THE EFFECTS OF DEHYDRATED CEREAL GRASS AND PLANE OF NUTRITION ON THE PERFORMANCE OF SWINE DURING GESTATION AND LACTATION

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William Martyn Palmer

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ABSTRACT

THE EFFECTS OF DEHYDRATED CEREAL GRASS AND PLANE OF NUTRITION ON THE PERFORMANCE OF SWINE DURING GESTATION AND LACTATION

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WILLIAM MARTYN PALMER

The effect on reproductive performance of the addition of 10 percent dehydrated cereal grass meal to swine gestation rations was studied. The investigation also compared the effects of providing three levels of nutrient intake during gestation. The three levels tested were the United States National Research Council recommended allowance, a Norwegian recommended allowance and an allowance which gave a feed intake during the gestation period of approximately 20 percent below that of the National Research Council recommendation. Six lots composed of 35 gilts were individually fed during gestation and observations were made on their subsequent reproductive performance. An additional study was conducted whereby certain prenatal observations were made at mid-gestation on 18 gilts which were subjected to the same ration treatments.

The inclusion of 10 percent dehydrated cereal grass meal in gestation rations resulted in lower daily body weight gains during gestation. Restricted feed intake from the 25th to the 76th day of gestation caused significantly slower gains during this period and subsequent lighter body weights of the gilts in this study both prior to and immediately after farrowing.

While there were no significant differences in the number of pigs

born, number of stillbirths, or in average pig birthweights, gilts receiving the dehydrated cereal grass had fewer stillbirths and somewhat larger litters. The gilts fed the restricted level of feed during mid-gestation farrowed slightly more live pigs than those allowed the Norwegian Standard, which in turn showed a slight superiority over the gilts on the National Research Council allowance.

Significantly more pigs survived to 3 weeks of age when 10 percent dehydrated cereal grass meal was included in gestation-lactation rations. Percent livability to 3 weeks was highest in the litters from gilts receiving the restricted level of dehydrated cereal grass meal during gestation. Livability was lowest in the litters from the gilts receiving the same level of the basal ration.

No significant differences in average 3 week weights of the baby pigs due to the ration treatments involved were noted in the study. There was, however, a highly significant difference due to interaction between the rations and feeding levels when total litter weight at 3 weeks was considered. The heaviest litters were from the gilts receiving the restricted level of the dehydrated cereal grass ration during gestation, whereas the gilts which received restricted level of the basal ration had the lightest litters at 3 weeks.

The body weight losses and feed consumption of the gilts during lactation were more dependent on the number of pigs being nursed than on prenatal effects.

The results of this study would suggest that satisfactory reproductive performance of swine can be obtained by feeding gilts a ration containing 10 percent dehydrated cereal grass meal at a level which is 20 percent below the National Research Council recommended allowance for gestating swine.

Differences among numbers of corpora lutea observed in 18 gilts slaughtered at mid-gestation were not significant, indicating no significant ration or level effect upon ovulation rates. Ovulation rates were somewhat higher in the gilts receiving all levels of the standard basal ration.

Gilts receiving the ration containing dehydrated cereal grass had a larger percentage of their corpora lutea represented by normal embryos at mid-gestation. Gilts receiving the restricted levels of both rations from the 25th to the 57th day of the gestation period exhibited lower total embryonic loss to mid-gestation than those receiving the National Research Council or Norwegian Standard levels of feed. However, these differences were not statistically significant under the conditions of this study.

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INTRODUCTION

The success of a swine enterprise is dependent upon the productivity of the sows and gilts in the breeding herd. The productive ability of a sow is influenced by her genetic make up and the environment in which she has been raised. It is generally agreed, however, that heritability of litter size and birthweight in swine is quite low and, therefore, any variance in the above reproductive traits is largely due to environmental factors such as age of the sow and the nutritional regime provided during gestation.

Nutrition is, then, of vital importance in the various physiological phenomena related to the reproductive capability of swine. Adequate nutrition must be provided to a sow during gestation to provide nutrients for the demands of the developing litter over and above those required for her own body functions. Also, in the case of a young sow, the ration should provide an allowance that will not jeopardize her own continued growth. In addition a pregnant sow requires nutrients to build up her body reserves in preparation for the demands of the lactation period following parturition. Which of the above mentioned body functions is most severely affected by inadequate nutrition is a matter of some conjecture.

Numerous studies have demonstrated that dehydrated alfalfa meal improves the reproductive performance of sows and gilts and the value of green pasture forage of the cereal grasses has long been recognized. There have, however, been no reports in the literature on the use of a dehydrated cereal grass product in swine gestation-lactation rations.

Preliminary investigations at the University of Manitoba indicated that this product in self-fed rations did exert a beneficial effect on the reproductive performance of sows and gilts. It was decided to study further the effect of this product on swine gestation-lactation performance using individual feeding techniques. Individual feeding gives a more precise control of feed intake thus enabling more valid comparisons between feed intake and the various body functions during gestation.

A considerable amount of research has been conducted on the nutritive requirements of growing-finishing pigs. There have been, however, relatively few studies on the needs of gestating-lactating swine. Consequently many of the present nutrient allowances recommended for breeding sows and gilts are extrapolations from experiments carried out on younger growing animals. It is generally agreed that embryonic mortality, most of which occurs during early pregnancy, can be decreased by restricting the feed intake of sows and gilts during early gestation. It is also known that most of the growth of a developing litter takes place during the last one-third of the gestation period. It would therefore appear that pregnant animals should be fed essentially a maintenance diet during the first two-thirds of the gestation period with some additional allowance during the last one-third of pregnancy. Some of the feeding standards do partially recognize the above considerations but the United States National Academy of Science--National Research Council suggests a constant level of feed intake in its outline of requirements for gestating swine, and these are only given for young gilts and for mature sows. It is assumed that animals intermediary in body weight would be given proportional allowances based on their body weight.

It was therefore decided to study in more detail gestation-lactation requirements of swine. The National Research Council requirements, the standard recognized by research workers on this continent, was compared with: (1) a Norwegian Standard which recommended a somewhat higher feed intake than did the National Research Council and which also recommended an increased nutrient intake during the last three weeks of the gestation period, and (2) a restricted allowance which gave a feed intake which was approximately 20 percent below that of the National Research Council recommendation.

REVIEW OF LITERATURE

Plane of Nutrition

Under nutrition and overfeeding both appear to interfere with normal reproduction. Severe restriction of the food intake will delay sexual maturity in young animals and cause an irregularity or cessation of the estrous cycle in mature individuals. On the other hand, overfeeding causing extreme obesity also appears to be deleterious to reproduction. The ovaries may become infiltrated with fat, a condition which hinders the development of follicles and thereby results in irregularity or cessation of estrus.

Evans and Bishop (13) demonstrated that in the immature female rat under feeding resulted in small ovaries, absence of large follicles, follicular atresia, and failure of ovulation; while inanition in adult animals resulted in failure of follicles to develop to maturity, follicular atresia, and loss of libido. Similarly, Guilbert (20) found that restriction of the food intake in rats to 20 or 30 percent of the voluntary intake had a deleterious effect on reproduction. Furthermore, cessation of estrus resulted from restricting food intake to the extent of a loss of 15 percent in body weight.

Hanson *et al* (22) found that a restriction in feed intake of slightly over 40 percent resulted in a reduction of 1.25 live pigs farrowed and a decrease of 0.23 pounds per pig in birthweight.

King and Young (29) restricted the feed intake of young sows so severely that they lost on the average 23 pounds between breeding and slaughter 28 days later. They found that 7 of the 28 severely restricted animals in the test were not pregnant. McKenzie (33) also found that gilts reared on a low plane of nutrition (41--48 percent of a full ration) gave birth to fewer pigs than those reared on a medium or high plane. The development of the genital organs was so retarded that some of the gilts did not come into heat until nearly one year of age.

Burger (3) restricted the feed intake of gilts so that they were about 50 percent of the normal expected body weight at 28 weeks of age. The mean age of the restricted gilts at first estrus was 235 days, while that of the gilts fed to appetite was 188.5 days. Robertson et al (37) also found that full-fed gilts tended to reach puberty earlier than did the gilts limited to 70 percent of the feed intake of the full-fed group.

On the other hand, overfeeding also may delay the appearance of first estrus. Self et al (40) observed that a ration restricted to two-thirds of full feeding resulted in earlier sexual maturity in gilts although the difference between the restricted and full-fed rations was not significant. They suggested that full feeding was in fact over feeding. Christian and Nofziger (6) found no significant differences in age at puberty between full-fed gilts and ones receiving approximately 70 percent of full feed, despite the fact that full-fed gilts were significantly heavier at first estrus than the gilts on the lower plane of nutrition.

Plane of nutrition has been shown to significantly affect the ovulation rate in swine. Most investigations have found that a high plane of nutrition causes a significantly greater number of ova to be shed. Robertson and co-workers (37) reported that the full-fed gilts shed 11.7

ova at first estrus following puberty, as opposed to 8.8 for gilts limited to 70 percent of full feed; while at second heat the full-fed gilts ovulated 1.1 more ova per gilt than the restricted gilts. Similar results were reported by Christian and Nofziger (6). The ovulation rate for self-fed gilts in this trial was 15.1 as compared with 13.4 for gilts restricted to 70 percent of full feed. Self and his associates (40) also found that full-fed gilts shed significantly more ova than gilts limited to approximately two-thirds of full feed.

The ovulation rate in swine can be stimulated by increasing the nutrient intake for a short period of time prior to ovulation. Zimmerman et al (48) demonstrated that raising the nutrient intake (flushing) for periods of approximately 6, 10 or 14 days produced greater increases in ovulation rate from one estrual period to the next than occurred normally in unflushed gilts: the ovulation response tended to be greater with the longer flushing period. Baker (1) recorded much the same results when gilts were changed from a low energy ration to a high energy intake ten days prior to ovulation.

Although a high plane of nutrition stimulates ovulation rate in the sow, most workers agree that it has a detrimental effect on early embryonic survival. The prenatal death rate over the entire gestation period in the study of Christian and Nofziger (6) was estimated as 62.9 percent for high plane gilts as compared to 35.3 percent for the low plane test animals. The earlier findings of Robertson et al (37) were in close agreement in that limited-fed gilts tended to have more embryos at 25 days of gestation than those on full feed; the restricted gilts had 67 percent of the corpora lutea of second heat represented by normal embryos in contrast to only 43 percent for the full-fed individuals. This work tends to support the observation of Squiers et al (44) that most of the embryonic deaths in swine occurred prior to the twenty-fifth day of gestation. A later investigation by Lerner and associates (31) revealed that the majority of the mortality occurred before the seventeenth day of pregnancy. The studies of Self et al (40 and 41) also illustrated an advantage for limited feeding on embryo survival, although the differences were not significant in the latter report.

Some investigators have attempted to limit the nutrient intake in gestating swine by increasing the fiber content of self-fed rations. Hanson et al (23) limited the nutrient intake by substituting ground corn cobs at levels from 20 to 30 percent in a practical ration for breeding gilts. Weight gains were higher in the full-fed treatment groups and the number of live pigs farrowed was slightly higher. However, the litter survival rate and weight at weaning was in favor of the restricted dams.

Energy

A number of workers have studied the effect of energy intake on reproductive performance in swine by attempting to alter the energy intake *per se* without changing the entire level of nutrient intake.

Zimmerman et al (48) conducted two trials to determine if the stimulating effect of flushing on ovulation rate was attributable to increased energy intake. In the first trial young gilts were restricted to 60--75 percent of full feed from 154 days of age until puberty by feeding high fiber (14--18 percent fiber) rations. Gilts fed glucose as a source of added energy at the rate of 1 percent of individual body weight per day in the basal ration for approximately 2 weeks prior to ovulation were found to shed a greater number of ova than the gilts receiving only the basal ration (2.1 and 0.8 more ova in the two respective experiments). In the second experiment gilts fed a basal plus lard ration with the same caloric value as the basal plus glucose ration produced 1.9 more ova than the control gilts. The greatest response was obtained, however, when gilts were fed a basal plus lard ration at approximately 150 percent of the caloric intake of those fed glucose. They exceeded the ovulation rate of control gilts by 4.1 ova and the glucose and low fat gilts by 3.3 and 2.2 ova, respectively.

A study by Haines et al (21) was conducted to determine the effect of two levels of energy intake on attainment of puberty, ovulation rate and embryonic mortality. One group was fed to appetite a 16 percent protein ration; a second group was fed half the quantity of the first, the second ration being formulated so that the energy intake was reduced 50 percent, while the intake of other essential nutrients remained approximately the same. All gilts were bred at second heat following sexual maturity and one-third of each treatment group was sacrificed 3 days after breeding, another third at 25 days of gestation, while the remainder were allowed to farrow. The limited-fed gilts were 22 days older and 36 pounds lighter at puberty than the full-fed gilts, an observation which is in general agreement with the results of Burger(3) and Robertson (37). Corpora lutea counts revealed that full-fed gilts ovulated statistically greater numbers of ova, a finding consistent with those of Christian and Nofziger (6), Robertson et al (37) and Self et al (40). Prenatal mortality for the first 25 days of gestation was 11.6 percent for limited-fed gilts and 22.1 percent for full-fed gilts, and was 20.1 percent and 31.8 percent for the limited-fed and full-fed groups, respectively, for the entire gestation period. The observations from this study would seem to point out that gilts should be full-fed prior to ovulation for high ovulation rates, but limited-fed during early gestation to attain higher embryonic survival rates.

