



Aureomycin, vitamin B12, and dehydrated alfalfa in gestation-lactation and in growing-fattening rations for swine  
by Joseph G De Pape

A THESIS submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Animal Industry  
Montana State University  
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**Abstract:**

The results of feeding a commercial antibiotic-vitamin feed supplement, or substituting dehydrated alfalfa pellets for sun-cured alfalfa meal in two experiments involving 48 sows and gilts and their litters and 60 growing-fattening swine are reported. The basal ration consisted of the feeds commonly available to swine producers in this locality, i.e., barley, soybean meal or linseed meal, meat and bone meal and sun-cured alfalfa. Hand mixed trace mineralized salt was fed and the rations were fortified with irradiated yeast, riboflavin, niacin and pantothenic acid.

The addition of 0.5% APF-antibiotic supplement to the basal ration for brood sows during gestation and lactation resulted in a slight improvement with regard to number of pigs farrowed, number of pigs farrowed alive and number of pigs weaned per sow. The cost of the supplement was justified by the increase in number of pigs weaned. A highly significant negative result was obtained by substituting dehydrated alfalfa for sun-cured alfalfa meal in the gestation-lactation ration as judged by the number of pigs weaned. The extra cost of the dehydrated alfalfa combined with the lower reproductive performance of the females indicates that dehydrated alfalfa is definitely inferior to sun-cured alfalfa as a feed component in the rations of gestating-lactating gilts and sows.

By age groups it was noted that the extra weaning weight of those pigs from sows as compared with those from gilts was highly significant. Those animals mothering crossbred litters farrowed heavier pigs and weaned heavier pigs than did those animals suckling purebred Duroc or purebred Hamprace litters. Disregarding rations the Hamprace reproductive performance was superior to the Durdc.. Though not statistically significant the difference in number of pigs weaned from sows mated to the two , Hamprace boars suggests that there is sire effect.

In experiment II the addition of 0.5% APF-antibiotic feed supplement to a basal ration containing 8% meat and bone meal resulted in a slight improvement in feed efficiency. However, the reduced feed requirement did not justify the increased cost of the ration. The substitution of 0.5% APF-antibiotic supplement for half or all of the animal protein from natural sources resulted in a lowered feed efficiency and materially increased the cost per hundredweight of gain. The removal of all the protein from animal sources with no APF supplement produced a very low feed efficiency and a high cost of gain. The rate of gain was not adversely affected and presumably the low feed efficiency was in part due to excessive waste. The substitution of dehydrated alfalfa pellets for sun-cured alfalfa meal did not materially affect the feed efficiency or rate of gain but the extra cost of the ration increased the cost per hundredweight gain.

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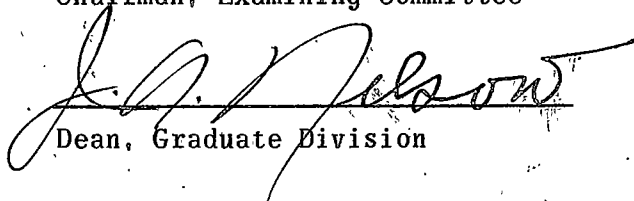
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ABSTRACT

The results of feeding a commercial antibiotic-vitamin B<sub>12</sub> feed supplement, or substituting dehydrated alfalfa pellets for sun-cured alfalfa meal in two experiments involving 48 sows and gilts and their litters and 60 growing-fattening swine are reported. The basal ration consisted of the feeds commonly available to swine producers in this locality, i.e., barley, soybean meal or linseed meal, meat and bone meal and sun-cured alfalfa. Hand mixed trace mineralized salt was fed and the rations were fortified with irradiated yeast, riboflavin, niacin and pantothenic acid.

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Introduction<sup>1</sup>

Knowledge of proteins is a relatively recent achievement, however basic cognition and theoretical aspects are of much earlier orientation. Scientific progress, stimulated by human curiosity, has accomplished much toward elucidation of the nature of food and its uses in the body.

Beginning with the fundamental work of such scientists as Antoine L. Lavoisier (1743-1794), Joseph Priestly (1733-1804) and others real progress was made in chemistry at the close of the eighteenth century. Subsequent years saw the rapidly expanding knowledge of biochemistry and physiology play its role in the founding of the science of nutrition and the establishment of protein as a basic nutritional principle.

Looking back over the cumbersome and tedious procedures available to chemists in the early part of the nineteenth century one is impressed with the service rendered by the Dutch chemist J. Kjeldahl (1849-1900). His method for catalyzed digestion of nitrogenous materials in sulfuric acid to produce ammonia quantitatively is of inestimable value to our present day knowledge of proteins.

Magendie's work with dogs proved that to maintain life animals require nitrogenous material in their diets in organic form. Also he is presumably

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<sup>1</sup> Chapter I, Sayhun, M. (1948) Proteins in Nutrition (Historical) provided valuable orientation material for this introduction.

the first man to record the occurrence of ophthalmic symptoms of vitamin A deficiency.

Throughout the last half of the nineteenth century there prevailed the unitarian theory that protein from whatever source was one and the same substance with all other proteins. Up to that time, there was no substantial reason for believing that proteins differed nutritionally.

The physiologically minded workers were responsible for uncovering a new facet in the protein problem. One after another the amino acids, simple components of the complex protein molecule, were being discovered. The significance of this protein analysis was probably not realized at the time; nevertheless, from it, men learned of the great diversity of proteins which actually exists in nature.

"The multiplicity of proteins in nature, the specific component amino acids in them, the theory of peptide linkage--all were becoming a part of the biochemical understanding," (Sayhun, 1948). It was thus that the scientists in the early part of this century viewed the protein problem in all its complexity. The newer amino acid concept aided materially the knowledge and understanding of the chemistry of digestion and the mode by which proteins from the food became available to the organism. It was subsequently determined that the animal organism obtained for its use, not the original dietary protein but the units from which the dietary protein was constructed.

Another fine contribution to the knowledge of the nutritive value of proteins was made by Willcock and Hopkins, as cited by Sayhun, with their demonstration that tryptophane is an essential or indispensable amino acid.

This observation, followed by the discovery of other essential amino acids, resulted in remarkable clarification of the position of proteins in nutrition. However the problem was not to be simplified so easily, as it was soon discovered that one protein had the ability to compensate for the deficiencies of another. This was instrumental in the development of the theory of specific amino acids being limiting factors in the nutritive value of proteins and as determinants of the "protein minimum" necessary for optimal growth.

The early work on the question of biological value of proteins was done with experimental animals testing mainly the biological value of naturally occurring food materials. It was soon learned that rat growth as a criterion was not fully adequate. Broader criteria of biological value were indicated and reproduction, fertility, lactation, and longevity were enumerated as being functions presenting specific demands for nutrients. Work at Wisconsin with dairy cattle indicated that milk proteins in the cows' diet were the most efficient for the formation of protein in the milk secreted. Medical scientists demonstrated that proteins from fresh cows' milk were superior to vegetable and cereal proteins in the production of human milk proteins and in the protection of maternal tissues against excessive nitrogen loss during milk production.

✓ The protein concept with specific regard to the nutrition of the domestic animal is in essence the result of a gradual development or evolution of feeding standards. Kellner and Armsby, the early proponents of such a system, published feeding standards designating protein in terms of digestible "true" protein. On this continent, the apparent invalidity of

the "true" and "crude" protein concept has long since resulted in its being deleted from the literature. The standards of Morrison which were expanded, revised, and re-edited in 1915 expressed allowances in terms of dry matter, digestible protein, and total digestible nutrients. These standards which have been more fully developed consistent with the publication of experimental findings, are the most commonly used today.

Depending on the availability of the data for establishing recommendations, allowances are stated as digestible protein. The energy requirement of the animal largely governs the total feed intake, thus there is some advantage in stating protein needs in relation to energy intake. The simplest procedure is to state the protein as a percentage of the total ration. This simplification, however, is attended with inaccuracies because it does not take into account digestibility. For practical purposes, and because of the rather high digestibility of those feeds making up the pigs diet, recommendations for swine are usually stated in percent protein of the total feed intake.

Many inaccuracies of the early standards have come to light and consistent with the accumulation of knowledge have been corrected. Doubtless the demonstration that quality of protein could be fully as important as quantity of protein in the ration had far reaching consequences. Science has progressed to the extent that our modern concepts demand that protein be supplied not only in adequate amounts but also that it be of requisite biological value.

Growth being essentially a process of anabolism of the body tissues and catabolism of the food material ingested, it naturally demands liberal

amounts of protein. The economy and rapidity of growth of swine are largely dependent on the protein level of the ration. This level is also affected by the quality of the protein. Protein supplements are usually required to make up the deficiencies in a ration composed of the farm grown grains. These supplements hold the key to profitable production. To obtain supplements which are economical and of high biological value is still a problem confronting the nutritionist.

As it concerns us, swine production and nutrition are centered around the feeding of cereal grains. The protein content of these grains varies with variety, season and climatic factors, but the most striking and consistent feature is that these grains are all low in percent of this nutrient. Also of material consequence is the fact that the protein they do contain is of low biological value. Generally speaking, however, they are better than corn with regard to both quality and quantity of protein. The need for protein supplements supplying those amino acids, which are not present or present in inadequate amounts, becomes self-evident. Because of their corrective value those supplements most commonly used today are meat meal, tankage, fish meal, soybean meal and linseed meal.

In the absence of milk, tankage and meat meal are the superior supplements. Conclusive evidence has been presented by Morrison, Bohstedt and Fargo (1920), Crampton (1940) and others, for the superiority of tankage and meat meal over soybean or linseed meal when used as the sole protein supplement. Even more pronounced results were obtained by using a combination of supplements representing both animal and vegetable sources. Conclusions of other investigators are consistent with these in confirming

the general belief that proteins of animal origin are superior nutritionally for swine to those of vegetable origin.

The general consensus of opinion indicates the need for the inclusion of some protein of animal origin in swine rations. No specifications as to amount are stated but an arbitrary figure of some 20% of the total protein seems reasonable. In the light of the modern knowledge of the role of vitamins and hormones in nutrition these recommendations are anything but unanimous. The effect of amino acid replacement on subsequent levels of other acids in determining the protein level, the apparent sparing action of some vitamins, and other unknown factors undoubtedly confuse the issue.

To the present time, animal protein concentrates as a general rule have been relatively expensive, especially fish meal. The last world war did have some effect, temporarily at least, in rendering some of these products unavailable. The question under these circumstances is to what extent vegetable protein concentrates can be substituted for animal protein concentrates and what adjustments if any are required. The empirical use of these animal protein concentrates indicates the value which has been placed upon their inclusion, in fact, by many workers they are regarded as being as essential constituent of swine rations.

The reason for the superior results are as yet apparently undetermined. The amino acid analyses have been an aid in that they are fundamental in the explanation of the "supplementary effect" of proteins. However, these analyses fail to reveal any qualitative differences between animal and vegetable proteins as they occur in mixtures of animal and vegetable feeds. Mitchell (1943) contends that some of the failure encountered in

substituting vegetable proteins for animal proteins can be explained on the differences in content of such vitamins as riboflavin, and nicotinic acid. In keeping with this general trend of thought, Philips and Hauge (1925) indicate an increased requirement for mineral supplements when plant feeds replace the animal protein concentrates.

Certainly tremendous progress has been made toward an elucidation of the factors and processes involved in the proper nutrition of farm animals. The object of this experiment was to study the value of fortifying a balanced ration with a commercial animal protein factor supplement, and to determine to what extent, if at all, a synthetic APF-supplement could replace animal proteins from natural sources, and also to compare the value of dehydrated alfalfa pellets with sun-cured alfalfa meal in a gestation-lactation feeding regime. Important criteria such as number of pigs farrowed, number of pigs weaned and percentage mortality were used in determining the relative value of these feeds. The second experiment was concerned with the use of an animal protein factor supplement with various levels of animal protein from natural sources in a growing-fattening swine ration. In this case, a comparison of sun-cured alfalfa meal and dehydrated alfalfa pellets was also made. For market hogs such as these, rate of gain and feed efficiency are of paramount importance.

## REVIEW OF LITERATURE

### Animal protein factor

The fact has long been recognized that differences exist between protein supplements of animal origin and those of plant sources. These differences were usually attributed to a more complete essential amino acid pattern in the animal protein supplements. However, as it has been possible to analyse for most of these amino acids, the hypothesis has not been consistently upheld. Recent discoveries in the vitamin field have done much to clarify the problem of understanding the reasons for improved results when certain types of protein supplements are used, particularly for young animals and for reproduction. This led to the postulation of the "Animal Protein Factor" and the eventual discovery of the nature of vitamin B<sub>12</sub>.

The cost of proteins of animal origin, e.g. tankage, meat meal, milk, and fish meal usually inhibits their use; yet, in view of the superior gains obtained with their use in swine and poultry feeding, they have almost become a necessity. The accelerated growth that these proteins promote suggests they supply an essential growth factor for both swine and poultry. Thus, for economical swine and poultry feeding, there is a need for a cheaper source of animal proteins or a substitute for them that will place the vegetable proteins on a nutritional par with those of animal origin, and at the same time keep the cost within the limits of profitable production.

Burkitt, et al. (1951) using two lots of 27 pigs each, compared a balanced ration containing meat and bone meal with a feeding regime

of only barley, alfalfa, salt, and bone meal. The rate of gain, feed required per 100 pound gain, and time to market weight were in favor of the balanced, fortified ration. Economy of gain was in favor of the barley, alfalfa, bone meal, and salt ration. The initial weight of these pigs ranged from 48 to 98 pounds, with an average of 74 pounds.

