THE USE OF METHANDROSTENOLONE AND SWEETENING AGENTS IN THE RATIONS OF YOUNG PIGS

by

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I. INTRODUCTION

Production of food and continuous supply thereof is perhaps the most critical factor in sustaining the growth, economy and security of a nation. This point is brought into the foreground most strikingly during periods of war, particularly when rationing has to be imposed.

During and since the Second World War, pressure on agriculture in general and on animal industry in particular has mounted continuously to produce more and better meat, milk and eggs, and at less cost to the consumer, to keep in step with the rapidly growing population. With the prices of basic livestock feeds and protein supplements remaining high or rising, nutritionists have exerted a tremendous effort to find ways and means to enhance utilization of the basic nutrients - protein, carbohydrate, fat.

The advances made in the livestock industry have been truly amazing. Because of improved nutrition, breeding and management, most animals are now growing considerably faster on much less feed as compared with

twenty years ago. The pig could be cited here as an example.

In keeping with the efforts to increase livestock production, within the last fifteen years a system known as early-weaning has come into being. With pigs, this involves the removal of piglets from their dams at between two to three weeks of age, i.e. about five weeks earlier than when normal weaning is practised. Its main purpose is to facilitate the development of heavier and more uniformly sized pigs by eliminating runts, and to increase the yearly production of sows by shortening the periods between farrowings. Although this system is as yet not widely practised, mainly because of the high cost of certain management procedures, the tremendous advantages which it promises, together with the continual increase in specialization in farming, favours its increased application in the pig industry.

Where early-weaning is practised, some substitute must be provided to meet the nutrient requirements of the piglet, which would normally be provided by the sow's milk. At first synthetic milks were used but these wet rations eventually gave way, during the early 1950's, to the more convenient and easier to use dry early-weaning rations.

Originally the dry early-weaning rations contained relatively large quantities of costly high biological

value protein supplements. However, investigations have failed to substantiate the need for such high protein levels and have justified the use of more economical rations. One such ration is the 24 per cent protein dry early-weaning pig ration developed in the Nutrition Laboratory of Macdonald College and which is currently recommended by the Quebec Feed Board to farmers in this province.

Rations such as this, although satisfactory in their effect on growth, may contain nutrient imbalances which may be undesirable, both nutritionally and economically. Eliminating excesses, along with the use of cheap but nutritionally satisfactory feed ingredients, in effect produces what are known as least-cost rations. However, the complexity and magnitude of computation is such that to arrive at a least-cost, nutritionally adequate formula is not feasible with a desk calculator. Within recent times the advent of the electronic computer has opened the door to the practical solution of such problems.

Although electronically computed least-cost rations will meet the requirement for all the nutrients specified in modern swine feeding standards, it does not necessarily follow that a ration so computed will be completely satisfactory, especially for young animals. The electronic computer cannot determine the acceptability or the texture of rations, although both are important

considerations in rations for early-weaned pigs. In point of fact, trials in which certain computed rations were fed have shown that, although pigs consuming them exhibited a greater feed efficiency than those on a standard diet, the feed intake and consequently the live weight gains of these animals were reduced. Since early-weaned pigs are thought to have a preference for feeds containing sweetening agents, the conjecture is that the addition of such agents to computed rations should make the rations more acceptable to these animals.

A notable aspect of attempts to improve the productive efficiency of the pig has related to the modification of its metabolic processes by the administration of exogenous endocrine stimulants. For instance, sex hormones, along with their analogues, have been used to counteract the observed sex differences in economic traits. The boar, for example, is a most efficient producer of lean meat, while on the other hand castration of males is undertaken to make the animal more docile, to reduce the possibility of dark-coloured meat and to eliminate the risk of "boar-taint". Castrates and gilts are known to accumulate more depot fat than the "entire" male pig.

Androgens, male sex hormones, increase protein anabolism, characterized by a greater degree of nitrogen retention, and in many cases an increase in live weight.

The administration of testosterone propionate or methyl testosterone appears to have a growth depressing effect upon pigs, although in the majority of cases feed efficiency has remained unaltered. In about 75 per cent of cases, however, a reduction in backfat thickness has been effected by androgen treatment together with an increase in carcass length and "eye" muscle area. Recently a new synthetic testosterone analogue, methandrostenolone, has been developed, and it is claimed that, for humans and rats, this compound has increased anabolic activity and reduced androgenicity when compared with other analogues of testosterone.

This research project was designed to investigate the effect of the inclusion of methandrostenolone in the rations of pigs from early-weaning to slaughter weight. The influence of this compound on nitrogen retention at different stages of growth and its effect on muscle fibre diameter in 200 pound pigs was to be examined. In addition, this study was carried out to determine the efficacy of sweetening agents in improving the acceptability of electronically computed rations fed to pigs from three to nine weeks of age.

II. REVIEW OF LITERATURE

A. ANDROGENS

Differences in the rate and nature of growth between the sexes were the first indications that sex hormones possibly could be used to induce beneficial growth changes.

The anabolic effect of the male hormone, which had long been suspected, was first clearly demonstrated by Kochakian and Murlin in 1935. They observed that extracts of male urine not only had an androgenic effect, but in addition caused a retention of nitrogen in dogs fed a constant diet. It was then shown that testosterone and testosterone acetate could also produce a positive nitrogen balance in the dog. Similar effects of testosterone propionate in decreasing urinary nitrogen excretion in human subjects were noted by Kenyon and co-workers, 1938 and 1940. The work of these and other investigators satisfactorily demonstrated that testosterone can cause a positive balance of nitrogen,

phosphorus, potassium and calcium.

The high cost and relative scarcity of the steroid sex hormones were for many years limiting factors in their use for detailed study of their effects on growth rate and other productive traits of meat-producing animals. Within recent times, however, the synthesis of comparatively inexpensive analogues, which have the physiological activities of the naturally occurring hormones, have led to their widespread use at all levels of livestock husbandry.

a. Effects on Laboratory Animals

The response to testosterone administration has been found to depend largely upon the level of protein in the diet. Working with rats, Kochakian and Van der Mark (1952) found that, provided the dietary protein level was adequate, a further increase in protein intake did not enhance the anabolic activity of testosterone propionate. The opposite effect was reported by Perlman and Cassidy (1953). Using castrated male dogs, they observed that the anabolic effect of testosterone propionate was manifested only at protein levels above that required for maintenance. On the basis of these results, they concluded that the mode of action of androgens was not in increased protein utilization, since there was no effect at the minimal level of protein.

Increase in weight of the levator ani muscle of

male rats was used by Saunders and Drill (1954) as a means of comparing the anabolic effect produced by injecting 17-ketosteroids. They compared several 17-ketosteroids and reported that testosterone propionate and 17-ethyl-19-nortestosterone displayed the most marked anabolic activity. Testosterone propionate also significantly increased the growth rate of castrated rats. These workers (Saunders and Drill, 1957) also evaluated the androgenic activity of several compounds by measuring the increase in weight of the seminal vesicles of castrated male rats, and found testosterone propionate to be by far the most potent androgen.

Severe criticism has been leveled by Nimni and Geiger (1957) at the use of the levator ani muscle, introduced by Eisenberg and Gordon (1950), as a method of assaying the anabolic effect of androgenic compounds. They found that in both entire and castrated male rats, growth of the levator ani muscle was promoted by injection with testosterone propionate even when protein-free diets were fed. This growth was brought about as the result of protein catabolism in other parts of the body. From these results, and from previous observations, these workers assumed that growth of the levator ani muscle was a sex-linked function and concluded that the hormone-induced growth of this muscle was not a suitable index for the anabolic activity of steroid compounds.

The growth rate of laboratory animals as affected by testosterone has received considerable attention. Rubinstein et al. (1939) observed the effect of the administration of different levels of this androgen upon the growth rate of entire and castrated male rats. When normal rats were given daily injections of 1 mg. testosterone propionate, it caused a depression of their growth rate. This effect became noticeable three to four weeks after commencement of the treatment. The same dosage given to castrated male rats depressed liveweight gain to a greater degree than that caused by castration alone (Rubinstein and Solomon, 1941a). These workers (Rubinstein and Solomon, 1940; 1941b) also reported that daily injections of 0.05 mg. testosterone propionate brought about an improvement of 17 per cent in the growth rate of entire male rats and 19.5 per cent with castrated males. From these results it would appear that the level of administration is of great importance, and this might explain why so many negative results have been reported.

A significant difference in growth response between the sexes to injections of testosterone propionate was noted by Shay et al. (1941). They found that whereas female rats showed an increase in liveweight gains, males failed to respond to androgen treatment.

Growth studies of rats were supplemented with carcass analysis by Kochakian et al. (1950). Rats were

injected over a period of three months with either 0.125 or 1.0 mg. of testosterone propionate and it was noted that treated rats showed an initial increase in growth rate, which was followed by a depression in gain. They observed that the chief effect of the steroid on the carcass was an increase in the weight of the accessory sex organs and the kidneys and a reduction in fat, especially if any surplus fat had been present initially.

Later work by Kochakian and Webster (1958) was in agreement with that previously reported. Injections of 0.25 to 2.5 mg. testosterone propionate per day brought about a depression in the liveweight gain of growing rats, and decreased the body weight of adult male rats. They theorized that the loss in body weight was due primarily to a reduction in subcutaneous and abdominal fat with an accompanying decrease in appetite. These workers further postulated that testosterone could promote the mobilization of fat for energy metabolism, utilizing fat deposits for this purpose rather than nutrients absorbed from the diet.

Apart from their effects upon protein anabolism and somatic growth, it has been reported that androgens accelerated skeletal development and caused premature epiphyseal closure (Turner et al., 1941; Silberberg and Silberberg, 1956). This explains the smaller ultimate body size of animals receiving large doses of an androgen.

b. Effects on Herbivorous Animals

The effect of testosterone on the growth rate of animal species other than the rat and dog has also been observed. Bergetrand (1950) reported that testosterone increased the growth rate of rabbits. Testosterone, noted Dinusson et al. (1950), did not have any measurable effect upon the gains of heifers, while Andrews et al. (1950) reached similar conclusions in regard to steers. O'Mary et al. (1952) observed that testosterone pellets were without effect on fattening lambs, but Andrews et al. (1949) reported that testosterone pellets increased feed efficiency and carcass quality of wether lambs. On the other hand, Bogart et al. (1951) and Burris et al. (1952) concluded that testosterone injections at the rate of 1 mg. per kg. body weight weekly, increased the rates of gain and improved the efficiency of feed utilization with both steers and heifers.

The results from trials in which androgen was administered to herbivorous animals are conflicting. Both positive and negative results have been reported for the same type of animal on similar treatments. Therefore, no valid conclusion as to the true effect of androgen on this class of livestock can yet be arrived at.

c. Effects in Pig Production

As previously noted, the administration of 17-keto steroids to rats has been claimed to promote increased

protein anabolism and fat mobilization. If other monogastric species responded in the same manner, one would expect that a primary result of androgen administration to the pig would be improvement of carcass quality. Woehling et al. (1951) implanted weanling pigs with 15 mg. testosterone at 43 pounds liveweight and again twelve weeks later. These animals were slaughtered at 210 pounds liveweight and carcass measurements were taken. The results of the trial showed that implantation had no effect on growth rate, feed efficiency, killing-out percentage, carcass length, backfat thickness or "eye muscle" area at the last rib. They noted, however, that testosterone produced demonstrable effects on the reproductive organs.

Sleeth et al. (1953) injected 35-pound pigs with 1 mg. testosterone propionate per kg. body weight once weekly for a period of six weeks and then twice weekly for another ten weeks until slaughter. Treated animals exhibited a decreased rate of gain, although feed efficiency appeared to be unaffected. They noted, too, that androgen treatment reduced carcass length and backfat thickness. However, since the injected animals were twenty pounds lighter than the controls at slaughter, valid comparisons could not be made. In further trials in which 0.5 mg. testosterone propionate per kg. body weight was injected twice weekly, they observed a

reduction in growth rate but no effect on carcass composition. The authors noted, too, that both treated barrows and gilts exhibited abnormal sexual behaviour and that the reproductive tracts showed the effects of marked hormonal stimulation.

High level implantations in pigs, of testosterone propionate were done by both Bratzler et al. (1954) and Semprini and Rappini (1958). Bratzler et al. (1954) noted that animals implanted with 193 mg. at ten weeks of age did not differ appreciably from the controls in any of the productive traits. Levels of 250 mg. testosterone propionate implanted in weanling gilts and again at three and five months of age, by Semprini and Rappini (1958), did not produce any significant difference in growth rate between the implanted animals and controls over a period of 21 weeks.