In a further investigation by the same station, reported by Goode et al (17), energy was restricted in a gestation ration by using high levels of dehydrated alfalfa leaf meal and ground oats. However, both diets were approximately equal in percent crude protein, minerals and B-vitamins. The observations on age and weight at puberty were in close agreement with the findings of Haines et al (21) in that the restricted gilts were older and lighter in weight at puberty than the full-fed individuals. Ovulation rates were slightly higher in the low energy treatment groups. Early embryonic losses were lower in the restricted gilts.

Gossett and Sorenson (19) compared gestation rations containing either 93 or 55 therms of productive energy per 100 pounds of feed. Gilts receiving the low energy diet tended to reach puberty earlier than did those on the higher energy level. This observation is not in agreement with the study of Haines et al (21), but the restriction in energy intake was more severe in the investigation by the latter. It does, however, agree with the suggestion of Self et al (40) that fatness of the animal as influenced by level of feeding may affect the attainment of puberty. An explanation of the discrepancies in the results of the two experiments may be that in the test of Haines et al (21) the full-fed gilts were at an optimum level and their restricted animals were undernourished, whereas in the studies of Gossett and Sorenson (19) restricted feeding was adequate and full feeding amounted to overfeeding. However, the weight for age of the gilts in the study of Gossett and Sorenson does not indicate excessive fatness in either group, and this factor alone does not seem to account entirely for the differences in age at sexual maturity in the two studies. The high energy gilts in this study showed a trend toward greater ovulation rates but this difference was not significant. Embryonic mortality at 40 days of gestation was significantly greater, however, in the high energy treatment group.

In a further study by the same workers, Sorenson et al (43), 96 gilts were used in a test whereby the same two energy levels (93 or 55 therms per 100 pounds of feed) were again compared. The results of this investigation led to the following conclusions: (1) Energy level caused no significant differences in age at puberty; (2) high energy rations resulted in heavier weights at sexual maturity; and (3) high energy intake increased the ovulation rate and also the early uterine mortality rate.

Dehydrated Forage Products

The beneficial effects upon reproduction of cereal grasses in the green pasture state have long been recognized (Hogan and Johnson (26), Carroll et al (4) and Krider et al (30)). The literature, however, contains few references to the use of dehydrated cereal grasses in rations for pregnant swine reared in drylot. Data from the University of Manitoba (Stothers (45)) on trials carried out during the years 1955 to 1959, in which levels of 10 and 20 percent dehydrated cereal grass had been included in gestation diets, showed a consistent favorable response for this dietary ingredient.

Several studies have been conducted to determine the effect of dehydrated alfalfa products on reproduction efficiency in swine. Early workers in the field demonstrated the value of alfalfa meal in practical brood sow rations. Freeman (15), using weight, strength and number of pigs farrowed as measurements, found that alfalfa hay was as efficient as tankage in supplementing corn for sows. In studies of the calcium requirement of brood sows, Hogan (25) succeeded in raising to weaning age 81 percent of the pigs from sows whose gestation ration had contained 15 percent of alfalfa meal, whereas sows whose ration had contained only 5 percent of alfalfa meal weaned only 51 percent of their pigs. A later report by Hogan and Johnson (26) showed that sows receiving 25 percent alfalfa meal in their diet weaned 81.6 percent of the pigs farrowed, whereas mortality to weaning was 39.1 percent in the control gilts. There was, however, no significant difference in the number of live pigs born.

Ross et al (38) found that a practical ration containing corn, soybean oil meal, salt, limestone and 5 percent ground alfalfa hay gave poor reproductive performance in sows. Litters weaned were small in both number and size of pigs. When the alfalfa was raised to 15 percent, at the expense of corn, reproduction was normal. Sows on this ration weaned twice as many pigs as the sows on the 5 percent alfalfa diet and the pigs were 25 percent heavier at weaning.

Further studies were reported by Ross et al (39) on the effect of a ration composed of yellow corn, expeller soybean oil meal, calcium carbonate, and common salt with varied levels of alfalfa meal and/or certain vitamins or vitamin concentrates. In the first part of this study, it was found that levels of either 5 or 15 percent alfalfa meal allowed sows to give birth to litters which were normal except for malformations of the feet and legs. There was no difference in number born under the two treatments. Considerable differences were, however, apparent when the two lots were carried through the lactation period. The sows which received the 15 percent alfalfa meal supplemented ration weaned nearly 100 percent more and 25 percent heavier pigs at 56 days of age than did those on the 5 percent level of alfalfa meal. In the second part of this experiment, which was a two-generation study, the reproductive performance of gilts selected from the first trial was studied. Congenital malformations such as syndactylism, talipes and paralysis agitans were observed in all litters, but the incidence was greater in the litters from sows fed the lower level of alfalfa meal. The inclusion of such practical supplements as tankage, fish meal, molasses and dried brewers' yeast in the diet late in the gestation period (10 days prior to parturition) failed to prevent the occurrence of the abnormalities.

Further observations by Cunha et al (8) again demonstrated the inadequacies of a gestation diet containing only 5 percent alfalfa meal. The inclusion of either 15 percent alfalfa meal or soybean lecithin plus pyridoxine resulted in normal reproduction. However, the single addition of either crystalline riboflavin, choline or one percent B-Y riboflavin supplement (a by-product of alcohol fermentation from grain or molasses, which is rich in riboflavin as well as other B-complex vitamins) to the 5 percent alfalfa meal diet proved to be ineffective. The workers in these studies concluded that good quality alfalfa meal contains some unidentified factor which will improve the reproductive performance of sows fed in drylot and that a level of 10 or 15 percent alfalfa is required with corn-soybean rations.

Studies by Fairbanks, Krider and Carroll (14) further demonstrated that a ration of yellow corn, soybean meal, tankage, fish meal, fortified with cod-liver oil and minerals was nutritionally inadequate for gestation and lactation under drylot conditions. Gilts on the above ration produced litters containing a higher percentage of stillborn and weak pigs than did those fed rations fortified with either dried corn distillers' solubles and alfalfa meal, alone or in combination, or crystalline B-vitamins (thiamine, riboflavin, niacin, pantothenic acid, pyridoxine and choline chloride). The fortified rations also improved breeding efficiency and fertility as measured by number of services required per conception and by the average number of pigs farrowed per litter. The value of the dried solubles and alfalfa meal was attributed by the workers in this study to the water-soluble vitamins contained in these products.

In addition to supplying the B-vitamins known to be required for growth, the alfalfa meal was probably supplying additional unknown factors, since litters from the gilts fed 10 or 12 percent alfalfa meal remained relatively free from abnormalities in skin, feet and legs while litters in the other groups showed certain abnormalities.

Teague (46) observed the reproductive performance of gilts when a diet containing 18 percent of sun-cured alfalfa or a well supplemented legume-free diet was fed prior to breeding and during gestation. The inclusion of alfalfa did not noticeably affect breeding performance, but significantly increased the number of live pigs farrowed. A greater number of pigs from alfalfa-fed sows survived to weaning age. Gilts which had received the alfalfa supplemented diet also possessed a greater number of corpora lutea when slaughtered at 25--30 days of age. This suggested either that the alfalfa had stimulated ovulation or that the legume-free ration had depressed it. The embryonic and foetal mortality was much the same in both treatment groups.

In an earlier study, De Pape _et al_ (10) found that sun-cured alfalfa meal was significantly better than dehydrated alfalfa pellets in a gestation-lactation ration as shown by the number of pigs weaned per sow and the total weight of pig weaned per sow. Of the total number of pigs farrowed, the percent mortality to weaning was 16 and 20 percent higher in two trials, respectively, when dehydrated alfalfa pellets were fed in place of sun-cured alfalfa meal.

Gard _et al_ (16) studied the effects of adding 10 percent dehydrated alfalfa meal to a purified gestation and lactation diet containing corn starch, soybean protein, dextrose, woodflock, corn oil, vitamins and minerals. The summary data of the three trials showed that sows given alfalfa meal farrowed 1.4 more total pigs per litter and 1.8 more live pigs. The dehydrated alfalfa meal did not have any consistent effect upon the number of pigs surviving or total litter weight at weaning per litter.

Earlier work by Ensminger et al (12) had demonstrated that the addition of 15 percent alfalfa meal to a purified diet had a favorable effect upon gestation and lactation performance in that pigs were heavier at weaning.

Heidebrecht et al (24) fed gilts a basal diet of ground yellow corn, soybean oil meal, 5 percent alfalfa meal, salt and limestone for 105 days prior to breeding. When alfalfa silage was given ad libitum, the percent survival to weaning and average pig weights at weaning were significantly increased. The percent pigs weaned of those born alive and average weaning weight per pig were 16.7 percent and 19.8 pounds, respectively, for the pigs from sows receiving the basal ration, whereas the comparative figures for those receiving alfalfa silage were 66.7 percent and 26.6 pounds.

Feed Requirements For Bred Sows

The daily nutrient requirements for breeding sows as given by the United States National Research Council (1959) are outlined in the following table.

	Young Gilts	Mature Sow
Liveweight, lbs.	300.0	500.0
Expected daily gain, lbs.	1.0	0.7
Total feed (air dry), lbs.	6.0	7.5
Total digestible nutrients (70% T.D.N.), lbs.	4.2	5.2

On this basis a 300-pound bred gilt would receive 2 pounds of feed per 100 pounds of body weight per day, while a 500-pound mature sow would receive a daily allowance of 1.5 pounds per 100 pounds of body weight.

The Danish recommended allowances for bred sows, as calculated by Jespersen and Olsen (27), are as follows.

Weight of Sow (kgs.)	Scandinavian Feed Units Daily*	
	First 3 Months	Last 3 Weeks
125 - 150	2.7	3.7
150 - 175	2.8	3.8
175 - 200	2.9	3.9
200 - 225	3.0	4.0
225 - 250	3.1	4.1

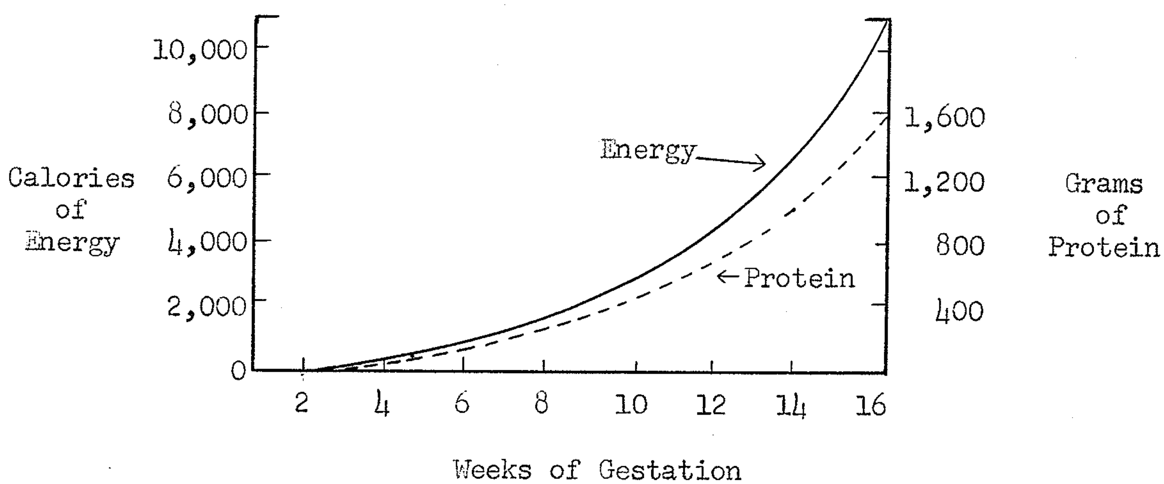
In Norway, Breirem (2) separated estimates of the requirements for pregnancy from those for maintenance. From studies on the nutritive

* 1 Scandinavian feed unit = approximately 2 pounds T.D.N.

requirements for growing-finishing pigs, he calculated that a sow of 150 kg. needs 1.2 Scandinavian feed units daily for maintenance; a sow of 200 kg., 1.5; and one of 250 kg., 1.7. He suggested that a pregnant sow in normal condition should have an extra 0.5 feed units daily to satisfy gestation requirements, while a sow in poor condition after a previous lactation should receive 1.0 feed unit daily above the maintenance requirement.

A more recent Norwegian recommendation by Valda et al (47) suggests the following requirements (in Scandinavian units): 3 weeks after weaning and 3 weeks before farrowing 2.5 to 3.0, for the remainder of pregnancy 2.0 to 2.5. The higher amounts are recommended for thin or young sows.

