litter weight, and maternal body-weight change. An. Prod. 30:469.

Holden, P. J., E. W. Lucas, V. C. Speer, and V. W. Hays. 1968. Effect of protein level during pregnancy and lactation on reproduction performance in swine. J. Anim. Sci. 27:1587.

Johnson, R. K. and I. T. Omtvedt. 1973. Evaluation of purebreds and two-breed crosses in swine: Reproductive performance. J. Anim. Sci. 37:1279.

Johnson, R. K. and I. T. Omtvedt. 1975. Maternal heterosis in swine: Reproductive performance and dam productivity. J. Anim. Sci. 40: 29.

Karam. 1959. Some factors affecting lamb mortality in Rohmani sheep. Emp. J. Exp. Agri. 27:133.

Libal, G. W. and Wahlstrom. 1977. Effect of gestation metabolizable energy levels on sow productivity. J. Anim. Sci. 45:286.

Lindemann, M. D., S. G. Cornelius, and R. J. Meade. 1980. Supplemental fat in late gestation and early lactation. Am. Soc. Anim. Sci. Annual Meeting, Abstract No. 256, p. 210.

Lodge, G. A. 1969. The effects of pattern of feed distribution during the reproductive cycle on the performance of sows. Anim. Prod. 11: 133.

Lodge, G. A., F. W. H. Elsley, and R. M. MacPherson. 1966a. The effects of level of feeding of sows during pregnancy. I. Reproductive performance. Anim. Prod. 8:29.

Lodge, G. A., F. W. H. Elsley, and R. M. MacPherson. 1966b. The effects of level of feeding of sows during pregnancy. II. Changes in body weight. Anim. Prod. 8:499.

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

Lucas, E. W., V. C. Speer, and V. W. Hays. 1966. Effect of protein intake on reproductive performance of sows. J. Anim. Sci. 25:1250 (Abstr.)

Lush, J. L., H. O. Hetzer, and C. C. Culbertson. 1934. Factors affecting birth weight of swine. Genetics 19:329.

Lush, J. L. and A. E. Molln. 1942. Litter size and weight as permanent characteristics of sows. USDA. Tech. Bull. 836.

Mahan, D. C. and L. T. Mangan. 1975. Evaluation of various protein sequences on the nutritional carry-over from gestation to lactation with first-litter sows. J. Nutr. 105:1291.

Manners, M. J. and M. R. McCrea. 1962. Protein requirements of baby pigs. Br. J. Nutr. 16:475.

Marthens, E. Van, S. Harel and S. Zamenhof. 1975. Experimental Intrauterine Growth Retardation. Biol. Neonate 26:221.

Mayrose, V. B., V. C. Speer, and V. W. Hays. 1966. Effect of feeding levels on the reproductive performance of swine. J. Anim. Sci. 25:701.

Meade, R. J., W. R. Dukelow, R. S. Grant, H. W. Hanke, K. P. Miller, J. W. Rust, and L. E. Hanson. 1966. Effects of feed and protein intakes on reproductive performance of gilts. J. Anim. Sci. 25: 1244 (Abstr.)

Mersmann, H. J., G. Phinney, R. L. Mueller, and H. C. Stanton. 1972. Glycogen metabolism in pre- and post-natal pigs. Amer. J. Physiol. 222:1620.

Mitchell, H. H., W. E. Carrol, T. S. Hamilton, and G. E. Hunt. 1931. Food requirements of pregnancy in swine. Uni. of Ill. Agr. Exp. Sta. Bull. 375.

Moulick, S. K. and O. Syrstad. 1970. Genetic and environmental causes of variation in birthweight of Black Bengal goats. J. Agric. Sci. Camb. 74:409.

O'Grady, J. F. 1967. Effect of level and pattern of feeding during pregnancy on weight change and reproductive performance of sows. Irish J. Agr. Res. 6:57.

Okai, D. B., F. X. Aherne, and R. T. Harden. 1977. Effects of sow nutrition in late gestation on the body composition and survival of the neonatal pig. Can. J. Anim. Sci. 57:439.

Okai, D. B., D. Wyllie, F. X. Aherne, and R. C. Ewan. 1978. Glycogen reserves in the fetal and newborn pig. J. Anim. Sci. 46:371.

Omtvedt, J. T., C. M. Stanislaw, and J. A. Whatley, Jr. 1965. Relationship of gestation length, age and weight at breeding, and gestation gain to sow productivity at farrowing. J. Anim. Sci. 24:531.

Omtvedt, I. T., J. A. Whatley, Jr., and R. L. Willham. 1966. Some production factors associated with weaning records in swine. J. Anim. Sci. 35:730.

Pike, I. H. 1970. The effect on nitrogen utilization in the sow of variation in dietary protein concentration and pattern of feeding in pregnancy. J. Agr. Sci. Camb. 74:209.

Pike, I. H. and T. G. Boaz. 1969. The effect on the reproductive performance of sows of dietary protein concentration and pattern of feeding in pregnancy. J. Agr. Sci., Camb. 73:301.

Pond, W. G. 1973. Influence of maternal protein and energy nutrition during gestation on progeny performance in swine. J. Anim. Sci. 36:175.

Pond, W. G., D. N. Strachan, Y. N. Sinha, E. F. Walker, Jr., J. A. Dunn, and R. H. Barnes. 1969. Effect of protein deprivation of swine during all or part of gestation on birthweight, postnatal growth rate, and nucleic acid content of brain and muscle of progeny. J. Nutr. 99:61.

Pond, W. G., W. C. Wagner, J. A. Dunn, and E. F. Walker, Jr. 1968. Reproduction and early postnatal growth of progeny in swine fed a protein-free diet during gestation. J. Nutr. 94:309.