Work dealing with orally administered androgens to swine was begun by Beeson et al. (1955). They fed 20 mg. of methyl testosterone per animal daily from weaning to 125 pounds liveweight, and thence 40 mg. daily until the pigs were slaughtered at 220 to 230 pounds liveweight. Oral administration did not improve growth rate or feed efficiency. Carcass analysis data revealed that the treatment resulted in the deposition of significantly less backfat, while chemical analysis of the ground carcass showed that the pigs receiving testosterone had

about five per cent less fat and five per cent more lean than the controls.

In the work conducted by Beeson et al. (1955) at Purdue, only one level of methyl testosterone was fed. Perry et al. (1956) continued this investigation in order to test the effect of various levels of methyl testosterone in the diets of growing-fattening swine. Pigs were fed a ration of maize and a protein supplement containing the androgen, at levels ranging from 10 to 70 mg. of methyl testosterone per pound of supplement, on a free-choice basis. All pigs were slaughtered between 210 and 220 pounds liveweight.

It was observed that a daily intake of 27 mg. or more of methyl testosterone resulted in a highly significant growth depression. However, the authors noted that it was in this range that a decreased fat deposition was apparent as indicated by significantly less backfat thickness.

Levels of 0.015 to 1.5 mg. methyl testosterone per kg. body weight were fed by Noland and Burris (1956) over a 76-day feeding trial to boars, barrows, gilts and spayed gilts. They found that the levels of methyl testosterone fed were not effective in inducing a growth stimulus in swine. The rate of gain of females was slightly depressed by the 0.15 mg. level of methyl testosterone, while the gain of males was unaffected. In

general, pigs fed the methyl testosterone produced somewhat leaner carcasses than the control-fed animals.

The growth-depressing effect of methyl testosterone when fed at levels of 9 and 15 mg. per pound of ration has been reported by Johnston et al. (1957). In addition they noted that the administration of androgen resulted in an increase of the lean-fat ratio in the carcass.

Thrasher et al. (1959) reported that the oral administration of various testosterone analogues had no significant effect upon the growth rate or carcass quality of growing-finishing swine. However, the feeding of 5.0 mg. of methyl testosterone and 0.9 mg. of 11 beta-hydroxy-17 alpha-methyl testosterone per pound of ration produced effects suggesting improved carcass leanness. Other levels of the latter hormone (0.3 and 1.2 mg. per pound of ration) reduced the average live backfat depth. They also observed that methyl testosterone significantly increased the iodine number of the extracted fat from the edible portion of the carcass.

In work done by Whiteker et al. (1959), there was no effect on rate of gain or feed efficiency when 20 mg. of methyl testosterone were orally administered daily to growing-finishing pigs. However, there was a significant reduction in live backfat measurement and a higher percentage of lean cuts in the pigs receiving the methyl testosterone than in those fed the basal ration.

Hale et al. (1960) also fed growing-finishing pigs 20 mg. of methyl testosterone per day, but in this case it was in combination with diets containing two levels of energy and two levels of protein. They observed no effect on rate of gain, feed efficiency, carcass length or area of "eye muscle". However, testosterone decreased the backfat thickness of pigs on all diets with the greatest reduction in those fed low-protein diets.

Administered subcutaneously as testosterone propionate or orally as methyl testosterone, androgens appear to have a growth-depressing effect upon pigs, although in most cases feed efficiency is unaltered. The ability to improve carcass quality, as shown by a reduction in backfat thickness, increase in carcass length and "eye muscle" area, seems to be one of their qualities. However, trials with pigs have not produced any supporting evidence of the anabolic activity of androgens, although this trait may be reflected in the increased lean-fat ratio of treated animals.

d. A New Androgen, Methandrostenolone[1] (Danabol®)

A synthetic testosterone derivative, methandrostenolone, recently developed by CIBA Company Limited, has been claimed to have increased anabolic activity and reduced androgenicity, when compared with other analogues

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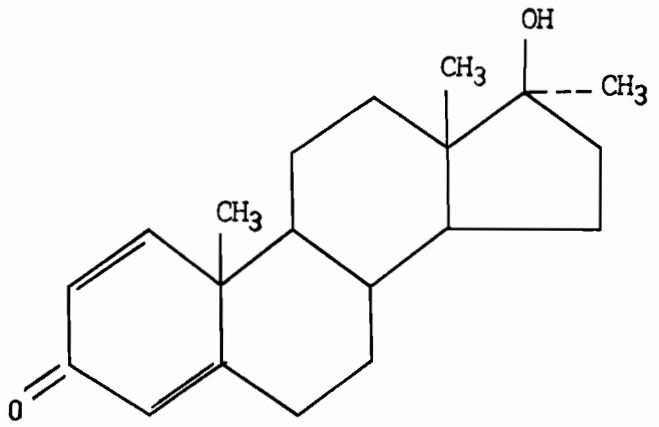
[1]Methandrostenolone supplied as Danabol® by CIBA Pharmaceutical Products Inc.

of testosterone (Liddle and Burke, 1960). An orally active anabolic agent, methandrostenolone is said to provide a better separation of androgenic and anabolic effect than has been hitherto possible with other substances.

Reduced androgenicity of androgens that are used exclusively as anabolic agents is important, especially in human medicine. Normally, their marked sexual effects make their use hazardous in women as well as in children. How important this factor is where animals are kept solely for meat is not quite clear. However, various workers (Woehling et al., 1951; Sleeth et al., 1952; Johnston et al., 1956; Noland and Burris, 1956; Perry et al., 1956) have observed abnormal developments in the sexual glands and behaviour patterns, particularly of females, in both swine and sheep, to which testosterone had been administered.

(i) Chemical Structure

This new substance, 17∝-Methyl-17β-hydroxy-androsten-1,4-diene-3-one, was given the name of Danabol®. It is a methyl testosterone dehydrogenated in the A ring. (See formula, page 18.) Thus it does not belong to the nortestosterone series. In other words the methyl group between the A and B ring at the C atom is still there.



(ii) Anabolic Activity

The effectiveness of methandrostenolone in bringing about weight gains has been shown in many trials. Work done in the CIBA laboratories (1960) showed that this compound, like testosterone propionate and 19-nor-17a-ethyl-testosterone with which it was compared, produced gains in body weight which were dependent on the dose. That is, a positive response was obtained only within a certain range of dose levels. After relatively large doses, the weight gain response was less marked and was absent with very large doses.

It has been reported, too, that this substance has the ability to stimulate the appetite (CIBA, 1960). This quality was also noted by Beiglboeck and Brummond (1960) who observed "healthy" increases of appetite, without attacks of voracity, soon after the intake of methandrostenolone tablets by hospitalized patients.

The published reports, all of which deal with its use on either rats or human subjects, tell of weight

gains obtained with methandrostenolone. Beiglboeck and Brummond (1960) obtained weight gains in 51 of 52 hospitalized patients. They observed that the greatest weight gains were obtained at the start of therapy, falling off after the second week. They also reported that methandrostenolone was favourable in its extremely marked protein-anabolic effect. The ratio of androgenic-anabolic protein effect, 1:0.43 with testosterone, rose to 1:1.76 when methandrostenolone was used.

Vilanova (1962) noted weight gains in 79 per cent of patients treated on the geriatric ward of a mental hospital. During the same period 61 per cent of the patients in the control group lost weight.

Desaulles (1960) observed that methandrostenolone exerted a similar action on the weight gains of male and female rats. This was unlike testosterone and its derivatives which exerted their greatest effect on males (Kochakian, 1950; Kochakian and Beall, 1950) and derivatives of nandrolone whose effects were primarily on females (Nimni and Geiger, 1957).

(iii) Androgenic Activity

The alleged superiority of methandrostenolone over other steroids that are used to promote muscle protein synthesis is its relative lack of androgenicity. CIBA (1960), working with castrated male rats and using the criterion of weight gains in the accessory sexual glands,

found the activity of methandrostenolone to be 1/100 times that of testosterone propionate and 1/17 that of 19-nor-17a-ethyl-testosterone. According to that test, methandrostenolone had a 4-8 times weaker action than testosterone propionate. Desaulles (1960), using the capon growth criterion, established the androgenicity of methandrostenolone as being 1/150 that of testosterone propionate, 1/70 that of methyl testosterone and 1/80 that of norethandrolone.

CIBA (1960) concluded that although methandrostenolone, testosterone propionate and 19-nor-17a-ethyl-testosterone produced distinct weight gains and that these substances could not be differentiated in this direction, the relative lack of androgenic effect displayed by methandrostenolone, even when given in large doses, made it distinct from the other substances. It is upon this relative lack of androgenicity that its claim of superiority over other anabolic agents is based.

(iv) Effects at Different Dosage Rates

In early reports, higher doses than are now seen to be necessary were used (Brancaccio et al., 1960; Guidi and Scardigli, 1960; Raymondi and Clausi-Schettini, 1960). Liddle and Burke (1960) showed increased nitrogen retention in rats with doses as low as 1.25 mg. daily and considered 2.5 mg. daily to be the most suitable dose for weight gain over a period of several months. Other authors (Beiglboeck

and Brummond, 1960; Martina et al., 1960; Misurale, 1960) obtained satisfactory results with doses ranging from 10 to 20 mg. daily, although most of their patients originally received much higher doses.

With human subjects it was observed that individual sensitivity played a role in the manifestations of side-effects. Some female patients have been reported as receiving 50 to 100 mg. daily with no signs of virilization or menstrual difficulties (Brancaccio et al., 1960; Guidi and Scardigli, 1960; Foss, 1960) whereas others have shown side-effects on doses as low as 25 mg. daily (Beiglboeck and Brummond, 1960) and even 10 mg. daily (CIBA, 1960).

(v) Recommended Levels

CIBA (1960) recommended an average adult human dosage of methandrostenolone of from 5 to 10 mg. daily. When used in treating animal health problems, a daily rate of 10 mg. per 100 kg. liveweight was suggested for large animals (cattle, horses, pigs).

The producers have suggested that methandrostenolone can bring about weight gains when used as a feed additive for poultry, as well as for cattle and pigs. These weight gains were especially correlated with protein synthesis. However, independent reports on its use in this capacity are almost non-existent. When used as a feed additive in poultry rations, the producers have

recommended levels of 1.0 to 2.5 mg. per kg. of feed.

B. EARLY-WEANING RATIONS FOR PIGS

a. Early-weaning and its Advantages

It is customary for most animal husbandmen to leave piglets with their dams for at least 56 days following their birth. Within recent times, however, there has been a growing trend towards the shortening of this period to two or three weeks and to artificially rear the piglets, on a ration containing protein supplements of high biological value, for the remainder of the eight weeks. This is called the early-weaning of piglets.

Although early-weaning was tried and advocated by Green et al. (1947) it is still not widely practised. Compared with the method which is more often used, there are many advantages, according to Braude as cited by Hammond (1954), to be derived from early-weaning.

1. More pigs are reared per litter through reduction of losses and saving of surplus pigs.
2. Pigs are heavier and more uniform in weight at eight weeks of age.
3. An adequate amount of food for each pig results in a minimum of runts being produced.
4. No setbacks as experienced during normal suckling when lactation yield decreases.
5. The production of more than two litters per sow per year.

6. A complete control of the ingredients of the starter ration results in the optimal supply of nutrients to the young pig.
7. Better disease control.
8. No necessity for additional feeding of sows during the lactation and hence a decrease in the production costs.
9. A great saving in cost and labour in cases of sows giving birth to a very small litter.
10. Earlier marketing of sows.

Where satisfactory management procedures are practised, therefore, early-weaning offers the possibility of rearing a greater number of bigger and, according to Lucifero (1959), more cheaply produced pigs per sow per year.

b. Influence of Weight at Weaning on Eight-week Weight of Pigs

With a great amount of attention being given to the problems associated with the early-weaning of pigs, much emphasis is being placed on age at weaning, which may vary from two to twenty-one days instead of the customary fifty-six days. The result has been that age has become the determining factor in the early-weaning of pigs. Some workers, however, have reported that weight at weaning plays a much greater part than does age. Weaning at seven to ten days of age or a minimum weight of five pounds has been suggested by Speer et al. (1954).