Mitchell et al (34) slaughtered pregnant gilts at weekly intervals from the fifth to the sixteenth week of gestation and determined the nutrients stored in the fetuses and placenta. The data were corrected to a standard litter of eight and treated mathematically to provide curves showing the increase in nutrient storage over the gestation period. The following graph based on this study and reproduced from Maynard and Loosli (32) illustrates that most of the nutrient deposition takes place during the last third of pregnancy.



Based on the above observations, Crampton (7) suggests that a sow should receive an extra 2.5 pounds of T.D.N. above the maintenance requirement during the last third of pregnancy.

The foregoing review of recommended nutrient allowances for gestating swine would suggest a number of inadequacies. Firstly, most of the suggested nutrient allowances are based on investigations involving growing-finishing swine. Secondly, with the exception of the Danish recommendations, no attempt has been made to give nutrient requirements for sows or gilts intermediate in weight between the suggested levels for young gilts or mature sows. Lastly, the extra nutritional demands of the last one-third of pregnancy, although given some consideration by the suggested Danish and Norwegian allowances, are fully realized only in the recommendation of Crampton (7).

The review of literature revealed only one reference which studied the effect of adding extra nutrients during the last third of the sow's gestation period. In this study by Johnson et al (28), 12 pounds of corn silage per sow per day, supplemented with a corn silage balancer containing carbohydrates, proteins, vitamins, minerals, and antibiotics, was fed to 52 sows and 60 gilts. In the even fed group, 2.95 pounds of the balancer was given daily to the sows and the gilts received 3.20 pounds daily from breeding to the 110th day of gestation. The other group of sows and gilts was fed the same amount of corn silage daily, but 2.50 and 2.75 pounds, respectively, of the balancer during the first two-thirds of gestation and 3.75 and 4.55 pounds, respectively, of the same balancer during the last one-third of gestation. The feeding systems were designed so that both the even and the low-high groups received the same amount of corn silage and balancer during the entire gestation period. The low-high system of feeding produced 1.41 more pigs per sow litter and 1.54 more pigs per gilt litter, when compared to the even system. There was little difference in the 4-day-old pig weights from either feeding system.

EXPERIMENTAL PROCEDURE

Gestation-Lactation Study

The gestation-lactation phase of this study was conducted during the period from May to October, 1961. The experimental animals consisted of 41 gilts which averaged 335 days of age (range--323 to 347 days) and 338 pounds in weight (range--278 to 405 pounds) at the time they were bred. The gilts were selected from the fourth generation of a breed development project at the University of Manitoba. The average contributions of the 7 foundation breeds to these gilts were: Landrace, 36.6 percent; Wessex Saddleback, 26.2 percent; Welsh, 11.4 percent; Minnesota No. 1, 14.3 percent; Berkshire, 9.3 percent; Yorkshire, 6.7 percent; and Tamworth, 5.5 percent. The treatment of the experimental animals prior to the test period was as follows: (1) All gilts had been fed a standard protein-supplemented barley-oats ration from approximately 180 pounds in weight. (2) Three weeks prior to breeding 20 gilts were fed a standard barley-oats gestation ration (ration I) and the remaining 21 gilts were given a ration which contained 10 percent dehydrated cereal grass meal* (ration II).

The gilts were self-fed during this pre-experimental period and the composition of the diets used in the study is indicated in Table I.

For breeding, the gilts were sub-grouped as equally as possible

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*Sold commercially in Canada under the trade name of Cara Gras.
Consists of: Orchard Grass, _Dactylis glomerata_ and New Zealand Rye Grass, _Lolium sp._
Guaranteed analysis: protein, 16 percent minimum; fat, 3.5 percent minimum; fibre, 22 percent maximum.

TABLE I

COMPOSITION OF DIETS

Components (lbs.)	Ration I Gestation	Ration II Gestation	Ration I Lactation	Ration II Lactation
Oats	45	35	30	--
Barley	44	48	59	83
Dehydrated Cereal Grass Meal	--	10	--	10
Soybean Oil Meal	7.5	3.5	7.5	3.5
Meat Meal	2.0	2.0	2.0	2.0
Limestone	1.0	1.0	1.0	1.0
Trace Mineralized Salt	0.5	0.5	0.5	0.5
Vitamin A (5,000 I.U./gm.)	30 gm.	--	30 gm.	--
Vitamin D (6,000 I.U./gm.)	1.25 gm.	1.25 gm.	1.25 gm.	1.25 gm.

CHEMICAL ANALYSIS

Nutrients (percent)	Ration I Gestation	Ration II Gestation	Ration I Lactation	Ration II Lactation
Protein	14.5	14.6	14.9	14.6
Fat	2.8	3.1	2.9	2.2
Fibre	7.2	7.9	6.6	6.9
Calcium	0.67	0.67	0.62	0.68
Phosphorus	0.43	0.40	0.40	0.37
Calculated T.D.N.	71.3	69.8	74.0	74.0

according to breeding and weight to six pens each of which contained a boar of similar breeding. Three pens of gilts received ration I and the remaining three were given ration II. The boars were continuously maintained in the breeding pens and were rotated among pens three weeks subsequent to the beginning of the breeding period.

Gilts were removed from the breeding pens 25 days after service at which time they were considered to be pregnant since they had not exhibited visual signs of estrus during the intervening period. The gilts were then individually fed twice daily for the remainder of the gestation period. Three levels of feed intake were tested for each of the two rations. The experimental design was therefore a 2 x 3 factorial with 2 rations and 3 levels.

A description of the 3 levels is indicated below and the feeding regime is outlined in Table II.

(1) <u>United States National Academy of Science--National Research Council Subcommittee on Swine Nutrition--Nutrient Requirements of Swine</u>* (35)

The amount of feed was calculated according to the National Research Council recommendation that a 300-pound gilt be given a daily allowance of 4.2 pounds of Total Digestible Nutrients (T.D.N.) while a 500-pound sow should receive 5.2 pounds. A straight line graph was drawn between these two levels to determine the requirements for gilts between the two extremes in body weight. The gilts were weighed every two weeks and feed adjustments were made according to body weight. One

*Referred to hereafter as the N.R.C. allowance.

TABLE II

DAILY FEED ALLOWANCES DURING GESTATION (LBS. FEED)

Weight of Gilt (lbs.)	N.R.C. Allowance	Norwegian Allowance Middle Period (25-93 Days)	Norwegian Allowance Last 3 Weeks	Restricted Allowance Middle Period (25-76 Days)	Restricted Allowance Last Third (38 Days)
300	6.00			2.70	6.30
310	6.05			2.75	6.35
320	6.10			2.80	6.40
330	6.20			2.90	6.50
340	6.30			3.00	6.60
350	6.35			3.10	6.70
360	6.40			3.20	6.80
370	6.50			3.30	6.90
380	6.60	7.00	8.50	3.40	7.00
390	6.65			3.50	7.00
400	6.70			3.60	7.10
410	6.80			3.65	7.20
420	6.90			3.70	7.30
430	6.95			3.75	7.40
440	7.00			3.80	7.50
450	7.05			3.90	7.60
460	7.10			4.00	7.70
470	7.20			4.10	7.80
480	7.30			4.20	7.90
490	7.40			4.30	8.00
500	7.50			4.35	8.00

Above feed allowances calculated on the basis of rations containing 70% T.D.N.

gilt receiving this level of the cereal grass ration aborted 31 days after breeding and was removed from the test.

(2) Norwegian Allowance--Valda *et al* (47)

The gilts were fed according to the Norwegian recommendation that a young sow be given 3.0 Scandinavian feed units daily for 3 weeks after weaning and 3 weeks before farrowing and 2.5 Scandinavian feed units per day for the remainder of the gestation period. It was assumed that a Scandinavian feed unit equals approximately 2 pounds of Total Digestible Nutrients (Duncan and Lodge (11)). Therefore the allowance given in terms of T.D.N. was 5.0 pounds of T.D.N. during the middle period of pregnancy (25--93 days) and 6.0 pounds of T.D.N. during the last three weeks. One gilt in each breeding lot failed to conceive and hence was not included in the trial.

(3) Restricted Allowance

The gilts receiving this allowance were fed at a level which was calculated to be approximately 15 percent less than the N.R.C. recommended allowance for the entire gestation period. However, the feeding regime was conducted so that the gilts received an additional 2.5 pounds of T.D.N. during the last third of pregnancy as recommended by Crampton (7). Thus, they were quite severely restricted during the middle part of the gestation period, being allowed essentially only a maintenance ration. Feed adjustments were made according to the bi-weekly body weight recorded for the gilts. One gilt in each experimental group aborted 30 days after breeding and one gilt receiving the dehydrated cereal grass ration failed to conceive.

The chart below indicates the rations, levels and number of animals in each lot.

	N.R.C. Allowance		Norwegian Allowance		Restricted Allowance	
	Initial No.	Final No.	Initial No.	Final No.	Initial No.	Final No.
Ration I	6	6	6	5	8	7
Ration II	6	5	6	5	9	7

The gilts were kept in dirt lots, provided with shelters, and had free access to water. The animals were moved into the farrowing barn approximately one week prior to the calculated farrowing date. They were weighed at frequent intervals in order to obtain a weight within 48 hours of farrowing and were put into farrowing crates about 2 days prior to the expected farrowing date. They were weighed within 12 hours after farrowing and were injected with either 2,000,000 units of a mixture of penicillin and streptomycin or 500 milligrams of terramycin as a preventative measure against fever and scouring.

The gilts were hand-fed to appetite during lactation similar rations to those fed during gestation, but with some adjustments made to give a higher T.D.N. intake. The baby pigs were injected with an iron-dextran compound within 3 days of birth. A commercial creep feed was provided to the young pigs at between 2 and 3 weeks of age. Two litters from each treatment group were weaned at 3 weeks of age to alleviate a pen shortage problem in the farrowing barn. The remainder of the litters were weaned at 6 weeks of age.

The data collected during the experimental period were as follows:

1. Weight of gilts at breeding.
2. Weights of gilts at bi-weekly intervals.
3. Pre-farrowing weight, i.e., within 48 hours of farrowing.
4. Post parturient weight within 12 hours after farrowing.
5. Gilt weights 3 weeks post farrowing.
6. Number of pigs farrowed (total and alive).
7. Birth weights of all pigs farrowed.
8. Number of pigs surviving at three weeks of age.
9. Three week weights of baby pigs.
10. Feed consumption of gilts during gestation and lactation.

Prenatal Study

A further study was undertaken in August, 1961 to observe certain prenatal reproductive characteristics of swine as influenced by the same rations and feeding levels as were used in the gestation-lactation study.

Twenty-one gilts were allotted into the same six treatment groups that were employed in the previous study. The age and weight of the gilts at time of breeding and all other methods of procedure closely paralleled those of the gestation-lactation trial. Three gilts receiving the dehydrated cereal grass ration failed to conceive. The chart below outlines the rations, levels and number of animals in each lot.

	N.R.C. Allowance		Norwegian Allowance		Restricted Allowance	
	Initial No.	Final No.	Initial No.	Final No.	Initial No.	Final No.
Ration I	3	3	4	4	4	4
Ration II	3	2	3	2	4	3

The gilts were sacrificed midway through the gestation period and the following observations were made:

1. Number of corpora lutea and normal embryos.
2. Weight of entire reproductive tract.
3. Weight of the embryos.
4. Weight of the empty uterus.
5. Weight of the uterine fluids.
6. Crown-rump length of the embryos.
7. Length of the uterine horns.

Statistical methods employed for analysis of data were analysis of variance and covariance as described by Snedecor (42).

RESULTS AND DISCUSSION

I. GESTATION-LACTATION STUDY

Feed Consumption of Gilts During Gestation

The feed consumption data are summarized in Table III and presented pictorially in Figure 1.

When the study was designed it was felt that gilts receiving the Norwegian Standard would receive approximately 15 percent more feed during the entire gestation period than would those fed the National Research Council (N.R.C.) recommended allowance. As a consequence the Restricted Level was designed so that gilts on this level of feed intake would receive approximately 15 percent less than the N.R.C. recommendation, thus giving a comparison of feeding levels which were 15 percent above and below the N.R.C. suggested level. However, as will be noted from the results in Table III, the total feed consumption for the entire gestation period was almost the same (7.41 and 7.30 pounds per day, respectively) for the Norwegian Standard and the N.R.C. levels. This was because the gilts receiving the N.R.C. allowance gained in weight rapidly during the early period of gestation and were soon at a weight requiring an allowance equal to that given to the gilts allowed the Norwegian Standard. Therefore the gilts given the N.R.C. allowance, which was based on their body weight, received approximately the same amount of feed (6.97 pounds) during the middle part of pregnancy (25--76 days) as did those on the Norwegian Standard which received a constant daily allowance of 7.0 pounds of feed. The gilts on the Norwegian Standard (which allowed a daily feed intake of 8.5 pounds during the last 3 weeks of gestation)

TABLE III

AVERAGE DAILY FEED CONSUMPTION OF GILTS DURING GESTATION (LBS.)

