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"EFFECTS OF DIET COMPLEXITY ON FEED INTAKE AND PERFORMANCE OF PIGLETS AND EFFECTS OF CREEP INTAKE AND COMPOSITION ON STARTER INTAKE AND BABY PIG PERFORMANCE"

by

© DANIEL BOYE OKAI

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ANIMAL NUTRITION

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "EFFECTS OF DIET COMPLEXITY ON FEED INTAKE AND PERFORMANCE OF PIGLETS AND EFFECTS OF CREEP INTAKE AND COMPOSITION ON STARTER INTAKE AND BABY PIG PERFORMANCE" submitted by DANIEL BOYE OKAI in partial fulfillment of the requirements for the degree of Master of Science in Animal Nutrition.

Supervisor

Date Feb 5th 1974

ABSTRACT

A total of 36 crossbred sows and their litters were used in an experiment designed to study the effects of creep feed composition on feed intake and performance as measured by weight gain and efficiency of gain. The experiment was also designed to determine the influence of creep feed composition and intake on starter diet intake and piglet performance. Diets used were a simple wheat, barley, soybean meal diet, a semi-complex diet and a complex diet containing purified carbohydrate sources and proteins of high biological value. These 3 diets were used during the pre- and post-weaning periods.

Litters were equalized to 7 or 8 piglet before 3 days of age. Piglets were creep-fed either the simple, semi-complex or complex diet from 10 to 20 days of age and were weaned on the following day. A fourth group of piglets were not given any creep feed. At weaning, pigs from each litter were paired and were alloted to the 3 starter treatments. They were fed their respective diets until they were 7 weeks of age. The nitrogen and energy digestibilities of the 3 starter diets were determined using the total collection method. An estimate of the milk production of 9 of the 36 sows used in the experiment was determined on days 10 and 20 postpartum.

The pre-weaning data suggested that a complex creep feed results in a significantly ($P < 0.001$) higher feed intake as compared with a simple or a semi-complex creep feed. This however was not reflected in improved piglet performance probably because the feed intake was generally low. Low creep feed intake prior to weaning may have been due to the fact that the estimated milk yield of the sows was quite good. In the starter period however, the significantly ($P < 0.001$)

greater feed intake when a complex starter was fed, was reflected in significantly ($P < 0.001$) improved performance. The order of superiority was complex > semi-complex > simple. The improvement in performance on feeding a complex starter was probably due to the significantly ($P < 0.05$) better nitrogen and energy digestibility of this diet.

There were no significant ($P < 0.05$) differences in the means of the various creep-starter combinations compared but there were indications that creep diets could have some influence on starter intake and piglet performance.

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INTRODUCTION

The main aim in pig production should be to produce the maximum amount of lean meat as economically as possible. Two important criteria used in determining the efficiency and profitability of swine production are the average daily gain and the feed conversion efficiency. Both of these are influenced to a considerable extent by genetics and environment. Some of the more important environmental factors are nutrition, disease and housing. The percentage increase in gain, as measured by lean body mass and feed conversion efficiency are greater in the younger than in the older pig. The importance of maximizing weight gain in the younger pig is therefore obvious. Bowland (1965a) suggested that if maximum profits are to be obtained, baby pigs should be fed so that they reach 23 kg. liveweight as quickly as possible.

Numerous studies have been undertaken on the nutrition of young pigs; these studies have involved the use of sweeteners, enzymes and diets of varying complexity. Efforts to increase feed intake of suckling pigs by the use of sucrose and sweeteners have frequently failed to give significant improvement in pig performance. The incorporation of enzymes into baby pig rations as a means of increasing digestibility of feeds has also proved unsuccessful and uneconomical in spite of the relatively underdeveloped enzyme system of the young pig (Catron *et al.*, 1957). The composition and protein level of creep and starter diets have been investigated but there is still some doubt as to the protein level and degree of diet complexity needed to optimise piglet performance. Moreover, the relationship between the creep and starter periods have not been well established although it is generally agreed that one of the most important factors affecting liveweight at 56 days of age is creep intake (Whitelaw et al., 1966).

The objective of the experiment reported below was to study the effects of diet complexity on feed intake and performance of piglets weaned at 3 weeks of age and to relate the effects of creep intake and composition on starter intake and pig performance.

LITERATURE REVIEW

INFLUENCE OF DIET COMPLEXITY ON FEED INTAKE AND PIGLET PERFORMANCE

(a) Influence of sweeteners on feed intake, ration cost and pig performance.

McMillan and Wallace (1954) compared the palatability of eight creep feed mixtures with or without the addition of 10% sucrose when fed to one-week old suckling pigs. The control ration contained ground yellow corn, ground rolled oats, soybean meal (SBM), dried skim milk (DSM) and appropriate vitamin-mineral-antibiotic fortifications while the experimental rations had some of the corn replaced by other energy sources. They observed that the inclusion of sucrose in creep rations increased feed intake. In a starter-preference study, Lewis et al., (1955) observed that baby pigs selected starters containing sucrose and that the addition of sucrose led to higher feed intake and weight gains and significantly improved feed conversion efficiency (FCE). They pointed out that the inclusion of sucrose in starter diets made them expensive but the added expense may be justified by the high FCE of the baby pig and the subsequent increase in weight gains. However, Smith and Lucas (1956) did not observe any increase in feed intake by the addition of 10% sucrose to a complex diet containing corn starch, fish meal (FM), oat groats and DSM. They did obtain a significant improvement in rate of gain and FCE and attributed this to a better digestibility of sucrose as compared to corn starch which it replaced. A simple diet containing 10% sucrose was compared to similar diets containing other flavours in addition to the sucrose by Sibbald and Bowland

(1956). Pigs were creep-fed from 2 to 9 weeks of age. They reported no significant increase in feed intake between the different diets. However, Aldinger et al. (1959) observed a significant ($P < 0.05$) linear increase in the feed intake of 2-week-old pigs with increasing levels of saccharin. Bowland (1965b) reported that the addition of "Flance", a flavour compound, to a diet containing wheat, fat, sucrose, FM, meat meal and SBM had no significant effect on feed intake. Slightly depressed weight gains and FCE were however, observed, when the diet was fed to pigs from 3 to 10 weeks of age.

Meade (1967) in a comparative feeding trial, fed a simple corn-SBM diet to 3-week-old pigs and compared their intake and performance to those fed diets containing 10% sucrose. The addition of 10% sucrose did not increase feed intake, daily gain, nine week weight or FCE. Similarly, Zimmerman (1972) found no significant improvement in feed intake, weight gain or FCE when he included 5% sucrose or various levels of molassed-beet pulp in a pig starter ration.

These results suggest that the addition of sucrose or other sweeteners to creep or starter diets does not consistently increase feed intake or performance. When given a choice of feeds with or without the addition of sweeteners pigs tend to select the diet with the added sucrose or sweetener. However, when not given a choice, feed intake is frequently not significantly different between diets.

(b) Carbohydrate sources and baby pig performance.

Hudman et al. (1955) compared different sources of carbohydrates in semi-purified diets for pigs 1 to 5 weeks of age. They reported that the best weight gains and FCE were obtained on the diet containing lactose followed by corn syrup solids, sucrose, yellow corn, dextrose, corn starch, oat groats and corn flakes, in that order.

Lucas and Lodge (1961) observed that glucose was a satisfactory source of carbohydrate for baby pigs and that whey, which is rich in lactose, was quite a satisfactory substitute. They were of the opinion that by 7 days of age pigs have developed the capacity to utilize sucrose and that sucrose could therefore be satisfactorily included in the diet of pigs of that age.

To examine the effects of lactose fed either as DSM, beta-lactose or dried whey (DW), Sewell and West (1965) added these to semi-purified diets containing soybean protein, corn starch, glucose and oil. They observed significantly ($P < 0.01$) faster weight gain on the lactose-containing diets, with the DSM-diet giving slightly better gains than the other lactose sources. FCE was improved by the addition of lactose to the diets. Bowland (1965b) compared varying levels of DSM in the diets of pigs from 3 - 10 weeks of age. He observed that performance on the 20% DSM diet was similar to that on the 40% DSM diet. A 10% DSM diet led to a reduction in weight gain but not FCE.

Studies with 2, 4, 6 and 7 day-old pigs to compare glucose, lactose sucrose and fructose as carbohydrate sources in synthetic milk for these various age groups have been reported by Aherne et al. (1969). They found that glucose and lactose were satisfactory sources of carbohydrates for the pig during its first week of life. On the other hand sucrose and fructose were poor sources until the pig was at least 6 days of age. These findings were based on weight gain and FCE and suggest an increase in sucrase activity with age.

This review of carbohydrate sources established the desirability of including certain feed ingredients in the diets of young pigs and indicates that sucrose, lactose, either pure or as DSM or whey, can be efficiently utilized by pigs after the first week of age.

(c) Protein sources and baby pig performance.

Hudman et al. (1955) reported that pig weight gain and FCE increased significantly ($P < 0.05$) from 1 to 3 weeks of age as the levels of DSM in the diet were increased from 0 to 20 or 40%. Catron et al. (1957) reported an experiment in which pigs were weaned at 1 week of age and were fed to 5 or 8 weeks of age on diets containing either DSM, Drackett protein, 50% SBM or a combination of SBM and DSM. They observed that pigs fed DSM made significantly faster gains on less feed per kg. of weight gain than did those fed either Drackett protein or 50% SBM.

The effect of the inclusion of DSM in starter rations was also studied by Lucas et al. (1959). They observed that simple diets resulted in a lower feed intake than similar diets containing DSM. Replacing one-half of the DSM with FM increased pig weight by 4% due more to a slight improvement in FCE than an increased feed intake. However, when they replaced all of the DSM with FM they observed a 6% reduction in growth and a lower feed intake. They pointed out that the reductions in DSM content had no significant effect upon FCE prior to 11.8 kg. liveweight. One effect of the replacement of DSM with FM and oat groats was to reduce the cost of DSM-based diet.

Zimmerman (1972) reported studies with 2 - 3 week-old-pigs fed diets containing DSM in addition to corn, SBM and sucrose. He found a significant improvement in gain ($P < 0.01$) and FCE ($P < 0.05$) only during the first week and concluded that the inclusion of DSM in a corn-SBM diet was not beneficial after 1 to 2 weeks post-weaning. Zimmerman (1972) also reported that pigs weaned at 3 kg. benefitted the most from DSM supplementation as compared with those weaned at 4.5 kg. He suggested that the replacement of the DSM in corn-SBM diets by DW reduced the cost of the diet while maintaining reasonable weight gain.

This review of protein sources has shown that the performance of early-weaned pigs can be improved by the inclusion of high quality protein in their diets.

(d) Protein and carbohydrate mixture for baby pigs.

Meade (1967) weaned pigs at 3 weeks of age and fed them diets of varying complexity from 3 to 9 weeks of age. The simple corn-SBM diet gave excellent results and the addition of 10% sucrose to this diet did not result in any increase in feed intake, average daily gain, 9 week weight or FCE. The modification of the basal diet to contain 10% DSM but no supplemental sucrose or FM did not significantly increase daily gains or 9 week weights relative to the performance of pigs fed the basal diet but there was a slight improvement in FCE. The addition of 3% FM, 10% sucrose, 10% DSM to the basal diet resulted in significant increases ($P < 0.05$) in 9 week weight and improvement ($P < 0.01$) in FCE. The magnitude of the improvement in the latter was 5.4% and Meade expressed some doubts as to whether this increase would be sufficient to offset the added cost of the complex starter. Two other experiments reported at the same time confirmed the superiority of the complex starter. In one of these he observed that even though a corn, SBM, sucrose, DSM and FM diet gave the best performance, this diet was 44.4% more expensive than a simple diet. A corn, SBM, DW and FM diet was 8.5% more expensive than the simple corn, SBM diet.

The effects of protein level sequence and composition of starter diets on the growth rate, FCE and on carcass quality of pigs have been studied by Meade et al. (1969a). Using pigs which were 5 weeks old and had been creep-fed for 2 weeks prior to weaning, they noticed that a diet containing 10% DSM, 10% sucrose and 3% FM resulted in the greatest feed intake and heaviest 9 week weights irrespective of the protein level. Relative to a more simple diet however, the gain per feed ratio did not improve on this complex diet. In a subsequent experiment using 5% DSM, 5% sucrose and 3% FM, Meade et al. (1969b) did not observe any improvement in weight gain. The authors attributed this to the 50% lower levels of DSM and sucrose added.

Bayley and Carlson (1970) observed a greater, but not significant, feed intake when 18-day-old pigs were fed a diet containing corn, wheat, oat groats, SBM and DSM as compared with a simple corn-SBM diet. They obtained higher weight gains on the former diet which also gave a significantly better ($P < 0.05$) FCE. In a second experiment they used the same diet and studied baby pig performance during the first week post-weaning; there was no difference in feed intake but weight gain was higher on the complex diet. The addition of glucose to the complex diet resulted in a depression in weight gain; this they attributed to a higher incidence of scours with such diets. Over the whole experimental period the complex diet gave a higher feed intake, significantly higher ($P < 0.05$) weight gain and a better FCE.