Presumably, there would have been a greater advantage for the pigs fed the balanced, fortified ration, in regard to rate of gain, feed efficiency, and time to market weight, if the pigs had been started at weaning weight.

The life of a pig from weaning to 75 pounds is one of the nutritionally critical periods and necessitates an adequately balanced ration.

The inherent growth promoting substance of proteins derived from animal sources has for some time been spoken of as the "Animal Protein Factor". The term animal protein factor was in wide circulation long before it was ever used in print. It never had official sanction and it never was defined, but in the minds of most investigators it stood for whatever vitamins swine or poultry required, in addition to those that had been recognized at the time. It was called APF because the only known sources were protein concentrates of animal origin. It is not a protein and is not directly of animal origin; hence the name is not appropriate.

The Animal Protein Factors denote something vitamin in nature. At least three vitamins have now been isolated from what is commonly referred to as APF. Those generally recognized at present are vitamin B<sub>12</sub>, the one best known, the second called the "whey factor", necessary for growth in chicks, and a third designated vitamin B<sub>14</sub>. Vitamin B<sub>12</sub> is a member of the B-complex, and judging from its effect on growth it seems to be one

of the more important constituents of APF. There is sufficient evidence now to support the statement that vitamin B<sub>12</sub> and APF definitely are not synonymous, but rather that vitamin B<sub>12</sub> is a separate entity and a constituent of the latter.

The most recent trend in this particular aspect of nutrition is that concerning itself with the use of antibiotics. An antibiotic as defined by Ferrin (1950) is a product of the activity of microbes which alters growth or metabolic changes in bacteria and other microscopic forms of life. Probably the best known of these is penicillin because of its valuable properties in curing infections in humans. Others more inexpensive have been developed for livestock use; the principal ones include aureomycin, streptomycin and terramycin. The possibilities in this field seem unlimited, as over 130 substances with antibiotic activity have now been recognized.

Just one year following the discovery of the role of liver in pernicious anemia, Parkhurst (1927) reported that normal hatchability of eggs could not be obtained unless breeding rations contained some protein of animal origin. Van der Hoorn, et al. (1935) reported that crude casein provided a growth factor for chicks and that hatchability of eggs produced by hens on an all vegetable protein diet was subnormal. These and other findings concerning the use of proteins of animal origin in both swine and poultry feeding led to the postulation of the new "Animal Protein Factor".

Hammond, et al. (1944) found that not only was fish meal effective in vegetable type chick rations, but also that dried rumen contents and cow manure promoted growth under much the same conditions as the sardine meal

they had been using. This certainly was a departure from the conventional feeding practice prior to that time. Heuser, et al. (1946) showed that an unidentified factor present in animal proteins and liver extract was required by chicks fed on a soybean meal supplemented ration. These same investigators also indicated that a soybean meal ration supplemented with 2% to 3% fish meal greatly enhanced the growth rate of chicks. These results were further confirmed by Nichol (1948) in feeding whole liver powders and condensed fish solubles, which resulted in a comparable accelerated growth rate of chicks.

Extensive research with chicks, in search for more information regarding the unidentified factor(s) in protein supplements of animal origin led to the discovery by Rubin, et al. (1946) that the chick growth factor present in cow manure was also present in the droppings of hens. In as much as the growth-essential was not found in the diet fed to the hens but was found in the droppings it is suggested that some synthesis must have occurred enroute.

McGinnis, et al. (1947) demonstrated that the animal protein factors were not present in freshly voided hens feces but upon incubation at 30°C for some 72 hours the potential became active and supplemented the diet of the hen. An alcohol liver extraction produced a growth response slightly in excess of that produced by the incubation of hens feces. McGinnis further suggested that synthesis takes place to a large extent after the voiding of the feces and to no appreciable degree in the digestive tract.

Cary, et al. (1946) found that there was a factor present in liver extract necessary for growth and maintenance of life in rats. They

concluded that the factor was required in amounts in direct proportion with the protein level of the diet. This was the first indication of any direct relationship between utilization and efficiency of the protein ingested.

From this, one might contend that the APF concentrate, impure as it is, contains some constituent which aids in the digestion of protein providing it be present in the proper ratio.

Johnson, et al. (1942) had presented evidence to the effect that casein and liver meal contained a factor essential for chick growth which was distinct from vitamin A, thiamine, riboflavin, nicotinic acid, pantothenic acid, para-aminobenzoic acid, choline or pyridoxine. Hammond (1942) concluded that the substance contributed by the cow manure was not a protein or any of the chemically characterized vitamins. Rubin and Bird (1946) showed that the growth factor in cow manure was not identical with any of the Lactobacillus casei factors (from liver, yeast or fermentation residues), factors U, R, or S, vitamins B<sub>10</sub>, B<sub>11</sub>, synthetic folic acid, or pyracin lactone. In their attempts to isolate and identify the growth factor(s), Rubin and Bird (1946) succeeded in extracting and concentrating the factor(s) from cow manure. This extract proved to be heat stable, moderately water soluble, fat insoluble and non-dialyzable through cellophane, indicating it to be a large molecule. The concentration of the factor(s) was a big step forward as hitherto prohibitive quantities of liver or other substances used as sources of the factor were required to supplement the chicks diet.

Vitamin B<sub>12</sub>

Rickes, et al. (1948) announced the isolation of biologically pure, active crystalline material from clinically active liver concentrates. Simultaneously, but working independently, Smith (1948) reported the purification of two amorphous forms of the antipernicious anemia factor from liver, exhibiting highly similar physical and chemical properties to the pure crystalline material. Because of its vitamin nature and properties akin to those of other members of the B-complex it was tentatively designated as vitamin B<sub>12</sub>. Smith (1948a) in England reported the presence of cobalt and phosphorous in the crystalline material, a finding which was simultaneously confirmed by Rickes, et al. (1948a) in this country.

Ott, et al. (1948) reported that the crystalline vitamin B<sub>12</sub> when added to purified basal diets with 40-70% soybean meal as the only source of protein, exerted animal protein factor activity in chicks from hens on all plant ration such as described by Rubin and Bird. Chicks also responded to substances known to be sources of animal protein factor and also to vitamin B<sub>12</sub> in doses as small as 6 micrograms per kilogram of diet. The optimum growth requirement appeared to be less than 30 micrograms per kilo of diet. Ott and associates hypothesized that since the crystalline substance induced growth response comparable to those obtained by supplementation with crude sources of Animal Protein Factor, it was possible that vitamin B<sub>12</sub> was identical with or closely related to this factor.

Johnson, et al. (1948) observed that antipernicious anemia liver extracts exerted marked growth response in pigs when added to a synthetic type of ration containing alpha protein and methionine as the protein

source. They indicated that the response apparently was not due to any previously described vitamin required by the pig and presumed that this growth factor in the liver extract was identical to the Animal Protein Factor.

Lillie, et al. (1948) found crystalline B<sub>12</sub> completely effective for chick growth, given either orally or by intramuscular injection. The results of these varied forms of therapy are particularly interesting in view of the fact that this vitamin is a potent bacterial growth factor. It serves to show that the effect of the vitamin on the chick is direct and not mediated through the intestinal flora. Johnson, et al. (1948) observed that there was no difference in growth response between pigs injected daily with 2 micrograms of crystalline B<sub>12</sub> and pigs injected daily with 0.1 ml. of antipernicious anemia liver extract or reticulogen (assayed at 19 micrograms B<sub>12</sub> per ml.) These findings confirm the work of Ott, et al. (1948) and Lillie, et al. (1948) and point to B<sub>12</sub> as being the limiting factor in the basal diets and is the factor which is being supplied by the antipernicious anemia liver extract.

Anderson, et al. (1949) with only a small quantity of the vitamin available made an investigation of the vitamin requirement of the suckling pig. Because of the age of the experimental subjects, a synthetic diet was used. The vitamin fed pigs had smoother and glossier hair coats; however, it was not until after the sixth week that any difference in rate of growth could be detected. A further investigation was made using weanling pigs. The pigs that received the vitamin B<sub>12</sub> concentrate or fish meal ate more, grew faster, and required less feed per pound of gain than did those pigs

receiving no supplement of the animal protein factor.

Cunha, et al. (1949) in an experiment with weanling pigs reported an accelerated rate of gain of approximately 30% as the result of the addition of an APF supplement to the basal diet. A B<sub>12</sub> concentrate materially improved the basal ration but failed to accelerate the growth as much as the afore mentioned treatment.

Catron and Culbertson, (1949) tentatively established the requirements of vitamin B<sub>12</sub> at 10 micrograms per pound of total ration. Neuman, et al. (1950) established the optimum rate of vitamin B<sub>12</sub> to be fed as a concentrate to be 50 micrograms per kilogram dry matter. They described the symptoms of a vitamin B<sub>12</sub> deficiency as follows: "hyper-irritability, dullness, posterior inco-ordination, voice failure, and pain in the rear quarters. This vitamin deficiency results in the following hematopoietic manifestations: normacytic anemia, slight leucopenia, high marrow erythroid count, and either abnormally dry or hyperplastic marrow." There is also a failure to grow normally and is usually attended by a less efficient utilization of feed when the animal protein factors are lacking in the diet of the pig.

The actual mode of action of vitamin B<sub>12</sub> has as yet not been entirely elucidated but much work has been done. Investigations have been conducted to determine the toxicity of the vitamin. It was noted that despite the potency of the vitamin doses as much as 1600 mg. per kilo bodyweight failed to produce toxic effects.

It is now apparent that both vitamin B<sub>12</sub> and folic acid play some part in the synthesis and metabolism of labile methyl groups and possibly of

other one-carbon fragments. Jukes, et al. (1950) showed that the methionine requirement of chicks could be met with homocystine and vitamin B<sub>12</sub> may play a decisive role in the synthesis and utilization of labile methyl compounds. Also B<sub>12</sub> appears to have some function in connection with protein metabolism. Hartman, et al. (1949) suggests that vitamin B<sub>12</sub> helps to metabolize protein when the diet contains large amounts of protein. Henry and Kon (1950) showed an increased biological value of casein and also indicated an enhanced utilization of amino acids circulating in the blood, since the amino acid blood levels were lower in chicks receiving vitamin B<sub>12</sub> than in the deficient chicks. Jukes states that vitamin B<sub>12</sub> has some function in connection with the synthesis of nucleic acids by bacteria and probably by higher animals.

Because pure vitamin B<sub>12</sub> has been generally available for only about two years, it is hardly surprising that its hematopoietic and nutritional functions are not yet fully understood.

### Antibiotics

The concept has been widely accepted in recent years that the bacterial population of the intestine may supplement the diet of their host by supplying certain vitamins. An opposite viewpoint, namely, that growth may be improved by feeding certain antibacterial substances, is now coming to the fore.

Moore and coworkers (1946) at the University of Wisconsin found that 1% succinylsulfathiazole or 0.02% to 0.05% of streptomycin, when added to a purified diet, increased the growth rate of chicks. The announcement by

Stokstad and Jukes, April 9, 1950, that the addition of aureomycin to the ration of pigs increased the rate of growth by as much as 50%, provided the impetus for nutritionists to further investigate the inherent possibilities of these supplements. It was suggested that the superiority of certain APF supplements over those which contained vitamin B<sub>12</sub> alone might be explained on the basis of the antibiotic effect.

Much greater increases with the aureomycin fraction were obtained in experiments with pigs reported by Cunha and coworkers (1949) who used a diet containing corn and peanut meal and supplemented with minerals, vitamins A and D, and the usual members of the B-complex. The vitamin B<sub>12</sub> produced no increased growth as compared with the basal diet which was 150% as great as in the case of pigs on the basal, during a five week period. Catron at Iowa found the same general trend of results by feeding aureomycin fermentation products and also observed that the appearance of bloody diarrhea which was encountered in other experimental groups was prevented. This extra growth response was also obtained by McGinnis, et al. (1949) with turkey poults and by Couch and Reed (1949) with broiler chicks.

Bowland, et al. (1950) reported over 25% increase in rate of gain and a marked increase in efficiency of feed utilization in pigs from weaning to market weight when the basal ration supplemented with all vegetable protein or mixed vegetable and animal protein was fortified with 0.5% Lederle's APF No. 5. De Pape (1951) reported that the addition of small amounts of penicillin to a linseed oil meal-APF concentrate supplemented ration produced gains equal to those occurring with a ration in which the protein supplement was composed of fish meal, meat meal and linseed meal (the

conventional "trinity" ration).

Lepley, et al. (1950) conducted a trial with growing-fattening swine using dried whole aureomycin mash with and without meat and bone meal. The addition of aureomycin mash increased the average daily gains significantly in drylot and pasture regardless of the presence of meat and bone scraps. The antibiotic supplemented pigs were more uniform in hair coat, color and finish as well as having the incidence of diarrhea eliminated. It was suggested that the aureomycin or other nutritional factors present in the APF supplement prevented diarrhea. This control of diarrhea was further corroborated by Cunha and associates.

Catron, et al. (1950) in trials with growing-fattening swine reported significantly greater average daily gains as a result of the addition of aureomycin at levels of 5, 10, 20, and 40 milligrams per pound of feed. Pigs receiving vitamin B<sub>12</sub> in addition made significantly greater average daily gains than those receiving no additional B<sub>12</sub>; however, in no case was there a significant difference in feed efficiency. Luecke and coworkers (1950) reported an increase in average daily gain of approximately 50% with the addition of B<sub>12</sub> and streptomycin to a basal of yellow corn and soybean oil meal.