Ration I	No. of Gilts	1st 25 Days	25--76 Days	Last Third (38 Days)	Entire Gestation Period
N.R.C.	6	7.68	6.81	7.19	7.13
Norwegian Standard	5	7.28	7.00	7.66	7.28
Restricted	7	7.84	3.46	7.28	5.73
Average	18	7.63	5.67	7.36	6.62
Ration II					
N.R.C.	5	8.44	7.15	7.34	7.49
Norwegian Standard	5	8.28	7.00	7.77	7.54
Restricted	7	8.57	4.03	7.11	6.07
Average	17	8.44	5.82	7.37	6.92
Average of Rations I & II					
N.R.C.	11	8.03	6.97	7.26	7.30
Norwegian Standard	10	7.78	7.00	7.71	7.41
Restricted	14	8.20	3.75	7.20	5.90
Total	35	8.03	5.69	7.36	6.77

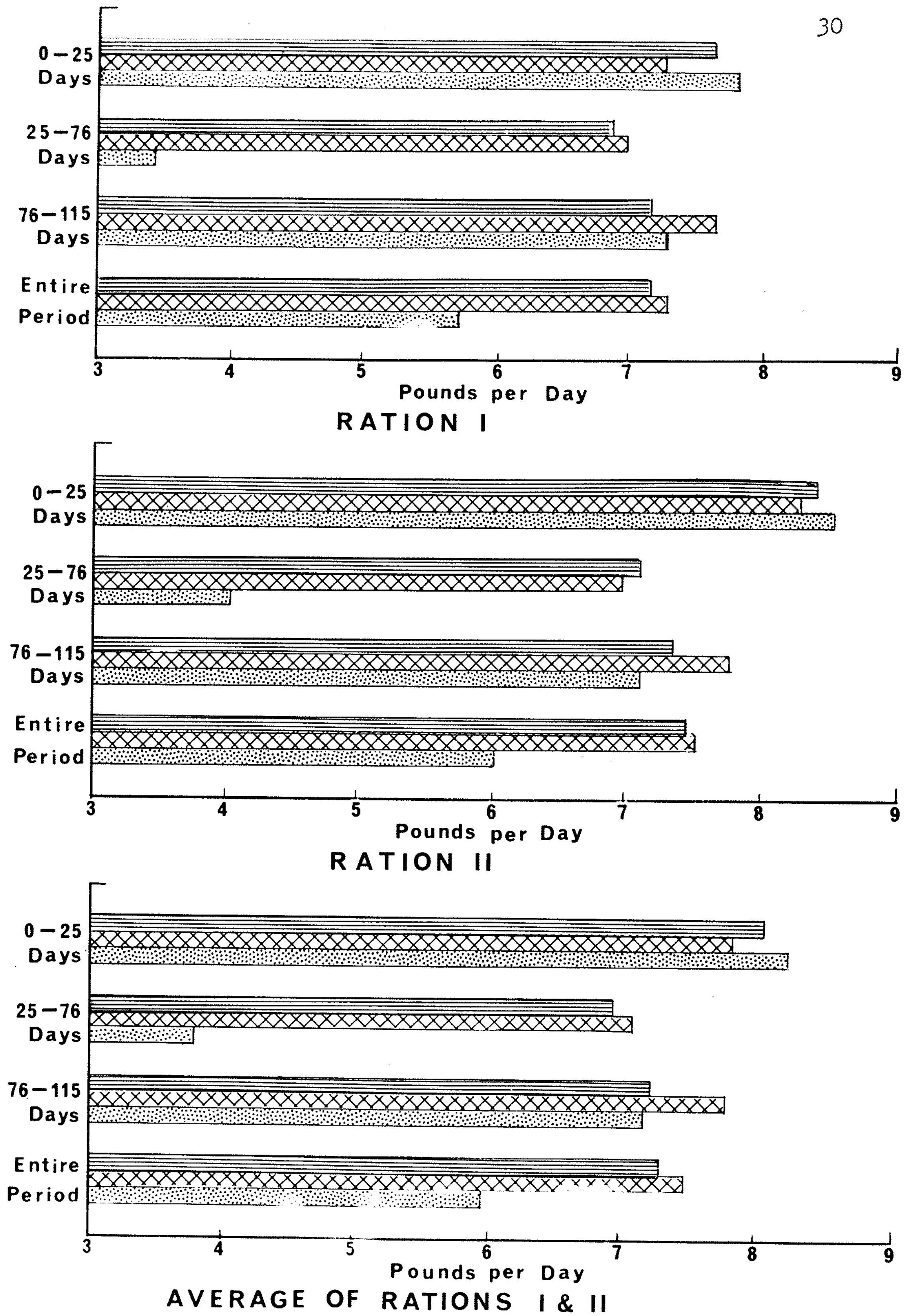

FIGURE 1

FEED CONSUMPTION OF GILTS DURING GESTATION

N.R.C. NORWEGIAN STANDARD RESTRICTED

did consume an average of 0.45 more pounds of feed daily during the last 38 days of the gestation period than did those on the N.R.C. allowance. This, however, was not great enough to give an appreciably greater feed intake when the entire gestation period was considered.

The gilts whose feed intake was restricted consumed an average of 5.90 pounds of feed per day over the entire gestation period, an amount which was 19.2 percent below that of the consumption of the gilts receiving the N.R.C. allowance. This restriction was made during the middle part of the gestation period (25--78 days). The average daily feed allowance to the restricted gilts during this period was 3.75 pounds of feed, or 2.6 pounds of Total Digestible Nutrients (T.D.N.), on the basis of 70% T.D.N. in the ration. This was only 0.4 pounds of T.D.N. above the calculated maintenance requirement of 2.2 pounds of T.D.N. for gilts of this weight.

The daily allowance to the restricted gilts was increased by 2.5 pounds of T.D.N. during the last one-third of pregnancy, thus giving a daily feed intake of 7.20 pounds which was nearly equal to that of the N.R.C. level of 7.26 pounds per day during the final third of the gestation period.

It will be noted from Table III that there was a considerable amount of variation in the feed consumption within the 6 treatment groups during the first 25 days of gestation, during which time the gilts were allowed to remain in the breeding pens. This was because all the test animals were self-fed during this period and strict regulation of the feed intake could therefore not be achieved. Removal of the gilts from the breeding pens and initiation of individual feeding immediately after breeding would have eliminated this variation in feed intake during the early part of pregnancy. However, the gilts were allowed to remain in the breeding pens for this 25 day period on full feed so that any gilts which failed to conceive at the first service could be rebred at the succeeding estrus, while still on a full feeding regime, which most investigators feel is necessary for maximum ovulation. If the gilts had been subjected to restricted feeding immediately after breeding, it would have necessitated removal from test of those which failed to become pregnant and returned to service at the next estrual cycle, since the limited feed intake would have had a deleterious effect on ovulation rate at the subsequent estrus.

The limited number of gilts available for this study necessitated the procedure which was carried out.

Body Weight Changes of Gilts During Gestation and Parturition

The average daily gains of the gilts during gestation are outlined in Table IV and shown graphically by Figure 2. The actual body weight changes during gestation and parturition are summarized in Table V. The statistical analyses of the data related to body weight changes are shown in Tables VI and VII.

A preliminary regression analysis of the effect of initial or breeding weights on body weight before farrowing and on weight after farrowing indicated heterogeneity of regression. This finding imposed the restriction that a typical 2 x 3 factorial analysis of variance would not be valid. Analysis of variance and covariance was hence conducted on a within and between treatment basis. It will be noted in the analysis of covariance in Tables VI and VII that six degrees of freedom have been removed from the error term by the adjustment for breeding weight. The analysis of data adjusted for breeding weight indicated a significant difference ($P < 0.01$) among rations as to their effects upon weight prior to and after farrowing.

Inspection of the average daily gain data suggests that this significance was due primarily to the feeding levels employed. The gilts on the restricted level of feed intake on both ration treatments made slower gains and were lighter in weight at farrowing time than those on the other two feeding levels. The slower gains were, of course, occasioned by the severe restriction in feed intake during the period from the 25th to the 76th day of gestation. The average daily gain of the gilts for this period on the restricted level of both ration treatments was 0.51 pounds as

TABLE IV

AVERAGE DAILY GAIN OF GILTS DURING GESTATION (LBS.)

Ration I	No. of Gilts	1st 25 Days	25--76 Days	Last Third (38 Days)	Entire Gestation Period
N.R.C.	6	1.49	1.35	1.53	1.44
Norwegian Standard	5	1.38	1.17	1.63	1.38
Restricted	7	1.87	0.41	2.10	1.31
Average	18	1.61	0.93	1.79	1.37
Ration II					
N. R. C.	5	1.74	0.99	1.56	1.35
Norwegian Standard	5	1.70	0.98	1.36	1.26
Restricted	7	1.49	0.61	1.95	1.26
Average	17	1.62	0.83	1.66	1.29
Average of Rations I & II					
N.R.C.	11	1.60	1.18	1.54	1.40
Norwegian Standard	10	1.54	1.08	1.50	1.32
Restricted	14	1.68	0.51	2.03	1.29
Total	35	1.62	0.88	1.72	1.33

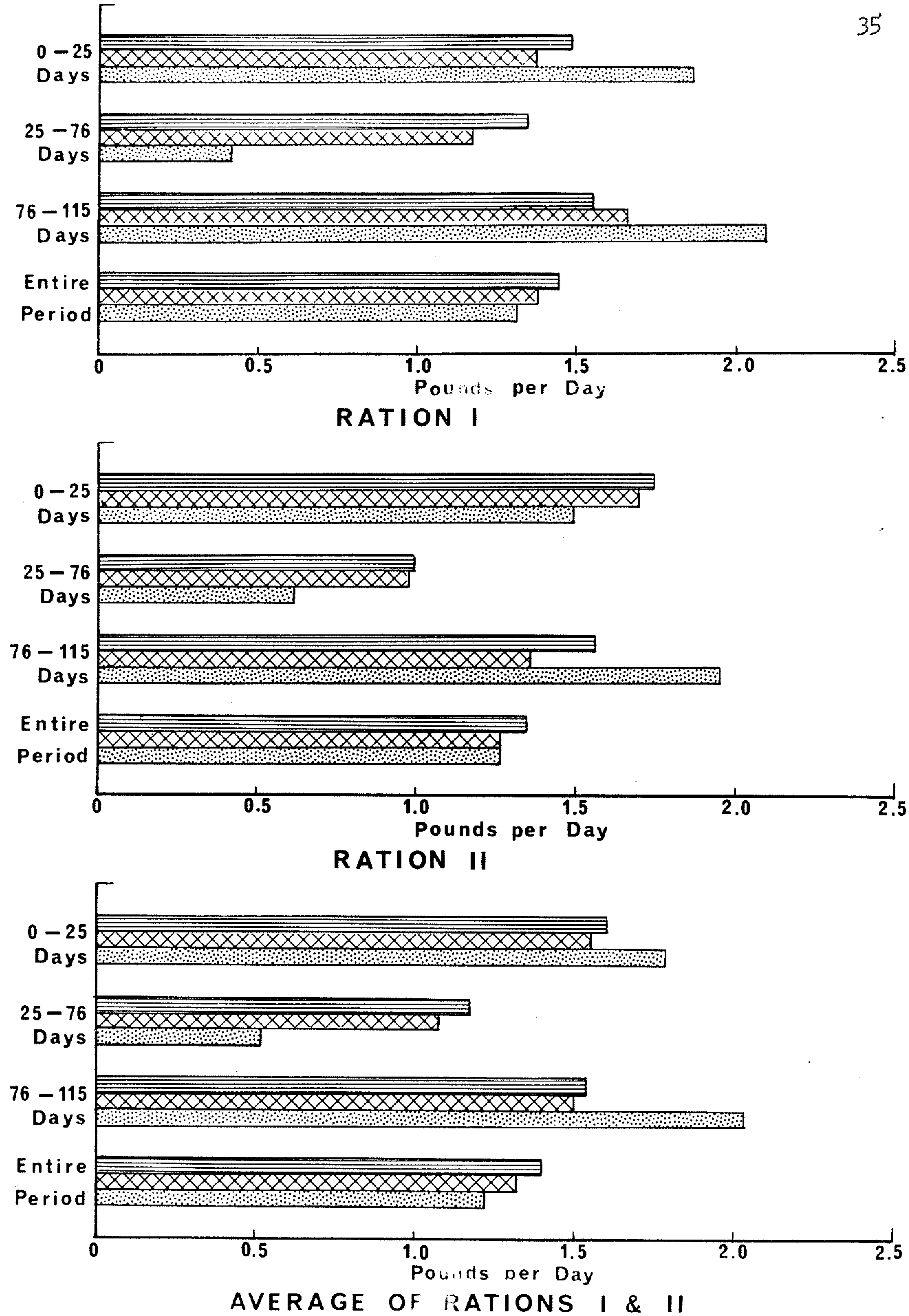

FIGURE 2

AVERAGE DAILY GAIN OF GILTS DURING GESTATION

N.R.C. NORWEGIAN STANDARD RESTRICTED

TABLE V

AVERAGE BODY WEIGHT CHANGES OF GILTS DURING GESTATION AND PARTURITION (LBS.)