Jensen et al. (1956) reported that each additional pound of pig weight at weaning (12 to 14 days of age) resulted in two additional pounds at 42 or 56 days. This work is in agreement with that of Teter and Hanson (1959) who, working with four breeds of pigs, showed that for each additional pound of pig weight at three weeks, an increase of approximately 2.4 pounds in eight-week weight may be expected. Over a period of three years, these workers also observed that the variation in the three-week weight accounted for from 48.2 per cent for the Chester White to 76.8 per cent for the Poland China of the variation in eight-week weight of pigs weaned at three weeks. These results were much higher than those reported by Donald (1939) where variation in three-week weights of suckling pigs accounted for 22 per cent of the variation in eight-week weight. Sewell and Maner (1960), in growth studies, found that winter-farrowed pigs gained faster than summer-farrowed pigs. This, they concluded, was due to the heavier weight at three weeks of age for the winter-farrowed pigs. Using correlation coefficients on weight values between the ages of three and eight weeks, Teter and Hanson (1959) showed that the weight at three weeks of age is very important in determining eight-week weight.

c. The Digestive Ability of the Young Pig

Observations indicate that the new-born pig is restricted by its lack of fully developed enzyme systems and is thus unable to efficiently make use of certain feed constituents. It has been found that, prior to eight weeks of age, significant changes in digestive secretions occur in the pig.

Work reported by Lewis et al. (1955), Peo (1956) and Combs et al. (1963) demonstrates that the performance of piglets fed all plant protein rations does not approach that of pigs fed milk protein. Lewis et al. (1955) attributed the poor utilization of soya protein to a lack of adequately developed proteolytic and amylolytic enzyme systems. This theory is supported by enzyme assays of piglets' digestive organs presented by Bailey et al. (1956), Kitts et al. (1956), Lewis et al. (1957) and Hudman et al. (1957), and also by digestibility studies reported by Lloyd and co-workers (1957). Combs et al. (1963) agreed with the latter workers who demonstrated that the pigs' ability to digest various nutrients improved as the pig progressed from three to seven weeks of age.

Other reasons for decreased digestibility in the young pig have also been given. Maner et al. (1962), in agreement with Osmon et al. (1957), reported that when soybean protein was fed to four-week old pigs it caused a

buffering action which delayed the activation of pepsinogen secreted by the chief cells of the gastric glands. Maner and associates (1962) concluded that the buffering action would also delay or prevent the aggregation of the protein which may be involved in proper digestion by the pig. Braude et al. (1958) reported the presence of a hard cheese-like clot in the stomach of the young pig during the suckling period.

Reports (Monson et al., 1950; Harper et al., 1953; Monson et al., 1954; Register and Peterson, 1958) indicate that the type of carbohydrate fed with the protein may also play an important part in the utilization of the protein. Monson et al. (1950) observed that rations with dextrin pass more slowly through the intestinal tract than those with sucrose. Geiger (1951) stated that proteins which remain in the intestinal tract longer promote better growth and amino acid utilization.

Although the new born pig is unable to satisfactorily utilize certain feed constituents within the first four weeks of life, there is sufficient development of the enzyme systems associated with digestion to allow it to utilize most feeds. Further development before the age of seven weeks enables it to efficiently digest nutrients from all common sources of feed ingredients.

d. Early-weaning Rations

The removal of piglets from their dam, when early-weaning is practised, necessitates the provision of a substitute to meet the animals' nutritional requirement which, under normal circumstances, would have been provided by the sow's milk.

Early work reported the satisfactory growth of piglets, weaned at one day of age, on both cow's milk (Green et al., 1947) and on milk diets supplemented with minerals and cod-liver oil (Weybrew et al., 1947; Anderson and Hogan, 1950). On the whole, cow's milk did not prove to be a suitable substitute for sow's milk, and because of the stringent sanitary requirements that were necessary when whole milk was used, the search began for a suitable substitute.

Johnston et al. (1948) and Lehrer et al. (1949) were among those who produced milk substitutes. These diets elicited satisfactory growth but they introduced the problems of labour of preparation and the thorough cleaning of utensils to prevent the "souring" of residual milk. Another objectionable feature was the addition of fats or oils to some of these diets. This ingredient, by reason of its physical nature, further complicated the problem of keeping feeding equipment acceptably clean.

Crampton and Ness (1954) proposed the weaning of piglets at ten days rather than 48 hours and the feeding

of a dry, self-fed ration that would eliminate the disadvantages experienced with liquid rations. They proposed a 30 per cent protein content for satisfactory rates of gain. Using liquid diets, Reber et al. (1953) and Sewell et al. (1953) reported a protein requirement of 35 per cent and 32 per cent, respectively. The protein content of the rations, therefore, was in line with that of sow's milk which was shown by Bowland et al. (1949) and Heidebrecht et al. (1951) to be 35 per cent on a dry matter basis.

Since protein supplements are much more costly than basal feeds, these ingredients are not only of nutritional but also of economic importance in ration formulation. It was therefore necessary to limit this constituent to the minimum amount that would allow optimum growth rate and feed efficiency.

Recent studies have shown no evidence in support of the high levels of protein that were previously used. Jensen et al. (1957) recorded fastest gains with a 17 per cent ration while Peo et al. (1957) observed maximum gains when a 20 per cent protein ration was fed. A study by Lloyd and Crampton (1958a) indicated that a protein level of 26 per cent in early-weaning rations was as satisfactory as one of 30 per cent. In subsequent trials they showed that a 22 per cent protein ration was not inferior to one containing 30 per cent protein (Lloyd

and Crampton, 1958b). Concluding further work, they suggested a level of 24 per cent crude protein in rations for pigs weaned before six weeks of age. This ration is at present recommended by the Quebec Feed Board (1962) to farmers in this province.

Within recent times the electronic computer has been used in the formulation of least-cost early-weaning rations (Bowland, 1962b; Lloyd et al., 1962). The nutritional value of rations formulated with this instrument are not supposed to be different in any way, from those compounded by the older method of "hand" computation. However, shortcomings in our present knowledge of animal requirements limit its universal acceptance as the "final word" in ration formulation.

e. Electronic Computation

Using high-speed electronic computers and the relatively new mathematical field of linear programming, it is now possible to overcome many of the physical problems formerly associated with formulating least-cost, nutritionally adequate rations from a wide number of available feeds. First discussed by Waugh (1951), little interest in its use developed until the publication of the work of Hutton et al. (1958).

The potential reduction in cost per ton of feed (Lloyd et al., 1962; Bowland, 1962; Potter et al., 1962) is sufficient to make the use of electronic computation

highly desirable in the formulation of livestock diets. For this reason, it has already gained limited acceptance by commercial feed manufacturers (Bowland, 1962).

The difficulties encountered in the calculation of a large linear programming problem using hand, or even a desk calculator are so enormous that it is almost impossible to make this technique practical without the aid of an electronic computer. Although there are many possible solutions to a series of linear equations, only one yields the formula for the least-cost ration.

A prerequisite in the use of an electronic computer is a "programme" of machine instructions for solving linear programming problems. Although there are several types of programmes which may be used, there is a limitation in that a particular machine may only be suitable for a specific type of programme. In programming the data the following information must be supplied in the matrix:

1. The minimum and/or maximum amount of each nutrient required in the final ration.
2. The nutrient composition of each ingredient used in the formulation.
3. The cost of all ingredients at the point of mixing.
4. Restrictions and qualifications for ingredients and nutrients may have to be added.
5. Some ingredients, for example common salt, may be

added at a constant level and need not be incorporated in the programme. This reduces the number of variables and hence the cost of programming.

It should be borne in mind that the solution of a linear programming problem is no better than the values which enter into its construction. This fact places emphasis on the accuracy in the values used for the nutrient composition of ingredients (Potter, 1962; Lloyd et al., 1962).

There are only a few reports on the use of electronically computed early-weaning rations. From work done at the University of Alberta, Bowland (1962) concluded that, although the rations used were not of the type that a nutritionist would usually formulate for pig starters, they did give good results, demonstrating the role that linear programming could play in ration formulation. He warned, however, that although a formulated ration may meet the existing recommended requirements it may not necessarily give good results when fed to animals.

At Macdonald College (McGill University), Lloyd et al. (1962) noted a statistically significant difference in feed efficiency in favour of a specific computed ration for early-weaned pigs. These workers presumed that the net increased feed efficiency of this ration was in some way related to a better balance of nutrients. In further trials they compared modified computed rations with a

proven control ration. Only in the case of the control and a ration computed on the basis of an increased variety of feed ingredients available for selection, was feed efficiency of an acceptably high order. On the basis of these findings, they concluded that (1) present feeding standards do not describe optimum rations for early-weaned pigs, or (2) ration nutrient source or physical form is of nutritional significance for pigs of this age, or (3) the rations used did not provide nutrients at the estimated levels.

f. The Use of Sweetening Agents

One of the problems associated with the early-weaning of pigs is to obtain adequate feed intake, especially during the immediate post-weaning period. Husbandmen who practise early-weaning are aware that, because of this inadequate intake, most animals make very little gain in the period just after weaning, and in many cases there may be a loss of weight. The sudden change to a feed to which the animal is not accustomed may be one reason for the sub-optimum intake.

Maintaining a satisfactory level of intake, therefore, is important in order to prevent early setbacks in the animal's growth. Lloyd and Crampton (1961) noted that often more feed is consumed by early-weaned pigs between six and eight weeks of age than between two and six weeks of age. To increase feed consumption, particularly during the first four weeks

following weaning, efforts have been aimed at increasing both the nutritional adequacy and the acceptability of early-weaned rations. Increasing acceptability has been accomplished through the addition of sweetening agents.

Preference studies have shown that piglets prefer a ration containing a sweetening agent to one without (Lewis et al., 1955; Jensen et al., 1955; Aldinger et al., 1959; Krüger et al., 1960; Grinstead et al., 1961). The commonly used sweetening agents are sucrose, saccharin and molasses.

In studies conducted by Jensen et al. (1955), pigs offered choices of different levels of sucrose and 0.05 per cent saccharin consumed nine times as much of a 20 per cent sucrose ration as of the ration containing saccharin. Hanson et al. (1954) conducted three preference trials with three-week-old pigs offering rations containing no sucrose, 10 per cent sucrose and saccharin equivalent to 10 per cent sucrose in sweetness. The pigs preferred the ration containing 10 per cent sucrose. Other workers (Legagneur et al., 1956; Combs and Wallace, 1959, Grinstead et al., 1961) have also reported a preference for the 10 per cent sucrose level.

Lewis et al. (1955) and Diaz et al. (1956) reported that both gain and feed efficiency were improved as the level of sucrose in starter rations was increased from 0 to 15 per cent. Aldinger et al. (1961) comparing sucrose

and saccharin, obtained maximum gains on a ration containing one pound saccharin per ton. They also observed that pigs two weeks old showed greater response to saccharin than pigs four weeks old.

Becker and Terrill (1954) reported that livability and weight gains of new born pigs fed sucrose were unsatisfactory, and attributed this to their lack of ability to hydrolyze the glycosidic bond of sucrose. They found, in contrast to the new born pig, the weanling pig utilized sucrose efficiently, but had difficulty utilizing lactose when fed at a level of 50 per cent of the diet. However, Danielson et al. (1957) demonstrated that the baby pig could satisfactorily utilize whey (70 per cent lactose) when fed at a level of 71 per cent of the diet. Hudman (1956), as reported by Aldinger et al. (1961) found that lactose at a level of 49 per cent was the carbohydrate of choice of the baby pig.

Wiggins (1950) showed that cane molasses may contain as much as 30 per cent sucrose; consequently it may also be used as a sweetening agent in early-weaning rations. Willett et al. (1946) reported no significant difference in the feed consumption of pigs between a control ration containing 10 per cent raw cane sugar and one containing 10 per cent molasses. Above 20 per cent of molasses they observed a lowered consumption which they attributed to the resulting bitter taste and the

physical nature of the food. Their results, in agreement with those of Husby (1941), indicated that the maximum level of molasses that would allow satisfactory gain and efficient feed utilization was 20 per cent. On the basis of their results, these workers favoured the use of molasses instead of cane sugar because of its relative cheapness.