The performance of 4-week-old pigs on diets of differing complexity has been studied by Castell (1972). Best weight gains and FCE were obtained on the more complex diets which contained sucrose, FM and butter milk powder in addition to wheat and SBM. A diet with sucrose and FM added to the basal feed proved to be superior to another diet with added sucrose and butter milk powder. He observed that even though relative cost favoured the use of a less expensive starter diet the potential performance of the pig is rarely achieved with such rations.

There appears to be general agreement that piglet performance can be maximized by the use of complex pig starter diets, whether the increased performance offsets the increased cost of such diets is less certain. It is worth noting that most of the above experiments involving complex diets were of 3 - 4 weeks duration. Due to the fact that enzyme development is quite high by the age of 5 weeks perhaps such diets may not be necessary for pigs weaned subsequent to this age. Complex diets could therefore be fed for a short period immediately after weaning in an effort to reduce the post-weaning set back and reduce the total cost of feed.

DIET COMPLEXITY, GROWTH CHECK AND SCOURS

Pigs weaned early in life experience a growth check period soon after weaning (Smith and Lucas, 1956). They reported that this check takes the form of weight loss, scouring, unthriftiness and a decrease in feed intake and could last from 3 to 15 days with the average of 10 days. In an attempt to reduce the extent of this periods, Smith and Lucas (1956) included 10% sucrose in a diet containing casein and corn starch. They observed that the sucrose had no effect on the length of the check period but did lead to a significant ($P < 0.01$) improvement in growth rate. In a subsequent experiment they reported that a high fat diet was not effective in reducing the length of the check period or in improving weight gain.

According to Bayley and Carlson (1970) the addition of glucose to a complex diet containing corn, wheat, oat groats, SBM and DSM did not reduce the extent of the post-weaning check but rather aggravated it.

Research aimed at reducing scours during this check period has not been very successful. Smith and Lucas (1956) observed that protein level or sucrose content of diets did not reduce the incidence of piglet scours. A subsequent experiment by the same workers compared diets containing varying levels of antibiotics, minerals or vitamins. High levels of antibiotics did not affect the incidence of scours. They suggested that certain management practices, such as the withholding of feed but not water for 24 hours could reduce the incidence of piglet scours.

CREEP FEED AND STARTER RELATIONSHIP

Creep feeding can be justified for several reasons: (1) The decline in the milk supply of the sow after 3 to 4 weeks of lactation and the desire to maximize growth rate at this stage. (2) Under conditions of hypogalactia, when the milk supply of the sow is low. (3) In sows with large litter sizes. (4) As a means of introducing pigs to dry diets so that at weaning they are accustomed to such diets. This is of vital importance in early-weaning systems. The provision of a creep-feed ensures that piglets have a diet best suited to their stage of development instead of scavenging from the sow's feed trough.

Lucas and Lodge (1961) suggested that for 4-week-old pigs a creep feed should contain 25% crude protein (CP) and 3190 kcal digestible energy per kg. It has been suggested that weaning should occur only after the piglet had ingested at least one kg of feed or about 10 kg for the whole litter.

There is very little direct evidence of the influence of creep feed composition and intake on starter intake and piglet performance. An observation by Meade et al. (1969a) is probably the only relevant research finding: they introduced simple and complex diets to nursing piglets when they were 3 weeks of age and fed these until weaning at 5 weeks. Higher weaning weights were observed for pigs fed the complex diet. Average 35-day weights varied from 9 to 9.7 kg and from 8.6 to 8.9 kg for the pigs on the complex and simple diets, respectively. This trend persisted for the following 4 weeks. Obviously there is need to know more about creep-starter relationships.

PROTEIN LEVELS IN STARTER RATIONS

Prior to 1960 several attempts were made to establish the dietary protein level needed to maximize performance of young pigs. Protein levels ranging from 17 - 41% have been recommended for pigs of 2 - 2. days of age. In spite of the realization that the amino acid composition and balance of the diet is as important as protein level, studies on protein requirement still continue to arouse some interest and research time.

Blair (1961) compared 28, 23 and 18% CP diets containing oat groats, DSM, sucrose, yeast and either white FM or SBM. He reported that from 4.5 to 11.4 kg. liveweight, there was an improvement in growth rate of 11% ($P < 0.05$) and an improvement in FCE of 14% ($P < 0.001$) when the level of crude protein was increased from 18 to 23% in the diets based on FM. Growth rate and FCE were not improved further by increasing the level of crude protein from 23 to 28%. He observed that with diets based on SBM, neither weight gain nor FCE was improved by increasing the protein level from 18 to 23%. The performance on such a SBM-based diet was similar to that on the 18% protein diet based on white FM. Pigs fed the SBM diet containing 28% CP were unthrifty and grew slowly. He concluded that for 4.5 - 11.4 kg. pigs a diet based on FM, DSM, oat groats, sucrose and containing 23% CP was as good as one with 28% CP.

Lloyd and Crampton (1961) recommended that a complex early-weaning diet should contain 24% CP for pigs from 2 to 6 weeks of age and suggested a change to an 18% CP diet after that period.

The protein-energy ratios for corn-SBM and purified diets have been studied by Sewell et al. (1961). They reported a marked increase in growth rate of pigs weaned at 3 weeks of age when the dietary protein level was raised from 10 to 15%. There was a slight increase in gain when protein level was increased from 15 to 20% CP. FCE was improved with increasing protein level.

Rutledge et al. (1961) suggested that for pigs weaned at 3 weeks of age, a 20% CP diet of high quality is required to promote maximum nitrogen retention during the early stages of the subsequent growing period. They pointed out however, that the dietary protein requirement for growth is lower than that required for maximum nitrogen retention.

Three years later Kellogg et al. (1964) obtained maximum gains and best FCE with a protein level of 25% for 3 to 7 week old pigs. Meade et al. (1965) indicated that corn-SBM diets containing 18, 20 and 22% CP supported equal performance when fed to early-weaned pigs from 3 to 9 weeks of age. A lower level (16 or 14%) led to a significant reduction in performance.

Whitelaw et al. (1966) compared three protein levels, 14, 18 and 22% in creep feeds for young pigs. The diets contained corn, barley, rolled oat groats, DSM, FM and peanut meal (PNM). There were no significant differences in either growth rate or FCE from 21 to 56 days of age when pigs were fed these diets even though the 18% CP diet gave a slightly better gain.

Bunch et al. (1967) reported that an 18% CP diet resulted in significantly better weight gains and better FCE than a 16% CP diet when fed to pigs from 6 to 9 weeks of age.

Newman and Sharp (1968) reported no significant differences in weight gain or FCE when pigs were fed diets containing 18, 20 and 22% CP from 3 to 7 weeks of age.

Hendricks et al. (1969) fed a purified diet to baby pigs weighing 3 kg and observed that a 24% CP diet based on isolated soy protein resulted in a better performance than a similar diet containing 16 or 32% CP. Meade et al. (1969c) fed simple diets containing either 12, 15, 18, 21, 24 or 27% CP to pigs from 5.9 to 23.5 kg liveweight. There were significant ($P < 0.01$) differences in gain per feed ratios and weight gain of pigs fed either the 12 or 15% CP diets and both these levels were significantly inferior to the 18% or higher levels of CP. He did not observe any carryover effect in the subsequent growth phases.

Meade et al. (1969a) showed that protein level sequence had no significant effects on 63-day weights, average daily gain or gain per feed ratios. Protein level sequence did not affect weight gain, FCE or carcass characteristics subsequent to 63 days of age. In an effort to study the influence of weaning age, kind of starter and protein content on performance, Meade et al. (1969b) weaned pigs at 3, 5 or 8 weeks of age and fed 20 or 17% CP diets. They observed that pigs weaned at 8 weeks of age were significantly heavier than those weaned at 3 weeks and fed either 17 or 20% CP diets. They concluded that dietary protein level had no influence on 8 week weight or gain per feed ratios of pigs weaned at 3 weeks of age. There were no carryover effects on weight gain and gain per feed ratios at subsequent phases. They did notice the presence of more fat in the carcasses of pigs weaned at either 3 or 5 weeks as compared with those weaned at 8 weeks. A further experiment showed that when pigs are weaned at 3 weeks a 20% CP diet, whether simple or complex, was better than a 17% CP diet.

Tjong-A-Hung et al. (1972) studied protein level sequence and sex and their effects on growing swine and carcass characteristics. They observed that from 5.4 to 23.1 kg liveweight pigs fed 16 or 20% CP diets gained significantly ($P < 0.01$) slower than those fed a 24% CP diet. There was poorer FCE on the 16% CP diet as compared to 20 and 24% CP diets. They did not observe any carryover effect of the starter performance on subsequent growth periods.

Rust et al. (1972) compared 18, 20 and 22% CP diets for pigs weaned at 3 weeks of age and also compared the following protein sources: SBM, dry roasted soybeans and extruded soybeans. They observed significantly ($P < 0.05$) greater weight gains on the 20 and 22% CP diets than on the 18% diets. They pointed out the contrast between their results and those of Meade (1967) and Meade et al. (1965, 1969c) and also noted that their results agree with those of Rutledge et al. (1961), Sewell et al. (1961) and Blair (1961).

Zimmerman and Khajarern (1973) studied starter protein nutrition and compensatory growth responses. The two diets fed (from 5.3 to 23.0 kg) contained either 10 or 24% CP. They reported significantly better weight gains and FCE ($P < 0.01$) with the latter diet but due to compensatory growth during the growing and finishing phases, there was no significant overall treatment differences, though the 24% CP diet gave better growth rate. A second experiment with 9, 12 and 16% CP complex diets indicated that the higher protein level led to a significant ($P < 0.01$) increase in gain and FCE. Because of a more efficient utilization of feed in the later stages there was no significant treatment effect over the entire experiment.

In spite of the differences in the suggested protein levels for baby pigs, there is sufficient evidence to suggest that a level of 20 to 22% CP in the diet would support maximum performance in pigs weaned at 3 weeks of age. However, one should not lose sight of the fact that the amino acid composition and balance are of primary importance and thus efforts should be made in any nutritional study to determine the amino acid makeup of any diet.

DIGESTIBILITY OF STARTER DIETS.

Several factors affect the digestibility and therefore the nutrient availability of swine diets; among these are breed, age, sex, type of diet and individual differences. The literature on digestibility of swine diets is quite extensive, hence this review will be restricted to studies with early-weaned and young pigs.

Lucas and Lodge (1961) have reviewed some of these studies and observed that protein digestibility by 3-week-old pigs can range from

69 to 85% depending on the protein source. A DSM, SBM and yeast diet gave a value of 85%; DSM, SBM, FM and yeast was 78%; meat meal, SBM, FM and yeast was 69% and SBM, FM and rapeseed meal was 81% for 3-week-old pigs. At 7 weeks of age the range was from 78 to 88 percent. They indicated that scours when they do occur can lower protein digestibility by 3 to 7 percent.

Their review also indicated a range in carbohydrate digestibility of 80 to 90% for 3-week-old pigs and 84 to 91% for 7-week-old pigs.

Lloyd, et al. (1957) compared the digestibility by 3- and 7-week-old pigs of a semi-complex diet containing DSM, molasses, wheat, oat groats, SBM, FM, chromic oxide, yeast and oil. Protein and energy digestibility by the 3-week-old pigs were 85.3 and 85.8% respectively. There was a significant ($P < 0.05$) improvement in protein and energy digestibility at 7 weeks of age, (i.e. 88.5 and 88.6% respectively), indicating that the digestive enzyme system of the younger pig was not fully developed. The addition of 20% fat to the diets also resulted in an improved digestibility by the 7-week-old pig.

A subsequent study, Lloyd and Crampton (1958) again using the chromic oxide indicator method, confirmed the above-mentioned improvement in digestibility with age. Protein digestibility values were 78 and 84% for the 3- and 7-week-old pigs while energy digestibility was 79 and 85%, respectively. Replacing the DSM of the ration used (see Lloyd et al., 1957) with meat meal and DW led to a 4 - 9% reduction in digestibility values.

Feeding fairly simple 18, 21 and 25% CP rations containing corn, grease, SBM and tankage to 8-week-old pigs, Asplund et al. (1960) obtained a protein digestibility value of 77%; this was increased to 84 and 83% in the presence of fat added at the 10 and 20% levels respectively in the diet.

Blair (1961) determined the digestibility of several semi-complex diets fed with chromic oxide to pigs of 4.5 to 11.4 kg in weight. Average protein digestibility values were 83.5, 84.06 and 82.3% for the 28, 23 and 18% CP diets, based on FM and 79.5 and 80.8% for the SBM diets containing 23 and 18% CP, respectively. Digestibility tended to increase with age in this experiment.

Likuski et al. (1961) obtained digestibility values of 81 to 89% for energy and 78 to 89% for nitrogen for 8 kg pigs weaned at 3 to 4 weeks and fed a simple diet. They did not observe any species difference (rats and pigs) in nitrogen and energy digestibility but they observed that lowering the energy in the diets led to a reduction in nitrogen digestibility.

The digestibility of several simple diets containing various protein sources and sucrose was compared by Combs et al. (1963). SBM-based diets gave values of 69.9 and 79.8% for nitrogen and energy respectively when fed to 5- to 6-week-old pigs. Corresponding values for PNM-based diets were 70.0 and 78.8% respectively. In a second experiment involving DSM, SBM and FM, the protein and energy digestibility were 81.6 and 85.2 for DSM, 75.9 and 82% for SBM and 69.6 and 79.1% for the FM diet respectively. Here again the effect of age was demonstrated and significant differences were obtained between the values obtained at 7 to 8 weeks and 5 to 6 weeks.