Ferrin and Anderson (1950) conducted a 90 day feeding trial and found no harmful effect in feeding streptomycin residues up to levels as high as 87 grams per pound of APF concentrate. Despite its potency, the toxic level is apparently quite high.

Rather conflicting evidence has been reported by various investigators with regard to the growth stimulating effect of the different antibiotics

in swine rations. Cunha, et al. (1950) reported aureomycin and streptomycin to be of value in promoting growth but that penicillin was of no benefit. These results were further substantiated by Lepley, et al. (1950), Bowland, et al. (1950), Catron, et al. (1950) as well as others. However, almost simultaneously Lasley, et al. (1950) and Luecke, et al. (1950) reported very significant increases in growth rate of pigs fed either 30 grams streptomycin or 15 grams penicillin per pound of APF fed at levels of 0.25% and 0.05% respectively.

X  
The quantities of aureomycin, penicillin, and other antibiotics, used are much smaller than normal therapeutic doses. Just how they exert their growth promoting effect is still a matter of presumption. One plausible theory is that antibiotics inhibit the growth of the intestinal bacteria which may be harmful, and the results of the inhibition have two possible explanations. According to one explanation given by Hogan (1950) when harmful bacteria are destroyed, beneficial bacteria have a better chance to grow and they synthesize the Animal Protein Factor. The other explanation of the theory lies in the fact that all pigs have a low grade infection and this infection is cleared up by the antibiotic. A second theory is that the bacteria in the intestinal tract absorb a considerable amount of feed. With the antibiotic being fatal to some bacteria it is conceivable that more feed becomes available to the animal. It has been suggested that the suppression of Clostridium perfringens may have a beneficial effect on growth but it appears that other organisms may also be involved. All theories seem to agree however, that when the antibiotics are effective, the feed intake increases and this increase explains the more economical

gains. In the light of the present knowledge it is apparently established that aureomycin, streptomycin, terramycin and penicillin are all useful in rations for swine.

Reproduction -- Nutritional aspect

Early work using simplified rations containing 82% yellow corn, 11.5% soybean oil meal, 5% alfalfa meal, 0.5% salt and 1% limestone resulted in failure of sows to reproduce normally as judged by size of litter and number of pigs weaned. Reproduction was greatly enhanced when the alfalfa was increased to 15% at the expense of the corn. Krider, et al. (1945) demonstrated the value of alfalfa meal as a practical source of the water soluble vitamins by increasing the percent pigs weaned from 13% to levels as high as 48%, 50% and 83% with various supplementations. The basal ration was composed of soybean meal, tankage, fish meal, minerals, salt and cod-liver oil but no alfalfa. The addition of 6% distillers corn solubles and 4% alfalfa meal or 10% alfalfa meal to the above mentioned basal improved breeding efficiency, fertility and strength of the pigs farrowed. The value of the alfalfa and the solubles was attributed to water-soluble vitamins, known or unknown, contained in these products.

Ensminger, et al. (1951) indicated that a purified basal diet of casein, sucrose, lard and minerals, vitamins A, D, E, K, and C and six B-complex vitamins (thiamine, riboflavin, nicotinic acid, pyridoxine, pantothenic acid and choline) was nutritionally inadequate for satisfactory reproduction and lactation for the sow. Some factor or factors, either one or more of the other known B-complex vitamins not included in the

purified ration used, or some unknown factor(s) are essential for reproduction and lactation in swine.

Anderson (1949) using a very limited number of gilts showed that animals on a basal of corn, soybean meal, tankage, alfalfa meal, cod-liver oil, trace mineralized salt and bonemeal farrowed more and larger pigs than those receiving, in addition to the basal, a B<sub>12</sub> concentrate or fish meal. However, the gilts in the vitamin B<sub>12</sub> and fish meal groups lost fewer pigs and their litters were heavier at weaning.

Heidebrecht, et al. (1950) reported that gilts and sows fed basal rations (essentially corn, soybean and 5% alfalfa) performed as well during reproduction and lactation as did gilts and sows fed the basal rations fortified with either 10% alfalfa, iodine, vitamin A, or APF supplement No. 1 and 2 (Merck), or those injected with liver extract (Lederle). In a second trial using APF No. 5 (Merck) the supplemented group raised more pigs than the sows fed the basal and the pigs weighed slightly more at weaning.

Krider, et al. (1946) noted that under drylot conditions a basal ration composed of corn, soybean, 5% dehydrated alfalfa meal, fortified with cod-liver oil and minerals was nutritionally inadequate for gestation and lactation. The addition of either 3% or 6% sardine condensed fish solubles effectively corrected the deficiency (or deficiencies) in that it raised the percentage survival of pigs to weaning from 26% to 92%. In another trial Krider, et al. (1948) using the same basal as above indicated that the addition of 0.5%, 1.0% or 2.0% of B-Y, a riboflavin supplement, did not correct the deficiency of the basal ration.

X Carpenter, (1951) using an APF concentrate containing aureomycin increased the average weaning weight of pigs from 25 lbs. to 36 lbs. and greatly reduced the incidence of diarrhea. An equal number of pigs farrowed dead were reported in all groups and almost equal numbers of pigs farrowed alive. The results indicate that the antibiotic supplement does not affect litter size nor the number of pigs born dead. The author also indicates that the growth stimulation of the weanlings was due to the aureomycin present in the APF supplement (creep diet contained 1% of the supplement) and not due to any substance transferred to the pigs through the milk.

Van Poucke, et al. (1950) by supplementing a basal ration with 0.1% Merck No. 3, with 5% dried whey, a combination of the two, or with the combination plus 5% alfalfa meal and 4% meat and bone meal were able to raise the percent pigs weaned from 6.9% to 64.5%, 70.6%, 82.4% and 88.4% respectively. After actual examination of the basal diet, the reason for the poor performance of the control lot becomes quite obvious. The basal ration consisted of corn and soybean with no alfalfa and no protein of animal source. Moreover riboflavin was the only member of the B-complex with which the ration was supplemented.

#### Reproduction - Genetic aspect

The size of the litter depends partly upon the number of ripe ova available but far more upon the number of fetuses that survive in the uterus and are eventually born as piglings. Squiers (1948) indicates that apart from complete sterility the sire has little influence on the size of

litter. The investigation suggests that the sires' effect on litter size is directed through his influence on the inherited ability of the pigs to live. Musson (1949) is in complete agreement with this work and points out what might be called a threshold of some width between complete fertility and sterility. However, the quality of the semen is reflected in the litter size as well as in the number of sows that settle, according to Weaver, et al. (1943). In the case where the quality or quantity of the semen is borderline, there is an obvious advantage in mating more than once during the same estrous period. Apparently there is a higher percentage conception rate with multiple matings and it follows that there would be a greater opportunity for more of the ova to become fertilized.

Fetal degeneration accounts for a large percentage of the ova that are fertilized but do not in the course of events become weanling pigs. This fetal degeneration apparently is not due to bacterial infection because it can and does occur in an entirely aseptic uterus. Rather conflicting evidence is reported on overcrowding as being a cause of fetal mortality. Anatomically considering the distention capacity of the organ as well as the fact that atrophy is just as prevalent in those cases where there are few fetuses, it hardly seems possible that overcrowding could be of any great consequence. Marshall and Hammond (1947) indicate that the embryo or fetus atrophies before the embryonic or fetal membranes, on which its food supply depends, and in some cases before attachment to the uterine wall. The most logical explanation seems to be as a result of genetic lethal factor or factors, a physiological condition or disharmony of organization that in some way prevents the fetus from undergoing normal development.

The ability of sows to farrow large litters and to raise their pigs to market age and weight is one of the basic factors of successful swine production. Stewart (1945) concluded that the litter size increased with an increasing age of the dam. This is one of the most consistent observations of men studying the various factors affecting productivity. Apparently the fertility curve reaches its peak at about the sow's fourth year of age and then gradually declines with approaching senility. Because this characteristic is reasonably heritable, in the neighborhood of 25%, it seems a logical criterion to use in a selection program. Blunn and Baker (1949), making heritability estimates of sows' productivity, indicated that the age of the sows was more important than their inbreeding or the inbreeding of the litters.

The weaning weight has little value as an index of the hereditary growth impulse but it is a useful measure of the sows' milking capacity. Within limits, an increase in the size of litter does not result in a decrease in average weight per pig at weaning. Weaver and Bogart (1943) have shown that there is a direct relationship between the weight of the pig at weaning, the feed lot performance after weaning, and consequently the weight at market age (180 days). It seems a point of good judgment to select gilts from efficiently producing sows, as they will tend to inherit their productive ability.

#### Dehydrated alfalfa

Some work has been done using dehydrated alfalfa in rations for ruminants, but for the monogastric animal, particularly in reproduction

rations, only a very limited number of reports can be found in the literature. Two investigations by Krider, et al. (1946) and by Catron, et al. (1948) have been previously cited in this paper under the heading - reproduction, page 27.

In drylot rations with weanling pigs, Krider, et al. (1947) obtained faster growth as well as 13% less feed requirement per 100 lbs. gain with the addition of 4% dehydrated alfalfa meal to a basal ration of corn, soybean meal, meat scraps, minerals and fortified with vitamin A and D oil. By increasing the level of dehydrated alfalfa meal from 4% to 10%, still more rapid and economical gains were obtained. Catron, et al. (1948) indicated that the addition of 10% high quality dehydrated alfalfa meal as a source of water soluble vitamins, to a plant protein basal ration, did not improve significantly the gestation-lactation performance in three swine experiments. Also the addition of animal protein to the basal ration fed to the sows during gestation and/or lactation failed to increase pig livability and growth.

EXPERIMENT I

METHODS AND PROCEDURE

The pigs used in this experiment were of purebred Duroc and Montana No. I breeding. The Montana No. I breed, more commonly referred to as the Hamprace, is the result of an original cross of unbelted Hampshire by Landrace. The breed was developed at the U.S. Department of Agriculture, Station at Miles City, Montana, and the Agricultural Experiment Station at Bozeman, Montana. An average figure of 8.1 pigs weaned per litter for the period 1939-1947 inclusive illustrates the high prolificacy and mothering ability of this stock, Hutton, (1948). The coefficient of inbreeding of the strain at that time was approximately 32%.

On November 22, 1950, the sows and gilts were allotted and as near as possible equalized according to breed and past performance as judged by number of pigs farrowed per sow in previous litters. Equal numbers of gilts were put in each lot and they were distributed on the basis of their dams' reproductive performance. The animals were weighed at the beginning of the experiment and were fed rations as indicated in Table II.

The present breeding program, of the Montana No. I breed, is rather unique in that it makes provision to color test all animals before they are considered for herd replacements. Any animals that show evidence of the red gene are discarded from the herd after they have raised their first litter. Actually, then, the primary selection of animals is based on their performance in crossbreeding. Sows and gilts were assigned to boars equalizing the number of females per boar per lot, by the number cross bred in each lot; provision was made to avoid brother-sister matings and

TABLE I  
COMPOSITION OF FEEDS USED IN CALCULATING RATIIONS

	Crude protein	Calcium	Phosphorous
	%	%	%
Wheat	10.7	0.04 <sup>1/</sup>	0.39 <sup>1/</sup>
Barley	9.2	0.06 <sup>1/</sup>	0.37 <sup>1/</sup>
Milo feed	11.1 <sup>2/</sup>	0.03 <sup>2/</sup>	0.27 <sup>2/</sup>
Wheat bran a.a.	16.9 <sup>1/</sup>	0.14 <sup>1/</sup>	1.29 <sup>1/</sup>
Linseed oil meal	37.1	0.43	0.50
Soybean oil meal	49.0	0.38	0.40
Meat meal	52.5	3.65	4.25
Sun-cured alfalfa meal	17.6	1.54	0.18
Dehydrated alfalfa pellets	20.6	1.40	0.27
Monosodium phosphate	-	-	22.00 <sup>1/</sup>
Calcite	-	38.00 <sup>1/</sup>	-
APF (Lederle's Aurofac) <sup>3/</sup>	10.0 <sup>1/</sup>	-	-
Irradiated yeast - Fidy type 27 F -- 12,000,000 units vitamin D per lb.			
"Fortafeed" (Lederle) - 2 gms. riboflavin (per lb.)           4 gms. calcium pantothenate 9 gms. niacin 10 gms. choline chloride			
Sun-cured alfalfa meal - 8.6 mg. carotene per lb.			
Dehydrated alfalfa       - 77.7 mg. carotene per lb.			

<sup>1/</sup> Average figures (Morrison). All others are analyses by Agricultural Chemistry Research Department.

<sup>2/</sup> Milo feed analyses done by Misco Mills, Bozeman, Montana

<sup>3/</sup> Guaranteed to contain at least 1.8 gms. aureomycin/lb.  
1.8 mlg. vit. B<sub>12</sub>/lb.

most if not all dam-son matings.

From a management standpoint, the including of both sows and gilts in the same lot was not considered the best procedure but was done to avoid the necessity of providing additional facilities. Fighting was noticed for only a short while, and because the breeding herd was fed once daily, the gilts were able to maintain fairly good breeding condition. Houses were provided for shelter during the winter months. The animals had access at all times, to freshwater from a creek.

Approximately a week prior to the calculated farrowing date the animals were moved into the barn to become accustomed to their farrowing quarters. Not all the offspring spent an equal length of time in the central farrowing house; those sows farrowing first remained in the barn until the space was needed. As breeding was started on the same day in each lot, it is reasonable to presume that there were probably about equal numbers of sows from all lots in the barn at the same time. While in the barn the animals were fed their respective rations but no attempt was made to keep records of their individual feed consumption.