Ration I	No. Gilts	Breeding Weight	Weight at Farrowing	Standard Error	Weight Gain	Weight after Farrowing	Standard Error	Weight Loss	Standard Error
N.R.C.	6	344.3	510.0	± 14.3	165.7	470.8	± 17.0	39.2	± 6.3
Norwegian Standard	5	355.4	514.6	± 15.7	159.2	468.6	± 18.6	46.0	± 6.9
Restricted	7	338.8	491.7	± 13.3	152.9	451.7	± 15.7	40.0	± 5.8
Average	18	345.3	504.2	± 8.3	158.9	462.8	± 9.8	40.5	± 3.6
Ration II									
N.R.C.	5	375.6	533.4	± 15.7	157.8	497.6	± 18.6	35.8	± 6.9
Norwegian Standard	5	369.8	516.8	± 15.7	147.0	488.8	± 18.6	28.0	± 6.9
Restricted	7	338.1	484.0	± 13.3	145.9	440.8	± 15.7	43.2	± 5.8
Average	17	358.4	508.1	± 8.5	149.7	471.6	± 10.1	36.5	± 3.7
Average of Rations I & II									
N.R.C.	11	358.5	520.6	± 10.6	162.1	483.0	± 12.5	37.6	± 4.6
Norwegian Standard	10	362.6	515.7	± 11.1	153.1	478.7	± 13.2	37.0	± 4.9
Restricted	14	338.5	487.8	± 9.4	149.3	446.3	± 11.1	41.5	± 4.1
Total	35	351.7	506.1		154.4	467.1		39.0	± 2.6

TABLE VI

REGRESSION ANALYSIS OF WEIGHT AT FARROWING ON BREEDING WEIGHT

Treatment	Sum of Squares Within	Sum of Squares Due to Regression	Sum of Squares Due to Error
Ration I--N.R.C.	2960.0	153.25	2806.75
--Norwegian Standard	6015.0	3006.66	3008.34
--Restricted	10997.0	8719.46	2277.54
Ration II-N.R.C.	5797.0	5727.57	69.43
--Norwegian Standard	6363.0	4786.10	1576.90
--Restricted	3550.0	2639.30	910.70
Total	35682.0	25032.34	10649.66

ANALYSIS OF VARIANCE AND COVARIANCE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value	Adjusted for Breeding Weight			
					SS	DF	MS	F
Treatment (Ration)	5	9619.55	1923.91	1.56	9619.55	5	1923.91	4.15**
Error	29	35682.00	1230.40		10649.66	23	463.03	
Total	34	45301.55			20269.25	28		

** Significant at 1% level

TABLE VII

REGRESSION ANALYSIS OF WEIGHT IMMEDIATELY AFTER FARROWING ON BREEDING WEIGHT

Treatment	Sum of Squares Within	Sum of Squares Due to Regression	Sum of Squares Due to Error
Ration I --N.R.C.	3648.8	31.5	3617.3
--Norwegian Standard	7775.2	5677.4	2097.8
--Restricted	17139.4	14240.1	2899.3
Ration II--N.R.C.	4905.2	4711.6	193.6
--Norwegian Standard	9430.8	7072.1	2358.7
--Restricted	7274.9	4156.7	3118.2
Total	50174.3	35889.4	14284.9

ANALYSIS OF VARIANCE AND COVARIANCE

Sources of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value	Adjusted for Breeding Weight			
					SS	DF	MS	F
Treatment	5	13578.5	2715.7	1.57	13578.5	5	2715.7	4.37**
Error	29	50174.3	1730.1		14284.9	23	621.1	
Total	34	63752.8			27863.4	28		

** Significant at 1% level

compared to 1.18 and 1.08 pounds per day, respectively, for the N.R.C. and Norwegian Standard feeding levels. The restricted gilts did, however, gain weight much more rapidly during the last third of the gestation period when their daily feed intake was increased by 2.5 pounds of T.D.N. Average daily gains during this period were 2.03, 1.54 and 1.50 pounds, respectively, for the restricted, N.R.C. and Norwegian Standard levels of feed intake. However, when the entire gestation period was considered the restricted gilts gained only 1.29 pounds daily compared to average daily gains of 1.40 and 1.32 pounds, respectively, for the N.R.C. and Norwegian Standard gilts.

The daily gains for the gilts on all three levels of feed intake were considerably higher than the gain of 1.0 pound per day which is recommended by the National Research Council as the optimal daily gain during the gestation period of a gilt. The results of this study would therefore suggest that the N.R.C. recommended allowance for pregnant gilts is excessive if body weight gains during gestation are used as a measure. However, none of the gilts in this study appeared to be excessively fat at the time of farrowing.

The average body weight loss at parturition of the 35 gilts involved in this investigation was 39.0 pounds. There was a considerable amount of variation among individuals within treatment groups and body weight changes at this time appeared to depend more on total litter size and birthweight than on previous ration treatments.

Number of Pigs Born

Table VIII summarizes the farrowing performance of the 35 gilts used in the experiment. The average total litter size for the 35 litters was 10.2 and the average litter size of pigs born alive was 9.8. Analyses of variance for total pigs born (Table IX) and for total pigs born alive (Table X) revealed that there were no significant differences due to ration, feeding level or interaction for either criteria of reproductive performance. An analysis of covariance (Table XI) of percent livability at birth on total litter size (using the arcsine transformation) also indicated that there were no statistically significant differences in the number of stillbirths due to treatments when the effect of litter size was removed. The difference in livability was however significant at the 10 percent level of probability.

The average litter size of total pigs born was almost the same, when the averages of the two ration treatments were considered. The gilts receiving ration I farrowed an average of 10.2 total pigs per litter, whereas those on the dehydrated cereal grass ration gave birth to an average of 10.3 pigs. However, there were a larger number of stillbirths in the litters from the gilts on ration I and therefore the litters from the dehydrated cereal grass-fed gilts showed a slightly more favorable performance when the number born alive was considered. Average litter size of the pigs born alive for rations I and II was 9.5 and 10.2, respectively.

This favorable response of dehydrated cereal grass on litter size at birth was not as marked as that obtained during previous trials con-

TABLE VIII

NUMBER OF PIGS BORN

	No. of	Total Born			Stillborn		Born Alive		
Ration I	Litters	Total	Mean	S.E.	Total	Mean	Total	Mean	S.E.
N.R.C.	6	61	10.2	± 1.1	7	1.2	54	9.0	± 1.1
Norwegian Standard	5	51	10.2	± 1.2	1	0.2	50	10.0	± 1.2
Restricted	7	72	10.3	± 1.0	4	0.6	68	9.7	± 1.0
Average	18	184	10.2	± 0.6	12	0.7	172	9.5	± 0.7
Ration II									
N.R.C.	5	47	9.4	± 1.2	1	0.2	46	9.2	± 1.2
Norwegian Standard	5	48	9.6	± 1.2	1	0.2	47	9.4	± 1.2
Restricted	7	80	11.4	± 1.0	-	-	80	11.4	± 1.0
Average	17	175	10.3	± 0.6	2	0.1	173	10.2	± 0.7
Average of Rations I & II									
N.R.C.	11	108	9.8	± 0.8	8	0.7	100	9.1	± 0.8
Norwegian Standard	10	99	9.9	± 0.8	2	0.2	97	9.7	± 0.9
Restricted	14	152	10.8	± 0.7	4	0.3	148	10.5	± 0.7
Total	35	359	10.2	± 0.4	14	0.4	345	9.8	± 0.5

TABLE IX

ANALYSIS OF VARIANCE FOR AVERAGE LITTER SIZE OF TOTAL PIGS BORN

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value
Ration	1	0.05	0.05	0.007
Levels	2	8.43	4.21	0.590
R x L	2	7.01	3.50	0.490
Error	29	207.20	7.14	
Total	34	222.69		

TABLE X

ANALYSIS OF VARIANCE FOR AVERAGE LITTER SIZE OF PIGS BORN ALIVE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value
Ration	1	3.29	3.29	0.42
Levels	2	13.85	6.92	0.88
R x L	2	7.85	3.92	0.50
Error	29	227.30	7.84	
Total	34	252.9		

TABLE XI

REGRESSION ANALYSIS OF PERCENT LIVABILITY AT BIRTH ON TOTAL LITTER SIZE

Treatment	Sum of Squares Within	Sum of Squares Due to Regression	Sum of Squares Due to Error
Ration I --N.R.C.	1119.8	211.0	908.8
--Norwegian Standard	247.9	28.8	219.1
--Restricted	897.0	131.5	765.5
Ration II--N.R.C.	194.8	164.8	30.0
--Norwegian Standard	342.9	20.0	322.9
--Restricted	0.0	0.0	0.0
Total	2802.4	556.1	2246.3

ANALYSIS OF VARIANCE AND COVARIANCE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value	Adjusted for Litter Size			
					SS	DF	MS	F
Treatment	5	1138.5	227.7	2.36	1138.5	5	227.7	2.33
Error	29	2802.4	96.6		2246.3	23	97.7	
Total	34	3940.9			3384.8	28		

ducted at the University of Manitoba, in which there was an average of 1.1 more live pigs per litter when 10 percent dehydrated cereal grass was included in gilt gestation rations. However, it was noted in the earlier studies that the differences in favor of the dehydrated cereal grass were not as marked in the litters from sows. The gilts used in the present investigation were older and heavier in weight than those of the former investigations, thus were more comparable in physiological size to the sows in the earlier study. The results of this study are in close agreement with those of Stothers (45) when this comparison is made.

Only slight differences were noted in the average litter size of live pigs born from gilts receiving the three levels of feed intake. The gilts on the restricted feed intake during gestation farrowed slightly more live pigs than did the gilts on the Norwegian Standard, which in turn showed approximately the same degree of superiority over the gilts on the N.R.C. allowance. Average litter sizes of live pigs for the three levels of feed intake were: N.R.C., 9.1; Norwegian Standard, 9.7; and Restricted, 10.5.

The larger litters of live pigs at birth from the gilts on a limited feed intake, although not significant in this study, are in general agreement with the findings of Christian and Nofziger (6), Robertson et al (37), Self et al (40 and 41) and Haines et al (21).

Pig Birth Weights

The birth weights of the pigs farrowed by the gilts in this study are outlined in Table XII.

The average weight of the live pigs born was almost the same for the two ration treatments--2.92 pounds per pig for gilts receiving ration I and 2.94 pounds per pig for litters farrowed from gilts on ration II. Differences in the average weights of live pigs born were noted in the litters farrowed from the three feeding level groups. Largest average weights of live pigs born were recorded from litters from the gilts which had been fed the N.R.C. allowance during gestation, while the smallest pigs were in the litters of the limited-fed gilts. The average live pig weights for each of the feeding levels were: N.R.C., 3.17 pounds; Norwegian Standard, 2.96 pounds; and Restricted, 2.76 pounds.

However, the lighter birth weights for the pigs in the Norwegian Standard and Restricted gilt litters appeared to be due to the greater number of pigs per litter from the gilts subjected to these two feeding regimes during gestation. Total litter weight at birth is probably a more adequate measure of the effect of a ration upon reproduction. An analysis of covariance of total litter birthweight on total litter size (Table XIII) revealed that no significant differences due to treatments were evident when the total litter size was held constant. A similar statistical technique (Table XIV) gave the same result for treatment effects on total litter birthweight of the pigs which were born alive.

TABLE XII

PIG BIRTH WEIGHTS (LBS.)