Bowland (1964) reported that although statistically significant differences in digestibility of energy and protein are obtained in practical starting diets for pigs these differences are numerically small and are not a major factor in the observed differences in performance obtained from different diets. In the study reported, he obtained a digestibility range of 86 to 95% for energy and 85 to 94 for nitrogen with pigs 3 to 4 weeks of age and fed for 6 weeks.

Digestibility studies conducted by Sewell and West (1965) with pigs weaned at 3 weeks of age and fed semi-purified diets containing cornstarch, glucose, DSM, DW and corn oil yielded protein digestibilities of between 92.6 and 95.5%. A diet containing 42% DSM gave a protein digestibility of 95.5%, whereas the non-lactose diet gave an average value of 92.6%, indicating that lactose improves protein digestibility. They reported nitrogen Free Extract (NFE) digestibility values of 97.4 to 98.9% for the diets under study.

Bayley and Carlson (1970) in a comparison of simple and complex diets fed to early-weaned (2 to 3 weeks old) pigs, reported nitrogen digestibilities of 83.5 and 87% for the simple and complex diets, respectively. There was a trend towards increased digestibility with age. Digestible energy values for the simple and complex diets were 3.16 kcal/g and 3.26 kcal/g, respectively. In a second experiment they obtained protein digestibility of 66.5 and 64.5% for the simple and complex diets, while energy was 3.12 and 3.14 kcal/g, respectively. They attributed this reduction to the inclusion of feces from pigs which scoured in the nitrogen and energy determinations.

The 3 dies used in this experiment were formulated with ingredients whic[illegible] have been used in most of the experiments reviewed above and have been shown t[illegible] [illegible] of some use to baby pigs.

OBJECTIVES

The objectives of these studies were:

(1) To determine the effect of diet complexity on creep feed intake and to relate creep feed intake and composition to starter intake and performance of baby pigs weaned at 3 weeks of age.

(2) To examine the effects, if any, of diet composition on the first week post-weaning intake and performance.

(3) To estimate the digestibility of three starter diets.

(4) To study the milk production of the sows.

EXPERIMENTAL PROCEDURES

MATERIALS AND METHODS

(a) Animals and diets:

Thirty-six crossbred sows and their litters were used in this study. Sow parities ranged from one to six and sows were served by crossbred boars. Sows were moved into the farrowing barn a few days before they were due to farrow. Barn temperature was maintained at 21^{o} C throughout the experiment. There were 3 batches of farrowing; they are subsequently referred to as phase 1, 2 and 3. All sows farrowed in raised, partially slotted farrowing crates and litters were given supplemental heat by means of infra-red bulbs. Litters were equalized to 7 or 8 pigs within 3 days of birth. Piglets were injected with 2 cc. Imposil 200 before 3 days of age.[1] Piglets were castrated at one week of age. Sows and their litters were then randomly allotted to the 4 pre-weaning treatments as shown in Figure 1. Lactating sows were fed a lactation ration (17% crude protein) on a scale which ensured that at 10 days postpartum, each sow was receiving 5.5 kg of feed daily until weaning at 3 weeks of age. They received water on an *ad libitum* basis. Piglets were introduced to the diets shown in Table 1 at 10 days of age. Fresh feed was provided daily in flat aluminum pans which were later replaced by self-feeders. To provide a more accurate assessment of feed intake by piglets, plastic sheets were placed beneath the pans

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[1] Imposil 200 -- Iron dextran complex. Fisons (Canada) Limited. 26 Prince Andrew Place, Don Mills, Ontario. Contains 200 mg iron in every 2 cc dose.

Figure 1: DIETARY TREATMENTS -- PRE- AND POST-WEANING TREATMENTS[4]

Pre-weaning Treatments[5] Day 10 - 20	Day 21	Post-weaning Treatments[6] Day 21 - 49
No Creep Feed (9)[5]	Wean and Pair (6 pigs from each litter)	Simple
		Semi-complex
		Complex
Simple Creep Feed (9)[5]	Wean and Pair	Simple
		Semi-complex
		Complex
Semi-complex Creep Feed (9)[5]	Wean and Pair	Simple
		Semi-complex
		Complex
Complex Creep Feed (9)[5]	Wean and Pair	Simple
		Semi-complex
		Complex

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4 The same three diets were used for the pre- and post-weaning treatments (see Table 1).

5 Figures in brackets (9) indicate the total number of replicates for each pre-weaning treatment.

6 There were 9 pairs of pigs on each post-weaning treatment for each of the 4 pre-weaning treatments. Each post-weaning pair constitutes a post-weaning replicate. There were a total of 36 replicates for the 3 post-weaning treatments. Each pair (post-weaning replicate) was used for feed intake and weight gain per feed ratio studies. Weight gains were determined with each individual pig within a pair.

TABLE 1: FORMULATION AND COMPOSITION OF DIETS

Diet:	Simple	Semi-complex	Complex
Ingredients %			
Wheat	45.0	25.0	----
Barley	13.5	15.0	----
Oat groats	----	25.0	----
Dextrose	----	----	----
Sucrose	----	----	10.0
Cornstarch	----	----	7.0
Tallow	----	----	17.5
Soybean meal (45.8%)	3.0	2.0	1.0
Herring meal (70.6%)	34.0	13.0	13.0
Dried skim milk	----	6.4	11.0
Dried whey	----	10.0	20.0
Vermiculite+	----	----	15.0
Iodized salt	----	----	3.0
Calcium phosphate	0.5	0.4	0.5
Calcium carbonate	1.5	1.0	0.5
Vitamin-mineral premixø	1.0	0.7	----
	1.5	1.5	1.5
Composition (calculated)			
Crude protein (%)	22.7	22.7	22.5
Metabolizable energy (Mcal/kg)	3.1	3.1	3.1
Calcium (%)	0.8	0.9	0.9
Phosphorus (%)	0.6	0.8	0.8
Composition (analyzed)			
Crude protein (%)	23.8 (21.8-24.7)*	22.5 (20.7-23.9)*	23.4 (22.0-24.5)*
Gross energy (Mcal/kg)	4.055	4.188	3.801
Crude fibre (%)	4.2	3.1	0.9

\+ Vermiculite -- a fine aggregate form. Vermiculite is expanded or exfoliated mica, relatively inert chemically and has a water holding capacity of 300% of its weight.

ø Supplied the following per kg of diet: 4400 I.U. vitamin A; 665.5 I.U. vitamin D_2; 11 I.U. vitamin E; 66 mg vitamin B_{12}; 11.1 mg Riboflavin; 22.2 mg Calcium pantothenate; 50.5 mg Niacin; 55.7 mg Choline chloride; 1.65 mg Folic acid. It also provided Cobalt 2.8 ppm; Copper 24.6 ppm; iron 294.1 ppm; Manganese 76.2 ppm; Zinc 88.5 ppm and Iodine 1.5 ppm. In addition, it provided 110 mg per kg of diet of oxytetracycline.

* Range observed for the different batches of feed mixed.

and self-feeders to hold any spilled feed.

Following weaning at 21 days of age, litter sizes were adjusted to 6 and the pigs were paired so as to arrive at 3 uniform weight groups. In 3 instances owing to wide variations in pig weights, this was not possible and pigs had to be allotted randomly without creating uniform weight groups. Sex was disregarded in the allotment at weaning. Following weaning the pigs were moved to the weaner barn and each pair was penned in wire cages measuring 0.61 x 1.22 m. Barn temperature was held at 24^{o} C throughout the experiment. Feeding was again on an *ad libitum* basis, daily feed intake was recorded and fresh water was made available at all times. The same three diets were used for both the pre- and post-weaning periods and were mixed when needed.

All pigs were weighed at birth, 10 days of age and at 3, 4, 5, 6, and 7 weeks of age, at which time the experiment was terminated. The daily weights of all pigs in the last 2 phases were recorded for the first week post-weaning. Pigs which scoured were treated with either Combiotic[2] or Gallimycin[3]. During the second and third phases of the 7 week experiment, all pigs were injected with either of these antibiotics at weaning.

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[2]Combiotic: Penicillin G. Procaine and Dihydrostreptomycin sulphate in acqueous solution. Pfizer Co. Ltd. Agricultural Division, Montreal, Canada.

[3] Gallimycin - 200: Erythromycine base. Abbot Agricultural and Veterinary Products Division Abbot Laboratories Ltd. Montreal, Canada.

(b) Milk production of sows

Milk production was estimated with 9 of the 36 sows used in the experiment. Milk yields were measured on day 10 and 20 postpartum by weighing pigs before and after suckling. Pigs were allowed to suckle at hourly intervals for 14 hours. Only the final 12 measurements were included in the estimation of daily milk production. Between nursing periods, pigs were kept in heated cubicles measuring 0.61 x 0.91 m and were provided with water and with feed if they were on a creep feed treatment. They were transported to the sow in 2 plywood boxes containing polyurethane foam mats to absorb any urine voided. Pigs were weighed before and after suckling in these boxes. Pigs were allowed a 5 minute exercise period in which to urinate and defecate before the pre-suckling weighing. Adjustments were made for the few urinations and defecations which occurred while pigs were with the sow as suggested by Salmon-Legagneur (1956). The factors used were 10 and 20 g for urine for day 10 and 20 respectively. For feces these were 5 g and 10 g for day 10 and 20 respectively.

Milk samples were obtained on day 11 and 21 postpartum. Milk let-down being induced at these times by injecting 30 I.U. oxytocin into an ear vein. Milk samples were drawn from each functional teat and mercuric chloride was added as a preservative. Samples were kept frozen (at 0^{o} C) until analyzed. The crude protein (N x 6.38), dry matter (DM) and gross energy content of the samples were determined by (1) Kjeldahl method, (2) freeze-drying and (3) bomb calorimetry respectively. The dried samples were pelleted for the energy determination.

(c) Digestion trials:

Nine pigs from the last 4 sows on the experiment were weaned directly into rabbit cages which were modified to facilitate feeding and collection of feces. Feeding was ad libitum and daily feed intake was recorded. Water was provided at all times. There was a 7-day introductory-feeding period followed by a 3-day collection period.

Selection and allotment of pigs were such that pigs from each litter showed very little difference in weight but on the whole, the pigs used ranged from 4.25 to 6.60 kg in weight. The entire feces from each pig was collected twice daily into aluminum pans. Between collections feces were kept at 3^{o} C. At the end of each trial, the total feces collected for each pig was dried in a forced-air oven[7] at 60^{o} C for 72 hours and then allowed to equilibrate with air moisture for 24 hours. Both feed and feces were ground in a laboratory mill and representative samples were used for the following determinations: (a) Gross energy was determined in a Parr Oxygen Bomb Calorimeter[8]. (b) Kjeldahl crude protein (N x 6.25) determinations were as described in AOAC (1965). For the Kjeldahl analysis, a commercial "kel-pak"[9] was used to supply the catalyst and ammonia was collected in a 4% boric acid solution and titrated with standard H_2SO_4.

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7 Style V31, Despatch Oven Co., Minneapolis, Minn., U.S.A.

8 Parr Instrument Co., Moline, Illinois. Temperature changes registered by a Brown Electronik Recorder manufactured by Minneapo -Honeywell Regulator Co., Philadelphia, Pennsylvania.

9 Matheson Scientific, East Rutherford, New Jersey. Supplied a mixed catalyst containing HgO, K_2SO_4, and $CuSO_4$.

METHODS OF STATISTICAL ANALYSIS

Analysis of variance was performed on the data collected (Appendix Table 1, 2, 3). Eight pigs died during the post-weaning period of the experiment. Their distribution according to the three starter treatments, were 4, 3 and 1 for the simple, semi-complex and complex starter treatments, respectively. The data for these pigs and their pen mates were discarded and analyses of covariance to estimate missing observations (Steel and Torrie, 1960) were undertaken. The estimated values were used for the analyses of variance. Probabilities for the analysis of variance are indicated as very highly significant (***), highly significant (**) and significant (*). The multiple comparison of means were however, made only at the 5% ($P < 0.05$) level of probability using Duncan's procedure (Steel and Torrie, 1960). For the multiple comparisons of means of the creep-starter relationship data, the procedure of Ciccheti (1972) was used, modified by using the Upper Duncan Value rather than the Tukey value as proposed by Ciccheti (1972).

The following symbols were used to denote tests of significance:

Symbol	Meaning
*	The three means are significantly different at $P \leq 0.05$.
**	The three means are significantly different at $P < 0.01$.
***	The three means are significantly different at $P < 0.001$.
a, b, c, d, e.	Means bearing the same letter are not significantly different at $P < 0.05$.

RESULTS AND DISCUSSION

The experiment consisted of pre-weaning and post-weaning stages. The pre-weaning study involved 36 sows and 266 piglets. There were 9 sows and their litters on each of the 4 pre-weaning treatments. During the post-weaning stage there was a total of 216 piglets with 72 piglets on each of the 3 post-weaning treatments. However, due to the fact that pigs were paired, the means for weight gain were for 72 pigs for each treatment while the means for feed intake and gain per feed ratios were for 36 pairs of pigs (Figure 1). No differences were observed in the three phases and thus the data for all replicates were grouped and used for the analysis.