C. MUSCLE FIBRE DIAMETER

a. Effect of Age on Muscle Fibre Diameter

Hammond and Appleton (1932) and Joubert (1956) showed that with age the diameter of the muscle fibre increased in Suffolk rams. McMeekan (1940-41), working with pigs, observed the same effect. A gradual increase in fibre diameter with increasing age was noted for the *longissimus dorsi* muscle by Tuma *et al*. (1962).

b. Effect of Sex Hormones on Muscle Fibre Diameter

More recent attempts have been made to explain muscular development on an endocrinological basis. Papanicolaou and Falk (1938) reported that general muscular hypertropy can be induced experimentally by injections with testosterone propionate into castrated males or spayed female guinea pigs. Progesterone and estrogen will not produce this effect. Hence it was concluded that androgenic compounds have an activating

effect on muscle fibre development.

c. Effect of Muscle Fibre Diameter on Meat Quality

Since muscle fibres constitute more than three-fourths the entire volume of muscle, Wang et al. (1956) asserted that obviously they are important in any consideration of tenderness. The size of muscle fibres and muscle bundles as related to tenderness has been investigated by several workers. Satorius and Child (1938) noted that both texture and tenderness scores correlated significantly with the diameter of muscle fibres and the number of fibres per bundle. This work agrees with that done by Brady (1937). Hiner et al. (1953) also reported that meat having small fibres is more tender than meat having large fibres.

III. OBJECT OF RESEARCH

The objectives of this research were:

1. To determine, in a preliminary trial, the most advantageous level of methandrostenolone to be used in a subsequent growth trial using early-weaned pigs.
2. To determine, in a main trial, the effect of the addition of a specific level of methandrostenolone (level to be determined in preliminary trial) upon:
   (a) Growth, feed intake and feed efficiency by early-weaned pigs fed a variety of rations.
   (b) Apparent digestibility of ration components by early-weaned pigs.
   (c) Nitrogen retention by pigs at different stages of growth.
   (d) Muscle fibre diameter in 200-pound pigs.
3. To examine the effect of the addition of sweetening agents on the acceptability of electronically computed, least-cost rations for early-weaned pigs.

IV. PRELIMINARY DOSAGE TRIAL

A. EXPERIMENTAL PROCEDURE

a. General

The preliminary trial was conducted to observe the effect of different levels of an androgen, methandrostenolone, on the growth of early-weaned pigs. Thus, the most advantageous level to be used in a subsequent growth trial using pigs from three to nine weeks of age was determined.

This trial was carried out using a 4 x 2 factorial design, the variables being sex and four levels of androgen treatment: 0, 0.5, 1.0 and 1.5 mg. methandrostenolone per kg. feed.

b. Animals

A total of 32 cross-bred Yorkshire x Landrace pigs, farrowed in the Macdonald College herd and divided equally as to sex, were weaned and placed on test at an average age of 21.8 days. This trial consisted of a 42-day feeding period during which the pigs were penned

individually in a suitably heated building. Both the allocation of pig to pen and feed to pig were done on a random selection basis (Table 1). At the end of the six-week feeding period, four animals, two males and two females, from each treatment were chosen at random and fed through to 200 pounds liveweight (Table 2).

Table 1. Allotment of Pigs: 6-week Feeding Period.

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	4	4	4	4
F	4	4	4	4

Table 2. Allotment of Pigs: Beyond 6-week Feeding Period.

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	2	2	2	2
F	2	2	2	2

c. Rations

During the six-week feeding period all animals on test received the standard Quebec Feed Board (Q.F.B.) early-weaning pig ration (Table 3). The composition of the Vitamin-Mineral-Antibiotic (V-M-A) Supplement included in the ration varied according to the levels of androgen

Table 3. (A) Physical Composition of Rations Fed (from 3 to 9 weeks of age (%))*
(B) Physical Composition of Vitamin-Mineral-Antibiotic (V-M-A) Supplements (indicating amounts in gm. in a 5 kg. mix)
(C) Androgen Content of Rations (mg. methandrostenolone per kg. feed)

Ration Ingredients	RATIONS			
	1	2	3	4
(A)				
Wheat	19.30	19.28	19.25	19.23
Oat groats	30.00	30.00	30.00	30.00
Soy bean oilmeal	9.00	9.00	9.00	9.00
Skim milk powder	14.00	14.00	14.00	14.00
Fishmeal	9.00	9.00	9.00	9.00
Brewer's yeast	5.00	5.00	5.00	5.00
Molasses	10.00	10.00	10.00	10.00
V-M-A Supplement	3.70	3.72	3.75	3.77
(B)				
Ground limestone	3197	3178	3158	3139
Salt (NaCl)	544	542	538	534
Ferrous Sulphate	167	166	165	164
Riboflavin (16 gm./lb.)	0.55	0.54	0.54	0.54
Pyridoxine	0.55	0.54	0.54	0.54
Pantothenic acid (32 gm./lb.)	1.09	1.08	1.08	1.07
Vitamin A (250,000 I.U./gm.)	2.32	2.30	2.29	2.27
Vitamin D (1654 I.U./gm.)	54	54	54	53
Vitamin B_{12} (20 mg./lb.)	17	16	16	16
Cr_2O_3	340	338	336	334
Danabol (0.22%)	-	31	61	91
Bacifern	676	672	668	664
(C)	0	0.5	1.0	1.5

* All rations were computed to be equal in total crude protein (24%) and digestible energy (1700 Cals./lb.) and contained adequate amounts of all other nutrients known to be required by the early-weaned pig.

treatment to which the animals were assigned. Those pigs which remained on test to 200 pounds liveweight received a 16% protein ration to 120 pounds (Table 4) and a 14% protein ration from 120 pounds to 200 pounds (Table 5).

Chromic oxide was incorporated in the early-weaning ration to the extent of approximately 0.25% of the ration dry matter content for the determination of digestion coefficients according to the method of Schürch et al. (1952).

d. Management

(i) Housing

Early-weaned animals were penned in individual cages which were set up in a one-tier, "battery style" arrangement in a suitably heated building. Each cage, approximately 4 feet by 2 feet by 2 feet in measurement, had a solid steel floor, partly solid sides, and a heavy steel wire covering. One-half of the floor was covered with a movable slab of flat board and this represented the sleeping area. A heat lamp was suspended, at a suitable height, over the board and this kept the sleeping area both dry and warm. Attached to the front of each pen were feed and water troughs.

Excreta and spilled feed were removed from the cages at least once a day during the six-week feeding period.

At the end of the first six weeks, those animals

Table 4. (A) Physical Composition of 16% Protein Ration Fed (from 9 weeks of age to 120 lb. liveweight (%))
(B) Physical Composition of Vitamin-Mineral-Antibiotic (V-M-A) Supplements (indicating amounts in gm. in a 5 kg. mix)
(C) Androgen Content of Rations (mg. methandrostenolone per kg. feed)

Ration Ingredients	RATIONS			
	1	2	3	4
(A)				
Ground corn	79.75	79.73	79.70	79.68
Soy bean oilmeal	15.50	15.50	15.50	15.50
Fishmeal	3.00	3.00	3.00	3.00
V-M-A Supplement	1.75	1.77	1.80	1.82
(B)				
Ground limestone	2856	2820	2784	2749
Salt (NaCl)	1428	1410	1392	1375
Vitamin A (250,000 I.U./gm.)	0.40	0.40	0.40	0.40
Vitamin D (1654 I.U./gm.)	34.20	33.75	33.35	32.90
Riboflavin (16 gm./lb.)	7.10	7.00	6.90	6.85
Pantothenic acid (32 gm./lb.)	17.80	17.55	17.35	17.15
Vitamin B_{12} (20 mg./lb.)	85	84	83	82
DL-Methionine	571	564	557	550
Danabol (0.22%)	-	64	127	188
(C)	0	0.5	1.0	1.5

Table 5. (A) Physical Composition of 14% Protein Ration Fed (from 120 lb. liveweight to slaughter (%))
(B) Physical Composition of Vitamin-Mineral-Antibiotic (V-M-A) Supplements (indicating amounts in gm. in a 5 kg. mix)
(C) Androgen Content of Rations (mg. methandrostenolone per kg. feed)

Ration Ingredients	RATIONS			
	1	2	3	4
(A)				
Ground corn	85.25	85.23	85.20	85.18
Soy bean oilmeal	10.00	10.00	10.00	10.00
Fishmeal	3.00	3.00	3.00	3.00
V-M-A Supplement	1.75	1.77	1.80	1.82
(B)				
Ground limestone	2856	2820	2784	2749
Salt (NaCl)	1428	1410	1392	1375
Vitamin A (250,000 I.U./gm.)	0.40	0.40	0.40	0.40
Vitamin D (1654 I.U./gm.)	34.20	33.75	33.35	32.90
Riboflavin (16 gm./lb.)	7.10	7.00	6.90	6.85
Pantothenic acid (32 gm./lb.)	17.80	17.55	17.35	17.15
Vitamin B_{12} (20 mg./lb.)	85	84	83	82
DL-Methionine	571	564	557	550
Danabol (0.22%)	0	64	127	188
(C)	0	0.5	1.0	1.5

kept on to 200 pounds were each moved to larger individual pens. Each pen, approximately 9 feet by 3.5 feet by 3.5 feet in size, had solid wooden sides, a concrete floor and an open top. They were all equipped with a feeding trough and an automatic watering font. A bedding of wood shavings was provided in each pen. These larger pens were cleaned out as often as it was thought to be necessary.

(ii) Feeding Practice

Pigs received all rations ad libitum in dry form, and water was available at all times.

(iii) Feed Mixing

All rations were prepared in two stages. In the first stage the "micro" constituents, which formed the vitamin-mineral-antibiotic supplement, were well mixed to form a premix. A fixed quantity of this premix was then added to the "macro" components of the ration and the whole thoroughly mixed. The resulting mixture formed the ration that was fed to the animals.

e. Collection Period

One representative feces sample was collected daily for each pig during the sixth week of the trial. All feces samples were placed in DIXIE® plastic coated paper cups,[1] tightly covered and immediately stored in a freezer.

[1] Dixie Cup Co. of Canada, Brampton, Ontario, Canada.

At the end of the collection period, they were dried at 100° C. for 24 hours, composited for each pig and finely ground for chemical analysis.

f. Records

All pigs were weighed at the beginning of the trial and weekly thereafter throughout the experiment. Feed consumption per week and waste feed, usually damp spillage, were also recorded.

g. Chemical Analyses

All feed and feces samples were analyzed for moisture, ash, crude protein and ether extract according to A.O.A.C. methods (1960). Because the crude fibre content of all rations was negligible, the total carbohydrate was determined by difference. The gross energy values were determined using a Parr Oxygen Bomb calorimeter (Parr, 1960) fitted with an automatic recording device (Crampton et al., 1954). Chromic oxide determination on all samples was carried out according to the method of Christian and Coup (1954).

h. Calculations

The average daily gain and average daily feed consumption, as well as the feed efficiency expressed as average daily gain adjusted statistically to equal feed intake, were calculated for each pig during the early-weaning period.

The apparent digestion coefficients of crude protein, ether extract, total carbohydrate, dry matter and gross energy were computed by the chromic oxide index method. The apparent digestibility of each nutrient was calculated by the formula:

Digestibility =

$$100 - \left(100 \frac{\%\ \text{indicator in feed}}{\%\ \text{indicator in feces}} \times \frac{\%\ \text{nutrient in feces}}{\%\ \text{nutrient in feed}}\right)$$

(i) Statistical Analysis of Data

Analyses of variance were carried out on all data obtained using standard analytical procedures (Goulden, 1952). Differences among treatment means were evaluated according to the procedure outlined by Duncan (1955).

B. RESULTS

a. Growth and Feed Consumption

The average daily gain and feed consumption for each pig during the six-week feeding period is given in Appendix Tables I and II, respectively. Analyses of variance carried out on these data are shown in Appendix Tables III and IV. Summarized below in Table 6 are the effects of the different treatments on average daily gain, average daily feed consumption and average daily gain adjusted to equal feed intake.

Table 6. Summary of the main treatment effects on gain, feed consumption and feed efficiency by 32 pigs fed an early-weaning ration between three and nine weeks of age.

Criterion Tested	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
Ave.daily gain (gms.)	369[a]	346[a]	398[a]	356[a]
Ave.daily feed consumption (gms.)	755[a]	669[a]	734[a]	703[a]
Adjusted ave.daily gain (gms.)	355[a]	362[a]	391[a]	360[a]

Figures in rows having the same superscript are not significantly ($P > 0.05$) different.