Farrowing data were recorded by the herdsman and his assistant who maintained a 24 hour watch. The birth weight, sex, and ear notch identification were recorded for each piglet, in most cases within 12 hours after birth and in all cases within 24 hours after the completion of farrowing.

The rations were formulated to meet the National Research Council recommendations given in Table II. The composition of feeds as used in the experiment are shown in Table I. Lot 1 received the basal or control

TABLE II

PRE-BREEDING AND GESTATION RATIONS FOR SOWS AND GILTS

Ration No.	1	2	3
	%	%	%
Barley	60.0	60.0	60.0
Wheat	13.0	12.5	13.0
Soybean oil meal	7.0	7.0	7.0
Meat meal (50%)	4.0	4.0	4.0
Sun-cured alfalfa meal	15.0	15.0	-
Dehydrated alfalfa pellets	-	-	15.0
Salt	0.5	0.5	0.5
Calcite	0.5	0.5	0.5
APF supplement <sup>1/</sup>	-	0.5	-
-----			
Crude protein (percent)	15.08	15.03	15.33
Calcium (percent)	0.65	0.64	0.63
Phosphorous (percent)	0.50	0.50	0.51

<sup>1/</sup> Lederle's Animal Protein Factor supplement No. 5

Rations fortified with 750 I.U. vitamin D per lb. of feed

Rations fortified with 1/2 lb. per 1000 lbs. ration of Lederle "Fortafeed".

Rations fortified with 10 ppm Cu, 50 ppm Fe, 25 ppm Mn, and 1 ppm Co.

ration which was essentially a barley, soybean meal, meat meal ration with 15% sun-cured alfalfa. The latter was good quality baled alfalfa reduced to size by a hammermill so that it could be incorporated into the ration. Lot 2 received a ration identical with that of Lot 1 with the exception that to it was added 0.5% of Lederle's Aurofac (Animal Factor Supplement No. 5). Lot 3 ration except for the substitution of dehydrated alfalfa for sun-cured alfalfa was identical to the Lot 1 ration. As will be noted from Table II, all rations contained 4% meat and bone meal, 0.5% trace mineralized salt, and were fortified with vitamin D as well as riboflavin, niacin, calcium pantothenate and choline chloride.

The suckling pigs were creep fed. The rations were of similar composition as those fed to their mothers. Feed was made available for the suckling pigs as they reached two weeks of age, and until they were weaned. Undoubtedly there was some individual, as well as, litter variation in the length of time the pigs were creep fed.

The feed was mixed in a vertical type mixer, and all mixing was supervised by the author. Batches of 800 lbs. were mixed and stored in bunks immediately adjacent to the sow pasture lots.

At the onset of the experiment, some difficulty was encountered in getting the animals to eat the dehydrated alfalfa pellets. Apparently some of the animals were sorting their feed as the pellets began accumulating in the troughs. However, this sorting was of limited duration and the animals seemed to be eating well, and without sorting, by the time breeding began.

The animals were fed once daily a measured amount of feed equivalent

TABLE III.

LACTATION RATIONS FOR SOWS AND GILTS

Ration No.	1	2	3
	%	%	%
Barley	50.0	50.0	50.0
Wheat bran	15.0	15.0	15.0
Wheat	10.0	9.0	10.5
Soybean oil meal	10.0	10.5	9.5
Meat meal (50%)	4.0	4.0	4.0
Sun-cured alfalfa meal	10.0	10.0	-
Dehydrated alfalfa pellets	-	-	10.5
Salt	0.5	0.5	0.5
Calcite	0.5	0.5	0.5
APF supplement	-	0.5	-
-----			
Crude protein (percent)	16.97	17.10	17.08
Calcium (percent)	0.56	0.56	0.55
Phosphorous (percent)	0.65	0.64	0.65

to 6 lbs. per head. The weight records of the day prior to the commencement of breeding and the general condition of the animals indicated the desirability of increasing the feed allowance. December 13, 1950 the day breeding began, the feed was increased to 6 1/2 lbs. per head per day.

A farrowing ration was fed from the time the animals came into the barn until approximately a week after parturition. The respective treatments were unaltered but 15% bran was incorporated into the ration and the alfalfa was decreased to 10%. This ration contained a calculated 17% protein.

On April 20, 1951 the stock supply of barley was depleted; and only heavily ergotized barley was obtainable. Rather than use this ergotized barley, milo feed was obtained to replace the barley and the ration was adjusted slightly to maintain the same protein level.

The sows and gilts were treated for lice during the early part of the winter. They were sprayed with a gamma isomer of benzene hexachloride twice within a twenty-day interval.

TABLE IV

COMPARISON OF EXPERIMENTAL RATIONS WITH DAILY NUTRIENT ALLOWANCES RECOMMENDED FOR SWINE

	<u>Pregnant stock</u>		<u>Lactating stock</u>		<u>Experimental rations</u>	
	<u>Sows</u>	<u>Gilts</u>	<u>Sows</u>	<u>Gilts</u>	<u>Pregnant</u>	<u>Lactating</u>
Total feed (lbs.)	7.5	6.0	12.5	11.0	6.5	10.0 <sup>1/</sup>
Crude protein (lbs.)	0.90	0.90	1.90	1.65	0.98	1.70
Calcium (gms.)	15.3	15.0	28.5	28.5	19.2	25.6
Phosphorous (gms.)	10.2	10.0	19.5	19.5	14.7	29.3
Salt (gms.)	17.0	13.6	28.5	24.0	14.7	22.7
Carotene (mg.)	23	18	37.5	32.5	8.4	8.6 <sup>2/</sup>
					75.8	77.8 <sup>2/</sup>
Vitamin D (I.U.)	375	300	625	550	4800	4800
Riboflavin (mg.)	6.3	5.0	10.5	9.2	6.5	10.0 <sup>3/</sup>
Niacin (mg.)	38	30	63	55	29.2	45.0

<sup>1/</sup> 10 lbs. feed during lactation is an estimated figure as all animals were fed according to appetite and condition after farrowing.

<sup>2/</sup> Carotene figures represent only that contained in the sun-cured alfalfa and the lower figures only that contained in the dehydrated alfalfa.

<sup>3/</sup> These figures represent the actual amounts of riboflavin and niacin added by supplementing with Lederle's "Fortafeed".

EXPERIMENT I

RESULTS AND DISCUSSION

The combined fertility of the sow and the boar is represented by the number of pigs a sow farrows. This same criterion also reflects something of the quality of management she received to that time. The margin of profit, however, is not determined by the number of pigs born but rather in the number of pigs weaned. Various estimates have been made to denote what is expense and what is profit in terms of number of pigs raised. The figure generally agreed upon seems to be that those pigs in a litter over and above the first five raised, determine the extent of profit contributed to the enterprise.

Management has relatively little influence on the hereditary and physiological capacity of the sow to produce pigs, but is of paramount importance in the survival of pigs after farrowing. Annual losses amount to approximately 35% of all pigs farrowed. This loss varies greatly between farms; and presumably a large part of this variation is due to difference in management.

In this experiment, the animals were fed daily a measured amount of feed during gestation and thereafter according to appetite. Some difficulty was experienced, from a management standpoint, by running both sows and gilts together. A rather slight margin in feeding regime was required to ensure adequate nutrition for fetal development and for growth by gilts and also to prevent over fatness on the part of the sows. Most of the regulation was done by visual observation of the dams' condition particularly during gestation. Thus, handling of the pregnant animals was

kept to a minimum.

The basal ration was formulated to meet the nutrient allowances recommended by the National Research Council. The ration could possibly be criticized with regard to carotene content. However, 15% sun-cured alfalfa in the ration meets the usual recommendations for a legume; presumably this particular hay was of low carotene content. The dehydrated alfalfa more than met the standards in this respect.

Ten gilts and six sows comprised a group. Each female was hand mated to one of the four boars. The actual pairing was previously described, in the event of over use of any one sire in the same day a boar of the same breed was substituted. This excess use was a rare occurrence. In lot 1 a Duroc sow and a Duroc gilt were removed from the experiment on April 25, 1951 because they had not conceived. These were both purebred matings but by different boars. In lot 2 a Duroc gilt was removed February 17, 1951 and a Hamprace sow May 9, 1951 for the same reason. One Hamprace sow was removed from lot 3 after being exposed to a Hamprace boar but apparently failing to conceive. It will be noticed that of the five animals that failed to conceive they represent matings by all four boars used. There apparently was no tendency for any one group to have a greater or lesser number of females farrowing. The presumption, then, that the failure to conceive was due to the inherent infertility of the individuals in question or purely to chance, and not due to any particular sire or feeding regime seems valid. One Hamprace gilt in lot 3 died March 18, 1951. Post-mortem examination revealed nine apparently normal young; the cause of death was unknown. This examination also showed an excessive amount of internal

hemorrhage with no explanation. In the calculations of all criteria with the exception of total number of pigs farrowed, 13 litters will be considered in lot 2. Because of some error in recording the calculated farrowing date, a Hamprace gilt farrowed outside and, consequently, all pigs died. She had a litter of nine pigs; their loss was attributed to faulty management rather than to the effect of any experimental treatment.

The reproductive performance of the animals was compared on the basis of the following criteria: (1) number of pigs farrowed per sow - total number of expelled fetuses which the herdsman counted, (2) number of pigs farrowed alive, (3) number of pigs weaned at 56 days of age, (4) average birth weight of pigs within litters, and (5) weaning weight of pigs - average within litters corrected to 56 days after the method of Whatley, et al. (1937).

The unequal numbers of animals within groups resulting from their removal for failure to conceive complicated the statistical analyses. A simple test was run comparing the rations fed the sows as was reflected in the above mentioned criteria. The effect of treatment on the number of pigs weaned was highly significant. The average number of pigs weaned per sow of 7.4 on the basal, 7.6 on the APF supplemented and 6.0 using the dehydrated alfalfa is indicative of the trend of their performance. Calculation of the least significant difference indicated the difference between the basal and the dehydrated ration to be significant at the 1% level; however, there was no detectable difference between the basal and the APF supplemented ration. Presumably there was no difference in management, and the same sires were used an equal number of times in each lot. A total of

TABLE V

SUMMARY BY TREATMENTS OF REPRODUCTIVE PERFORMANCE<sup>1/</sup>

<u>Item</u>	1	2	3
Number of females exposed	16	16	16
Number of females conceived	14	14	15 <sup>2/</sup>
Number of females farrowed	14	13 <sup>3/</sup>	14
Number of pigs farrowed	132	132	136
Number of pigs farrowed alive	119	123	117
Average number of pigs per litter	9.4	10.2	9.7
Average number live pigs per litter	8.5	9.5	8.4
Total birth weight of litter per sow	364.4	346.5	328.0
Average birth weight of pigs	3.1	2.8	2.8
Number of pigs weaned	103	99	84
Average number of pigs weaned per sow	7.4	7.6	6.0
Average weaning weight per litter <sup>4/</sup>	215.9	203.5	154.9
Average weaning weight per pig <sup>4/</sup>	28.3	28.2	25.9
Percent pigs farrowed dead	9.8	6.8	13.9
Percent pigs weaned of total pigs farrowed	78.0	75.0	61.8
Percent pigs weaned of pigs farrowed alive	86.5	80.5	71.8
Percent mortality of total no. farrowed to weaning	22.0	25.0	38.2

<sup>1/</sup> This table is a summary of all the reproduction-lactation data appearing in Table X-A, B and C, pages 78-80 of the appendix.

<sup>2/</sup> One pregnant gilt died March 18, 1951.

<sup>3/</sup> One sow farrowed outside and lost all her pigs. The loss was attributed to faulty management and hence her litter is not included above.

<sup>4/</sup> Average weaning weight per pig corrected for age after the method of Whatley, et al. (1937).

136 pigs farrowed by the sows in lot 3 is comparable to the other lots, but 14% of these were dead at birth. This high fetal mortality coupled with either a predisposition to disease of early life or consistent with an unfavorable uterine environment weighs heavily against the chances for a sow to wean a large litter. The percent pigs weaned of those alive at parturition as shown in Table V provides an interesting comparison. General lack of vigor of those pigs from sows fed dehydrated alfalfa was again reflected in the greater percentage mortality to weaning, i. e., 13.5%, 25.0%, and 38.2%.

Upon further analysis, it was found that although differences did exist in the averages of the groups with regard to the number of pigs farrowed, the number of pigs farrowed alive, birth weight, and weaning weight none of the differences approached significance. Apparently the factors affecting the ultimate destiny of the pigs were incapable of exerting sufficient influence by parturition time. However, by weaning at 56 days, which actually includes gestation and lactation, the physiological response was sufficiently large to be significant at the 1% level. In retrospect, a significant difference is conceivable because high fetal mortality and poor suckling performance are effects of the same cause.

Table VI presents the economics of the above differences. The feed prices used in calculating the cost of a ton of ration are listed in Table XI. Actually they are fairly expensive rations. These calculations are based on the cost of feed only. It includes a two week warm-up period prior to breeding, gestation, and includes all of lactation. This feed period covers some 182 days; so considering a two-litter a year swine

TABLE VI

RATIONS COMPARED ON THE BASIS OF FEED COST PER PIG FARROWED AND WEANED

Ration.	1 Basal	2 APF-suppl.	3 Dehy. alf.
Cost of feed per ton			
Pre-breeding gestation	\$47.50	\$51.30	\$53.50
Lactation	\$49.70	\$53.30	\$53.70
Feed cost per sow	\$31.30	\$33.81	\$34.83
Number of sows farrowing	14	13	14
Number of pigs farrowed	132	132	136
Number of pigs farrowed alive	119	123	117
Number of pigs weaned	103	99	84
Cost of feed per pig farrowed	\$3.32	\$3.33	\$3.58
Cost of feed per pig farrowed alive	\$3.68	\$3.57	\$4.17
Cost of feed per pig weaned	\$4.25	\$4.44	\$5.81
Difference from basal			
Per pig farrowed	--	+\$0.01	+\$0.26
Per pig farrowed alive	--	-\$0.11	+\$0.49
Per pig weaned	--	+\$0.19	+\$1.56

breeding program the 182 days feeding regime covers the entire feed cost to weaning.