PRE-WEANING PERFORMANCE

(a) Creep intake:

Table 2 shows that there were significant ($P < 0.001$) differences in the feed intake of the 3 groups which were given creep feed. The higher intake of the complex creep was probably due to the presence in this diet of sucrose and DSM. It should however, be mentioned that there were wide variations in the daily feed intake as shown in Table 3. These variations were more pronounced in the pigs fed the simple and semi-complex creep diets. Generally feed intake was very low even on the complex diet on most days and it was not unusual for the various diets to remain untouched for a couple of days even though fresh feed was supplied daily. It has been suggested that a piglet should have eaten about 1 kg of feed before it is weaned; in this experiment the highest feed intake was 71.33 g, the big difference may however, be due

TABLE 2: CREEP FEED INTAKE (g)

Period: 10 to 20 Days of Age				
Treatment:	No Creep	Simple Creep	Semi-complex Creep	Complex Creep
Number of litters	9	9	9	9
Number of piglets	67	68	67	64
Total Creep intake (g)	0	848	1458	4565
Creep intake per piglet (g) ***	0[a]	12.47[b]	21.75[c]	71.33[d]

TABLE 3: MEAN DAILY CREEP FEED INTAKE PER PIGLET (g)

Treatment:	No Creep	Simple Creep	Semi-complex Creep	Complex Creep
Period: 10 to 20 Days of Age				
Day 10	--	1.16	1.33	2.50
Day 11	--	1.66	1.91	3.70
Day 12	--	2.34	2.39	3.89
Day 13	--	1.04	0.97	4.61
Day 14	--	0.54	2.54	4.31
Day 15	--	1.88	1.49	5.05
Day 16	--	0.94	0.04	7.42
Day 17	--	0.54	1.13	7.36
Day 18	--	0.79	1.22	8.64
Day 19	--	0.59	3.12	11.44
Day 20	--	0.99	5.61	12.41
TOTAL		12.47	21.75	71.33

TABLE 4: LIVEWEIGHT AND WEIGHT GAIN (kg)

Treatment:	No Creep	Simple Creep	Semi-complex Creep	Complex Creep
Number of pigs	67	68	67	64
Mean birth weight	1.33	1.30	1.33	1.33
Mean 10-day weight	2.96	2.76	2.85	2.80
Mean 10-day gain	1.63	1.46	1.52	1.47
Mean 21-day weight	5.12	4.76	4.88	4.87
Mean 21-day gain	3.79	3.46	3.55	3.54
Mean weight gain (Day 10-21)	2.16	2.00	2.03	2.07

to the shorter feeding period used here.

The increase in feed intake with increase in diet complexity has also been reported by Meade (1967), Meade et al. (1969a, b), Bayley and Carlson (1970) and Castell (1972).

(b) Liveweights and weight gain:

Weight gains during the 10-day creep feeding period were not significantly different (P < 0.05) for any of the 4 treatments (Table 4). The heaviest weaning weights were recorded for the non-creep-fed litters but the difference was not significant (P < 0.05) and was more a reflection of the 10-day weights than of the weight gain. There is the possibility that the piglets which were not creep-fed may have eaten some of the sow's ration.

POST-WEANING PERFORMANCE

Figure 2 shows the outline for the discussion of the post-weaning performance data. These have been described as Section I, II, III and IV.

Section I is a straight forward comparison of the feed intake and piglet performance on the 3 starter diets. The pre-weaning treatment is not taken into consideration. Section II considers the data on the basis of the pre-weaning treatments. The section thus goes across all 3 starter treatments. Section III compares feed intake and piglet performance on the 3 starter diets but within each pre-weaning treatment. Section IV compares each type of starter across all 4 pre-weaning treatments.

Figure 2: OUTLINE FOR DISCUSSION OF POST-WEANING DATA

Pre-weaning Treatment	Post-weaning Treatment	Designated As
No Creep Feed	Simple	1
	Semi-complex	2
	Complex	3
Simple Creep Feed	Simple	4
	Semi-complex	5
	Complex	6
Semi-complex Creep Feed	Simple	7
	Semi-complex	8
	Complex	9
Complex Creep Feed	Simple	10
	Semi-complex	11
	Complex	12

SECTION I: 1 + 4 + 7 + 10 versus 2 + 5 + 8 + 1 versus 3 + 6 + 9 + 12.

SECTION II: 1 + 2 + 3 versus 4 + 5 + 6 versus 7 + 8 + 9 versus 10 + 11 + 12.

SECTION III: (a) 1 versus 2 versus 3.

(b) 4 versus 5 versus 6.

(c) 7 versus 8 versus 9.

(d) 10 versus 11 versus 12.

Figure 2: OUTLINE FOR DISCUSSION OF POST-WEANING DATA (Continued)

SECTION IV: (a) 1 versus 4 versus 7 versus 10.

(b) 2 versus 5 versus 8 versus 9.

(c) 3 versus 6 versus 9 versus 12.

SECTION I: Simple versus Semi-complex versus Complex starter diets

(a) Incidence of scours:

Some post-weaning scouring was observed during the experiment but the incidence of scouring was considerably reduced during the second and third phases of the experiment when antibiotic was administered to pigs at weaning. Post-weaning scours appeared to be more common with pigs fed the complex diet. A two-week record of the incidence of scours in pens showed that out of the 16 individual cases observed, 9 of these were from pigs on the complex diet while 4 and 3 cases were observed with pigs fed the complex and simple diets, respectively.

Smith (1973) in a review of post-weaning problems indicated that post-weaning scours were more common with pigs eating the most feed. He noted that among other things, there was malabsorption of nutrients allowing toxin-producing micro-organisms to multiply quickly and cause scours.

(b) Feed intake:

During the first week of the post-weaning periods, there were differences in the intake of the simple, semi-complex and complex diets fed (Table 5). The differences between the means were highly significant ($P < 0.001$). The highest feed intake was for pigs fed the complex diet. Even though more of the semi-complex diet was eaten as compared to the simple, the difference between these two was not significant ($P < 0.05$). The same trend was observed during the second week. In the third and fourth weeks, very highly significant ($P < 0.001$) differences were again observed; during these periods however, the differences in the intake of

TABLE 5: MEAN FEED INTAKE[1] (kg/week/pen)

Treatment:	Simple	Semi-complex	Complex
Week 1 ***	1.48[a]	1.67[a]	2.27[b]
2 ***	4.63[a]	4.96[a]	5.87[b]
3 ***	7.59[a]	8.64[b]	9.66[c]
4 ***	10.94[a]	11.74[b]	12.54[c]
TOTAL ***	24.64[a]	27.01[b]	30.34[c]

[1] The values above represent the means of 36 experimental units or replicates for each of the three dietary treatments.

the simple and semi-complex diets were significant ($P < 0.05$). The highest feed intake was obtained on the complex diet and the lowest was with the simple diet. Very highly significant difference ($P < 0.001$) was recorded for the total period. The mean feed intake for the total period was greatest for the complex diet; this was significantly ($P < 0.05$) different from the intake of the semi-complex and the latter was significantly ($P < 0.05$) different from the intake of the simple diet. Similar observations have been reported by Meade _et al_. (1969a), Bayley and Carlson (1970). It is possible that the higher level of 20% DSM as compared to Meade _et al_.'s (1969a) level of 10% may have increased feed intake. The preference of pigs for sucrose may also have contributed towards the differences in feed intake observed in the experiment.

(c) _Post-weaning weekly weights:_

Table 6 shows that there were very highly significant ($P < 0.001$) differences in the weights of the 3 groups of pigs for all the four weeks of the post-weaning period. Following the first week there were significant ($P < 0.05$) differences between the weights of pigs fed the simple and complex diets, this difference was in favour of the complex diet. The differences between weights of pigs on the semi-complex and complex diets were not significant ($P < 0.05$), however. The significance recorded in the second and third weeks were of the same magnitude: ($P < 0.001$) here, however, pigs on the complex diet had a significantly ($P < 0.05$) better growth rate than those on the

TABLE 6: MEAN WEEKLY WEIGHTS[1] (kg)

Treatment:	Simple	Semi-complex	Complex
Weaning Weight	5.14	5.21	5.01
Week 1 ***	5.20[a]	5.34[ab]	5.63[b]
2 ***	6.73[a]	7.25[b]	7.81[c]
3 ***	9.36[a]	10.23[b]	11.06[c]
4 ***	12.60[a]	13.74[b]	14.46[b]

1 The above represents the mean weekly weight for the 72 pigs on each of the three dietary treatments.

semi-complex; the latter were significantly (P < 0.05) better than those recorded on the simple diet. The weight differences obtained in the fourth week were also very highly significant (P < 0.001). Even though pigs fed the complex diet recorded the highest weight after 4 weeks, this was not statistically different from that recorded for pigs fed the semi-complex diet; these two were however, significantly (P < 0.05) different from the weights recorded on pigs fed the simple diet. It is worth noting that in spite of the slightly lower initial weight of pigs on the complex ration, they gave the best growth rate. The very highly significant (P < 0.001) differences in the growth rate of pigs on the three diets reflect the differences in feed intake and feed utilization. Meade (1967), Meade et al., (1969a, b), Bayley and Carlson (1970) and Castell (1972) have all reported improvement in piglet performance when complex diets were fed. These differences indicate that complex diets would help in the achievement of higher weights at the earliest possible time and thus help maximize daily profits as suggested by Bowland (1965a).

(d) Post-weaning weight gain:

The mean weekly liveweight gain of the pigs on the three treatments are shown in Table 7. At the end of the first week, the differences in the weight gains were very highly significant (P < 0.001). The complex diet produced significantly (P < 0.05) better weight gains than the semi-complex diet which was also significantly (P < 0.05) better than the simple diet. A similar relationship between diets was also observed during the second and third weeks. In the fourth week, the

TABLE 7: MEAN WEIGHT GAIN[1] (kg/week)

Treatment:	Simple	Semi-complex	Complex
Week 1 ***	0.07[a]	0.24[b]	0.63[c]
2 ***	1.53[a]	1.81[b]	2.18[c]
3 ***	2.63[a]	2.98[b]	3.25[c]
4	3.24[a]	3.51[a]	3.40[a]
TOTAL GAIN ***	7.46[a]	8.54[b]	9.46[c]

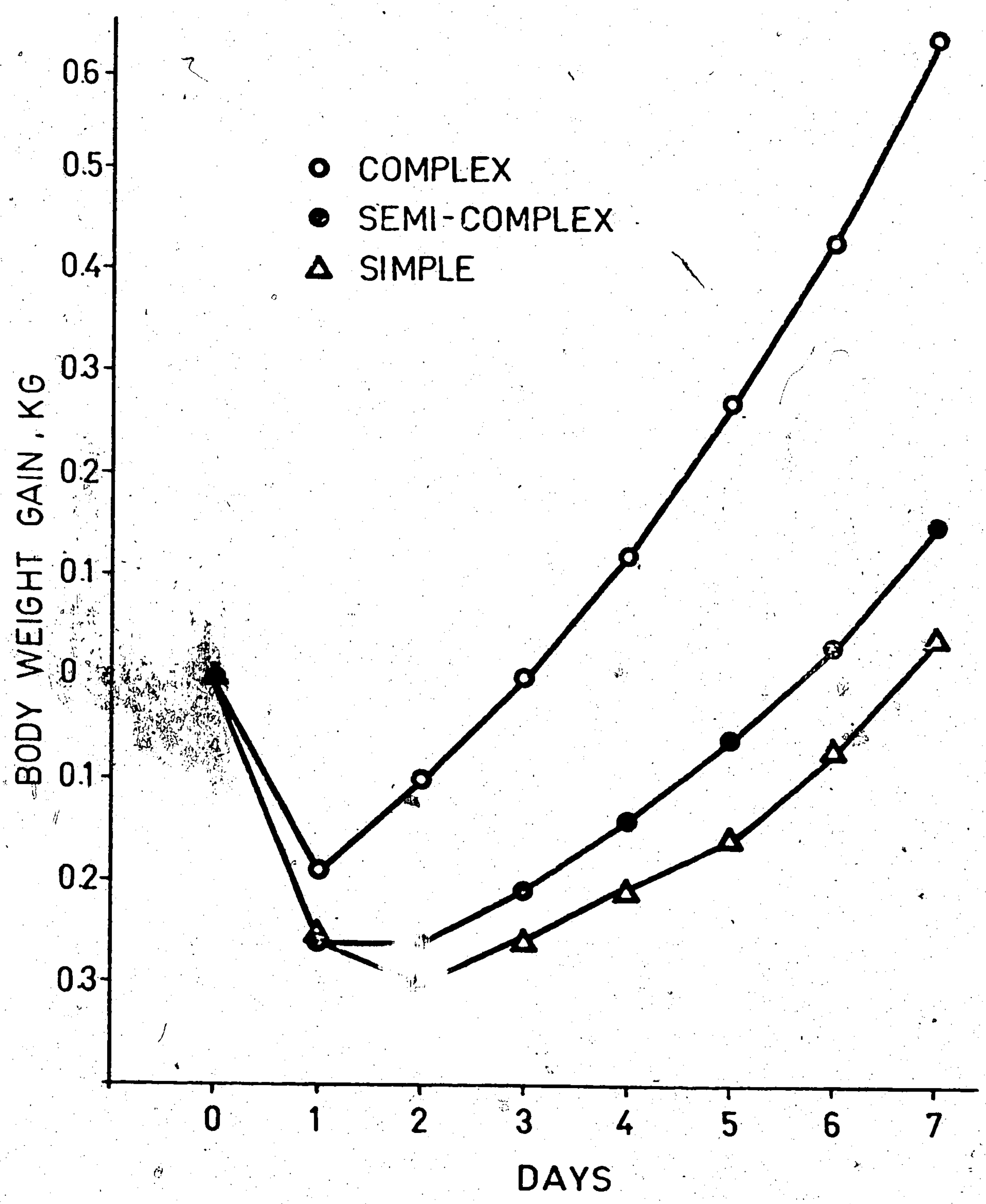
1 The table above shows the mean weekly liveweight gain of the 72 pigs on each treatment and also the mean total weight gain for the 4 week post-weaning period.

weight gains for the 3 treatments were not significant. The best weight gains were recorded by pigs fed the semi-complex, complex and simple diets, in that order. The mean total weight gains were very highly significant ($P < 0.001$). The lowest total weight gain was recorded by pigs fed the simple diet while the pigs fed the semi-complex diet showed a weight gain intermediate to the pigs fed the simple and complex diets.