Inspection of this table reveals that although the 1.0 mg. level of androgen encouraged the highest average daily gain, either unadjusted or adjusted to equal feed intake, its effect was not significantly different from those of the other levels of androgen. The 0 mg. level of androgen elicited the highest average daily feed consumption but this was not significantly different from those of the other treatments. The effects of the different levels of androgen on gain and feed consumption during the six-week feeding period are illustrated graphically in Figures 1 and 2.

Compared with the 0 mg. and 1.0 mg. levels, both the 0.5 mg. and the 1.5 mg. level exhibited a trend towards decreased average daily gain and average daily feed consumption. Although feed consumption was not

FIGURE 1. The effect of different levels of methandrostenolone on the cumulative weight gains of 32 early-weaned pigs over a six-week period.

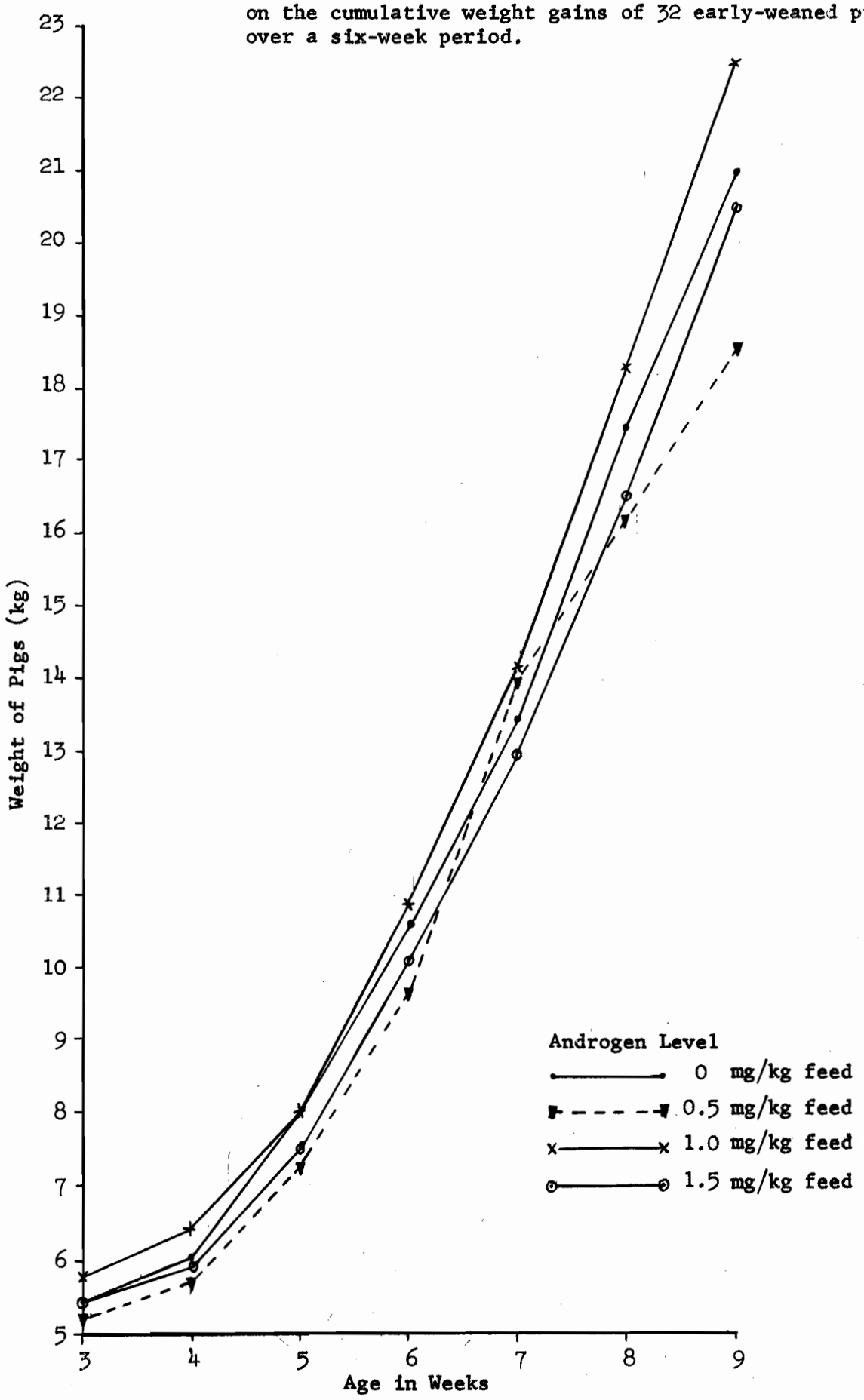
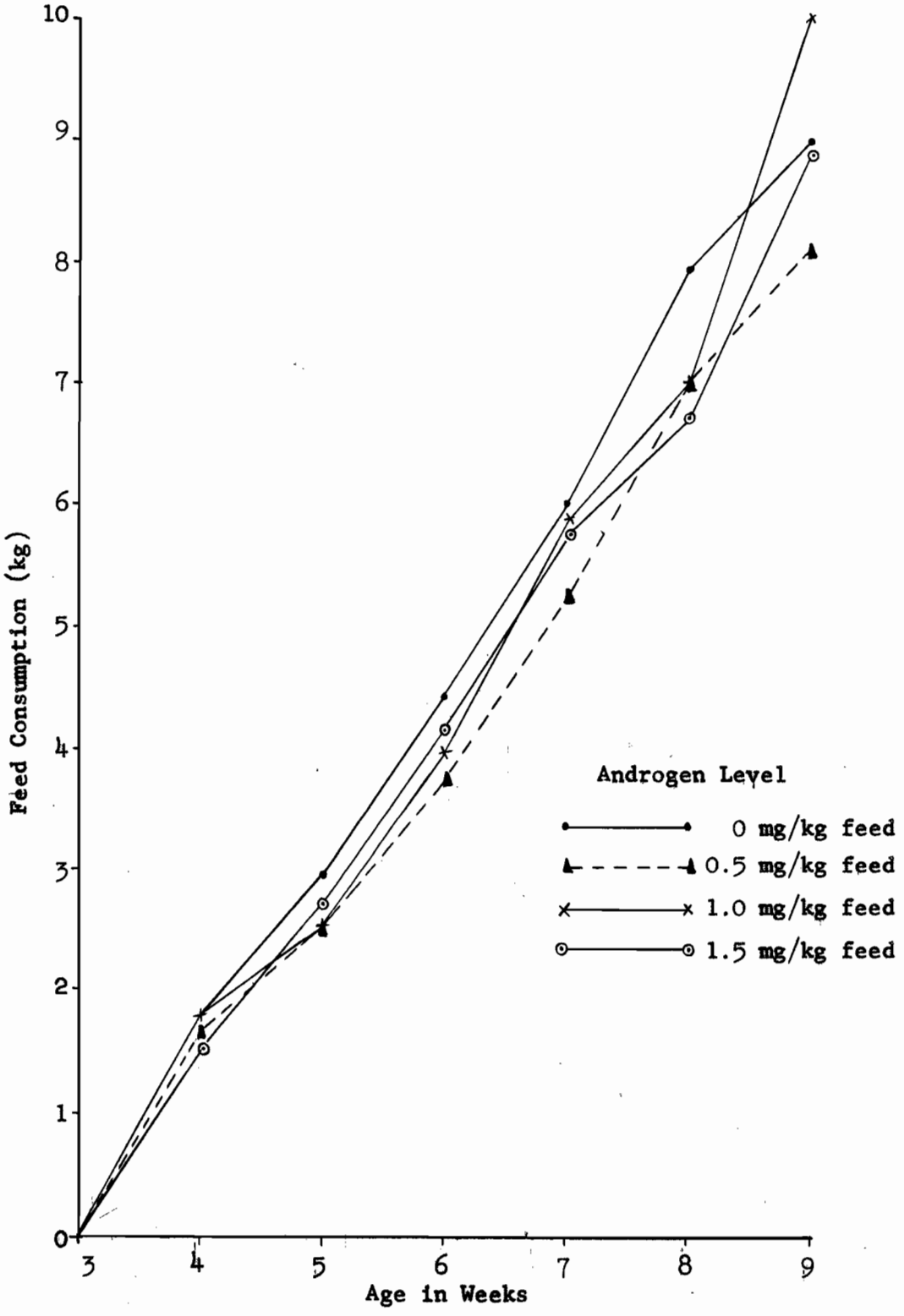


FIGURE 2. The effect of different levels of methandrostenolone on the cumulative feed consumption of 32 early-weaned pigs over a six-week period.



decreased significantly by androgen inclusion, in all cases except for the 1.0 mg. level, it tended to parallel a decrease in gain.

Neither sex nor the interaction between androgen and sex was statistically significant (Appendix Tables III and IV).

The data for those animals kept after the conclusion of the six-week feeding period were grouped into four stages, namely, 3-9 weeks; 9 weeks - 120 pounds; 120 pounds - 200 pounds and 3 weeks - 200 pounds. The average daily gain and average daily feed consumption for these stages are given in Appendix Tables V to XII. Analyses of variance carried out on these data are shown in Appendix Tables XIII to XX.

The effect of androgen level on average daily gain, average daily feed consumption and average daily gain adjusted to equal feed intake for each stage, are summarized in Tables 7 to 10.

Table 7. Summary of the main treatment effects on gain, feed consumption and feed efficiency by 16 pigs fed an early-weaning ration between three and nine weeks of age.

Criterion Tested	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
Ave.daily gain (gms.)	377[a]	341[a]	410[a]	349[a]
Ave.daily feed consumption (gms.)	732[a]	693[a]	717[a]	674[a]
Adjusted ave.daily gain (gms.)	365[a]	346[a]	404[a]	362[a]

Figures in rows having the same superscript are not significantly ($P > 0.05$) different.

Table 8. Summary of the main treatment effects on gain, feed consumption and feed efficiency by 16 pigs fed a 16% grower ration between nine weeks of age and 120 pounds liveweight.

Criterion Tested	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
Ave.daily gain (lb.)	1.18[a]	1.23[a]	1.43[a]	1.34[a]
Ave.daily feed consumption (lb.)	3.73[a]	3.72[a]	4.00[a]	3.91[a]
Adjusted ave.daily gain (lb.)	1.24[a]	1.29[a]	1.35[a]	1.30[a]

Figures in rows having the same superscript are not significantly ($P>0.05$) different.

It is seen in Tables 7 and 8 that androgen level had no effect on either average daily gain, average daily feed consumption or adjusted average daily gain during either the three-to-nine-weeks or the nine-weeks-to-120-pounds stage. Sex did not produce any significant difference in gains (Appendix Tables XIII and XV). However, males showed a significantly ($P<0.05$) greater feed consumption (Appendix Table XVI), although this difference was not sufficient to give any significance to gains when the latter was adjusted to equal feed intake (Table 8).

The analyses of variance (Appendix Tables XVII and XVIII) of average daily gain and average daily feed consumption for the 120-pound to 200-pound stage, showed that androgen had no effect on either of these criteria. Use of the Multiple Range Test (Duncan, 1955), however,

indicated significant differences between treatments for both the average daily feed consumption and the adjusted average daily gains (Table 9). The average daily feed consumption for animals on the 1.0 mg. level was significantly ($P<0.05$) lower than that for animals on the 0 mg. level, and this difference was sufficient to give significance when gains were adjusted to equal feed intake.

Table 9. Summary of the main treatment effects on gain, feed consumption and feed efficiency by 16 pigs fed a 14% finisher ration between 120 pounds liveweight and slaughter.

Criterion Tested	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
Ave.daily gain (lb.)	1.90^{a}	1.60^{a}	1.71^{a}	1.84^{a}
Ave.daily feed consumption (lb.)	7.61^{a}	6.34^{ab}	6.02^{b}	6.39^{ab}
Adjusted ave.daily gain (lb.)	1.03^{a}	1.81^{b}	2.19^{c}	2.01^{bc}

Figures in rows having the same superscript are not significantly ($P>0.05$) different.

The three-weeks to 200-pound stage represents a combination of the three growth periods: 3-9 weeks; 9 weeks - 120 pounds; 120 pounds - 200 pounds. The analyses of variance (Appendix Tables XIX and XX) indicated that androgen had no effect on either average daily gain or average daily feed consumption. With reference to Appendix Table XX, both sex and the interaction between androgen and sex were significant ($P<0.05$).