In the cost of the feed per pig farrowed, no difference was observed between those on the basal ration and the APF supplemented ration, but the dehydrated alfalfa ration cost \$0.26 extra, per pig farrowed. With regard to the number of pigs farrowed alive, the APF supplemented group cost some \$0.11 less per pig than the basal; this reduced cost per pig resulted from a reduced fetal mortality of approximately 3.5%. Again the dehydrated alfalfa ration was more expensive to the extent of \$0.49 per pig farrowed alive. The cost of weaning a pig is the most important of these factors in a swine enterprise. The extent of the profit will depend on the number of pigs weaned as well as on the cost of weaning them. The APF supplemented group weaned slightly more pigs per sow but at an extra expense for feed of \$0.19 per pig weaned. However, the most striking point of this whole economic aspect is the \$5.81 which represents the feed cost of weaning every pig of the dehydrated alfalfa group. This cost per pig weaned in comparison with the basal is an increase of \$1.56 per pig. Two factors causing this increase cost are, the higher cost of the dehydrated alfalfa resulting in a higher price per ton of feed (all lots being kept on an equal feed consumption) and the fewer number of pigs weaned. Under the conditions of the present experiment, the substitution of dehydrated alfalfa for sun-cured alfalfa is not justified.

The measurable difference in performance, combined with the economics of the feeding regime, should allow for some postulation as to why these results were obtained. Apart from the addition of 0.5% APF supplement to

the lot 2 ration, it and the basal rations were identical. There is a trend in favor of the performance of those females receiving the APF supplement as indicated by the number of pigs farrowed, the number of pigs farrowed alive, and the number of pigs weaned per female, however, the birth weight and the weaning weight of the litter were greater for those of the basal ration. Previous reports as cited in the review of literature have been rather conflicting as to the benefit of the APF supplement in reproductive rations. This investigation offers no great elucidation as the sows weaned 0.2 more pigs per sow but at an extra cost of \$0.19 per pig weaned compared with the basal. The APF supplement is valued at \$0.20 per ton of ration consumed. The actual amount of feed consumed by the sows during gestation and lactation was approximately 1300 lbs. per head. Therefore, the supplement enabling these females to wean an average of 0.2 more pigs per litter, increased the feed cost per female by approximately \$0.13. Under the conditions of the experiment, the addition of the APF supplement has some beneficial effect though not significantly so.

In substituting dehydrated alfalfa for sun-cured alfalfa, on the basis of the carotene content of the ration, the lot 3 ration was improved as indicated in Table IV. Considering the carotene from the alfalfa, only the basal ration fails to meet the recommended nutrient allowance in this respect. The actual analyses of the pellets shows more than adequate amounts of carotene. All rations were fortified with riboflavin, niacin and pantothenic acid which have been shown to be required for successful reproduction by Ensminger, et al. (1951). The animals had direct exposure

to sunlight as well as having their rations fortified with irradiated yeast. Iodized-trace mineralized salt supplied 10 ppm copper, 50 ppm iron, 25 ppm manganese, and 1 ppm of cobalt. The rations met the established protein requirements and approximately 14% of the protein was from an animal source. A high percent fetal mortality and a reduced percent of pigs raised to weaning as a result of substituting dehydrated alfalfa for sun-cured alfalfa seems to point to some altered nutritive value as a result of the dehydration process. Alfalfa is usually regarded as one of the best sources of water soluble vitamins. The question arises as to whether the dehydration process destroys the activity of some of these vitamins, renders them insoluble, or produces some kind of a toxin. The actual mode or mechanism whereby these unexplainable losses are incurred is beyond the bounds of this paper.

Using a two variable classification, an analysis of variance was computed testing the interaction of treatment by type or kind of mating. In this discussion the treatment refers to the basal ration, the APF-antibiotic supplemented ration, and the dehydrated alfalfa ration respectively. The type or kind of mating denoted whether the offspring were the result of a purebred Duroc, purebred Hamprace, or crossbred mating. The crossbreds represent the Duroc by Hamprace cross as well as the reciprocal cross. No attempt was made to separate the reciprocal crosses because of the resulting small numbers involved. Also it is doubtful that the expected hybrid vigor would be materially affected regardless of which way the cross was made. Tables XIV and XV indicate a highly significant interaction between treatment and type of mating with respect to the total

number of pigs farrowed and the number of pigs farrowed alive. The APF supplemented ration was superior to both the basal and the dehydrated alfalfa rations for the crossbred pigs considering number of pigs farrowed and number of pigs farrowed alive per sow. The purebred Duroc litters were not beneficially affected by the APF supplement but were adversely affected by substituting dehydrated alfalfa for sun-cured alfalfa in the ration. On the other hand, the purebred Hamprace litters from the APF supplemented ration were inferior to those from the two other rations in number of pigs farrowed and number of pigs farrowed alive per sow. This beneficial action of the APF-antibiotic supplement in the case of the crossbreds is of particular interest. Hypotheses as to the mode of action of antibiotic feed supplements have been propounded in the case of fattening swine. The concurrent results would almost dictate that the supplement has some beneficial effect on the uterine environment promoting greater livability.

By analyzing for separate components of variance, the number of pigs weaned was shown to be statistically significant in favor of the crossbreds. This then is a concrete example of the phenomenon of hybrid vigor because the interaction of type of mating and treatment did not approach significance. This hybrid vigor is further reflected in a significant difference in birth weight and a highly significant difference in weaning weight in favor of the crossbreds. These increased weights are in agreement with the proponents of crossbreeding who claim greater productivity due to hybrid vigor. From an economic standpoint the greater weaning weight is of obvious advantage.

A similar analysis was calculated to determine the extent of interaction between treatment and age. The age is merely subdivided into two groups: gilts and all other females having had one or more litters previously. In number of pigs farrowed, number of pigs farrowed alive, and in number of pigs weaned there was no material difference in response to treatment or by age groups. There was a significant interaction of treatment and age as reflected in the birth weight of the pigs. The sows on the basal or APF farrowed the heaviest pigs, whereas the gilts on the APF farrowed the lightest pigs. There was a consistent trend in all treatments for sows to farrow heavier pigs than gilts. In furtherance of this birth weight advantage of the older females, it is not difficult to visualize a highly significant difference in the corrected weaning weight. Apparently the potential milking capacity becomes more fully developed with an increasing number of pregnancies up to about the sows' fourth year. The interaction between treatment and age was significant at the 5% level. The general relationship was somewhat altered from that of the birth weight. The gilts responded more favorably to the basal ration than did the sows but poorly to the dehydrated alfalfa ration. This response could possibly be due to sorting by the older sows followed by excessive consumption of roughage by the gilts. The pigs weaned from the sows on the APF ration were the heaviest of all. Those weaned from sows on the dehydrated alfalfa ration were heavier than any weaned from the gilts or sows on the basal. Perhaps a point could be made of the response of the age groups to the dehydrated alfalfa. A difference of some 7.5 lbs. in the mean weaning weight of all pigs weaned from gilts and from sows on

this ration is economically important. Possibly this increase weaning weight of those pigs from sows indicates that the growing animals (gilts) have a greater demand for some specific factor(s) than the mature animals. Prior to feeding the experimental rations, the 48 females involved received sun-cured alfalfa and/or pasture in their diet. It is conceivable that during the pre-experimental feeding regime only the maintenance requirements of the growing animals were met, whereas the mature stock were capable of storage.

In testing the interaction of the breeds and treatment, there was no significant difference in any of the previously discussed criteria. There were variations between means of the classes or sub-groups but none of sufficient magnitude. Because differences did exist, a further analysis was indicated testing the effect of treatment on each breed separately. It was found that the Durocs reacted significantly different to the various treatments at least in the case of the number of pigs farrowed alive. Apparently the APF ration was of material benefit in increasing the number of pigs farrowed alive from 7.0 per sow on the basal to 10.0 per sow on the APF supplemented ration. The breeding females on the dehydrated alfalfa ration gave birth to an average of 8.5 pigs per female. Because the Hamprace showed no detectable difference in response to an APF-antibiotic feed supplement, and the Durocs did there is some suggestion of breed difference. Analysis of variance for birth weight and for corrected weaning weight revealed no material difference.

In the previous analysis, there was no difference in response by age groups to treatment. However, taking each group separately hence within

group analyses the gilts on the APF ration farrowed a statistically greater number of live pigs than gilts on either of the other treatments.

According to the breeding program as previously outlined, it will be noticed that of the 27 farrowing gilts 19 resulted from crossbred matings. The main impact of the gilt reaction is a comparative response of hybrid vigor. These results are not surprising in the light of the significant differences obtained in favor of crossbreds in testing type of mating.

These same gilts on the basal ration weaned pigs having an average weight of 28.8 lbs. on the basal ration which was 4.0 lbs. heavier than those weaned from gilts receiving the APF supplemented ration and 5.6 lbs. heavier than gilts receiving the dehydrated alfalfa ration. This increase in weight was significant at the 5% level. The gilts farrowed 2.3 more pigs per gilt on the APF ration but weaned heavier pigs by 4.0 lbs. on the basal. The above results are conflicting from which no precise or clear cut conclusion can be drawn.

Ignoring all experimental treatment, as the breeds were evenly allocated anyway, and taking collectively all Durocs and all Hamprace, a direct breed comparison was made. The Hamprace females weaned 7.65 pigs per sow which was 1.50 pigs per sow more than the Durocs. The Hamprace were also slightly superior in number of pigs farrowed per sow and farrowed slightly heavier pigs. These differences became magnified with age and were reflected in a significant difference in the weaning weight of the pigs. The Hamprace females weaned pigs averaging 29.1 lbs. as compared with 25.3 lbs. for the Durocs. These apparent breed differences are to be interpreted with caution. The 18 Durocs that farrowed 39% of

the litters were the result of crossbred matings whereas, in the Hamprace 65% of the 23 litters that were born were of crossbred matings. Hence, it is difficult to ascertain how much of the increase in weaning weight was due to the superior mothering ability of the Hamprace sows and how much was due to the hybrid vigor of the greater percentage of crossbred pigs.

Some information can be gleaned from the data relative to sire effect. Both Duroc boars had an average of 7.0 pigs weaned per sow from the females to which they were mated. Hamprace boar #16 sired 8.0 pigs as compared with 6.0 pigs weaned per sow from Hamprace boar #47. First impressions would indicate that the greater number of pigs weaned from the H-16 matings were due, at least in part, to the greater number of crossbred matings by this boar. However, analysis of the data reveals that the H-16 purebred matings weaned larger litters than the H-16 crossbred matings, and, furthermore, in H-47 litters, the purebreds equaled the crossbreds in numbers per sow. Presumably the large within group variation combined with the small number of animals involved, obscured the results as no statistical significance was noted. The limited data suggest that there may be sire effect on the number of pigs weaned.

## EXPERIMENT II

### METHODS AND PROCEDURE

The pigs used in this growing-fattening trial were weaned from sows and gilts of Duroc and Montana No. I breeding. They were the fall litters of animals similar to those described in Experiment I.

Six groups of 10 pigs each were allotted on the basis of breed, sex, weaning weight, and litter and were placed in pens in the barn adjacent to exercise lots with concrete floors. In these lots, they had access to a self-feeder and a trough of water. Ordinary baled wheat straw was used for bedding. During cold weather, to prevent icing, waterers with contained kerosene lamps were tried. Little success was attained with them, and the herdsman resorted to hand watering.

The pigs were weaned at eight weeks of age and wormed at approximately 10 weeks. This treatment consisted of mixing 1% sodium flouride in the ration for one day. This treatment has proven to be adequate in the past when combined with farrowing house sanitation (as the herd has been maintained with a relatively low worm infestation).