Thus, in spite of the lack of significance in the gains obtained during the fourth week, there was a very highly significant improvement in total gain when pigs were fed the complex diet. This was obviously due to the better weight gains made in the previous weeks. An improvement in digestibility with age and thus more efficient feed utilization by pigs on the less complex diets (Catron et al., 1957) may have been responsible for the lack of significance during the fourth week. Another factor may have been the higher incidence of scours observed with pigs fed the complex diet, which could have affected weight gain and FCE. Cunningham and Brisson (1957) have reported that scouring could reduce protein digestibility and thus nutrient utilization by about 3 to 7%.

The very highly significant differences in the first week post-weaning weight gains is of special interest. Figure 3 shows the post-weaning growth curve of an average of 47 pigs for each of the treatments. It indicates that at weaning there was a growth check. It appears that the type of diet has an influence on the extent and length of this check period. The attempts made in the past to reduce this period have already been mentioned. (Smith and Lucas, 1956, Bayley and Carlson, 1970). Whereas pigs fed the complex diet took about

Figure 3: DAILY WEIGHT GAIN -- FIRST WEEK POST-WEANING


COMPLEX
SEMI-COMPLEX
SIMPLE
BODY WEIGHT GAIN, KG
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
0.2
0.3
0
1
2
3
4
5
6
7
DAYS

3 days, those on the semi-complex and simple diets took 5.5 and 6.5 days respectively to regain their weaning weights. These differences are probably due to the increased palatability and digestibility of the complex diet.

(e) Mean kg liveweight gain per kg of feed:

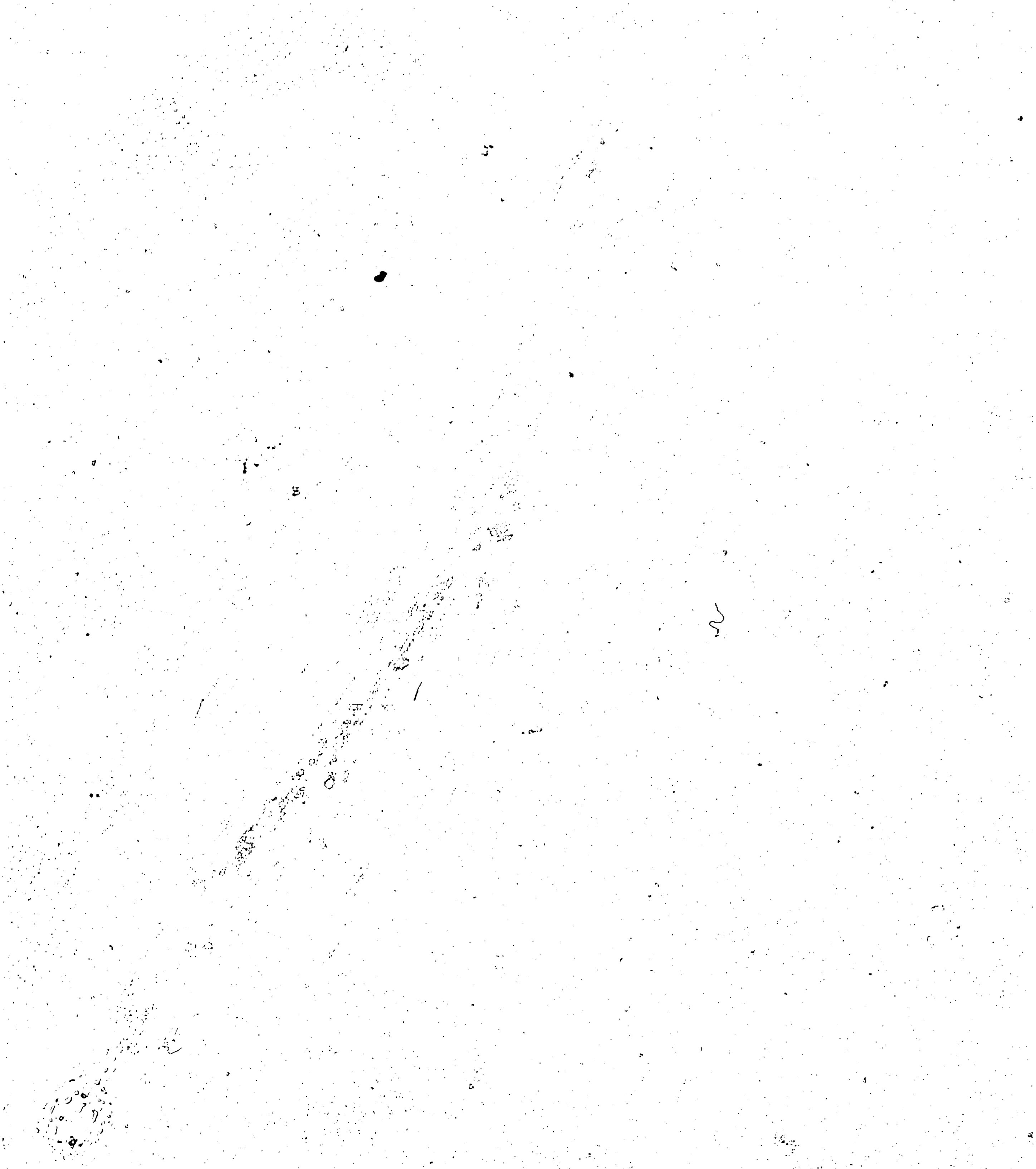
Under normal circumstances an efficient utilization of feed is reflected in improved gains for each kg of feed consumed. The results ($P < 0.001$) in Table 8 and Figure 4 show that there were very highly significant differences in the efficiency of utilization of the 3 diets during the first week post-weaning. Other studies have shown that complex diets similar to the semi-complex diet used here have given better FCE than simple diets (Meade, 1967; Bayley and Carlson, 1970). In the second week there were highly significant ($P < 0.01$) differences in the gain per feed ratios for the 3 diets. The best ratio was obtained with the complex diet; the difference between this value and that for pigs fed a semi-complex diet was not significant ($P < 0.05$) however; but both were significantly ($P < 0.05$) better than that of the pigs fed a simple starter diet. In the third week and fourth weeks, the gain per feed ratios were better in the simple and semi-complex diets, respectively. In the third week however, the differences were not significant but in the fourth week they were very highly significant ($P < 0.001$). This may not be a reflection of poor utilization of the complex diet but rather the result of (1) the higher incidence of scours and (2) feed wastage. In the course of this experiment it was observed that the complex diet formed a sticky mass when it came into contact with saliva and water. This sticky mass formed a cake

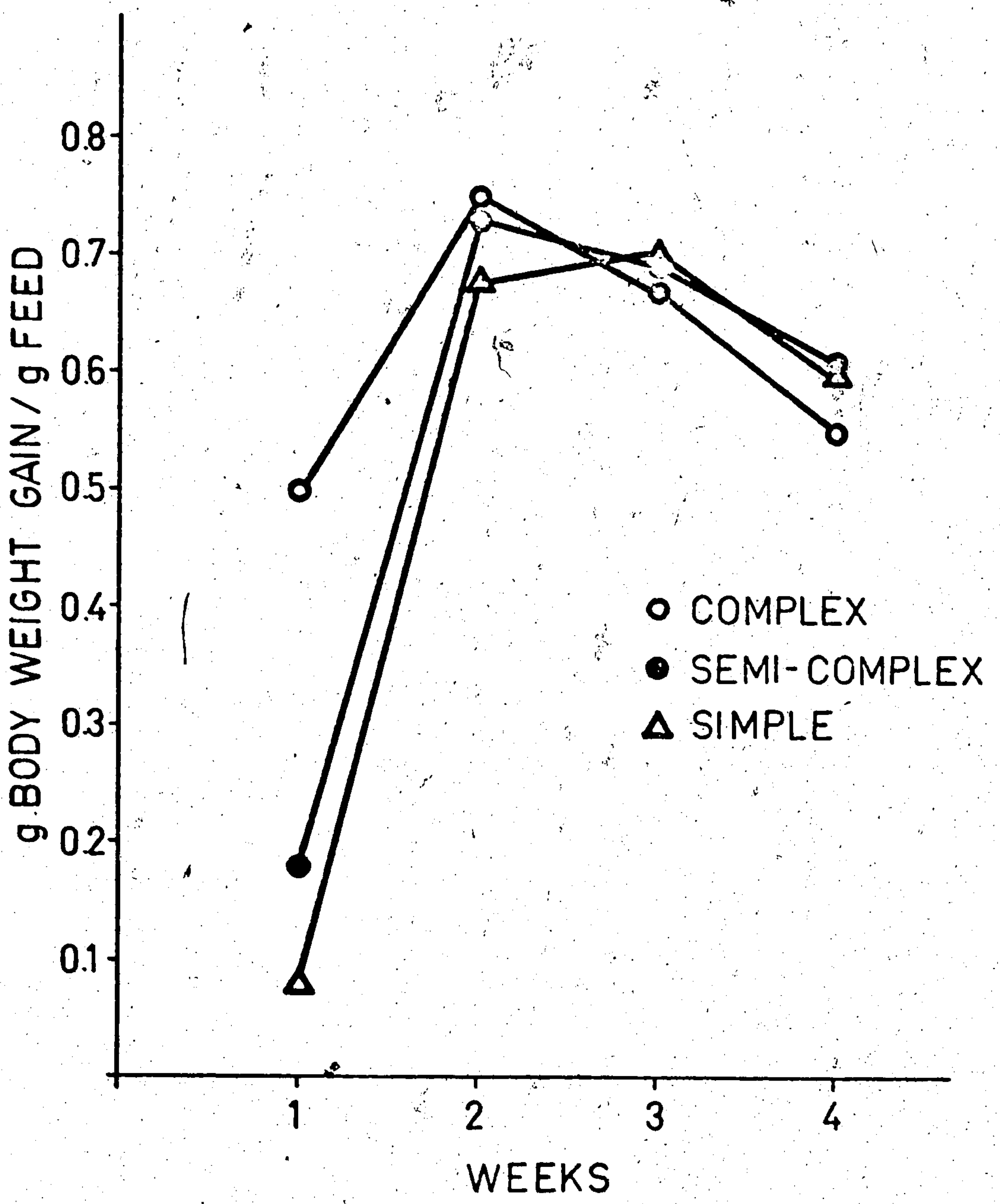
TABLE 8: MEAN WEIGHT GAIN PER KG OF FEED[1]

Treatment:	Simple	Semi-complex	Complex
Week 1 ***	0.08[a]	0.18[b]	0.50[c]
2 **	0.68[a]	0.73[b]	0.75[b]
3	0.70[a]	0.69[a]	0.67[a]
4 ***	0.60[b]	0.61[b]	0.55[a]
OVERALL	0.62	0.64	0.63

[1] There were 72 pigs per treatment i.e. 36 replicates.

Figure 4: MEAN WEEKLY WEIGHT GAIN (KG) PER KG OF FEED




g BODY WEIGHT GAIN / g FEED
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1
2
3
4
WEEKS
COMPLEX
SEMI-COMPLEX
SIMPLE

in the feeder which was difficult to remove. Feed intake, throughout the experiment was based on the difference between the quantity fed daily and the feed left over and collected on the following day. Since some of this feed adhered to the trough after each collection, the feed intake recorded was over estimated to some extent. These two factors were responsible for the depression in gain per feed ratios and the absence of significant difference in the overall data. It is not improbable that this is the feed wastage mentioned by Meade et al. (1965) when he fed a simple diet supplemented with DW and FM and observed a depression in FCE. Perhaps pelleting such a diet might help but it has been suggested (Jensen and Becker, 1965; Bayley and Carlson, 1970) that pelleting could affect the amino acid availability of the proteins in DSM since these are more susceptible to heat damage than SBM protein. Restricted feeding also tends to minimize feed wastage.