In spite of this difference in average daily feed consumption between the sexes, the Multiple Range Test (Duncan, 1955) revealed no differences between androgen levels for this criterion (Table 10). On the other hand, it showed that the 0.5 mg. level of androgen elicited significantly ($P < 0.05$) lower average daily gains than the other levels. When gains were adjusted to equal feed intake the 1.0 mg. and the 1.5 mg. levels of androgen were significantly ($P < 0.05$) higher than the 0 mg. and the 0.5 mg. levels.

Table 10. Summary of the main treatment effects on gain, feed consumption and feed efficiency by 16 pigs fed various rations between three weeks of age and slaughter.

Criterion Tested	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
Ave.daily gain (lb.)	1.28^a	1.21^b	1.35^a	1.32^a
Ave.daily feed consumption (lb.)	4.23^a	3.94^a	3.95^a	3.93^a
Adjusted ave. daily gain (lb.)	1.23^a	1.23^a	1.36^b	1.34^b

Figures in rows having the same superscript are not significantly ($P > 0.05$) different.

The effects of the different levels of androgen on gain and feed consumption during the period from nine weeks to 200 pounds are graphically illustrated in Figures 3 and 4.

FIGURE 3. The effect of different levels of methandrostenolone on the cumulative weight gains of 16 pigs during the growing and finishing periods.

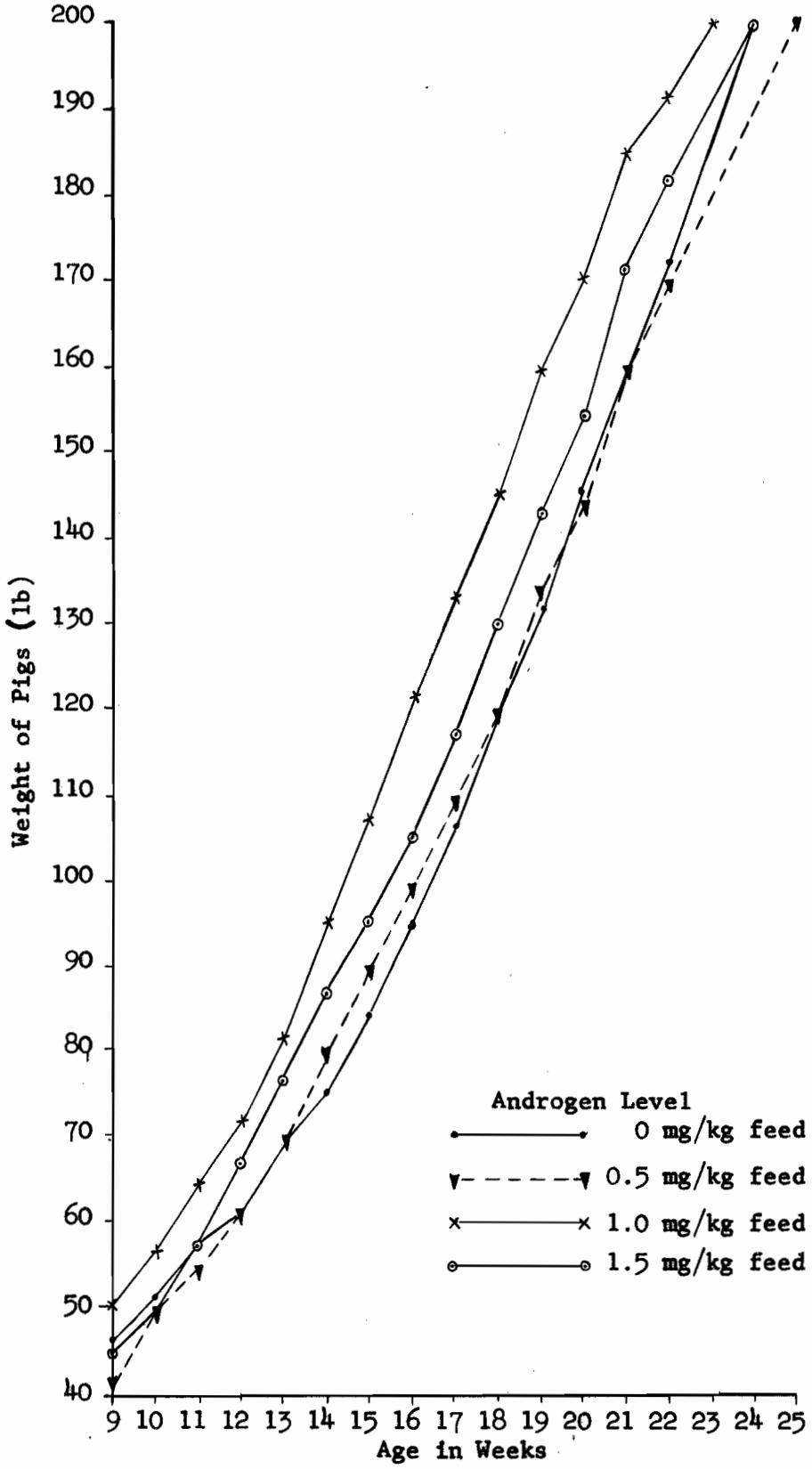
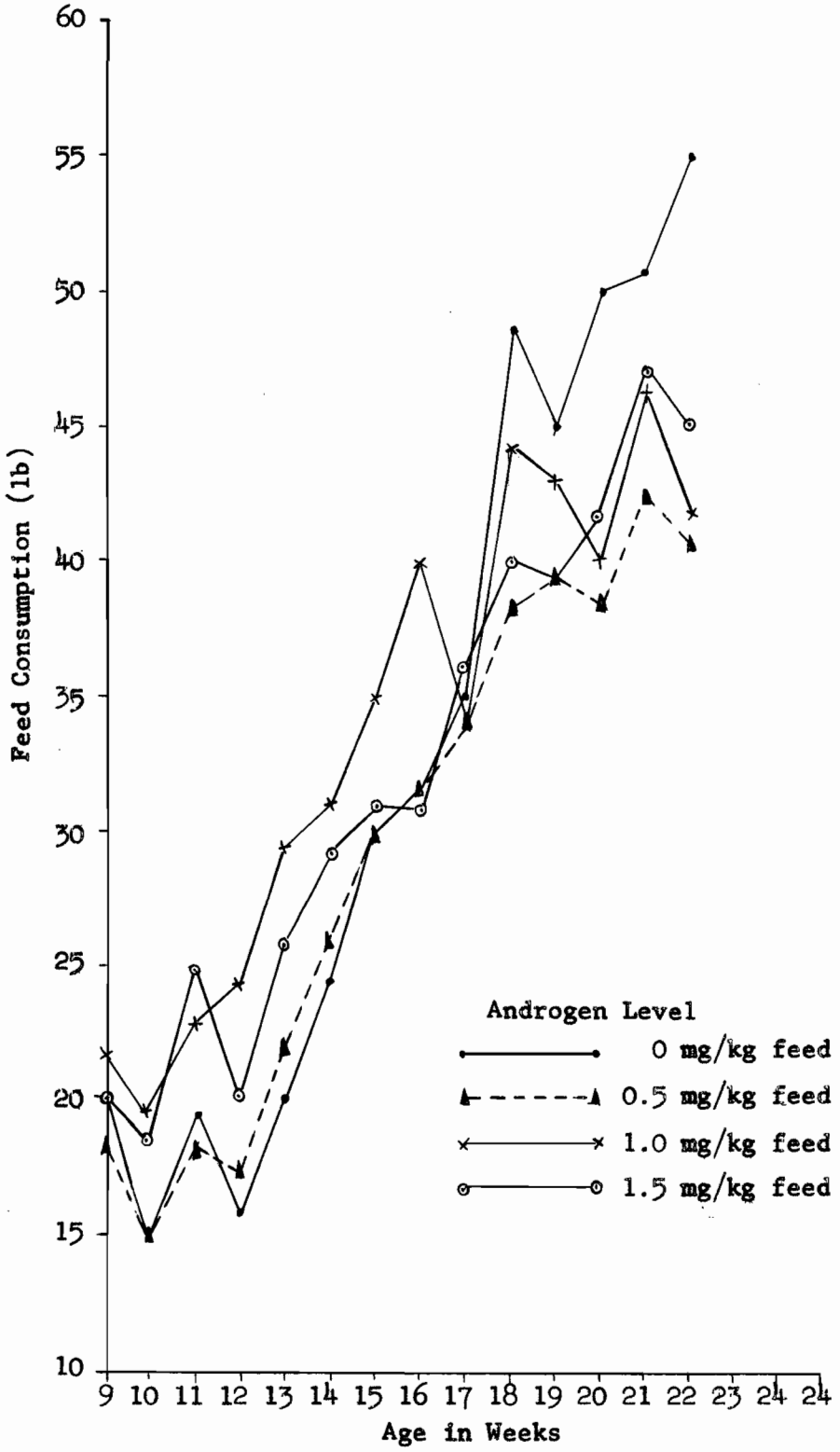


FIGURE 4. The effect of different levels of methandrostenolone on the cumulative feed consumption of 16 pigs during the growing and finishing periods.



b. Digestibility

The percentage composition of crude protein, ether extract, total carbohydrate, dry matter and gross energy in the rations fed are given in Appendix Table XXI. The digestibility coefficients of these constituents are stated in Appendix Tables XXII to XXVI. Analyses of variance carried out on these data are shown in Appendix Tables XXVII to XXXI.

The effects of androgen level on the crude protein, ether extract, total carbohydrate, dry matter and gross energy apparent digestibility coefficients are summarized in Table 11.

Table 11. Summary of the main treatment effects on various digestibility coefficients by 32 pigs fed on early-weaning rations between three and nine weeks of age.

mg. methandrostenolone per kg.feed	No. of Pigs	Mean apparent digestibility coefficients (D.M. Basis)				
		Crude protein	Ether extract	Total carbohydrate	Dry matter	Gross energy
0	8	78[a]	67[ab]	89[a]	81[a]	82[a]
0.5	8	74[a]	65[a]	87[a]	78[a]	79[a]
1.0	8	80[a]	73[b]	89[a]	81[a]	83[a]
1.5	8	76[a]	72[ab]	88[a]	78[a]	80[a]

Figures in columns having the same superscript are not significantly ($P > 0.05$) different.

It is seen in this table that, when the Multiple Range Test (Duncan, 1955) was applied, androgen level had no effect on the apparent digestibility coefficients of crude protein, total carbohydrate, dry matter or gross energy. The apparent digestibility coefficient of the ether extract fraction for those animals kept on the 0.5 mg. androgen level was significantly ($P<0.05$) lower than that for animals kept on the 1.0 mg. level.

None of the digestibility coefficients showed any significant differences due to sex. Also, the interaction between androgen and sex was not statistically significant for any of the coefficients tested.

C. DISCUSSION

a. The Six-week Feeding Period - Three to nine weeks of age

This trial was undertaken to determine the effect of the inclusion of the androgen, methandrostenolone, in the ration of pigs, from 3-9 weeks of age. Four different levels - 0 mg., 0.5 mg., 1.0 mg. and 1.5 mg. per kilogram feed - were fed to four groups of early-weaned pigs. Each group containing eight animals, divided equally as to sex, was fed a ration containing only one level of androgen for the duration of the trial.

The results show that none of the different levels of androgen was really effective in increasing daily

gains, daily feed consumption or feed efficiency (adjusted daily gains) during the period from 3-9 weeks of age. It is possible that the number of animals used in this trial may have been too small to overcome inherent differences between animals and still satisfactorily elucidate any differences in the effect of different dosages on growth.

A closer examination of the data reveals that the 1.0 mg. per kilogram of feed level induced the largest daily gains, a slightly reduced daily feed consumption, and had the highest figure when gains were adjusted to equal feed intake. On the basis of the rate of gain, therefore, the results of this test tend to suggest this level as the most satisfactory of the treatments used. However, although it exhibits a trend which may represent a superiority over the other levels, we must nevertheless remember that it was not statistically proven to be significantly different from the other treatments.

An inspection of Figure 1 reveals that animals on the 1.0 mg. level of treatment were, on the average, initially heavier than animals on the other treatments. It is also seen that the groups maintained basically the same relative positions, as far as weights were concerned, from the beginning to the end of the experiment.

Jensen et al. (1956) reported that each additional pound of pig weight at weaning (12 to 14 days of age) resulted in two additional pounds at 42 or 56 days. This

work was in agreement with that of Teter and Hanson (1959) who, working with four breeds of pigs, showed that for each additional pound of pig weight at three weeks, an increase of approximately 2.4 pounds in eight weeks may be expected.