Ration I	No. of Litters	Total Pigs Born		Pigs Born Alive			
		Average Litter Wt.	Average Pig Wt.	Average Litter Wt.	S.E.	Average Pig Wt.	S.E.
N.R.C.	6	31.9	3.14	28.7	± 2.9	3.19	± 0.08
Norwegian Standard	5	29.3	2.87	29.0	± 3.2	2.90	± 0.09
Restricted	7	27.9	2.71	26.5	± 2.7	2.73	± 0.07
Average	18	29.6	2.90	27.9	± 1.7	2.92	± 0.04
Ration II							
N.R.C.	5	29.3	3.12	28.9	± 3.2	3.14	± 0.09
Norwegian Standard	5	29.0	3.03	28.4	± 3.2	3.02	± 0.09
Restricted	7	31.8	2.78	31.8	± 2.7	2.78	± 0.07
Average	17	30.3	2.94	29.9	± 1.7	2.94	± 0.04
Average of Rations I & II							
N.R.C.	11	30.7	3.13	28.8	± 2.2	3.17	± 0.06
Norwegian Standard	10	29.2	2.95	28.7	± 2.3	2.96	± 0.06
Restricted	14	29.8	2.75	29.1	± 1.9	2.76	± 0.05
Total	35	29.9	2.92	28.9	± 1.2	2.93	± 0.03

TABLE XIII

REGRESSION ANALYSIS OF TOTAL LITTER BIRTHWEIGHT ON TOTAL LITTER SIZE

Treatment	Sum of Squares Within	Sum of Squares Due to Regression	Sum of Squares Due to Error
Ration I --N.R.C.	490.0	475.2	14.8
--Norwegian Standard	146.1	12.4	133.7
--Restricted	354.2	219.1	135.1
Ration II--N.R.C.	120.6	77.9	42.7
--Norwegian Standard	193.9	192.6	1.3
--Restricted	55.7	3.1	52.6
Total	1360.5	980.3	380.2

ANALYSIS OF VARIANCE AND COVARIANCE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value	Adjusted for Litter Size			
					SS	DF	MS	F
Treatment	5	85.9	17.19	0.35	85.9	5	17.19	1.04
Error	29	1360.5	46.91		380.2	23	16.53	
Total	34	1446.4			466.1	28		

TABLE XIV

REGRESSION ANALYSIS OF TOTAL BIRTHWEIGHT (PIGS ALIVE) ON TOTAL BORN ALIVE

Treatment	Sum of Squares Within	Sum of Squares Due to Regression	Sum of Squares Due to Error
Ration I--N.R.C.	594.1	577.6	16.5
--Norwegian Standard	167.7	41.1	126.6
--Restricted	363.3	245.1	118.2
Ration II-N.R.C.	97.0	52.5	44.5
--Norwegian Standard	217.3	216.4	0.9
--Restricted	55.7	3.1	52.6
Total	1495.1	1135.8	359.3

ANALYSIS OF VARIANCE AND COVARIANCE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value	Adjusted for Litter Size			
					SS	DF	MS	F
Treatment	5	90.75	18.15	0.35	90.75	5	18.15	1.16
Error	29	1495.10	51.55		359.30	23	15.60	
Total	34	1585.85			450.05	28		

Baby Pig Survival to Three Weeks of Age

The data outlining the percent survival at three weeks of age of the total pigs born and of the total pigs born alive are presented in Table XV. The data are given for only 33 of the 35 litters which were farrowed in the investigation. One litter in the Restricted ration I treatment group was chilled at birth and only 2 of the 13 pigs farrowed survived to 3 weeks. One gilt on the Norwegian Standard ration I had no milk and 8 of the 10 pigs which were farrowed failed to survive. Hence, these two litters were not included in the summary data or statistical analysis.

A simple analysis of variance for percent survival using the arcsine transformations (Table XVI) revealed that significantly more of the total pigs farrowed survived to three weeks of age when 10 percent dehydrated cereal grass was included in the gilts' gestation-lactation ration. The average survival to 3 weeks for all 3 feeding levels containing the dehydrated cereal grass was 80.6 percent as compared to an average survival of only 67.1 percent in the litters from the gilts which were fed ration I.

These results support the evidence obtained in the studies of Stothers (45) which suggested that baby pig survival rates to 3 weeks are enhanced by the inclusion of 10 percent dehydrated cereal grass in gestation-lactation rations.

Percent survival to 3 weeks of age of total pigs born alive was also higher in the litters from the dehydrated cereal grass-fed gilts. The difference was, however, not significant when a statistical analysis

TABLE XV

BABY PIG SURVIVAL TO 3 WEEKS OF AGE

Ration I	No. of Litters	Number of Pigs at 3 Weeks			% Survival	
		Total	Average per Litter	Standard Error	of Total Pigs Born	of Total Pigs Born Alive
N.R.C.	6	45	7.5	± 0.9	73.8	83.3
Norwegian Standard	4	30	7.5	± 1.2	73.2	75.0
Restricted	6	33	5.5	± 0.9	55.9	60.0
Average	16	108	6.7	± 0.6	67.1	73.0
Ration II						
N.R.C.	5	35	7.0	± 1.0	74.5	76.1
Norwegian Standard	5	31	6.2	± 1.0	64.6	65.9
Restricted	7	75	10.7	± 0.9	93.7	93.7
Average	17	141	8.3	± 0.6	80.6	81.5
Average of Rations I & II						
N.R.C.	11	80	7.3	± 0.7	74.1	80.0
Norwegian Standard	9	61	6.8	± 0.8	68.5	70.1
Restricted	13	108	8.3	± 0.6	77.7	80.0
Total	33	249	7.5	± 0.4	74.3	77.6

TABLE XVI

ANALYSIS OF VARIANCE FOR PERCENT SURVIVAL TO 3 WEEKS OF TOTAL PIGS BORN

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value
Ration	1	1647.0	1647.0	6.82*
Levels	2	266.9	133.5	0.55
R x L	2	1844.4	922.2	3.82*
Error	27	6521.5	241.5	
Total	32	10279.8		

* Significant at 5% Level

TABLE XVII

ANALYSIS OF VARIANCE FOR PERCENT SURVIVAL TO 3 WEEKS OF TOTAL LIVE PIGS BORN

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value
Ration	1	840.5	840.5	3.57[1]
Levels	2	327.7	163.8	0.70
R x L	2	2110.2	1055.1	4.48[2]
Error	27	6350.7	235.2	
Total	32	9629.1		

[1] Significant at 10% Level
[2] Significant at 5% Level

(Table XVII) was conducted on this comparison. This was because there were larger numbers of stillbirths in the litters from gilts receiving ration I and hence percent survival was higher in this treatment group when this factor was not considered.

No statistically significant differences in survival rates were found to be due to the feeding levels in this study. Average survival rates to three weeks of age of the total live pigs born for the three levels were: N.R.C., 80.0 percent; Norwegian Standard, 70.1 percent; and Restricted, 80 percent.

The statistical analysis revealed a significant interaction between rations and feeding levels. This was most apparent in the difference in survival rates in the restricted levels of feed intake. The survival of the total live pigs born to 3 weeks was 60.0 percent in the litters farrowed from gilts receiving ration I on the restricted level of feed intake, whereas 93.7 percent of the total number of live pigs farrowed from gilts on the same level of feed intake in ration II were alive at 3 weeks of age.

Three Week Litter Weights

The data concerning the baby pig weights at 3 weeks of age are summarized in Table XVIII.

Very little difference was apparent in the average pig weights in the two ration treatments. The average weight per pig in the litters from the gilts receiving ration II was 11.5 pounds, which may be compared with an average weight of 11.4 pounds for the pigs from gilts in the ration I treatment group. Somewhat greater differences were apparent when the average 3 week pig weights were compared for the three feeding levels. The heaviest pigs were in the litters of the Norwegian Standard gilts and the lightest in the restricted-fed gilt litters. The average pig weights for the three feeding treatments were: N.R.C., 11.8 pounds; Norwegian Standard, 12.1 pounds; and Restricted, 11.0 pounds.

These differences in average pig weights were, however, probably due more to differences in average litter size than to the effect of the dam's feed intake during gestation. This was apparent when total litter weight, which is a more meaningful measure of a gilt's reproductive worth, was considered.

The total litter weight of the gilts receiving the ration II formulation, containing dehydrated cereal grass, was considerably greater than that of the litters from the gilts fed ration I (95.8 pounds vs. 80.0 pounds). This was of course related to the litter size and again was a reflection of the greater number of pigs which survived to 3 weeks in the litters from the gilts receiving dehydrated cereal grass in their diet. An analysis of variance (Table XIX) revealed, however, that

TABLE XVIII

AVERAGE 3 WEEK LITTER WEIGHTS (LBS.)

Ration I	No. of Litters	Total Litter Weight	Standard Error	Weight per Pig	Standard Error
N.R.C.	5	102.3	± 9.7	12.2	± 0.4
Norwegian Standard	4	80.1	±10.8	10.7	± 0.4
Restricted	6	61.2	± 8.8	11.1	± 0.4
Average	15	80.0	± 5.6	11.4	± 0.2
Ration II					
N.R.C.	5	78.9	± 9.7	11.3	± 0.4
Norwegian Standard	5	83.4	± 9.7	13.4	± 0.4
Restricted	7	116.7	± 8.2	10.9	± 0.3
Average	17	95.8	± 5.2	11.5	± 0.2
Average of Rations I & II					
N.R.C.	10	90.6	± 6.9	11.8	± 0.3
Norwegian Standard	9	81.9	± 7.2	12.1	± 0.3
Restricted	13	91.1	± 6.0	11.0	± 0.2
Total	32	88.4	± 3.8	11.5	± 0.1

TABLE XIX

ANALYSIS OF VARIANCE OF TOTAL 3 WEEK LITTER WEIGHT

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value
Ration	1	0.97	0.97	0.002
Levels	2	57.03	28.51	0.060
R x L	2	11807.00	5903.50	12.550**
Error	26	12225.00	470.20	
Total	31	24090.00		

** Significant at 1% Level

this difference between rations was not statistically significant. The average total litter weights for the three feeding levels, which were: N.R.C., 90.6 pounds; Norwegian Standard, 81.9 pounds; and Restricted, 91.1, were also shown to be not significantly different.

There was, however, a highly significant difference ($P<0.01$) due to inter-action between the rations and feeding level treatments. In the ration I lots, the heaviest litters at three weeks were from gilts fed the N.R.C. level during gestation and the lightest were in the restricted-fed gilt litters. Average total litter weights for the three ration I feeding levels were: N.R.C., 102.3 pounds; Norwegian Standard, 80.1 pounds; and Restricted, 61.2 pounds; whereas, the inverse was true for the litters in the three feeding level groups of ration II. The litters from the restricted gilts were the heaviest in this ration treatment and those of the N.R.C. gilts were the lightest. Average total litter weights were: N.R.C., 78.9 pounds; Norwegian Standard, 83.4 pounds; and Restricted, 116.7 pounds.

These differences in total litter weights are again due to the differences in the total number of pigs in the litters at 3 weeks after farrowing and are a reflection of the survival rates to 3 weeks within the various treatment groups. The physiological reason for this inter-action which is most evident in the data for the litters from the gilts subjected to the two restricted feeding regimes during the middle period of gestation is difficult to explain. Perhaps some limiting nutrient or nutrients became deficient because of the restricted level of feed afforded the gilts on ration I which lowered the strength and thrift of their offspring and hence the lower survival. On the other hand, no explanation can be given as to why the feed restriction during mid-gestation should cause an increase in livability in the young pigs from gilts fed a ration containing 10 percent dehydrated cereal grass.

Body Weight Losses and Feed Consumption of Gilts During Lactation

The average loss of body weight of the gilts during the first three weeks of lactation and the gilts' average daily feed consumption for the same period is summarized in Table XX.

All the gilts were hand-fed to appetite during lactation and the summary data reveal very minor differences in feed consumption between lots. There was considerable within group variation but in general gilt feed consumption during gestation tended to vary directly with the number of nursing pigs in their litters. This is evidenced by the fact that the highest average daily feed consumption (11.35 pounds) was shown by the gilts in the ration II Restricted group. This group of gilts had the greatest number of pigs (an average of 10.7) in their litters. The gilts in the ration II Norwegian Standard, with an average of only 6.2 pigs per litter, consumed the least amount of feed (10.2 pounds per day) during the 3 week lactation period.

There was also a great deal of within group variation in the body weight losses of the gilts and, again, this experimental observation appeared more dependent on the number of pigs being nursed rather than on the effect of any ration treatment during the gestation period. Gilts fed the dehydrated cereal grass ration exhibited greater body weight losses than did those receiving ration I (26.3 pounds vs. 17.3 pounds) but once again this was believed to be a consequence of the larger litters nursed by the gilts on the former ration treatment. The least weight losses occurred in the gilts on the restricted level of ration I which also had the smallest average litter size at 3 weeks

TABLE XX

AVERAGE BODY WEIGHT LOSS AND AVERAGE DAILY FEED CONSUMPTION OF GILTS DURING LACTATION (LBS.)

		Loss of Weight		Average Daily Feed Consumption	
Ration I	No. of Gilts	Mean	S.E.	Mean	S.E.
N.R.C.	5	32.2	± 7.0	10.46	± 0.64
Norwegian Standard	4	16.5	± 7.8	10.39	± 0.71
Restricted	6	5.5	± 6.4	10.82	± 0.58
Average	15	17.3	± 4.0	10.59	± 0.37
Ration II					
N.R.C.	5	22.0	± 7.0	10.38	± 0.64
Norwegian Standard	5	28.4	± 7.0	10.20	± 0.64
Restricted	7	27.8	± 5.9	11.35	± 0.54
Average	17	26.3	± 3.8	10.72	± 0.35
Average of Rations I & II					
N.R.C.	10	27.1	± 4.9	10.42	± 0.45
Norwegian Standard	9	23.1	± 5.2	10.29	± 0.47
Restricted	13	17.5	± 4.3	11.10	± 0.40
Total	32	22.1	± 2.8	10.66	± 0.25

subsequent to farrowing.

The observations which were made on the litters and gilts at 6 weeks after farrowing are not included in the discussion of this study. One reason is that the trends noted at the 3 week interval were not markedly altered at the 6 week date. It was also felt that any effects of the gestation rations upon post-farrowing performance would be more likely to be apparent within the 3 week period. The post-farrowing performance of the litters subsequent to 3 weeks of age would also be affected by their creep feed consumption and therefore would further mask any effect of their dam's gestation ration. Also a number of the litters were weaned at 3 weeks of age because of a pen shortage in the farrowing barn. Hence 6 week observations were not available on all of the original 35 litters farrowed in the course of the experimental period.