SECTION II: Overall creep effect on post-weaning performance

(a) Feed intake and gain per feed ratios:

The effect of creep-feeding on post-weaning feed intake (Table 9) was not significant ($P < 0.05$) during any of the 4 weeks that the experiment was in progress. The total feed intake was highest with pigs which had been fed the semi-complex creep feed. This was however, not significantly ($P \leq 0.05$) different from the total feed intake of the pigs given either simple, or complex creep diets and those not creep-fed. Gain per feed ratios for the various weeks and for the overall period were also not significantly ($P < 0.05$) affected by pre-weaning treatment.

TABLE 9: MEAN POST-WEANING FEED INTAKE AND LIVEWEIGHT GAIN PER FEED RATIOS

Pre-weaning Treatment:	No Creep	Simple Creep	Semi-complex Creep	Complex Creep
A. Feed Intake				
Week 1	1,80	1,76	1,84	1,84
Week 2	5,40	4,89	5,31	5,02
Week 3	8,95	8,30	9,06	8,21
Week 4	11,87	11,11	12,01	11,88
TOTAL	28,02	26,06	28,31	26,95
B. Liveweight Gain Per Feed Ratios				
Week 1	0,20	0,17	0,16	0,28
Week 2	0,73	0,72	0,71	0,71
Week 3	0,70	0,68	0,70	0,67
Week 4	0,58	0,57	0,56	0,64
OVERALL	0,63	0,62	0,61	0,64

1 Each value is the mean for 27 pens each containing 2 pigs.

2 Each mean is for 27 pens containing pairs of pigs.

(b) Liveweights and weight gain:

As shown in Table 10, no significant ($P < 0.05$) differences were observed in the weaning and final weights. There were no significant ($P < 0.05$) differences in the weekly and total weight gain for the 4-week period. Here again, pigs not creep-fed showed the highest weaning and final weights and total weight gain. The results thus indicate that pre-weaning treatment has no significant ($P < 0.05$) effect on either feed intake, weight gain or gain per feed ratios. It has been noted (Page 31) that creep-treatment had no significant ($P < 0.05$) effect on weight gain of piglets at 21 days of age. The lack of significant ($P < 0.05$) differences in the post-weaning performance on the basis of pre-weaning treatment is a further indication that creep-feeding pigs in a 3-week weaning program is of questionable value.

TABLE 10: MEAN WEEKLY WEIGHT GAIN (kg)[1]

Pre-weaning Treatment:	No Creep	Simple Creep	Semi-complex Creep	Complex Creep
Weaning Weight[2]	5.30	4.94	5.16	5.08
Final Weights	14.17	12.90	13.79	13.54
Week 1	0.33	0.33	0.25	0.32
Week 2	1.98	1.74	1.91	1.73
Week 3	3.15	2.79	3.15	2.72
Week 4	3.42	3.10	3.32	3.69
TOTAL GAIN	8.88	7.96	8.63	8.46

1 Each value is the mean for 54 pigs.

2 Differences between the weaning weights shown here and those in Table 4 are the result of the use of missing values in the determination of the former.

SECTION III: Comparison of starter diets within each pre-weaning treatment

(a) Feed intake:

Table 11 illustrates the differences in the post-weaning feed intake of the pigs on the various creep treatments.

1. Starter intake of pigs not creep fed:

The intake of the complex starter recorded in the first, second and third weeks post-weaning were significantly ($P < 0.05$) greater than the intakes of the simple starter but not of the semi-complex starter. Feed intake in the fourth week was highest for the complex starter but the differences were not significant. The total feed intake was significantly ($P < 0.05$) better for pigs fed a complex starter as compared with a simple starter but was not significantly ($P < 0.05$) different from the intake of pigs fed the semi-complex starter.

2. Starter intake of pigs given a simple creep feed:

During the first 3 weeks of the feeding period, the pigs fed a simple creep consumed significantly ($P < 0.05$) more of a complex starter than either the simple or the semi-complex diets. In the fourth week feed intake was highest with the complex starter but was only significantly ($P < 0.05$) better than the intake of the simple starter. The total intake of the complex starter was significantly ($P < 0.05$) better than the intake of either the simple or the semi-complex diet.

TABLE 11: CREEP STARTER RELATIONSHIP -- POST-WEANING FEED INTAKE (kg/week/pen)[1]

COMPARISON OF STARTER INTAKE WITHIN EACH PRE-WEANING TREATMENT

Pre-weaning Treatment:	No Creep			Simple Creep			Semi-complex Creep			Complex Creep		
Post-weaning Treatment:	Simple	Semi-Complex	Complex	Simple	Semi-Complex	Complex	Simple	Semi-Complex	Complex	Simple	Semi-Complex	Complex
Week 1	1.38^{a}	1.72^{ab}	2.32^{b}	1.26^{a}	1.61^{a}	2.40^{b}	1.73^{a}	1.66^{ab}	2.12^{b}	1.57^{a}	1.71^{a}	2.25^{b}
Week 2	4.74^{a}	5.43^{ab}	6.03^{b}	4.22^{a}	4.58^{a}	5.87^{b}	5.05^{a}	4.86^{a}	6.01^{b}	4.52^{a}	4.98^{ab}	5.55^{b}
Week 3	7.95^{a}	9.29^{b}	9.62^{b}	7.23^{a}	8.11^{a}	9.55^{b}	8.32^{a}	8.69^{a}	10.17^{b}	6.87^{a}	8.46^{b}	9.30^{b}
Week 4	11.15^{a}	12.18^{a}	12.27^{a}	10.11^{a}	10.93^{ab}	12.28^{b}	11.09^{a}	11.99^{ab}	13.20^{b}	11.39^{a}	11.83^{a}	12.43^{a}
TOTAL	25.22^{a}	28.62^{ab}	30.06^{b}	22.82^{a}	25.23^{a}	30.10^{b}	26.19^{a}	27.20^{a}	31.50^{b}	24.35^{a}	26.98^{ab}	29.53^{b}

[1] Each value is the mean for 9 replicates or experimental units consisting of 18 pigs.

3. Starter intake of pigs given a semi-complex creep feed:

As was observed with the preceding treatments, starter feed intake increased with diet complexity. The intake of the simple and semi-complex starter during the first week were not significantly ($P < 0.05$) different; neither were the intakes of the semi-complex and complex starters. The intake of the complex diet was significantly ($P < 0.05$) better than the intake of the simple starter. In the second and third weeks, significantly ($P < 0.05$) more of the complex diet was consumed than either the semi-complex or simple starter. Lowest intake was obtained on the simple starter. In the fourth week, more complex diet was eaten than either simple or semi-complex but there was a significant ($P < 0.05$) difference only between the intake of the simple and the complex starters. The total intake of the complex starter by pigs fed a semi-complex creep feed was significantly ($P < 0.05$) better than the intake of either the simple or the semi-complex diet Lowest total feed intake was by pigs fed a simple starter.

4. Starter intake of pigs given a complex creep feed:

During the first week pigs fed a complex creep had significantly ($P < 0.05$) higher intake of the complex diet than the semi-complex and simple diets. In the second week, the intake of the complex starter was significantly ($P < 0.05$) better than that of the simple starter but was not significantly different from the intake of the semi-complex starter. The semi-complex starter intake was also not significantly ($P < 0.05$) different from the intake of the complex starter. In the third week, feed intake of either the semi-complex or complex starter was significantly ($P < 0.05$) better than the intake of the simple starter.

TABLE 12: CREEP STARTER RELATIONSHIP -- POST-WEANING GROWTH RATE[1]

COMPARISON OF PIGLET PERFORMANCE ON STARTER DIETS WITHIN EACH PRE-WEANING TREATMENT

Pre-weaning Treatment:	No Creep			Simple Creep			Semi-Complex Creep			Complex Creep		
Post-weaning Treatment:	Simple	Semi-Complex	Complex	Simple	Semi-Complex	Complex	Simple	Semi-Complex	Complex	Simple	Semi-Complex	Complex
Weaning weight (kg)	5,28^{ab}	5,53^{b}	5,08^{a}	4,94^{a}	4,99^{a}	4,88^{a}	5,13^{a}	5,23^{a}	5,12^{a}	5,19^{a}	5,10^{a}	4,95^{a}
Final weight (kg)	12,91^{a}	14,81^{b}	14,79^{b}	11,91^{a}	12,67^{a}	14,13^{b}	12,89^{a}	13,86^{ab}	14,61^{b}	12,67^{a}	13,62^{ab}	14,32^{b}
<u>Weekly Liveweight Gain</u> (kg)												
Week 1	0,06^{a}	0,28^{a}	0,65^{b}	0,01^{a}	0,23^{a}	0,77^{b}	0,08^{a}	0,18^{a}	0,48^{b}	0,12^{a}	0,26^{a}	0,60^{b}
Week 2	1,63^{a}	2,03^{b}	2,28^{b}	1,48^{a}	1,59^{a}	2,16^{b}	1,64^{a}	1,85^{a}	2,24^{b}	1,38^{a}	1,77^{b}	2,03^{b}
Week 3	2,81^{a}	3,27^{b}	3,38^{b}	2,49^{a}	2,69^{a}	3,18^{b}	2,89^{a}	3,12^{ab}	3,43^{b}	2,31^{a}	2,83^{b}	3,01^{b}
Week 4	3,14^{a}	3,71^{b}	3,40^{ab}	2,99^{a}	3,17^{a}	3,14^{d}	3,14^{a}	3,49^{a}	3,33^{a}	3,67^{a}	3,66^{d}	3,73^{a}
TOTAL WEIGHT GAIN	7,64^{a}	9,29^{b}	9,71^{b}	6,97^{a}	7,68^{a}	9,25^{b}	7,75^{a}	8,64^{ab}	9,48^{b}	7,48^{a}	8,52^{ab}	9,37^{b}

[1] Each value is the mean for 18 pigs.

Even though feed intake in the fourth week was highest with the complex starter it was not significantly ($P < 0.05$) different from the intake of the simple and semi-complex starters. The intake of the semi-complex starter was however higher than the intake of the simple starter. Total feed intake was highest with the complex starter but was only significantly ($P < 0.05$) different from the total intake of the simple starter.

(b) <u>Growth rate:</u>

The mean weaning and final weights and the weight gains of pigs on the various treatments are shown in Table 12.

1. <u>Growth rate of pigs not creep fed:</u>

Differences existed in the weaning weights of the pigs which were not creep-fed. The differences were only significant ($P < 0.05$) between those allotted to the complex and semi-complex starter diets. The final weights were also significantly ($P < 0.05$) different, the pigs fed either the semi-complex or complex starter being significantly ($P < 0.05$) greater in weight than those fed the simple starter. The largest and smallest first week weight gains were obtained by pigs fed the complex and simple starter diets, respectively. The differences between these two were significant ($P < 0.05$). Weight gains in the second and third weeks were greatest for pigs fed the complex starter and were only significantly ($P < 0.05$) greater than the weight gains of pigs fed a simple starter diet. The highest fourth week weight gain was obtained for pigs fed a semi-complex starter; this was however, only significantly ($P < 0.05$) better than the weight gain of pigs given the simple starter. The best total weight gain was by pigs fed the complex starter but this was only significantly ($P < 0.05$) better than that of pigs fed the simple starter.

2. Growth rate of pigs given a simple creep feed:

The weaning weights were not significantly ($P < 0.05$) different but the final weights were significantly ($P < 0.05$) different, with pigs fed the complex starter having the heaviest final weight. In the first, second and third weeks, the highest and lowest weight gains were by pigs given the complex and simple starters, respectively. The weight gains were significantly ($P < 0.05$) better for the pigs fed a complex starter than for those fed the simple or semi-complex starter diets. Fourth week weight gains were highest with pigs fed the semi-complex starter but were not significantly ($P < 0.05$) better than the weight gains of those fed the simple or a semi-complex starter. Total weight gains were significantly greater for pigs fed the complex starter as compared to those fed the simple or semi-complex starter. The weight gain of pigs fed the semi-complex starter was greater than that of pigs fed the simple starter, but the differences were not significant ($P < 0.05$).

3. Growth rate of pigs given a semi-complex creep feed:

There were no significant differences in the weaning weights of the pigs assigned to the 3 post-weaning treatments. Final weights were significantly ($P < 0.05$) greater when pigs were fed a complex starter; as compared with those fed the simple starter. In the first 2 weeks the liveweight gains were significantly ($P < 0.05$) greater for pigs fed the complex starter than for those fed either the semi-complex or simple starter. Third week weight gains were highest for pigs given the complex starter but was only significantly ($P < 0.05$) better than the weight gain of pigs fed the simple starter diet. Weight gains in the fourth week were highest for pigs fed the semi-complex starter but the differences between the three treatments were not significant. Total weight gain was lowest when pigs were fed a simple starter and highest for pigs fed the complex starter, the difference between the two being significant ($P < 0.05$).

4. Growth rate of pigs given a complex creep feed:

There were no significant ($P < 0.05$) differences in the weaning weights. Final weights were greatest for pigs given the complex starter but this was only significantly ($P < 0.05$) better than the final weight of pigs fed the simple starter. Weight gains recorded in the first week were greatest and lowest for pigs fed the complex and simple starter diets, respectively. The differences between the weight gains for pigs fed the simple and complex starters were significant ($P < 0.05$). In the second and third weeks, weight gains of pigs fed the complex and semi-complex starter diets were not significantly ($P < 0.05$) different. Differences in these weight gains were significantly ($P < 0.05$) different from that for pigs fed a simple starter. Weight gains in the fourth week were not significantly different but were highest for pigs fed the complex starter diet. Total weight gain was highest for pigs given the complex starter, but was only significantly ($P < 0.05$) different from that of pigs fed the simple starter.