Although the figures obtained in this trial cannot be interpreted in the same light as those previously mentioned, it was observed that additional poundage at weaning did produce extra weight at 56 days of age. The increase in weight was somewhat higher than those reported by the aforementioned workers. A range of 5.1 pounds to 10.6 pounds, with an average of 6.8 pounds, at 56 days for each additional pound at weaning was noted. Under the circumstances, it would be expected that the extra weight observed was due to the effect of androgen on the growth rate of the animals. However, the total weight increase per additional pound of pig at weaning appeared to bear a direct relationship to weight at weaning, and was in no apparent way connected to the level of androgen fed.

Except for the ether extract fraction of the diet, androgen level did not have any effect on the apparent digestibility of the nutrients. In spite of the differences obtained for the ether extract fraction, the total percentage of this constituent in the ration was so small that its increased utilization by the animals on any

treatment was not expected to make significant contributions to their rate of growth. It is of interest to note that the utilization of nutrients by animals bore, in general, a direct relationship to growth rate.

One-half of the original animals were kept on to 200 pounds liveweight to determine the effect of continued treatment on growth at different stages. Over the three to nine weeks stage, the 16 animals selected for further study exhibited the same general response as did the 32 animals initially put on trial.

b. The Growing Period - Nine weeks to 120 pounds liveweight

During this period the trend was basically the same as that shown by the preceding period. Androgen level had no significant effect on any of the criteria measured.

c. The Finishing Period - 120 to 200 pounds liveweight

No significance was noted between androgen treatments for average daily gains. However, differences in average daily feed consumption between androgen levels resulted in significant differences when daily gain was adjusted to equal feed intake. These differences in feed consumption were apparently caused by a repression in intake which was effected by certain levels of the androgen. The reason for this is not known. It is possible though, that the slower growing androgen-fed pig

may require less energy for body maintenance and hence voluntarily reduces its feed intake. Working with rats that were injected daily with testosterone propionate, Kochakian and Webster (1958) theorized that losses in body weight were due primarily to a reduction in subcutaneous and abdominal fat with an accompanying decrease in appetite.

d. The Combined Growing Periods - Three weeks to 200 pounds liveweight

A combination of all the growing periods showed that the androgen-fed pigs had the lowest level of feed intake. With the exception of the 0.5 mg. level, however, this did not appear to have any effect on the daily gains.

e. General

The main effect of the androgen, methandrostenolone, in this trial seemed to be a trend towards a reduction in the daily feed consumption, as exemplified during the periods from 3-9 weeks of age, 120 pounds liveweight to slaughter, and 3 weeks of age to slaughter. With the exception of the 1.0 mg. level of the androgen, there was a tendency for this reduction of intake to be accompanied by a decrease in gain.

Some workers have reported growth depression resulting from different levels of androgen. Kochakian et al. (1950) noted that when rats were injected over a period of three months with either 0.125 or 1.0 mg. of

testosterone propionate, they showed an initial increase in growth rate which was followed by a depression. This effect was slightly evident for pigs on the 0.5 mg. level especially between six and nine weeks of age, (Figure 1). Levels of 0.015 mg. of methyl testosterone per kilogram body weight when fed to pigs by Noland and Burris (1956) were found to have a growth depressing effect on females, while the gain of males was unaffected.

It is possible that the levels of androgen used in this trial were not high enough to bring about increased weight gains, or that different levels of androgen are required at the various stages to induce increased rates of growth.

A major shortcoming of this trial was the method used for androgen dosage. The results might have been more satisfactory if levels of androgen had been adjusted to the weight of the animal rather than to a kilogram of feed. Using the latter system as was done in this trial, heavier animals eating more feed would have a higher androgen intake than their lighter counterparts with smaller appetites. It may be argued, however, that these differential intake levels, at least in part, solved the problem of adjusting androgen level to the weight of the animal.

The results obtained from this preliminary trial did not show that any of the levels of androgen used were

significantly superior in their ability to promote growth in pigs. In spite of this, the 1.0 mg. per kilogram of feed level appeared to have certain qualities which made it stand out when compared with the other treatments, i.e., the highest average daily gain and feed efficiency. Since the original objective of this experiment was to determine the best level of androgen for use in further growth trials, the comparatively good results of the 1.0 mg. level of androgen made it the obvious choice for subsequent use.

V. MAIN GROWTH TRIAL

A. EXPERIMENTAL PROCEDURE

a. General

Two computed rations that were found to elicit satisfactory feed efficiencies in previous trials in this laboratory (Lloyd et al., 1962), along with modifications of them based on an improvement in acceptability and/or texture, were fed.

There were two modifications of a computed ration used in the initial trial of this series (Lloyd et al., 1962 - Computed ration 1). In one case the amount of molasses was increased, and in the other sucrose was included. Three modifications of a second computed ration (Lloyd et al., 1962 - Computed ration 3), originally based on an increased variety of feed ingredients available for selection by the computer, were also fed. In one the molasses content was increased, and in the other two, sucrose and skim milk powder were added, respectively. These seven rations were compared with a proven ration,

developed at Macdonald College, and which was used as a standard in the trials reported by Lloyd et al. (1962).

To observe the anabolic effect of methandrostenolone, half of the pigs on trial received this hormone at the rate of 1.0 mg. per kg. of feed.

The main trial took the form of an 8 x 2 x 2 factorial design, the factors being ration, androgen treatment and sex, respectively. The effect of methandrostenolone on nitrogen balance was determined by nitrogen retention studies on a limited number of pigs at different stages of growth between 40 and 200 pounds liveweight, i.e. early-weaning, growing and finishing stages. These pigs were slaughtered at 200 pounds liveweight and samples taken from the longissimus dorsi muscle of each pig for subsequent histological examination.

b. Animals

A total of 96 Yorkshire x Landrace pigs, farrowed in the Macdonald College herd and divided equally as to sex, were weaned and placed on test at an average age of 23.7 days in three replicates. Each replicate of 32 pigs consisted of a six-week feeding period during which the pigs were penned individually in a suitably heated building. Both the allocation of pig to pen and feed to pig were done on the basis of random selection (Table 12).

At the conclusion of the six-week feeding period in each replicate, the four pigs, two males and two

Table 12. Allocation of pigs within replicates for main growth trial.

Androgen Treatment	Sex	RATIONS							
		1	2	3	4	5	6	7	8
		No. of Pigs							
Nil	M	1	1	1	1	1	1	1	1
	F	1	1	1	1	1	1	1	1
Plus	M	1	1	1	1	1	1	1	1
	F	1	1	1	1	1	1	1	1

females, that had been receiving the control ration were used in nitrogen balance studies (Table 13). A total of 12 pigs were used and observations were made between 45 and 60 pounds, 60 and 120 pounds, and 120 and 200 pounds liveweight. During the collection periods the pigs were confined in individual digestion crates, adapted for feces and urine collection.

Table 13. Allocation of pigs within replicates for balance trial.

Sex	Androgen Treatment	
	Nil	Plus
M	1 pig	1 pig
F	1 "	1 "

c. Rations

The rations fed were as follows:

1. The currently recommended Q.F.B. early-weaning pig ration.
2. Computed ration 1, used by Lloyd et al. (1962).
3. A modification of Ration 2, in which the molasses content was raised from 5 to 10 per cent.
4. A modification of Ration 2, in which 5 per cent sucrose was included in the ration.
5. Computed ration 3, used by Lloyd et al. (1962).
6. A modification of Ration 5, in which the molasses content was raised from 5 to 10 per cent.
7. A modification of Ration 5, in which 5 per cent sucrose was included in the ration.
8. A modification of Ration 5, in which 4 per cent skim milk powder was included in the ration.

The relevant composition of these rations is shown in Table 14. All rations were computed to be equal in total crude protein (24%) and digestible energy (1700 Cals./lb.), and contained adequate amounts of all other nutrients known to be required by the early-weaned pig. On the basis of the results of the preliminary dosage trial, 1.0 mg. of methandrostenolone per kg. feed was added to the rations fed to half of the animals in each replicate. This made, therefore, a total of 16 rations, namely 8 with and 8 without androgen.

Table 14. (A) Physical Composition of Rations Fed in Main Growth Trial (%).*

(B) Physical Composition of Vitamin-Mineral-Antibiotic (V-M-A) Supplements (indicating amounts in gm. in a 5 kg. mix).

(C) Androgen Content of Rations (mg. methandrostenolone per kg. feed).

Ration Ingredients	RATIONS															
	1	1a	2	2a	3	3a	4	4a	5	5a	6	6a	7	7a	8	8a
(A)																
Wheat	19.80	19.80	34.00	34.00	29.00	29.00	29.00	29.00	20.51	20.51	15.51	15.51	15.51	15.51	18.55	18.55
Oat groats	30.00	30.00	24.81	24.81	24.81	24.81	24.81	24.81	39.32	39.32	39.32	39.32	39.32	39.32	39.32	39.32
Soybean oilmeal	9.00	9.00	26.58	26.58	26.58	26.58	26.58	26.58	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Linseed Oilmeal	-	-	-	-	-	-	-	-	5.03	5.03	5.03	5.03	5.03	5.03	5.03	5.03
Skim milk powder	14.00	14.00	3.86	3.86	3.86	3.86	3.86	3.86	-	-	-	-	-	-	4.00	4.00
Fishmeal	9.00	9.00	-	-	-	-	-	-	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62
Meatmeal	-	-	3.94	3.94	3.94	3.94	3.94	3.94	3.00	3.00	3.00	3.00	3.00	3.00	0.96	0.96
Brewer's yeast	5.00	5.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Molasses	10.00	10.00	5.00	5.00	10.00	10.00	5.00	5.00	5.00	5.00	10.00	10.00	5.00	5.00	5.00	5.00
Sucrose	-	-	-	-	-	-	5.00	5.00	-	-	-	-	5.00	5.00	-	-
V-A-M supplement	3.20	3.20	1.81	1.81	1.81	1.81	1.81	1.81	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.52
(B)																
Ground limestone	3197	3158	1269	1242	1269	1242	1269	1242	-	-	-	-	-	-	-	-
Salt (NaCl)	544	538	1197	1172	1197	1172	1197	1172	1647	1606	1647	1606	1647	1606	1647	1606
Ferrous sulphate	167	165	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riboflavin (16 gm./lb.)	0.55	0.54	3.35	3.28	3.35	3.28	3.35	3.28	6.92	6.75	6.92	6.75	6.92	6.75	6.92	6.75
Pyridoxine	0.55	0.54	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pantothenic Acid (32 gm./lb.)	1.09	1.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vitamin A (250,000 I.U./gm.)	2.32	2.29	1.56	1.53	1.56	1.53	1.56	1.53	2.34	2.28	2.34	2.28	2.34	2.28	2.34	2.28
Vitamin D (1654 I.U./gm.)	54	54	30	29	30	29	30	29	44	43	44	43	44	43	44	43
Vitamin B_{12} (20 mg./lb.)	17	16	93	91	93	91	93	91	93	91	93	91	93	91	93	91
Methionine	-	-	623	610	623	610	623	610	738	720	738	720	738	720	738	720
Cr_2O_3	340	336	598	585	598	585	598	585	824	803	824	803	824	803	824	803
Bacifern	676	668	1185	1160	1185	1160	1185	1160	1645	1604	1645	1604	1645	1604	1645	1604
Danabol (0.22%)	-	61	-	108	-	108	-	108	-	128	-	128	-	128	-	128
(C)	0	1.0	0	1.0	0	1.0	0	1.0	0	1.0	0	1.0	0	1.0	0	1.0

*All rations were computed to be equal in total crude protein (24%) and digestible energy (1700 cals./lb.), and contained adequate amounts of all other nutrients known to be required by the early-weaned pig.

Animals on the balance trial received the early-weaning control ration up to 60 pounds liveweight (Table 14, Rations 1 and 1a), a 16 per cent protein ration from 60 to 120 pounds liveweight (Table 4, Rations 1 and 3) and a 14 per cent protein ration from 120 to 200 pounds liveweight (Table 5, Rations 1 and 3).

Chromic oxide was incorporated in the early-weaning rations to the extent of approximately 0.25 per cent of the ration dry matter content for use in the calculation of digestion coefficients according to the method of Schürch et al. (1952).

d. Management

(i) Housing

The pigs were housed in the same manner as described for the preliminary dosage trial (see page 41).