The rations were essentially barley, linseed meal and 5% alfalfa to which were added trace mineralized salt, calcite and/or monosodium phosphate as needed to meet the National Research Council recommendations. Until such time as the pigs attained an average weight of 150 lbs., the rations were further fortified with Lederle's "Fortafeed" (riboflavin, niacin, Ca pantothenate supplement) and irradiated yeast. The control ration consisted of the above mentioned ingredients and 8% meat and bone meal as shown in Table VII, lot 2 contained all the components of lot 1 in

TABLE VII

FEED COMPOSITION OF SWINE GROWING-FATTENING RATIONS

Rations - weaning to 75 lbs. liveweight (20% <sup>1</sup> protein)						
Lot number	1	2	3	4	5	6
Barley	49.0	48.5	46.1	43.0	43.5	49.0
Wheat	12.0	12.0	11.5	11.0	11.0	12.0
Linseed oil meal	25.0	25.0	31.0	37.6	37.6	25.0
Meat and bone meal	8.0	8.0	4.0	--	--	8.0
Sun-cured alfalfa meal	5.0	5.0	5.0	5.0	5.0	--
Dehydrated alfalfa pellets	--	--	--	--	--	5.0
Salt and trace minerals	0.5	0.5	0.5	0.5	0.5	0.5
Calcite	0.5	0.5	0.8	1.2	1.2	0.5
Monosodium phosphate	--	--	0.6	1.2	1.2	--
APF supplement	--	0.5	0.5	0.5	--	--
Crude protein (%)	20.14	20.15	20.00	20.02	20.01	20.29
Calcium (%)	0.70	0.70	0.69	0.72	0.73	0.69
Phosphorous (%)	0.71	0.71	0.68	0.66	0.66	0.71
Rations - 75 lbs. to 150 lbs. liveweight (17% protein)						
Crude protein (%)	17.13	17.14	17.04	17.24	17.14	17.28
Calcium (%)	0.66	0.66	0.73	0.62	0.62	0.65
Phosphorous (%)	0.69	0.69	0.54	0.51	0.51	0.69
Rations - 150 lbs. to market weight (14% protein)						
Crude protein (%)	14.03	14.04	14.01	14.06	14.05	14.10
Calcium (%)	0.59	0.59	0.67	0.58	0.58	0.56
Phosphorous (%)	0.60	0.60	0.50	0.49	0.49	0.60

the same ratio with the addition of 0.5% APF (Lederle's Aurofac). This feeding regime was set up to determine what effect, if any, the addition of an APF supplement to a ration containing both plant and animal protein would have on growing-fattening pigs. Lot 3 was essentially a repetition of lot 2 with the meat and bone meal reduced by half to 4%. Lot 4 had all the animal protein removed and the protein level maintained by additional linseed meal. The last two rations were designed to determine to what extent a commercial APF supplement could be substituted for a natural source of animal protein such as meat and bone meal. Lot 5 contained protein of plant origin only and served as a check on lot 4 which contained plant protein and 0.5% APF supplement. Lot 6 was set up to determine what value dehydrated alfalfa has in comparison with sun-cured alfalfa for growing-fattening swine. Apart from the preparation of the alfalfa, the rations for lot 1 and 6 were identical. Table VII shows the rations calculated to contain 20% crude protein from weaning to approximately 75 lbs. liveweight, 17% protein from 75 to 150 lbs. liveweight and 14% crude protein from 150 lbs. liveweight to market weight.

The week of December 10, iron strips were put on all feeders in an effort to reduce feed wastage. The fine consistency of the ration, because of the high content of the linseed oil meal, may have been, in part, responsible for the rooting out of the feed. December 23, rings were put in the pigs' noses, in a further effort to reduce feed waste; however, even that did not prove to be entirely satisfactory. Toward the latter part of the experiment, the strips had to be removed from the feeders, to prevent continued injury to the face and jowls of the pigs.

TABLE VIII

COMPARISON OF EXPERIMENTAL RATIONS WITH DAILY NUTRIENT ALLOWANCES RECOMMENDED FOR SWINE

	N.R.C. recommendations			Experimental (basal ration) <sup>1/</sup>		
	50	100	200	up to 75	75-150	150 plus
Calculated protein level				20.14%	17.13%	14.03%
Total feed (lbs.)	3.0	5.3	7.5	4.13	5.38	9.07
Crude protein (lbs.)	0.55	0.85	1.0	0.83	0.90	1.27
Calcium (gms.)	8.8	14.4	17.0	12.13	15.82	24.29
Phosphorous (gms.)	5.9	9.6	11.3	13.31	15.54	24.71
Salt (gms.)	6.8	12.0	17.0	9.37	11.98	20.59
Carotene (mg.)	2.0	4.0	8.0	1.78	2.29	3.91 <sup>2/</sup>
Riboflavin (mg.)	2.5	4.5	6.3	8.26	10.56 <sup>3/</sup>	--
Niacin (mg.)	15.0	27.0	38.0	37.17	47.52 <sup>3/</sup>	--
Vitamin D (I.U.)	150.0	265.0	375.0	3097.00	3960.00	6802.00 <sup>4/</sup>

<sup>1/</sup> Calculations based on the composition and feed consumption of the control ration (lot 1).

<sup>2/</sup> Carotene figures represent only that contained in the sun-cured alfalfa, the dehydrated alfalfa contained about 10x as much.

<sup>3/</sup> Riboflavin and niacin figures represent only that contained in the B-complex supplement (Fortafeed).

<sup>4/</sup> Vitamin D figures represent only that contained in the irradiated yeast.

The first week of March, the pigs were moved out into dirt lots to make the central farrowing barn available for the sows described in Experiment I. The groups retained their respective self-feeders, had straw-bedded shelters, and water in troughs. On two occasions some difficulty was experienced in keeping the pigs separated, as they were able to walk from one pen into another on the snow banks.

At the beginning of the experiment 28-day individual weights and 14-day group weights were obtained. With the change to the 17% protein level of feeding, 14-day weights were taken until the pigs were slightly over 200 lbs. Thereafter, the pigs were weighed weekly, in an effort to market them as nearly as possible at a weight of 220 lbs. The pigs were removed from the lots as they attained market weight; hence, the calculations are made on the number of pig days.

All the feed was mixed in a vertical type mixer in 1000 lb. batches. The feed was then weighed into the self-feeders as required. Records of feed consumption were made by periods (i.e. protein levels) for each lot as well as the total feed consumption for the entire feeding trial.

EXPERIMENT II

RESULTS AND DISCUSSION

Carroll and Krider (1950) in their discussion of management of fattening pigs as a factor in the cost of production state that feed takes into account upwards of 90% of the fattening pig costs. Labor, equipment, and interest on investment are of lesser importance, particularly where self-feeders are used. The importance of rations that will produce efficient and economical gains cannot be over emphasized.

The value of the pig to man lies in his ability to transform the feed he eats into the meat and fat which have a higher food value than the feed that produces them. Obviously, the amount of feed required to produce a pound of edible food is of paramount importance to the hog producer. For a matter of convenience and consistency, the usual connotation for feed efficiency is the number of pounds of feed required to produce 100 lbs. of gain.

The two main criteria for comparing the adequacy of a ration for growing-fattening swine are average daily gain and feed efficiency. As herein used, the daily gain is defined as the daily liveweight increase of the pigs from the beginning of the experiment to its termination when the animals weighed approximately 220 lbs. Feed efficiency has been previously defined.

Before embarking on any detailed discussion of the actual results at hand, a few points are worthy of explanation. The overall feed efficiency picture, considering the six rations collectively, was adversely affected by several factors. It should be borne in mind that, throughout the

entire experiment, the hogs had access only to an outdoor self-feeder. Also during the latter half of the trial they were penned in dirt lots covered with a foot of snow. The hogs did, however, have a dry shelter.

Mention in the experimental procedure was made of iron strips being put on the self-feeders to reduce waste. These same feeders were used in previous years and were highly recommended. Just why this particular group of hogs insisted on rooting out their feed is unknown. In lots 4 and 5, the ration did not contain any meat and bone meal, necessitating the inclusion of a greater percentage of linseed oil meal to maintain an equal protein level. For these particular rations, the resulting fine consistency undoubtedly had some adverse effect through feed wastage. The strips put on the feeders limited the space from which the animals could take their feed and conceivably could have affected feed consumption. No attempt was made to determine the amount of feed wasted. Comparative visual observation, however, tended to point adversely towards those pigs receiving only plant protein in their diet. The strips had to be removed from the feeders as the animals increased in size; it was thought that leaving them on might jeopardize the experiment and cause serious irritation on the jowls of the pigs.

The basal ration was formulated to meet all the known nutrients required in such proportion as to promote normal physiological function of the animals. Considerable controversy can be found in literature pertaining to the protein level of growing-fattening swine rations. The economy and rapidity of gain resulting from a specific protein level is largely determined by the grain-protein supplement cost ratio. In

localities where protein concentrates compare favorably, economically, with small grains a slightly higher level of protein nutrition is justified. On the basis of the chemical analyses of the feed components, the basal ration contained 20.14% protein for the initial period, 17.13% protein for 75 lbs. to 150 lbs. liveweight and was reduced to 14.03 % for the balance of the trial. The other five rations deviated very slightly from the percentage just quoted. Using the average daily feed consumption of those pigs in lot 1, Table VIII shows that the daily recommended nutrient allowances for protein are adequately met. In some liveweight ranges, the basal is materially more than the recommended daily allowances, but in view of the variation in feed consumption by experimental groups this safety margin is justified.

Recent trends in swine nutrition have emphasized the importance of protein adequacy in terms of both quality and quantity. Quantitative studies have established the lysine, tryptophane and methionine requirements essential for normal growth and development of the weanling pig. At present, no evidence is available but it seems logical to assume that other amino acids are also essential for swine growth. The protein of the basal ration is 21% derived from animal sources and the rest from several plant sources. Calculations using the percentage feed composition of the basal ration in Table VII and the amino acid content of feedstuffs from Morrison show that the ration more than adequately meets the recommended levels for lysine, tryptophane, and methionine.

The specifications of the National Research Council recommendations as given in Table VIII are all satisfied by the basal ration. In addition

to this so-called balanced ration, the pigs in lot 2 were fed 0.5% APF-antibiotic supplement. Previous investigations as cited in the review of literature have indicated an improved feed efficiency by adding a supplement. The summary of the weights, gain, and feed efficiency of the fattening trial are reported in Table IX. The addition of 0.5% APF supplement increased the feed efficiency to 450.7 lbs., an improvement of 30 lbs. per cwt. gain. The separate components of the analysis of variance testing the interaction of treatment (ration) and breed as well as treatment and sex show no significant difference due to treatment. Despite the somewhat improved feed efficiency the APF supplement increased the cost of feed per cwt. gain by \$0.57.

The lot 3 ration was formulated to determine to what extent, if at all, a commercial APF-antibiotic supplement could replace the usually considered expensive animal proteins of natural sources. The meat and bone meal was reduced to 4% of the ration and 0.5% APF supplement added. The efficiency was 42.5 lbs. per cwt. gain, poorer than the basal and 72.5 lbs. poorer than the 8% meat meal and APF ration of lot 2. Furthermore the cost increased by \$1.98 per cwt. gain compared with the basal and by \$1.41 compared with lot 2. Before drawing any conclusions, lot 4 where the meat and bone meal was eliminated entirely and the APF held constant, is worthy of examination. Here the feed efficiency was not equal to that of the 8% meal meat ration but better than the 4% meat meal, all three having equal amounts of the APF supplement. The increase cost of \$1.52 over the basal was also intermediate between lots 2 and 3.

Despite the fact that in lot 2 there was a slight increase in feed

TABLE IX  
SUMMARY OF PIG GAINS, FEED EFFICIENCY AND COST

Lot	1	2	3	4	5	6
	8% m.m. <sup>1/</sup>	8% m.m.	4% m.m.	no m.m.	no m.m.	8% m.m.
	basal	0.5% APF	0.5% APF	0.5% APF	--	pellets
Number of pigs	9 <sup>2/</sup>	10	10	10	9 <sup>3/</sup>	10
Average initial wt. (lbs.)	22.0	22.3	22.7	22.7	22.6	23.3
Average final wt. (lbs.)	225.9	219.7	219.4	220.7	222.4	220.7
Average number of days	170.7	164.3	165.4	174.0	171.4	166.2
Average daily gain	1.18	1.21	1.19	1.20	1.22	1.19
Av. lbs. feed/100 lbs. gain	480.7	450.7	523.2	505.5	563.2	482.5
Average daily feed (lbs.)	5.68	5.44	6.22	5.75	6.85	5.73
Cost feed per cwt. gain	\$12.99	\$13.56	\$14.97	\$14.51	\$15.30	\$13.56
Cost in excess of basal (lot 1)	--	0.57	1.98	1.52	2.31	0.57

<sup>1/</sup> M.m. --meat and bone meal (50%).

<sup>2/</sup> One pig died after 17 days on feed.

<sup>3/</sup> One pig died after 7 days on feed.

efficiency, in all three rations to which the commercial APF-antibiotic feed supplement was added, the cost of feed per cwt. gain increased, the increase varying from \$0.57 to \$1.98 per cwt. gain. From this the conclusion seems warranted that the addition of an APF supplement to a small grain ration adequately fortified with animal protein from a natural source is not, at present costs, economically feasible. Furthermore, the substitution of a commercial APF supplement for part or all of the protein of animal origin is not justified under the conditions of this experiment.

The all-plant protein ration of lot 5 is the direct counterpart of the basal with regard to protein of animal origin. The pigs were apparently in constant search of something they were not getting in the all plant protein diet. This was particularly observable from the amount of feed they were rooting out of their feeders in comparison with the other lots, even during the latter part of the experiment with the reduced protein level resulting in a more granular consistency of the ration due to the altered barley-linseed meal ratio. Not only did these pigs have the poorest feed efficiency of 563.2 lbs. feed per cwt. gain but this gain cost \$2.31 more than the basal. With the present day hog prices of about \$22.00 per hundred pounds liveweight an increased cost of production of \$2.31 is of obvious economic importance.

Lot 6 ration was formulated to study the value of dehydrated alfalfa pellets in substitution for sun-cured alfalfa meal in growing-fattening swine rations. As in the reproductive trial, some sorting of the feed was encountered at the beginning of the experiment. The difference in feed efficiency as compared with the sun-cured alfalfa ration was negligible.

The cost of the feed per cwt. gain was increased by \$0.57 presumably due to the extra cost of the dehydrated alfalfa.

No mention has been made so far of the average daily gain by groups on the various treatments. The variance between the extremes in average daily gain was only 0.04 lbs. and thus was not influenced, beneficially or otherwise, by any particular ration.

Table IX also gives figures for the average number of days on test. This is calculated from the total number of pig days divided by the number of pigs, thus making allowance for those lots wherein one pig died. There is a difference between the fastest and the slowest, of some 10 days, to reach market weight. However, it will be noted that there is a consistent trend for those groups with a greater number of days on test to have a heavier average final weight. Thus it is assumed that the difference in length of time on feed, if compared on the basis of a constant final weight, would be negligible.