(c) Weight gain per feed ratio:

The differences in the gain per kg feed ratios are shown in Table 13.

TABLE 13: CREEP STARTER RELATIONSHIP -- GAIN PER FEED RATIOS[1,2].

COMPARISON OF PIGLET PERFORMANCE ON STARTER DIETS WITHIN EACH PRE-WEANING TREATMENT

Pre-weaning Treatment:	No Creep			Simple Creep			Semi-complex Creep			Complex Creep		
Post-weaning Treatment:	Simple	Semi-Complex	Complex	Simple	Semi-Complex	Complex	Simple	Semi-Complex	Complex	Simple	Semi-Complex	Complex
Week 1	-0.15^a	0.23^b	0.51^b	-0.27^a	0.08^b	0.69^b	0.01^a	0.13^a	0.33^a	0.11^a	0.27^{ab}	0.46^b
Week 2	0.71^a	0.74^a	0.75^a	0.72^a	0.70^a	0.74^a	0.63^a	0.74^b	0.75^b	0.65^a	0.73^{ab}	0.75^b
Week 3	0.71^a	0.70^a	0.70^a	0.71^a	0.67^a	0.66^a	0.70^a	0.72^a	0.68^a	0.69^a	0.67^a	0.64^a
Week 4	0.56^a	0.62^a	0.56^a	0.60^a	0.59^a	0.52^b	0.58^a	0.59^a	0.51^b	0.67^a	0.64^a	0.62^a
OVERALL	0.61^a	0.65^b	0.64^{ab}	0.63^a	0.61^a	0.61^a	0.59^a	0.64^b	0.61^b	0.64^a	0.64^a	0.64^a

1 Each value in a subcolumn is the mean for 9 pens or replicates.

2 The gain per kg feed ratios in the tables are based on individual feed intake and weight gain and are not derived directly from the average feed intake and weight gain data in Tables 11 and 12.

1. Gain per feed ratios of pigs not creep-fed:

In the first week a negative weight gain per feed ratio was obtained by pigs fed a simple starter. The positive ratios obtained by those fed the semi-complex and complex starter were significantly ($P < 0.05$) different from the negative ratio but were not significantly different from each other. There were no significant differences in the ratios for the second, third and fourth weeks but the ratios were highest for those fed complex, simple and semi-complex starter diets respectively. Overall gain per feed ratio was best for pigs fed the semi-complex but this was only significantly ($P < 0.05$) different from that of pigs fed the simple starter diet.

2. Gain per feed ratios of pigs fed a simple creep feed:

During the first week pigs fed the simple starter diet recorded a negative gain per feed ratio while those fed the semi-complex and complex diets gave significantly ($P < 0.05$) better ratios. There were no significant differences in the ratios for the 2 subsequent weeks. The highest gain per feed ratios in the second and third weeks were obtained by the pigs fed the complex and simple starters, respectively. The fourth week gain per feed ratio was best for the pigs fed the simple starter but this was only significantly ($P < 0.05$) better than that for pigs fed the complex starter diet. There were no significant ($P < 0.05$) differences in the overall ratios but the best ratio was obtained by pigs fed the simple diet.

3. Gain per feed ratios of pigs fed a semi-complex creep feed:

For the first week, the gain per feed ratio was best for pigs fed the complex starter diet but the differences between the ratios for the 3 treatments were not significant ($P < 0.05$). Second week gain per feed ratios also favoured pigs fed the complex starter but was only significantly ($P < 0.05$) better than the gain per feed ratio for pigs fed the simple starter. Third week ratios were not significantly ($P < 0.05$) different but were highest with pigs fed the semi-complex starter. Fourth week ratios were best for pigs fed the semi-complex starter but was only significantly ($P < 0.05$) different from that for pigs fed the complex starter diet. The overall gain per feed ratio was significantly ($P < 0.05$) higher in pigs fed the semi-complex and complex starters than in pigs fed the simple starter.

4. Gain per feed ratios of pigs fed a complex creep feed:

During the first and second weeks, the best ratios were obtained with the complex starter but they were only significantly ($P < 0.05$) better than the ratios for pigs fed a simple starter diet. Highest third and fourth week gain per feed ratios were obtained by pigs fed the simple starter diet. These were however, not significantly ($P < 0.05$) different from those for pigs fed the semi-complex or the complex starter diets. Overall gain per feed ratios were not different numerically and thus there were no significant differences between these.

The results presented above have shown that there is an improvement in feed intake and growth rate with increase in diet complexity especially in the first couple of weeks post-weaning. A complex diet also reduces the extent of the growth check at weaning. It may thus be of importance in baby pig nutrition.

SECTION IV: Effects of the four pre-weaning treatments on feed intake and piglet performance for each of the three starter diets

There were 72 pigs on each post-weaning treatment, this consisted of 18 pigs from each of the four pre-weaning treatments described previously.

(a) Effects of the 4 pre-weaning treatments on intake and performance on a simple starter:

1. Feed intake:

Table 14 shows the intake of the simple starter for the 4 weeks of the experiment. The intake of the simple starter diet was not significantly ($P < 0.05$) influenced by the pre-weaning treatments on any of the 4 weeks of feeding. The total post-weaning feed intake was also not significantly ($P < 0.05$) affected by the pre-weaning treatment. Though no significant ($P < 0.05$) differences were observed the results indicate that feeding a simple starter to pigs given a similar diet as a creep feed may not facilitate optimum feed intake.

2. Growth rate:

The highest 7-week weight was obtained by pigs which had not been creep fed, (Table 14) but these pigs also had the highest weaning weight. There were no significant ($P < 0.05$) differences in the total

TABLE 14: CREEP-STARTER RELATIONSHIP - EFFECTS OF FOUR PRE-WEANING TREATMENTS ON FEED INTAKE AND PERFORMANCE OF PIGS FED A SIMPLE STARTER[1]

Pre-weaning Treatment:	No Creep	Simple Creep	Semi-complex Creep	Complex Creep
A. Feed Intake (kg)				
Week 1	1.38	1.26	1.73	1.57
Week 2	4.74	4.22	5.05	4.52
Week 3	7.95	7.23	8.32	6.87
Week 4	11.15	10.11	11.09	11.39
TOTAL	25.22	22.82	26.19	24.35
B. Growth Rate (kg)				
Weaning Weight	5.28	4.94	5.13	5.19
Final Weight	12.91	11.91	12.89	12.67
Weekly Weight Gain:				
Week 1	0.06	0.01	0.08	0.12
Week 2	1.63	1.48	1.64	1.38
Week 3	2.81	2.49	2.89	2.31
Week 4 *	3.14[ab]	3.99[a]	3.14[ab]	3.67[b]
TOTAL WEIGHT GAIN	7.63	6.97	7.75	7.48
C. Gain Per Feed Ratios				
Week 1	-0.15	-0.27	0.01	0.11
Week 2	0.71	0.72	0.63	0.65
Week 3	0.71	0.71	0.70	0.69
Week 4	0.56	0.60	0.58	0.67
OVERALL	0.61	0.63	0.60	0.64

[1] Source of Data: Tables 11, 12 and 13.

weight gain. There was a tendency for pigs given the semi-complex creep feed to gain the most in the second and third weeks and for the total period. In the final week, pigs fed the complex diet as creep had the highest weight gains but the difference was significant ($P < 0.05$) only in comparison to pigs fed a simple creep feed. The better weight gain of pigs fed the complex creep in the final week is a reflection of the better feed intake and gain per feed ratio recorded during this period.

3. Gain per feed ratio:

There was a tendency for the more complex creep diets to give better ratios in the first week but the differences were not significant ($P < 0.05$) during any of the 4 weeks or in the overall period. In fact, it was only in the first week that there was a substantial difference in the gain per feed ratios.

The results suggest that to obtain a higher initial weight gains on a simple starter, a semi-complex or a complex creep feed could be of some importance.

(b) Effects of the 4 pre-weaning treatments on feed intake and performance on a semi-complex starter:

1. Feed intake:

There were no significant ($P < 0.05$) differences in the weekly and total intake of the semi-complex starter by the pigs on the 4 pre-weaning treatments (Table 15). However, in the four weeks of the experiment pigs not creep fed tended to eat more of the semi-complex starter than the other groups of pigs. Their total feed intake was thus the

TABLE 15: CREEP-STARTER RELATIONSHIP - EFFECTS OF FOUR PRE-WEANING TREATMENTS ON FEED INTAKE AND PERFORMANCE OF PIGS FED A SEMI-COMPLEX STARTER[1]

Pre-weaning Treatment:	No Creep	Simple Creep	Semi-complex Creep	Complex Creep
A. Feed Intake (kg)				
Week 1	1.72	1.61	1.66	1.71
Week 2	5.43	4.57	4.86	4.98
Week 3	9.29	8.11	8.69	8.46
Week 4	12.18	10.93	11.99	11.83
TOTAL	28.62	25.22	27.20	26.98
B. Growth Rate (kg)				
Weaning Weight	5.52	4.99	5.23	5.10
Final Weight	14.81	12.67	13.86	13.62
Weekly Weight Gain:				
Week 1	0.28	0.23	0.18	0.26
Week 2	2.03	1.59	1.85	1.77
Week 3	3.27	2.69	3.12	2.83
Week 4	3.71	3.17	3.49	3.66
TOTAL WEIGHT GAIN	9.29	7.68	8.64	8.52
C. Gain Per Feed Ratio				
Week 1	0.23	0.08	0.13	0.27
Week 2	0.74	0.70	0.74	0.73
Week 3	0.70	0.67	0.72	0.67
Week 4	0.62	0.59	0.59	0.64
OVERALL	0.65	0.61	0.64	0.64

[1] Source of data: Table 11, 12 and 13.

highest. The weekly and total feed intake of pigs given a simple creep feed was the lowest. The feed intake of pigs given the semi-complex or complex diets as creep feed was slightly lower than those not creep fed but was higher than those given a simple creep.

2. Growth rate:

Even though differences existed in the weaning and final weights of the pigs from the 4 pre-weaning treatments, these differences were not significant ($P < 0.05$). There were differences in the weekly and total weight gains of these groups of pigs but these differences were also not significant ($P < 0.05$). The highest weekly and total weight gain was obtained by pigs which had not been given any creep feed. The weekly and total weight gain of pigs fed the semi-complex and complex diets as creep were quite similar and were higher than the weight gain of pigs which received a simple creep feed.

3. Gain per feed ratio:

The weekly gain per feed ratio data (Table 15) shows that the best gain per feed ratio for the overall period was obtained by pigs which had not been creep fed. The differences between these and the other 3 treatments were not significant ($P < 0.05$) however. In the first week the best ratio was obtained with pigs which had been given the complex diet as a creep feed; this was not significantly ($P < 0.05$) different from the ratios for the other 3 treatments. There were no significant differences in the ratios for the second and third weeks but they were highest for pigs fed semi-complex or not creep-fed and those fed the semi-complex creep feed respectively. In the fourth week the best gain per feed ratio was again obtained with pigs given the complex diet as creep feed. The ratio in this instance was not significantly ($P < 0.05$) greater than those of the pigs on the other 3 treatments. The lowest gain per feed ratio was obtained by pigs which received a simple creep feed. The results have shown that there is a trend towards reduction in feed intake and piglet performance when the simple diet is used as a creep feed.

(c) Effects of the 4 pre-weaning treatments on feed intake and performance on a complex starter:

1. Feed intake:

There were no significant ($P < 0.05$) differences in the weekly and total feed intake of the complex starter by the pigs on the 4 pre-weaning treatments (Table 16). In the first week pigs which had been given a simple creep ate the most indicating that when a simple creep is used, a complex starter may be the best feed to ensure adequate starter intake initially. Feed intake in the second week was highest in pigs which were not creep fed. In the third and fourth weeks however, pigs given a semi-complex creep feed showed the highest feed intake. The total intake of the complex starter was highest in pigs which were fed the semi-complex creep.

2. Growth rate:

Even though differences existed in the weaning and final weights of the pigs on the 4 pre-weaning treatment (Table 16) these differences were not significant ($P < 0.05$). Differences were also observed in the weekly and total weight gain of these 4 groups of pigs but these

TABLE 16: CREEP-STARTER RELATIONSHIP - EFFECTS OF FOUR PRE-WEANING TREATMENTS ON FEED INTAKE AND PERFORMANCE OF PIGS FED A COMPLEX STARTER[1]

Pre-weaning Treatment:	No Creep	Simple Creep	Semi-complex Creep	Complex Creep
A. Feed Intake (kg)				
Week 1	2.32	2.40	2.12	2.25
Week 2	6.03	5.87	6.01	5.55
Week 3	9.62	9.55	10.17	9.30
Week 4	12.27	12.28	13.20	12.43
TOTAL	30.24	30.10	31.50	29.53
B. Growth Rate (kg)				
Weaning Weight	5.08	4.88	5.12	4.95
Final Weight	14.79	14.13	14.61	14.32
Weekly Weight Gain:				
Week 1	0.65	0.77	0.48	0.60
Week 2	2.28	2.16	2.24	2.03
Week 3	3.38	3.18	3.43	3.01
Week 4	3.40	3.14	3.33	3.73
TOTAL WEIGHT GAIN	9.71	9.25	9.48	9.37
C. Gain Per Feed Ratio				
Week 1	0.51	0.69	0.33	0.46
Week 2	0.75	0.74	0.75	0.75
Week 3	0.70	0.66	0.68	0.64
Week 4*	0.56[ab]	0.52[a]	0.51[a]	0.62[b]
OVERALL	0.64	0.61	0.61	0.64

[1] Source of data: Table 11, 12 and 13.

differences were also not significant ($P < 0.05$). The highest first week weight gain was by the pigs which also ate the most of the complex starter namely pigs given the simple creep feed. Weight gain in the second week was highest in the pigs which were not creep fed and the lowest gain was by pigs which received the complex diet as a creep feed. Pigs given the semi-complex creep feed had the best third week weight gain. The fourth week and total weight gain was however, obtained by pigs which had not been fed any creep feed. Pigs given complex and semi-complex creep feeds were intermediate while those given the simple creep recorded the lowest fourth week and total weight gain.