II. PRENATAL STUDY

Average Daily Body Weight Gain of Gilts to Mid-Gestation

The average daily gains of the 18 gilts involved in the prenatal study are summarized in Table XXI. Because of the small number of gilts involved in each treatment group in this trial, these results and subsequent pertinent data are summarized only for the two ration treatments and the three feeding levels when the two ration treatments are combined.

The study began initially with 21 gilts, but 3 of the gilts fed the dehydrated cereal grass ration (ration II) failed to conceive and were removed from test. The fact that all 3 breeding failures occurred in ration II in this particular phase of the study was considered to be due to chance rather than ration treatment since approximately equal numbers of gilts in each of the two ration treatments failed to conceive in the gestation-lactation study.

The average age at breeding of the 18 gilts used in this prenatal study was 334 days which compares very closely with the average breeding age of 335 days for the 35 gilts employed in the gestation-lactation study. However, the gilts in this latter study were somewhat lighter in weight at the time of breeding. The average breeding weight of the 18 gilts in this study was 324.7 pounds or 27.0 pounds less than the 351.7 pound average breeding weight of the gilts in the gestation-lactation investigation.

Average daily gain of the 18 gilts during the first 25 days of gestation, while they were allowed feed <u>ad libitum</u>, was 1.47 pounds which was 9.3 percent less than the 1.62 pounds per day average gained by the

TABLE XXI

AVERAGE DAILY GAIN OF GILTS TO MID-GESTATION (LBS.)

	No. of Gilts	Breeding to 25 Days	25--57 Days	Breeding--57 Days
Ration I (Average of 3 Levels)	11	1.53	0.63	1.03
Ration II (Average of 3 Levels)	7	1.39	0.56	0.92
Average of Rations I & II				
N.R.C.	5	1.67	0.86	1.22
Norwegian Standard	6	1.44	1.05	1.22
Restricted	7	1.36	0.05	0.61
Total	18	1.47	0.61	0.99

gilts in the gestation-lactation study. Although feed consumption again varied considerably among treatment groups due to self-feeding, no overall marked difference was apparent between the two studies. Average daily feed intake for the first 25 days of the test period was 7.95 pounds in this latter study as compared to an average daily feed consumption of 8.03 pounds during the same period of the earlier gestation-lactation trial. Thus the difference in daily gains of the gilts in the two studies could not be accounted for by any difference in feed intake. It is suggested that the lower temperatures of the fall and early winter season, during which time the latter study was conducted, might be a possible reason for the slower gains exhibited by these gilts since a larger proportion of the food intake would necessarily be required to support body maintenance and normal body temperature during the period of lower ambient temperature.

Similarly, smaller daily gains were recorded during the subsequent individual feeding period of the prenatal study. Daily gains for the entire experimental group during the period from 25 to 57 days in the prenatal study averaged0.61 pounds as compared to an average gain of 0.78 pounds per day from the 25th to the 55th day of gestation by the gilts fed during the spring and summer months in the gestation-lactation experimental inquiry.

Gilts on the restricted level of food intake from the 25th day of gestation to the end of the experimental period at 57 days of gestation in this prenatal study made essentially no gain in body weight and gained only an average of 0.61 pounds per day over the entire trial period from breeding to 57 days of gestation. The gilts on the N.R.C. and Norwegian Standard levels of feed doubled the gain of the restricted gilts with both lots gaining 1.22 pounds daily over the entire trial period. Thus, although lower throughout, the comparative average daily gains of the gilts during the first half of the gestation period on the three different levels of feed intake in the prenatal study closely paralleled the results obtained in the gestation-lactation investigation.

Ovulation Rate and Number of Normal Embryos at Mid-Gestation

The summary data of the number of corpora lutea, the number of normal embryos at mid-gestation and the percent corpora lutea represented by normal embryos at 57 days of gestation are presented in Table XXII.

Ovulation rates (as determined by number of corpora lutea in the ovaries at mid-gestation) were higher in the gilts receiving ration I. Gilts receiving this ration treatment shed an average of 14.7 ova which was 1.3 more than the 13.4 average of the gilts fed ration II containing 10 percent dehydrated cereal grass. An analysis of variance statistical technique (Table XXIII) revealed, however, that this difference was not statistically significant.

No reference concerning the effect of dehydrated cereal grass on the ovulation rate of gilts was found in the review of literature. Teague (46) suggested that 18 percent sun-cured alfalfa meal in a practical ration favorably influenced the ovulation rate of swine, but Gard (16) using purified rations found no difference due to the addition of 10 percent dehydrated alfalfa meal.

The average ovulation rates when the three feeding levels were considered were: N.R.C., 15.4; Norwegian Standard, 13.5; and Restricted, 14.0. Statistical analysis revealed that these differences were not significantly different.

Gilts receiving the ration containing the dehydrated cereal grass had a larger percentage of their corpora lutea represented by normal living embryos at mid-gestation than did those fed the ration not including this dietary ingredient, although the difference was not

TABLE XXII

AVERAGE NUMBER OF CORPORA LUTEA, NORMAL EMBRYOS AND PERCENT SURVIVAL TO MID-GESTATION

	No. of Gilts	No. of Corpora Lutea	Standard Error	No. Normal Embryos	Standard Error	% Corpora Lutea Represented by Normal Embryos
Ration I (Average of 3 Levels)	11	14.7	$\pm$ 0.7	11.0	$\pm$ 0.7	74.7
Ration II (Average of 3 Levels)	7	13.4	$\pm$ 0.9	11.3	$\pm$ 0.8	84.0
Average of Rations I & II						
N.R.C.	5	15.4	$\pm$ 1.0	11.0	$\pm$ 1.0	71.4
Norwegian Standard	6	13.5	$\pm$ 0.9	10.3	$\pm$ 0.9	76.5
Restricted	7	14.0	$\pm$ 0.9	11.8	$\pm$ 0.8	84.7
Total	18	14.2	$\pm$ 0.5	11.1	$\pm$ 0.5	78.1

TABLE XXIII

ANALYSIS OF VARIANCE OF NUMBER OF CORPORA LUTEA

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value
Ration	1	10.21	10.21	2.00
Levels	2	10.41	5.20	1.02
R x L	2	0.0	0.0	
Error	12	61.15	5.09	
Total	17	81.77		

statistically significant, (Table XXIV). Gilts fed the ration containing the 10 percent dehydrated cereal grass had 84.0 percent of their corpora lutea represented by normal embryos at 57 days of gestation compared to 74.7 percent in the gilts receiving ration I.

The same comparison made for the three levels of feed intake also revealed no statistically significant differences. Gilts fed the N.R.C. level of feed intake from the 25th day of the gestation period to mid-gestation had 71.4 percent of their corpora lutea represented by normal embryos as compared to 76.5 percent and 84.7 percent, respectively, for the Norwegian Standard and Restricted treatment groups.

The lower prenatal mortality exhibited by the gilts on the limited feed intake was in agreement with the results reported by Christian and Nofziger (6), Gossett and Sorenson (19), Haines et al (21), Robertson et al (37) and Self et al (40).

Total embryonic loss for the 18 gilts involved in this study was 21.9 percent which was considerably lower than reported by some other investigators. Robertson et al (37) reported that only 55 percent of the ova in his study involving 96 gilts were represented by normal embryos at 25 days of gestation thus giving a total uterine loss of 45 percent. Self et al (40) found the uterine loss at 25 days to be 48.2 percent in two trials involving 110 gilts. However, Teague (46), Haines et al (21) and Lerner et al (31) reported total embryonic losses at 25 days of gestation of 27.3 percent, 16.8 percent and 33.6 percent in their respective studies. Lerner and his associates (31) suggested that the majority of the mortality had occurred before the 17th day of their investigation.

TABLE XXIV

ANALYSIS OF VARIANCE OF PERCENT CORPORA LUTEA REPRESENTED BY NORMAL EMBRYOS AT MID-GESTATION

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	Calculated F Value
Ration	1	145.87	145.87	0.76
Levels	2	585.36	292.68	1.52
R x L	2	183.92	91.96	0.48
Error	12	2304.24	192.02	
Total	17	3219.39		

Other Prenatal Observations at Mid-Gestation

The embryo weights and crown-rump lengths and the empty reproductive tract lengths and weights measured half-way through the gestation period are given in Table XXV.

The standard error terms cited in the table indicate the large amount of variation which existed among individuals within the treatment groups. As a consequence no significant differences due to ration treatment could be detected for these particular observations.

The average weight of the 200 embryos observed midway through their embryonic development was 127.2 $\pm$ 5.3 grams. This was somewhat greater than the observations quoted in the literature by other workers. Mitchell (34) reported that the average weight of 6 embryos at 8 weeks of gestation investigated in his study of swine litter composition was 83.0 grams. Gortner (18) in a study conducted in 1945 on the composition of pig fetuses at different stages of growth reported a mean embryo weight of 54.4 grams at 57 days of age. Reddy and his co-workers (36) investigating the intra-uterine environment in swine cited mean embryonic weights at 56 days of gestation which varied from 74.0 grams to 84.26 grams in four treatment groups involving a total of 295 embryos. He suggested that the weight of the individual embryos in a litter is inversely proportional to the number of viable embryos in the uterus. The same general observations also appear applicable to the findings of the writer in this pre-natal study.

The embryos in this investigation had an average crown-rump length of 119.8 $\pm$ 2.5 millimeters at mid-gestation, which was again somewhat

TABLE XXV

OTHER PRENATAL OBSERVATIONS AT MID-GESTATION

	Embryo Weight (gm.)		Embryo Crown-Rump Length (m.m.)		Empty Uterus Weight (gm.)		Length of Uterus (m.m.)	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Ration I (Average of 3 Levels)	130.8	± 6.9	124.2	± 3.3	3931.8	± 312.1	3768.4	± 204.1
Ration II (Average of 3 Levels)	121.9	± 8.5	113.0	± 4.0	4042.8	± 391.2	3849.9	± 255.9
Average of Rations I & II								
N.R.C.	121.7	+10.2	119.4	± 4.8	3640.0	± 462.9	3642.4	± 302.7
Norwegian Standard	123.2	± 9.6	121.7	± 4.5	3900.0	± 422.5	3729.6	± 276.4
Restricted	133.9	± 8.3	118.6	± 3.9	4278.5	± 391.2	3973.3	± 204.1
Total	127.2	± 5.3	119.8	± 2.5	3975.0	± 244.0	3800.1	± 159.5

greater than the measurements reported by earlier research workers. Gortner (18) quoted an average embryo length of 103.0 millimeters for the five 57-day-old fetuses analysed in his study of swine foetal composition.

The weight and length of the 18 reproductive tracts observed in this study also varied considerably from individual to individual within treatment groups as evidenced by the large error terms listed for these two measurements in Table XXV. The average uterus length was 3800.1 ± 159.5 millimeters and the mean empty uterus weight was 3975.0 ± 244.0 grams. These two factors again appeared to be more dependent on total embryonic numbers and weight rather than on any ration effect.

SUMMARY

The effect of the addition of 10 percent dehydrated cereal grass meal to swine gestation-lactation rations on subsequent reproductive performance was studied. Three levels of feed intake fed during gestation were also compared in the investigation.

Under the conditions of these investigations the following conclusions were reached:

1. The inclusion of 10 percent dehydrated cereal grass meal in gestation rations caused lowered daily body weight gains during gestation. Restricted feed intake during the middle portion of the gestation period (25--76 days) caused significantly smaller gains during this period and subsequent lighter body weights in the gilts in this study both prior to and immediately after farrowing.

2. There were no significant differences in the number of pigs born, the number of stillbirths or average pig birthweights among the 6 treatment groups. Gilts receiving the dehydrated cereal grass did, however, tend to have fewer stillbirths and somewhat larger litters. The gilts fed the restricted level of feed intake during the mid period of gestation farrowed slightly more live pigs than those allowed the Norwegian Standard, and they in turn showed a slight superiority over the gilts on the N.R.C. allowance in this respect.

3. Significantly more pigs survived to three weeks of age when 10 percent dehydrated cereal grass meal was included in the gilts' gestation-lactation ration. There was also a significant interaction between ration and feeding level in the survival rates to this period. Percent livability

to three weeks was highest in the litters farrowed from gilts receiving the restricted level of the ration containing dehydrated cereal grass during gestation, whereas livability was the lowest in the litters from gilts receiving the same feeding level during gestation of the ration not containing this dietary ingredient.

4. No differences in average three week weights of the baby pigs due to the treatments involved were noted in this study. There was, however, a highly significant difference due to interaction between the rations and feeding levels when total litter weight at 3 weeks was considered. The heaviest litters at 3 weeks of age were from gilts receiving the restricted level of the dehydrated cereal grass ration during gestation, whereas the gilts which received the same level of the basal ration had the lightest litters. These differences are due to the differing litter sizes and again point out the higher baby pig survival inthe former treatment lot.

5. The body weight losses of the gilts and their feed consumption during lactation were more dependent on the number of pigs being nursed than on the effect of any ration treatment allowed during the gestation period.