One Hamprace pig in lot 5, of an initial weight of 13 lbs., died a week after the experiment started. Dr. Seghetti diagnosed death due to necrotic enteritis. This is not uncommon and presumably has no reflection on the ration the pig was consuming. Another Hamprace pig was removed from lot 1, 17 days after initiation of the feeding trial. The cause of death was unknown.

There was a highly significant difference between breeds in average daily gains. In every treatment without fail, the Duroc had a higher daily gain than the Hamprace. A test of interaction of treatment by sex indicated a trend for the barrows to gain more rapidly than gilts.

The correlation between feed efficiency and average daily gain of groups was found to be 0.38. This figure is relatively low; hence further discussion seems superfluous. Facilities for individual feeding and penning were not available; feed efficiency can only be reported by groups.

The correlation between the initial weight and the rate of gain was 0.70. This is rather highly suggestive of pigs with heavier initial weights responding more favorably to feed.

Because of experimental procedure no correlation could be run between initial weight and feed efficiency. Only group feed efficiencies are available, and the mean initial weights of the groups were equalized.

## SUMMARY AND CONCLUSIONS

### EXPERIMENT I

The results of an experiment conducted with 48 sows and gilts of Duroc and Montana No. 1 breeding are reported. The experiment was designed to study the effect of supplementing a balanced ration with an APF-antibiotic feed supplement and of substituting dehydrated alfalfa pellets for sun-cured alfalfa meal in gestation-lactation rations. The basal ration consisted of barley, soybean meal, meat meal, and sun-cured alfalfa, fortified with vitamin D, riboflavin, niacin and pantothenic acid. The number of pigs farrowed, the number of pigs farrowed alive, the birth weight, the number of pigs weaned, and the weaning weight of the pigs were used in comparing the reproductive performance of the females on the various rations.

Under the conditions of the experiment the following conclusions seem warranted:

1. The difference in the number of pigs weaned from the females on the basal ration, the APF supplemented ration, and the dehydrated alfalfa ration was highly significant.
2. The least significant difference calculation indicated that the reduced number of pigs weaned from the sows fed the dehydrated alfalfa ration was significant at the 1% level.
3. The number of pigs farrowed, the number of pigs farrowed alive, and the number of pigs weaned were increased by feeding an APF-antibiotic supplement but the birth weight and weaning weight were inferior.

4. The cost of feeding the APF-antibiotic supplement was more than justified by the increased number of pigs weaned.
5. The extra cost of the dehydrated alfalfa ration, combined with the reduced number of pigs weaned, strongly indicated that dehydrated alfalfa pellets are not a satisfactory substitute for sun-cured alfalfa in swine gestation-lactation rations.
6. The fetal mortality of pigs farrowed by females fed rations containing dehydrated alfalfa pellets was 4.1% higher than those farrowed by females fed sun-cured alfalfa and 7.1% higher than females fed APF supplement.
7. No plausible explanation was forthcoming for the poorer performance by those females fed the dehydrated alfalfa pellets.
8. Pigs from crossbred matings were significantly heavier at birth than those from purebred matings. The increase in weaning weight from these same crossbreds was highly significant.
9. The animals mothering crossbred litters weaned a greater number of pigs, statistically significant at the 5% level.
10. Presumably the two conclusions immediately previous are the result of the hybrid vigor of the pigs in question.
11. There was a highly significant interaction between treatment (rations) and type of mating in number of pigs farrowed and number of pigs farrowed alive.
12. The sows expressed their superior milking capacity by weaning pigs whose weights were highly significantly heavier than weights of pigs weaned from gilts.

13. Considering gilts only, the basal ration was not improved by the antibiotic vitamin B<sub>12</sub> supplement or by the dehydrated alfalfa substitution as the gilts on the basal ration weaned significantly heavier pigs than did those females fed the other rations.
14. Ignoring all experimental treatment the Hamprace performance was superior to that of the Durocs. The difference in weaning weight of the pigs was significant at the 5% level.
15. The Duroc breed showed a significant increase in number of pigs farrowed alive when fed the APF-antibiotic concentrate.
16. There was no difference in the reproductive capacity of the Duroc sires used in the investigation.
17. The females bred to Hamprace #16 weaned larger litters than those bred to Hamprace #47, and although the difference was not statistically significant, there was a suggestion of sire effect.

## EXPERIMENT II

Six groups consisting of 10 pigs each, were fed growing-fattening rations with varying levels of animal protein, with and without a commercial APF-antibiotic feed supplement. Also in one ration dehydrated alfalfa was substituted for sun-cured alfalfa. The rations were compared with a basal of barley, linseed oil meal, 8% meat and bone meal and sun-cured alfalfa fortified with irradiated yeast, riboflavin, niacin and pantothenic acid. All animals were self-fed and removed from the trial as they attained market weight. Data was obtained on feed efficiency by lots and average daily gains by individuals.

Under the conditions of the experiment the following conclusions seem warranted:

1. An APF-antibiotic concentrate produced a slight improvement in feed efficiency but the additional cost did not justify its use.
2. The APF-antibiotic supplement was not a suitable substitute for all or part of the animal protein of natural source due to the increased feed consumption and cost of the ration.
3. Some protein of animal origin is required in growing-fattening swine rations for economical and rapid gains.
4. The substitution of dehydrated alfalfa pellets for sun-cured alfalfa meal was not justified because of the increased cost of feed per pound of gain.
5. The correlation between the initial weight and the rate of gain was 0.70.
6. The correlation between the group feed efficiency and the average daily gain of groups was 0.38.
7. The breed difference in the average daily gain was highly significant in favor of the Durocs.
8. The difference in average daily gain of gilts and barrows was not significant.
9. Compared on the basis of rate of gain by the pigs in the various groups, the rations were of equal quality.
10. Difference in feed efficiency was observed but was not statistically significant.

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APPENDICES

EXPERIMENT I

TABLES X - XXI . . . . . 78-91

EXPERIMENT II

TABLES XXII - XXIII . . . . . 92

TABLE X - A

SUMMARY OF SWINE REPRODUCTION LACTATION PERFORMANCE

LOT 1 - Basal Ration

Breed & No.	Age	Sire	Total No. Farrow.	No. Farrow Alive	Total Birth Wt.	Av. Birth Wt.	No. Weaned	Total Wean. Wt. <sup>1/</sup>	Av. Wean. Wt. <sup>1/</sup>
D 16	G	D20x1	8	8	21.5	2.7	8	264.0	33.0
D 17	G	D20x1			failed to conceive				
D 42	G	D13	4	3	8.0	2.7	2	42.0	21.0
D 73	G	H47	7	6	20.2	3.4	3	72.3	24.1
D 47	S	D13			failed to conceive				
D 256	S	H16	10	9	34.8	3.9	9	260.1	28.9
D 425	S	H16	9	9	32.8	3.6	9	244.8	27.2
H 2	G	D13	11	11	27.2	2.5	10	290.3	29.3
H 10	G	D20x1	10	8	24.8	3.1	8	242.4	30.3
H 12	G	D20x1	6	5	18.8	3.8	5	156.5	31.3
H 18	G	D13	9	9	26.0	2.9	9	267.3	29.7
H 41	G	D20x1	12	10	23.3	2.3	8	232.0	29.0
H 53	G	D13	8	8	23.5	2.9	8	252.0	31.5
H 541	S	H47	13	13	39.0	3.0	12	343.2	28.6
H 589	S	H47	14	12	40.5	3.4	10	315.0	31.5
H 613	S	H47	11	8	24.0	3.0	2	41.0	20.5

<sup>1/</sup> Average weaning weight per pig corrected for age after the method of Whatley, et al. (1937).

TABLE X - B

SUMMARY OF SWINE REPRODUCTIVE LACTATION PERFORMANCE

LOT 2 - APF Supplemented Ration

Breed & No.	Age	Sire	Total No. Farrow.	No. Farrow Alive	Total Birth Wt.	Av. Birth Wt.	No. Weaned	Total Wean. Wt. <sup>1/</sup>	Av. Wean. Wt. <sup>1/</sup>
D 2	G	D20x1			Failed to conceive				
D 10x	G	H16	11	10	22.2	2.2	9	186.3	20.7
D 22	G	D13	7	7	20.2	2.9	7	185.5	26.5
D 51	G	D20x1	12	12	26.0	2.1	6	146.4	24.4
D 262	S	D20x1	9	9	34.5	3.8	4	144.0	36.0
D 388	S	H47	12	11	34.0	3.1	9	234.9	26.1
D 420	S	D13	13	12	31.0	2.6	8	191.5	23.9
H 11	G	D13	14	12	32.5	2.7	8	195.2	25.2
H 17	G	D20x1	7	7	23.0	3.3	7	211.4	30.2
H 25	G	D20x1	12	11	25.8	2.3	10	232.5	23.2
H 44	G	D13	9		farrowed outside--all pigs lost				
H 57	G	D20x1	11	11	27.5	2.5	11	276.5	25.1
H 81	G	H16	9	9	25.5	2.8	9	211.5	23.5
H 583	S	H16			failed to conceive				
H 610x1	S	H16	10	8	27.8	3.5	8	293.6	36.7
H 617	S	H47	5	4	16.5	4.1	3	136.5	45.5

<sup>1/</sup> Average weaning weight per pig corrected for age after the method of Whatley, et al. (1937).

TABLE X - C

SUMMARY OF SWINE REPRODUCTIVE LACTATION PERFORMANCE

LOT 3 - Dehydrated Alfalfa Ration

<u>Breed &amp; No.</u>	<u>Age</u>	<u>Sire</u>	<u>Total No. Farrow.</u>	<u>No. Farrow Alive</u>	<u>Total Birth Wt.</u>	<u>Av. Birth Wt.</u>	<u>No. Weaned</u>	<u>Total Wean. Wt. 1/</u>	<u>Av. Wean. Wt. 1/</u>
D 19	G	D13	8	7	23.5	3.4	2	25.5	12.7
D 20x	G	D13	11	9	27.5	3.1	7	149.8	21.4
D 31	G	D20x1	9	8	19.5	2.4	5	136.0	27.2
D 60	G	D20x1	11	10	18.8	1.9	5	99.0	19.8
D 284	S	H16	9	7	22.8	3.2	7	179.2	25.6
D 290	S	H16	13	10	24.0	2.4	5	145.5	29.1
D 297	S	D20x1	14	9	22.8	2.5	5	135.5	27.1
H 5	G	D13	9	9	25.5	2.8	9	243.0	27.0
H 15	G	D20x1			died--contained nine young				
H 54	G	D20x1	10	10	27.0	2.7	8	171.2	21.4
H 55	G	D13	9	9	24.8	2.8	9	212.4	23.6
H 64	G	D13	7	7	21.8	3.1	5	151.0	30.2
H 82	G	D20x1	9	9	25.5	2.8	8	206.4	25.8
H 452	S	H47			failed to conceive				
H 465	S	H47	12	8	28.5	3.6	5	148.5	29.7
H 591	S	H47	5	5	16.8	3.4	4	166.0	41.5

1/ Average weaning weight per pig corrected for age after the method of Whatley, et al. (1937).

TABLE XI

FEED PRICES USED FOR SWINE NUTRITION RESEARCH PROJECTS 1950-51

<u>FEED</u>	<u>PRICE/ CWT.</u>
Barley, ground	\$ 2.00
Wheat, ground	3.00
Wheat bran	2.35
Linseed oil meal <sup>1/</sup>	4.10
Soybean oil meal	4.25
Meat and bone meal	6.15
Sun-cured alfalfa	1.50
Dehydrated alfalfa	3.50
Trace mineralized salt (hand mixed)	2.30
Iodized salt	1.70
Limestone (calcite)	1.05
Monosodium phosphate	14.00
Antibiotic-B <sub>12</sub> concentrate <sup>2/</sup>	40.00
Fortafeed (B-complex supplement) <sup>3/</sup>	66.00
Irradiated yeast	68.00

<sup>1/</sup> Cargill, Inc., Conrad, Montana, through Mr. Nelson, supplied linseed oil meal gratis.

<sup>2/</sup> Lederle's APF No. 5.