3. Gain per feed ratios:

The gain per feed ratios were generally not significantly ($P < 0.05$) different for the 4 treatments. However, the fourth week weight gains for pigs which had a complex diet as creep were significantly ($P < 0.05$) better than those of pigs which were fed simple and semi-complex creep diets. It was however, similar to that of the pigs which were not creep fed.

This study of creep-starter relationships has shown that a simple creep may lead to a slightly lower but not significantly ($P < 0.05$) lower post-weaning performance. There was a general trend toward an increase in feed intake and performance with an increase in diet complexity. Pigs which had not been creep fed ate more of the complex than the semi-complex and simple starter diets. Pigs which had simple, semi-complex or complex creep feed also ate more of the complex than the semi-complex and simple starter diets. Weight gains and gain per feed ratio data shown here also point to the "essentiality" of feeding a complex starter for optimum post-weaning performance regardless of the pre-weaning treatment.

DIGESTIBILITY STUDIES

The mean nitrogen and energy digestibilities of the three diets are shown in Table 17.

There were highly significant ($P < 0.01$) differences in the energy digestibilities of the three diets, the complex diet gave a significantly better digestibility than either the semi-complex or simple diet. There was no significant difference between the simple and semi-complex with regard to energy digestibility. The mean nitrogen digestion co-efficient was highest with the complex diet but was only significantly ($P < 0.05$) better than the simple diet. The values obtained were similar to values in the literature (Sewell and West, 1965; Bayley and Carlson, 1970). McCarthy et al. (1973) in baby pig digestibility studies observed energy and nitrogen digestibilities of a semi-complex diet to be 86.3% and 86.0%, respectively. The relatively higher digestibility of the complex diet suggests that more of the nutrients would be available for the formation of body tissues. This could explain the higher growth rate and gain per feed ratio of pigs fed this diet. The results of these studies agree with the suggestion of Catron et al. (1957) that the protein in milk products is more readily digested by baby pigs than that in soybean meal. Feeding baby pigs diets which are highly digestible is thus an important factor in the achievement of better performance.

MILK YIELD AND ITS POSSIBLE EFFECTS ON CREEP FEED INTAKE

The data on estimated milk yield, composition and nutrient intake of piglets are presented in Table 18. Milk yield increased from the second

TABLE 17: NITROGEN AND ENERGY DIGESTIBILITY DATA[1] (%)

Diet:	Simple	Semi-complex	Complex
% Digestible energy **	86.0^{a}	86.5^{a}	93.2^{b}
% Digestible nitrogen *	87.1^{a}	85.1^{ab}	90.5^{b}

[1] Each value is the mea[illegible] 3 pigs.

TABLE 18: MILK PRODUCTION, COMPOSITION AND INTAKE OF NUTRIENTS[1]

Day of lactation	10	20
Mean milk yield (kg)	5.2	6.5
Range (kg)	3.2 -6.7	4.7 -9.1
% Dry matter (DM)	19.4	18.6
% Crude protein (N x 6.38)	5.8	6.2
Gross energy (Mcal/kg)	6.0	6.0
Total DM (g)	1010	1100
Mean number of piglets/sow	7.8	7.7
Milk DM intake/pig (g)	129.5	142.9
Milk gross energy intake/pig (kcal)	773.1	858.6
Milk digestible energy intake/pig (kcal)[2]	749.9	832.8
Crude protein intake/pig (g)	38.7	51.9
Digestible crude protein intake/pig[3] (g)	37.9	50.9

[1] Mean for 9 sows.

[2] Based on a digestible energy coefficient of 97% for milk. (Lucas and Lodge, 1961)

[3] Based on a digestible crude protein coefficient of 98% for milk. (Lucas and Lodge, 1961)

to the third week of lactation. Percentage protein also increased but percentage dry matter decreased during this period. Total dry matter and protein both increased however, owing to the higher milk yield in the third week. The milk production determined in this experiment was in general agreement with those reported in the literature. Values ranging from 4.032 to 10.188 kg have been reported by several workers (Barber et al., 1955; Salmon-Legagneur, 1956; and Mahan et al., 1971). More recently, Lewis and Speer (1973) determined daily milk yields ranging from 6.18 to 7.47 kg for day 20 of lactation.

Lucas and Lodge (1961) have calculated the daily digestible energy and protein requirements of suckling pigs. They suggested values ranging from 965 kcal for 1 week old pigs to 2500 kcal for 8 week old pigs. They indicated that there was no need to give creep feed until pigs were 3 weeks old. The energy intakes recorded in this experiment were lower than the values reported by these workers. They seem to have been sufficient for normal growth and the low intake of the various creep rations may have been due to this apparently adequate nutrient intake. When milk yield is adequate the protein intake of the pigs from the milk is sufficient for pigs until they are 4 weeks of age (Lucas and Lodge, 1961).

The calculated digestible protein intake per pig of 50.9 g for the 20th day of lactation is similar to the 53 g determined by Lucas and Lodge (1961). There were indications that the piglets got enough nutrients from the milk and the low creep intake led to the absence of significant differences in the 21-day weight gains of the pigs on the various treatments.

GENERAL DISCUSSION

From January to September 1973, comparative feeding trials were conducted in the Swine Section, Edmonton Research Station, of the Department of Animal Science, University of Alberta, Edmonton. The results of these trials have been reported above. These trials showed that there is a higher creep feed intake when complex diets are fed to suckling pigs. It seems the higher feed intake was due to the added sucrose and DSM. Feed intake was generally low however, consequently there were no significant ($P < 0.05$) differences in the performances of the pigs fed the 3 pre-weaning diets. Pigs which were not creep fed had a higher 21-day weight gain. This suggests that the period of creep feeding was not of sufficient duration to cause significant differences in piglet performance. The fact that milk production reaches a peak between the third and fourth week of lactation supports the view that the piglets may have been getting enough nutrients from the milk for maximum growth and development. Perhaps results would be different if pigs were weaned later than 21 days of age and litters were larger. Alberta data (Kirk, 1972) has indicated that most swine producers are still on a 5-6 week weaning program, a study of this nature will therefore be of some relevance. In the course of this experiment the milk yield and composition of 9 of the 36 sows used were estimated. The average 10-and 20-day lactation yields were 5.2 and 6.5 kg respectively. These values and the dry matter values of 19.4 and 18.6 % respectively were similar to those reported in the literature (Mahan et al., 1971). The mean values thus suggest that the piglets were getting amounts of milk similar to what has been observed elsewhere.

Post-weaning feed intake and performances were higher when pigs were fed the complex diets. The significantly ($P < 0.05$) higher digestibility of the complex diets may have been responsible for the improvement in performance. The experiment showed that use of a complex starter as compared to a simple or semi-complex one can lead to a reduction in the length of the "growth check" period at weaning. It would seem that this is probably the most important use of a complex starter. By limiting the use of a complex starter to a short period immediately after weaning it might be possible to reduce or eliminate such problems as: (1) the higher incidence of scours owing probably to overeating and poor feed utilization, (2) the tendency for the complex starter to form a hard mass in the feeders and (3) feed costs. The price of a pound of feed ranged from 8 to 11 and 25 cents for the simple, semi-complex and complex starters, respectively. The complex diet was thus very expensive and the improvement in performance obtained may not justify its use. However, Catron et al., (1957) has reported that enzyme development in piglets was complete at about 5 weeks of age. It is thus possible to change to simple diets and still get good performance after the pigs are 5 weeks of age.

There were no significant ($P < 0.05$) differences in various creep-starter interactions studied. It could thus be postulated that such interactions do not exist or are unimportant. A trend was however, observed with some of these creep-starter relationships. There was a relatively lower intake of the simple creep feed; this was followed by a low intake of the same simple diet when it was offered as a starter post-weaning. There was consequently a reduction in piglet performance but this was not significantly ($P < 0.05$) different from the other creep-starter interactions even though the piglets on these treatments showed better performance. The results indicated a trend towards an improvement in the immediate post-weaning performance when the simple creep diet was replaced by the semi-complex or complex diet at weaning. Differences were again not significant ($P < 0.05$)

The results of this experiment have shown that feeding diets of varying complexity gave no significant ($P < 0.05$) creep-starter interactions.

GENERAL SUMMARY

It is generally agreed that a creep feed should be palatable and contain proteins of high biological value. Starter diets have generally ranged from simple wheat-SBM diet to a semi-complex or a complex diet. Evidence of the influence of creep feed composition on starter intake and post-weaning performance is rather scanty.

This experiment has shown that a complex creep feed leads to a higher feed intake than a simple or semi-complex creep feed. Intake is however, not of sufficient magnitude to influence performance when the creep feed is offered from 10 to 21 days of age. Milk production data determined in the course of this experiment indicated that the piglets were getting enough nutrients from the milk. Following weaning best feed intake and performance was obtained by pigs given the complex starter diet. This effect could be due to the higher nitrogen and energy digestibility of the complex starter. Feed intake and performance were lower when pigs were given a simple starter diet. However, the limitations of the complex starter diet namely wastage, scours and relatively higher cost seems to indicate that its use be restricted to a shorter period. Resorting to a semi-complex starter diet may also be of much benefit.

No significant ($P < 0.05$) differences were observed of creep feed effects on post-weaning performance using various creep-starter interactions. There was however, a trend. A simple creep diet led to a lower immediate post-weaning feed intake and performance when a similar diet was offered as a starter. The semi-complex and complex creep feeds promoted slightly better feed intake and performance. Generally however, differences between the various creep-starter comparisons were not significant ($P < 0.05$). The post-weaning performance of piglets which were not creep fed was similar to that of those receiving the various creep diets. However, regardless of the creep feed treatment, the best performance was obtained with the complex starter diet.

The problems associated with feeding a complex diet as opposed to a semi-complex or a simple diet have been discussed. One of these is the question of economics. This may severely limit the use of the complex starter and suggestions aimed at solving this problem have been mentioned.

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APPENDIX TABLE 1: SOURCE OF VARIATION AND MEANS SQUARES FOR MEAN POST-WEANING FEED INTAKE

Source of Variation	df	Means Square				
		Week 1	Week 2	Week 3	Week 4	Total
F	3	0.05	1.56	5.22	5.09	28.99
L/F	32	1.30	4.32	11.37	16.76	100.54
T	2	6.08***	14.67***	38.57***	23.28***	294.82***
TF	6	0.25	0.57	1.07	1.16	6.62
Error (TL/F)[2]	55	0.22	0.86	1.32	2.95	13.31

[1] L = litters; F = post-weaning data on pre-weaning basis; T = post-weaning treatments.

[2] Error df of 55 is the difference between 64 and 9 the latter being the total number of estimated missing data.

APPENDIX TABLE 2: SOURCE OF VARIATION AND MEANS SQUARES FOR MEAN POST-WEANING WEIGHT GAIN

Source of Variation	df	Means Square				
		Week 1	Week 2	Week 3	Week 4	Total
F	3	0.095	0.827	2.877	3.214	7.938
L/F	32	0.752	1.417	3.187	1.440	15.242
T	2	5.938***	7.542***	7.055***	1.336	71.575***
TF	6	0.114	0.128	0.180	0.287	1.346
Error (TL/F)[2]	55	0.116	0.257	0.246	0.504	2.296

[1] L = litters; F = post-weaning data on pre-weaning basis; T = post-weaning treatments.

[2] Error df of 55 is the difference between 64 and 9 the latter being the total number of estimated missing data.

APPENDIX TABLE 3: SOURCE OF VARIATION[1] AND MEANS SQUARES FOR MEAN POST-WEANING WEIGHT GAIN PER KG FEED RATIOS

Source of Variation	df	Means Square				
		Week 1	Week 2	Week 3	Week 4	Overall
F	3	0.08	0.004	0.009	0.037	0.005
L/F	32	0.41	0.036	0.021	0.023	0.008
T	2	2.997***	0.04[illegible]	0.007	0.035***	0.003
TF	6	0.223	0.009	0.002	0.005	0.002
Error (TL/F)[2]	55	0.122	0.008	0.003	0.004	0.001

[1] L = litters; F = post-weaning data on pre-weaning basis; T = post-weaning treatments.

[2] Error df of 55 is the difference between 64 and 9 the latter being the total number of estimated missing data.