Pond, W. G., J. T. Yen, R. R. Maurer, and R. K. Christenson. 1981. Effect of doubling daily energy intake during the last two weeks of pregnancy on pig birthweight, survival, and weaning weight. J. Anim. Sci. 52:535.

Rippel, R. H., O. G. Rasmussen, A. H. Jenson, H. W. Norton, and D. E. Becker. 1965. Effect of level and source of protein on reproductive performance of swine. J. Anim. Sci. 24:203.

Robertson, G. L., L. E. Casida, R. H. Grummer, and A. B. Chapman. 1951. Some feeding and management factors affecting age at puberty and related phenomena in Chester White and Poland China gilts. J. Anim. Sci. 10:841.

Salmon-Legagneur, E. 1962. Chronologic effect of change in plane of nutrition in pregnant sows. Ann. Zootechnic 11:173.

Salmon-Legagneur, E. 1964. Relations entre les graisses ingerees, les lipides corporels et les acides gras du milk chez la tuie. Ann. Biol. Anim. Biochem. Biophys. 4:141.

Schultz, J. R., V. C. Speer, V. W. Hays, and R. M. Melampy. 1966. Influence of feed intake and progestogen on reproductive performance in swine. J. Anim. Sci. 25:157.

Seerley, R. W., F. M. Griffin, and H. C. McCampbell. 1978a. Effect of sows dietary energy source on sow's milk and piglet carcass composition. J. Anim. Sci. 46:1009.

Seerley, R. W., J. S. Maxwell, and H. C. McCampbell. 1978b. A comparison of energy sources for sows and subsequent effect on piglets. J. Anim. Sci. 47:1114.

Seerley, R. W., T. A. Pace, C. W. Foley, and R. D. Searth. 1974. Effect of energy intake prior to parturition on milk lipids and survival rate, thermostability and carcass composition of piglets. J. Anim. Sci. 38:64.

Seerley, R. W. and D. R. Poole. 1974. Effect of prolonged fasting on carcass composition and blood fatty acids and glucose of neonatal swine. J. Nutr. 104:210.

Seerley, R. W., R. A. Snyder, and H. C. McCampbell. 1981. The influence of sow dietary lipids and choline on piglet survival, milk and carcass composition. J. Anim. Sci. 52:542.

Self, H. L., R. H. Grummer, and L. E. Casida. 1955. The effects of various sequences of full and limited feeding on the reproductive phenomena in Chester White and Poland China gilts. J. Anim. Sci. 14:573.

Self, H. L., R. H. Grummer, O. E. Hays, and H. G. Spies. 1960. Influence of three different feeding levels during growth and gestation on reproduction, weight gains, and carcass quality in swine. J. Anim. Sci. 19:274.

Shelton. 1964. Relation of birthweight to death losses and to certain productive characters of fall-born lambs. J. Anim. Sci. 23:355.

Smith, H. J. and J. B. McLaren. 1967. Performance of breeds and breed crosses of swine. Tenn. Agr. Exp. Sta. Bull. 434.

Sorensen, A. M., Jr., W. B. Thomas, and J. W. Gossett. 1961. A further study of the influence of level of energy intake and season on reproductive performance of gilts. J. Anim. Sci. 20:347.

Speer, V. C. 1970. Maximizing efficiency of the sow. Feedstuffs, Nov. 7, p. 8.

Stanton, H. C. and R. L. Mueller. 1974. Epinephrine-induced hyperglycemia and glycogenolysis in fed and fasted neonatal swine. Biol. Neonate 25:307.

Stewart, H. A. 1945a. An appraisal of factors affecting prolificacy in swine. J. Anim. Sci. 4:250.

Varley, M. A. and D. J. A. Cole. 1978. The relationship between the weight change of the sow and her reproductive output. British Society of Anim. Prod. Paper summaries, winter meeting, 1978, paper No. 28. (An. Breeding Abstr., Vol. 46, 5092).

Vermedahl, L. D., R. J. Meade, H. E. Hanke, and J. W. Rust. 1969. Effects of energy intake of the dam on reproductive performance, development of offspring, and carcass characteristics. J. Anim. Sci. 28:465.

Vestai, C. M. 1936. Feeding and management experiments with brood sows and litters. Ind. Agr. Exp. Bul. 413.

Widdowson, E. M. and D. E. Crabb. 1976. Changes in the organs of pigs in response to feeding for the first 24 hr. after birth. I. The internal organs and muscles. Biol. Neonate 28:261.

Willett, E. L. and C. Maruyama. 1946. The effect of intake of garbage fat upon fat content of sow's milk. J. Anim. Sci. 5:365.

Wolf, R. G., C. V. Maxwell, and E. C. Nelson. 1978. Effect of age and dietary fat level on fatty acid oxidation in the neonatal pig. J. Nutr. 108:1621.

Young, L. D., I. T. Omtvedt, and R. K. Johnson. 1974. Relationships of various measures of performance with ovulation rate and number of embryos 30 days after breeding in gilts. J. Anim. Sci. 39:480.

Zimmerman, D. R., H. G. Spies, H. L. Self, and L. E. Casida. 1960. Ovulation rate in swine as affected by increased energy intake just prior to ovulation. J. Anim. Sci. 19:295.

APPENDIX

TABLE X

NUMBER OF LITTERS PRODUCED IN EACH TREATMENT GROUP BY PARITY AND FARROWING SEASON

Farrowing Season	Parity	Treatment 1	Treatment 2
Jan. - Mar.	Gilt	14	11
	Sow	23	25
Apr. - Jun.	Gilt	1	3
	Sow	8	4
Jul. - Sept.	Gilt	5	5
	Sow	3	5
Oct. - Dec.	Gilt	2	4
	Sow	4	5
Total		60	62

2

VITA

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