<sup>3/</sup> Lederle's "Fortafeed"

TABLE XII

ANALYSIS OF VARIANCE - EFFECT OF RATIIONS

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F. Ratio</u>	<u>5%</u>	<u>1%</u>
1. NUMBER OF PIGS FARROWED						
between means of treat.	2	2.90	1.45	0.22	3.24	--
within means of treat.	39	255.22	6.54	--	--	--
2. NUMBER OF PIGS FARROWED ALIVE						
between means of treat.	2	11.52	5.81	1.16	3.25	--
within means of treat.	38	189.95	4.99	--	--	--
3. AVERAGE BIRTH WEIGHT OF PIGS						
between means of treat.	2	0.37	0.18	0.65	3.25	--
within means of treat.	38	10.45	0.28	--	--	--
4. NUMBER OF PIGS WEANED						
between means of treat.	2	20.68	10.34	9.32**	3.25	5.21
within means of treat.	38	42.30	1.11	--	--	--
5. CORRECTED WEANING WEIGHT OF PIGS						
between means of treat.	2	57.72	26.36	0.77	3.25	--
within means of treat.	38	1008.38	34.43	--	--	--

\* Significant at the 5% level

\*\* Significant at the 1% level

TABLE XIII

ANALYSIS OF VARIANCE - TOTAL NUMBER OF PIGS FARROWED

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F Ratio</u>	<u>5%</u>	<u>1%</u>
1. TREATMENT BY BREED (Duroc and Hamprace)						
between means of 6 classes	5	6.47	1.29	0.40	2.48	--
between means of 2 breeds	1	0.20	0.20	0.11	4.11	--
between means of 3 treat.	2	1.77	0.89	0.28	3.26	--
interaction (B x T)	2	4.50	2.25	0.70	3.26	--
experimental error	36	--	3.19	--	--	--
2. TREATMENT BY AGE (Sows and Gilts)						
between means of 6 classes	5	4.83	0.97	0.57	2.48	--
between means of 2 ages	1	2.28	2.28	1.33	4.11	--
between means of 3 treat.	2	0.13	0.07	0.04	3.26	--
interaction (A x T)	2	2.42	1.21	0.71	3.26	--
experimental error	36	--	1.71	--	--	--
3. TREATMENT BY TYPE OF MATING (Crossbred, Purebred Duroc or Hamprace)						
between means of 9 classes	8	26.04	3.26	2.21	2.25	3.12
between means of 3 matings	2	1.26	0.63	0.43	3.30	5.34
between means of 3 treat.	2	0.65	0.32	0.22	3.30	5.34
interaction (M x T)	4	24.13	6.03	4.08**	2.67	3.97
experimental error	32	--	1.48	--	--	--

\* Significant at the 5% level

\*\* Significant at the 1% level

TABLE XIV

ANALYSIS OF VARIANCE - NUMBER OF PIGS FARROWED ALIVE

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F Ratio</u>	<u>5%</u>	<u>1%</u>
1. TREATMENT OF BREED (Duroc and Hamprace)						
between means of 6 classes	5	5.95	1.19	2.04	2.48	--
between means of 2 breeds	1	0.08	0.08	0.14	4.12	--
between means of 3 treat.	2	2.33	1.17	2.10	3.27	--
interaction (B x T)	2	3.54	1.17	3.04	3.27	--
experimental error	35	--	0.58	--	--	--
2. TREATMENT BY AGE (Sows and Gilts)						
between means of 6 classes	5	5.61	1.12	1.36	2.48	--
between means of 2 ages	1	0.06	0.06	0.07	4.12	--
between means of 3 treat.	2	1.22	0.61	0.74	3.27	--
interaction (A x T)	2	4.33	2.17	2.64	3.27	--
experimental error	35	--	0.82	--	--	--
3. TREATMENT BY TYPE OF MATING (Crossbred, Purebred Duroc, Purebred Hamp)						
between means of 9 classes	8	27.02	3.38	3.31*	2.25	3.12
between means of 3 matings	2	2.16	1.08	1.06	3.30	5.34
between means of 3 treat.	2	2.13	1.07	1.05	3.30	5.34
interaction (M x T)	4	22.73	5.68	5.56**	2.67	3.97
experimental error	32	--	1.02	--	--	--

\* Significant at the 5% level

\*\* Significant at the 1% level

TABLE XV

ANALYSIS OF VARIANCE - AVERAGE BIRTH WEIGHT OF PIGS

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F Ratio</u>	<u>5%</u>	<u>1%</u>
1. TREATMENT BY BREED (Duroc or Hamprace)						
between means of 6 classes	5	0.25	0.05	1.35	2.48	--
between means of 2 breeds	1	0.02	0.02	0.54	4.12	--
between means of 3 treat.	2	0.04	0.02	0.54	3.27	--
interaction (B x T)	2	0.19	0.09	2.43	3.27	--
experimental error	35	--	0.037	--	--	--
2. TREATMENT BY AGE (Sows and Gilts)						
between means of 6 classes	5	0.53	0.11	2.53*	2.48	3.60
between means of 2 ages	1	0.11	0.11	2.53	4.12	7.42
between means of 3 treat.	2	0.06	0.03	0.69	3.27	5.27
interaction (A x T)	2	0.36	0.18	4.14*	3.27	5.27
experimental error	35	--	0.043	--	--	--
3. TREATMENT BY TYPE OF MATING (Crossbred, Purebred Duroc or Hamprace)						
between means of 9 classes	8	0.87	0.11	1.27	2.25	3.12
between means of 3 matings	2	0.67	0.34	3.93*	3.30	5.34
between means of 3 treat.	2	0.00	0.00	0.00	3.30	5.34
interaction (M x T)	4	0.20	0.05	0.06	2.67	3.97
experimental error	32	--	0.086	--	--	--

\* Significant at the 5% level

\*\* Significant at the 1% level

TABLE XVI

ANALYSIS OF VARIANCE - NUMBER OF PIGS WEANED

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F Ratio</u>	<u>5%</u>	<u>1%</u>
1. TREATMENT BY BREED (Duroc or Hamprace)						
between means of 6 classes	5	6.24	1.25	1.32	2.48	--
between means of 2 breeds	1	3.22	3.22	3.40	4.12	--
between means of 3 treat.	2	2.68	1.34	1.41	3.27	--
interaction (B x T)	2	0.34	0.17	0.18	3.27	--
experimental error	35	--	0.95	--	--	--
2. TREATMENT BY AGE (Sows and Gilts)						
between means of 6 classes	5	8.19	1.64	1.69	2.48	--
between means of 2 ages	1	0.45	0.45	0.46	4.12	--
between means of 3 treat.	2	3.99	1.99	2.05	3.27	--
interaction (A x T)	2	3.75	1.87	1.93	3.27	--
experimental error	35	--	0.97	--	--	--
3. TREATMENT BY TYPE OF MATING (Crossbred, Purebred Duroc or Hamprace)						
between means of 9 classes	8	19.80	2.48	1.81	2.25	3.12
between means of 3 matings	2	10.81	5.41	3.95*	3.30	5.34
between means of 3 treat.	2	5.15	2.57	1.88	3.30	5.34
interaction (M x T)	4	3.84	0.96	0.70	2.67	3.97
experimental error	32	--	1.37	--	--	--

\* Significant at the 5% level

\*\* Significant at the 1% level

TABLE XVII

ANALYSIS OF VARIANCE - CORRECTED WEANING WEIGHT OF PIGS

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F Ratio</u>	<u>5%</u>	<u>1%</u>
1. TREATMENT BY BREED (Duroc or Hamprace)						
between means of 6 classes	5	13.40	2.68	0.54	2.04	3.60
between means of 2 breeds	1	12.11	12.11	2.43	4.12	7.42
between means of 3 treat.	2	1.03	0.51	0.10	3.27	5.27
interaction (B x T)	2	0.26	0.13	0.03	3.27	5.27
experimental error	35	--	4.98	--	--	--
2. TREATMENT BY AGE (Sows and Gilts)						
between means of 6 classes	5	68.21	13.64	3.43*	2.48	3.59
between means of 2 ages	1	34.05	34.05	8.56**	4.12	7.42
between means of 3 treat.	2	4.42	2.21	0.55	3.27	5.27
interaction (B x T)	2	29.74	14.87	3.74*	3.27	5.27
experimental error	35	--	3.98	--	--	--
3. TREATMENT BY TYPE OF MATING (Crossbred, Purebred Duroc or Hamprace)						
between means of 9 classes	8	166.47	20.81	2.80*	2.25	3.12
between means of 3 matings	2	82.33	41.31	5.55**	3.30	5.34
between means of 3 treat.	2	6.16	3.08	0.41	3.30	5.34
interaction (M x T)	4	77.68	19.42	2.61	2.67	3.97
experimental error	32	--	7.44	--	--	--

\* Significant at the 5% level

\*\* Significant at the 1% level

TABLE XVIII

ANALYSIS OF VARIANCE - EFFECT OF TREATMENT ON DUROC PERFORMANCE

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F Ratio</u>	<u>5%</u>	<u>1%</u>
1. NUMBER OF PIGS FARROWED						
between means of treat.	2	28.99	14.45	0.79	3.68	--
within means of treat.	15	272.63	18.17	--	--	--
2. NUMBER OF PIGS FARROWED ALIVE						
between means of treat.	2	27.40	13.70	3.76	3.68	6.36
within means of treat.	15	54.60	3.64	--	--	--
3. AVERAGE BIRTH WEIGHT OF PIGS						
between means of treat.	2	1.01	0.50	1.52	3.68	--
within means of treat.	15	4.92	0.33	--	--	--
4. NUMBER OF PIGS WEANED						
between means of treat.	2	13.28	6.64	1.21	3.68	--
within means of treat.	15	82.50	5.50	--	--	--
5. CORRECTED WEANING WEIGHT OF PIGS						
between means of treat.	2	46.24	23.31	0.84	3.68	--
within means of treat.	15	415.44	27.70	--	--	--

\* Significant at the 5% level

\*\* Significant at the 1% level

TABLE XIX

ANALYSIS OF VARIANCE - EFFECT OF TREATMENT ON HAMPRACE PERFORMANCE

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F Ratio</u>	<u>5%</u>	<u>1%</u>
1. NUMBER OF PIGS FARROWED						
between means of treat.	2	11.95	5.97	0.81	3.47	--
within means of treat.	21	154.68	7.36	--	--	--
2. NUMBER OF PIGS FARROWED ALIVE						
between means of treat.	2	4.74	2.37	0.42	3.49	--
within means of treat.	20	112.57	5.62	--	--	--
3. AVERAGE BIRTH WEIGHT OF PIGS						
between means of treat.	2	0.02	0.01	0.05	3.49	--
within means of treat.	20	3.71	0.18	--	--	--
4. NUMBER OF PIGS WEANED						
between means of treat.	2	6.36	3.68	0.54	3.49	--
within means of treat.	20	136.86	6.84	--	--	--
5. CORRECTED WEANING WEIGHT OF PIGS						
between means of treat.	2	7.47	3.73	0.10	3.49	--
within means of treat.	20	739.76	36.90	--	--	--

TABLE XX

ANALYSIS OF VARIANCE - EFFECT OF TREATMENT ON GILT PERFORMANCE

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F Ratio</u>	<u>5%</u>	<u>1%</u>
1. NUMBER OF PIGS FARROWED						
between means of treat.	2	16.07	8.03	1.76	3.40	--
within means of treat.	24	109.12	4.55	--	--	--
2. NUMBER OF PIGS FARROWED ALIVE						
between means of treat.	2	32.93	16.47	4.26*	3.42	5.66
within means of treat.	23	88.96	3.87	--	--	--
3. AVERAGE BIRTH WEIGHT OF PIGS						
between means of treat.	2	0.44	0.22	1.16	3.42	--
within means of treat.	23	4.36	0.19	--	--	--
4. NUMBER OF PIGS WEANED						
between means of treat.	2	19.21	9.60	1.42	3.42	--
within means of treat.	23	155.44	6.76	--	--	--
5. CORRECTED WEANING WEIGHT OF PIGS						
between means of treat.	2	148.24	74.12	4.82*	3.42	--
within means of treat.	23	353.82	15.38	--	--	--

\* Significant at the 5% level

\*\* Significant at the 1% level

TABLE XXI

ANALYSIS OF VARIANCE - EFFECT OF TREATMENT ON SOW PERFORMANCE

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F Ratio</u>	<u>5%</u>	<u>1%</u>
1. NUMBER OF PIGS FARROWED						
between means of treat.	2	6.40	3.20	0.35	3.88	--
within means of treat.	12	109.20	9.10	--	--	--
2. NUMBER OF PIGS FARROWED ALIVE						
between means of treat.	2	14.54	7.27	1.21	3.88	--
within means of treat.	12	72.40	6.03	--	--	--
3. AVERAGE BIRTH WEIGHT OF PIGS						
between means of treat.	2	0.58	0.29	1.09	3.88	--
within means of treat.	12	3.17	0.26	--	--	--
4. NUMBER OF PIGS WEANED						
between means of treat.	2	26.10	13.10	1.55	3.88	--
within means of treat.	12	101.20	8.43	--	--	--
5. CORRECTED WEANING WEIGHT OF PIGS						
between means of treat.	2	199.26	99.63	2.75	3.88	--
within means of treat.	12	434.28	36.19	--	--	--

\* Significant at the 5% level

\*\* Significant at the 1% level

ANALYSIS OF VARIANCE - EXPERIMENT II

TABLE XXII

AVERAGE DAILY GAIN

<u>Source of variation</u>	<u>d.f.</u>	<u>S.S.</u>	<u>M.S.</u>	<u>F Ratio</u>	<u>5%</u>	<u>1%</u>
1. TREATMENT BY BREED (Duroc and Hamprace)						
between means of 12 classes	11	0.07	0.006	2.36*	2.00	2.66
between means of 2 breeds	1	0.04	0.04	15.74**	4.05	7.21
between means of 6 treat.	5	0.02	0.004	1.57	2.42	3.44
interaction (B x T)	5	0.01	0.002	0.79	2.42	3.44
experimental error	46	--	0.0025	--	--	--
2. TREATMENT BY SEX (Barrows and Gilts)						
between means of 12 classes	11	0.02	0.002	0.63	2.00	2.66
between means of 2 sexes	1	0.01	0.01	3.16	4.05	7.21
between means of 6 treat.	5	0.01	0.002	0.63	2.00	2.66
interaction (S x T)	5	0.00	0.00	0.00	2.42	3.44
experimental error	46	--	0.0032	--	--	--

TABLE XXIII

FEED EFFICIENCY - LBS FEED PER LB GAIN

(sum of 3 periods - protein levels)

between means of 6 treat.	5	4.97	0.99	0.74	3.11	--
within means of treat.	12	16.02	1.33	--	--	--
total	17	20.99	2.32	--	--	--

\* Significant at 5% level

\*\* Significant at 1% level

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