6. The results of this study would suggest that satisfactory reproductive performance of swine can be obtained by feeding gilts a ration containing 10 percent dehydrated cereal grass meal at a level which is 20 percent below the National Research Council recommended allowance for gestating swine.

7. There were no statistically significant differences in ovulation rates due to ration or feeding level in the prenatal study made on 18 gilts at mid-gestation. Ovulation rates did, however, tend to be higher in the

gilts receiving all levels of the basal ration.

8. Gilts receiving the ration containing dehydrated cereal grass had a larger percentage of their corpora lutea represented by normal embryos at mid-gestation. Gilts receiving the restricted levels of both rations from 25 to an average of 57 days of the gestation period exhibited lower total embryonic loss to mid-gestation than did those receiving the N.R.C. or Norwegian Standard levels of feed intake. However, these differences were not statistically significant under the conditions of this study.

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APPENDIX I

TABLE XXVI

FEED CONSUMPTION OF GILTS DURING GESTATION AND FIRST 3 WEEKS OF LACTATION (LBS.)

Ration I	Gilt No.	Gestation Period (Days)	Gestation 0--25 Days	Gestation 25--76 Days	Gestation Last Third	Lactation
N.R.C.	308R	114	211.5	344.6	264.2	214.0
	432R	114	195.1	357.0	268.4	--
	459R	114	195.1	341.6	270.8	171.0
	486R	118	168.5	348.8	307.2	204.0
	557R	120	192.5	343.0	315.2	261.5
	559R	111	189.5	349.0	264.0	258.5
Norwegian Standard	398R	115	176.9	357.0	303.8	228.2
	427R	115	181.6	357.0	287.0	205.0
	465R	115	169.1	357.0	305.2	255.8
	485R	117	200.9	357.0	317.6	236.0
	496R	116	182.1	355.9	302.4	--
	355R	Failed to conceive				
Restricted	425R	113	206.1	183.6	274.1	--
	449R	117	175.8	183.6	312.8	188.0
	468R	115	199.3	206.4	309.6	270.2
	0500R	119	185.6	172.0	317.8	266.5
	537R	114	206.1	178.8	276.4	246.1
	306R	116	192.4	159.1	278.5	211.6
	525R	119	206.1	153.0	292.3	203.0
	507R	Aborted 46 days after breeding				

TABLE XXVI (continued)

Ration II	Gilt No.	Gestation Period (Days)	Gestation 0--25 Days	Gestation 25--76 Days	Gestation Last Third	Lactation
N.R.C.	325R	117	193.7	370.6	308.6	254.0
	395R	118	245.9	353.6	318.8	162.5
	0440R	114	204.2	406.4	272.8	242.2
	0504R	118	196.8	334.9	289.6	228.5
	0550R	116	214.6	359.1	300.0	223.2
	469R	Aborted 30 days after breeding				
Norwegian Standard	387R	114	207.3	357.0	296.8	210.6
	0380R	117	207.3	357.0	322.0	216.7
	479R	116	208.7	357.0	312.2	260.4
	487R	118	205.1	357.0	320.2	206.7
	497R	116	206.3	357.0	310.8	217.5
	0350R	Failed to conceive				
Restricted	356R	115	152.1	218.6	281.8	250.0
	397R	115	240.5	193.6	306.8	236.2
	0423R	115	204.5	351.2	227.0	287.5
	466R	116	217.6	169.0	288.0	275.2
	489R	117	229.0	162.2	295.8	179.5
	419R	116	220.8	168.8	284.8	249.2
	378R	115	235.5	176.2	286.4	213.0
	346R	Aborted 30 days after breeding				
	526R	Failed to conceive				

TABLE XXVII

WEIGHTS OF GILTS DURING GESTATION AND LACTATION (LBS.)

Ration I	Gilt No.	Breeding	25 Days	76 Days	Farrowing	Immediately After Farrowing	3 Weeks After Farrowing
N.R.C.	308R	345	371	442	494	438	390
	432R	346	382	434	480	468	Gilt had no milk
	459R	337	365	433	492	444	380
	486R	358	399	478	540	473	455
	557R	327	388	456	528	504	475
	559R	353	385	467	526	498	496
Norwegian Standard	398R	370	393	460	541	494	466
	427R	397	439	495	532	504	488
	465R	362	402	469	554	503	505
	485R	297	346	410	472	412	388
	496R	351	370	415	474	430	Gilt had no milk
Restricted	425R	355	420	418	503	464	Litter chilled
	449R	374	400	423	497	482	462
	468R	388	450	470	570	538	554
	0500R	335	362	400	500	442	420
	537R	330	382	410	484	462	461
	306R	312	341	374	448	382	380
	525R	278	345	352	440	392	388

TABLE XXVII (continued)

Ration II	Gilt No.	Breeding	25 Days	76 Days	Farrowing	Immediately After Farrowing	3 Weeks After Farrowing
N.R.C.	325R	413	464	504	585	544	524
	395R	369	434	477	523	492	449
	0440R	359	397	465	517	465	450
	0504R	345	365	418	486	465	435
	0550R	392	436	485	556	522	520
Norwegian Standard	387R	380	429	470	533	503	470
	0380R	347	385	444	510	481	464
	479R	396	450	500	562	538	492
	487R	321	357	420	454	410	392
	497R	405	440	477	525	512	484
Restricted	356R	300	345	376	467	425	409
	397R	387	424	454	524	494	476
	0423R	352	410	450	510	486	473
	466R	338	368	386	486	435	398
	489R	320	350	385	460	418	386
	419R	329	364	386	475	423	387
	378R	341	367	408	466	405	362

TABLE XXVIII

LITTER DATA OF GESTATION-LACTATION STUDY

Ration I	Gilt No.	Birth				3 Weeks	
		Total No. Born	No. of Stillbirths	Total Litterweight (lbs.)	Total Litterweight Pigs Born Alive (lbs.)	No. Pigs	Total Litterweight (lbs.)
N.R.C.	308R	11	1	35.50	32.50	9	121.00
	432R	6	2	14.75	10.50	Gilt had no milk	
	459R	11	3	34.00	26.00	8	95.00
	486R	12	-	42.75	42.75	12	136.25
	557R	12	1	37.75	34.25	6	73.00
	559R	9	-	26.75	26.75	7	86.25
Norwegian Standard	398R	11	1	22.75	21.25	5	58.25
	427R	11	-	30.25	30.25	8	79.50
	465R	8	-	26.75	26.75	7	74.00
	485R	11	-	39.00	39.00	10	108.75
	496R	10	-	28.00	28.00	Gilt had no milk	
Restricted	425R	13	-	26.00	26.00	Litter chilled	
	449R	5	-	19.75	19.75	4	47.25
	468R	7	1	22.25	19.50	4	50.00
	0500R	14	-	41.00	41.00	12	119.00
	537R	14	-	30.25	30.25	5	56.00
	306R	11	2	34.25	28.75	5	60.25
	525R	8	1	22.00	20.25	3	35.00

TABLE XXVIII (continued)

Ration II	Gilt No.	Birth				3 Weeks	
		Total No. Born	No. of Stillbirths	Total Litterweight (lbs.)	Total Litterweight Pigs Born Alive (lbs.)	No. Pigs	Total Litterweight (lbs.)
N.R.C.	325R	8	-	25.25	25.25	7	89.00
	395R	14	1	35.50	33.25	6	61.75
	0440R	10	-	34.75	34.75	9	98.00
	0504R	8	-	23.50	23.50	8	99.50
	0550R	7	-	27.75	27.75	5	46.25
Norwegian Standard	387R	9	-	27.00	27.00	5	85.00
	0380R	8	1	26.75	23.50	6	82.75
	479R	15	-	39.25	39.25	8	100.00
	487R	11	-	31.75	31.75	7	57.00
	497R	5	-	20.50	20.50	5	92.25
Restricted	356R	12	-	34.75	34.75	12	112.00
	397R	12	-	32.00	32.00	10	105.00
	0423R	11	-	27.00	27.00	8	113.00
	466R	12	-	32.75	32.75	12	110.00
	489R	10	-	35.25	35.25	10	118.75
	419R	10	-	28.50	28.50	10	128.75
	378R	13	-	32.25	32.25	13	129.75

APPENDIX II

TABLE XXIX

FEED CONSUMPTION OF GILTS IN PRENATAL STUDY

Ration I	Gilt No.	Days Bred	Feed Consumption (lbs.) 0--25 Days	Feed Consumption (lbs.) 25 Days--End of Trial
N.R.C.	695R	64	171.0	264.0
	776R	60	174.0	222.6
	836R	49	182.0	146.5
Norwegian Standard	597R	64	191.0	273.0
	698R	65	185.0	280.0
	718R	57	176.0	224.0
	765R	42	178.0	119.0
Restricted	657R	63	177.0	108.0
	745R	65	180.0	129.9
	794R	60	172.0	106.5
	778R	45	163.0	60.0
Ration II				
N.R.C.	626R	65	184.0	280.7
	847R	41	177.0	104.8
	699R	Failed to conceive		
Norwegian Standard	0850R	62	165.0	259.0
	0800R	52	188.0	186.0
	838R	Failed to conceive		
Restricted	0691R	66	185.0	162.0
	749R	66	187.0	123.0
	777R	45	179.0	60.0
	656R	Failed to conceive		

TABLE XXX

WEIGHTS OF GILTS IN PRENATAL STUDY (LBS.)

Ration I	Gilt No.	Breeding	25 Days	At End of Trial
N.R.C.	695R	347	396	425
	776R	278	328	370
	836R	332	370	388
Norwegian Standard	597R	343	372	416
	698R	382	428	453
	718R	280	308	353
	765R	286	327	346
Restricted	657R	325	343	346
	745R	315	348	364
	794R	304	350	345
	778R	302	345	337
Ration II				
N.R.C.	626R	372	409	447
	847R	295	330	348
Norwegian Standard	0850R	327	360	396
	0800R	324	363	395
Restricted	0691R	412	440	446
	749R	310	342	352
	777R	310	349	338

TABLE XXXI

NUMBER OF CORPORA LUTEA, NUMBER AND WEIGHT OF EMBRYOS IN PRENATAL STUDY

Ration I	Gilt No.	No. Corpora Lutea	No. Normal Embryos	Weight of Embryos (gm.) Total	Mean	Range
N.R.C.	695R	13	11	2053.8	186.7	153.5--212.0
	776R	19	12	1770.1	147.5	103.9--173.0
	836R	15	6	231.4	38.5	34.0--46.8
Norwegian Standard	597R	15	13	2531.9	194.8	119.8--242.1
	698R	14	7	1335.9	190.8	173.8--218.1
	718R	15	11	1260.7	114.6	103.0--127.9
	765R	13	12	246.0	20.5	17.2-- 22.0
Restricted	657R	15	15	2388.9	159.3	129.3--178.4
	745R	12	11	2523.9	229.4	168.5--262.8
	794R	12	11	1166.2	106.0	97.2--116.2
	778R	19	12	308.2	25.7	23.8-- 29.0
Ration II						
N.R.C.	626R	14	13	2401.0	184.7	123.6--216.0
	847R	16	13	238.5	18.3	14.8-- 21.8
Norwegian Standard	0850R	11	9	1516.5	168.5	157.0--184.4
	0800R	13	10	750.0	75.0	64.3-- 86.1
Restricted	0691R	12	12	2230.1	185.8	119.6--213.5
	749R	14	9	2293.6	229.4	193.7--251.4
	777R	14	13	392.0	30.1	24.2-- 34.9

TABLE XXXII

OTHER PRENATAL OBSERVATIONS

Ration I	Gilt No.	Embryo Length (mm.) Mean	Embryo Length (mm.) Range	Weight of Entire Reproductive Tract (gm.)	Length of Uterus (mm.)	Weight of Empty Uterus (gm.)	Weight of Embryonic Fluids (gm.)
N.R.C.	695R	141	135--150	10,600	3,962	4,450	4,096
	776R	139	121--162	12,000	4,623	4,000	6,230
	836R	90	85-- 97	3,150	2,362	2,000	919
Norwegian Standard	597R	153	128--170	12,800	4,064	4,950	5,318
	698R	144	139--157	6,050	2,972	2,850	1,864
	718R	125	115--135	10,750	4,394	5,200	4,289
	765R	74	67-- 79	4,250	4,013	2,800	1,204
Restricted	657R	140	125--150	12,000	3,251	5,150	4,461
	745R	154	142--166	11,050	4,013	4,450	4,076
	794R	119	109--132	9,000	4,140	3,800	4,034
	778R	77	72-- 82	5,650	3,657	3,600	1,742
Ration II							
N.R.C.	626R	144	116--159	11,250	4,165	4,950	3,899
	847R	72	70-- 73	3,800	3,099	2,800	761
Norwegian Standard	0850R	140	132--147	8,600	3,708	4,250	2,833
	0800R	103	99--106	7,250	3,226	3,350	3,150
Restricted	0691R	140	127--147	12,100	4,115	4,150	5,718
	749R	153	143--160	11,250	4,801	5,150	3,806
	777R	82	75-- 90	6,650	3,835	3,650	2,608

APPENDIX III

FIGURE 3
INDIVIDUAL FEEDING UNITS