Due to the ability of the pig to retain bits of shavings in the alimentary tract for long periods of time, it was necessary to dispense with the bedding for a period of at least two weeks prior to nitrogen balance studies. It is believed that the solid particles became lodged in the caecum and were only expelled in small quantities by sudden contractions at irregular intervals.

(ii) Metabolism Crates

Two types of crates were used for nitrogen balance studies. For pigs on the early-weaning ration, circular

steel mesh crates, of diameter approximately 3 feet and a height of 2.5 feet, were used. Over the top of each cage a steel mesh lid was tightly fitted. Cages used for the larger pigs were rectangular in shape and measured approximately 5 feet by 2 feet by 2.5 feet. In these, the back, the top and one side were all adjustable.

Each crate was fitted with a single trough into which was placed the moistened feed. All crates were adapted for feces and urine collection.

(iii) Feeding Practice

Pigs received the early-weaning rations ad libitum in dry form, and water was available at all times. In the balance trial, although pigs were fed enough to satisfy their maintenance needs, they received just less than appetite in order to ensure a "clean" consumption of the offered feed. The daily ration was fed as a thin gruel, and was divided equally between morning and evening feedings.

Before being placed on balance trials, pigs were kept for at least 3 weeks on the test ration, i.e. early-weaning, growing or finishing ration. This was to allow for a complete removal of the remains of the previous ration fed from the alimentary tract and to allow the animal to become accustomed to the new ration.

(iv) Feed Mixing

All rations were prepared in the same manner as described for the preliminary dosage trial (see page 44).

e. Collection Period

During the sixth week of the main growth trial, feces samples were collected in the same way as described for the preliminary dosage trial (see page 44).

For each of the nitrogen retention studies, the collection period lasted for five days, following a preliminary feeding period of at least seven days. Collections were only begun when the animal could rapidly dispose of its feed allocation in a short period of time. For pigs on the early-weaning ration, feces aliquot (approximately two per cent by weight) and urine aliquot (one per cent by volume) were taken daily during the collection period. Complete feces collection and urine aliquots (one per cent by volume) were made for those animals on the growing and on the finishing rations (see Appendix, pages A1 and A2).

f. Records

Records were made throughout the main growth trial in the same manner as described for the preliminary dosage trial (see page 45).

g. Chemical Analyses

Chemical analyses done on samples collected during the main growth trial were the same as those described for the preliminary dosage trial (see page 45).

h. Histological Investigation

At the completion of the balance trial, the animals were slaughtered and samples were obtained from the longissimus dorsi muscle of the right loin opposite the seventh rib. A 1-cm. cube, approximately, was cut from the centre of the muscle and immediately placed in 10% formalin for storage. At the end of the collection period, two samples from each section were placed on separate slides and the muscle fibres carefully teased apart. Fifty microscopic measurements of muscle fibre diameters, 25 from each slide, were then made for each pig.

i. Calculations

Calculations done on values obtained during the main growth trial were the same as those described for the preliminary dosage trial (see page 45).

In the balance trial, the calculation of nitrogen intake and excretion over the test period enabled the determination of nitrogen retention.

j. Statistical Analysis of Data

Analyses of variance were carried out on all data obtained using standard analytical procedures (Goulden, 1952). Differences among treatment means were evaluated according to the procedure outlined by Duncan (1955).

B. RESULTS

a. Growth and Feed Consumption

The average daily gain, average daily feed consumption and average feed efficiency (daily gain adjusted to equal feed intake) of each pig are given in Appendix Tables XXXII to XXXIV, respectively. The analyses of variance carried out on these data are shown in Appendix Tables XXXV to XXXVII.

The main treatment effects on average daily gain, average daily feed consumption and average feed efficiency are summarized in Tables 15 to 17.

Appendix Table XXXV shows that androgen had no effect on the average daily gains. However, highly significant ($P < 0.01$) responses were evoked by rations and the interaction between sex and rations. The average daily feed consumption, unaffected by the level of androgen present in the feed (Appendix Table XXXVI), was significantly ($P < 0.05$) different between the rations. Here too, the interaction between sex and ration was significant ($P < 0.05$).

Table 15. Summary of the main treatment effects on gain, feed consumption and feed efficiency.

Rations	Androgen	No. of Pigs	Average Daily gain (gms.)	Average Daily Feed Consumption (gms.)	Adjusted Average Daily Gain (gms.)
1	Nil	6	393.7^{a}	821.8^{a}	329.7^{a}
	Plus	6	363.7^{ab}	731.7^{abc}	343.3^{a}
2	Nil	6	266.3^{e}	578.8^{d}	292.0^{a}
	Plus	6	271.8^{de}	570.3^{d}	300.0^{a}
3	Nil	6	333.0^{abcd}	775.2^{ab}	299.7^{a}
	Plus	6	331.0^{abcd}	645.3^{bcd}	336.5^{a}
4	Nil	6	299.3^{bcde}	660.2^{bcd}	300.8^{a}
	Plus	6	347.5^{abc}	688.2^{abcd}	340.2^{a}
5	Nil	6	341.7^{abc}	657.3^{bcd}	343.7^{a}
	Plus	6	270.2^{de}	544.7^{d}	305.8^{a}
6	Nil	6	270.8^{de}	603.0^{cd}	289.2^{a}
	Plus	6	291.3^{cde}	649.0^{bcd}	295.7^{a}
7	Nil	6	295.7^{cde}	647.5^{bcd}	300.5^{a}
	Plus	6	365.0^{ab}	818.5^{a}	318.8^{a}
8	Nil	6	341.5^{abc}	640.3^{bcd}	333.5^{a}
	Plus	6	310.7^{bcde}	590.3^{cd}	332.5^{a}

Figures, in columns, having the same superscript are not significantly ($P > 0.05$) different.

Table 16. Summary of the effect of rations on gain, feed consumption and feed efficiency.

Rations	No. of Pigs	Average Daily Gain (gms.)	Average Daily feed Consumption (gms.)	Adjusted Average Daily Gain (gms.)
1	12	378.7[a]	776.8[a]	336.5[a]
2	12	269.1[b]	574.6[bcd]	296.0[a]
3	12	332.0[ab]	710.3[ab]	318.1[a]
4	12	323.4[ab]	674.2[abc]	320.5[a]
5	12	306.0[b]	533.0[d]	324.8[a]
6	12	281.1[b]	626.0[bcd]	292.4[a]
7	12	330.3[ab]	733.0[ab]	309.7[a]
8	12	326.1[ab]	615.3[bcd]	333.0[a]

Figures, in columns, having the same superscript are not significantly ($P > 0.05$) different.

Table 17. Summary of the overall effect of androgen administration on the criteria tested.

Criterion Tested	Androgen		Average
	Nil	Plus	
Average Daily Gain (gms.)	317.8[a]	318.9[a]	318.3[a]
Average Daily Feed consumption (gms.)	673.0[a]	654.8[a]	663.9[a]
Adjusted Average Daily gain (gms.)	311.1[a]	321.6[a]	316.4[a]

Figures, in rows, having the same superscript are not significantly ($P > 0.05$) different.

It is seen in Table 16 that, although the highest average daily gain was made by animals on Ration 1, this value was not significantly different from the gain made by animals on several of the other rations. The same holds true for the average daily feed consumption. When gains were adjusted to equal feed intake, rations had no significant effect.

In general, the presence of androgen had no effect, within rations, on any of the criteria measured (Table 15). The exceptions were Rations 5 and 7 in which the androgen brought about significant ($P < 0.05$) differences in gain, a decrease for Ration 5 and an increase for Ration 7. In the latter ration, feed consumption was also significantly ($P < 0.05$) increased.

Table 18 shows that the different amounts of

Table 18. Summary of the effect of sweetening agents on the cumulative criteria tested.

Sweetening Agents	Average Daily gain (gms.)	Average Daily feed Consumption (gms.)	Adjusted Average Daily gain (gms.)
5% Molasses (Rations 2, 5 & 8)	300.4[a]	574.3[b]	317.9[a]
10% Molasses (Rations 1, 3 & 6)	330.6[a]	704.4[a]	315.7[a]
5% Molasses + 5% Sucrose (Rations 4 and 7)	326.9[a]	703.6[a]	315.1[a]

Figures, in columns, having the same superscript are not significantly ($P > 0.05$) different.

sweetening agents had no significant effect on average daily gains, although animals on the 10% molasses and the 5% molasses + 5% sucrose rations gained slightly more weight than those on rations containing 5% of molasses. On the other hand, pigs on the 5% molasses rations consumed significantly ($P < 0.05$) less feed than those on the other rations. When gains were adjusted to equal feed intake there was no difference between any of the treatments.

When the results of the test rations were accumulated for Ration 2 plus its modifications and for Ration 5 plus its modifications (Table 19), the gain produced by the control ration was significantly ($P < 0.05$) higher

Table 19. Summary of the effect of the cumulative test rations on the criteria examined.

Test Rations	Average Daily gain (gms.)	Average Daily feed Consumption (gms.)	Adjusted Average Daily gain (gms.)
Control	378.7[a]	776.8[a]	336.5[a]
Ration 2 and its modifications	308.2[b]	653.0[a]	311.5[a]
Ration 5 and its modifications	310.9[b]	626.8[a]	315.0[a]

Figures, in columns, having the same superscript are not significantly ($P > 0.05$) different.

than that of either of the test rations. On the other hand, the test rations themselves were similar with respect to liveweight gains. Neither feed consumption nor feed efficiency, although numerically different, was statistically dissimilar between any of the three ration groups tested.

b. Digestibility

The percentage composition of crude protein, ether extract, total carbohydrate, gross energy and dry matter in the rations fed are given in Appendix Tables XXXVIII to XLII, respectively. The digestibility coefficients of these constituents are stated in Appendix Tables XLIII to XLVII, and the analyses of variance carried out on these

data are shown in Appendix Tables XLVIII to LII.

The main treatment effects on the crude protein, ether extract, total carbohydrate, gross energy and dry matter apparent digestibility coefficients are summarized in Tables 20 to 22.

Appendix Tables XLVIII to LII show that the presence of androgen had no effect on the apparent digestibility of any of the constituents of the ration. None of the digestibility coefficients showed any significant differences due to sex. Also, none of the interactions was statistically significant. There were no differences in the apparent digestibility of the constituents between rations, except in the case of the ether extract fraction where a significant ($P < 0.05$) difference was noted.

In Tables 20 and 21, the Multiple Range Test (Duncan, 1955) was applied to the average apparent digestibility coefficients for the different constituents of the rations. The presence of androgen had no effect, within rations, on any of the criteria measured, with the exception of the ether extract fraction of Ration 1 (Table 20. However, between rations, there were significant ($P<0.05$) differences in the digestibility of ether extract, total carbohydrate and dry matter (Table 21). With regard to the observed differences, there was no tendency for any particular ration to be either higher

Table 20. Summary of the main treatment effects on various digestibility coefficients.

Rations	Andro-gen	No. of Pigs	Mean Apparent Digestibility Coefficients (Dry Matter Basis)				
			Crude Protein	Ether Extract	Total Carbo-hydrate	Dry Matter	Gross Energy
1	Nil	6	79^{ab}	74^{ab}	88^{ab}	81^{abc}	82^{abc}
	Plus	6	79^{ab}	66^{cd}	88^{ab}	81^{abc}	82^{abc}
2	Nil	6	80^{ab}	63^{d}	88^{ab}	82^{abc}	81^{abc}
	Plus	6	77^{b}	64^{d}	84^{b}	79^{c}	78^{c}
3	Nil	6	81^{ab}	66^{cd}	87^{ab}	82^{abc}	82^{abc}
	Plus	6	79^{ab}	67^{bcd}	88^{ab}	82^{abc}	81^{abc}
4	Nil	6	80^{ab}	68^{bcd}	89^{ab}	83^{ab}	82^{abc}
	Plus	6	83^{a}	69^{abcd}	90^{a}	85^{ab}	84^{a}
5	Nil	6	81^{ab}	69^{abcd}	88^{ab}	82^{abc}	82^{abc}
	Plus	6	78^{ab}	71^{abc}	86^{b}	80^{bc}	80^{bc}
6	Nil	6	77^{b}	75^{a}	87^{ab}	80^{bc}	80^{bc}
	Plus	6	76^{b}	73^{abc}	88^{ab}	81^{abc}	80^{bc}
7	Nil	6	79^{ab}	71^{abc}	89^{a}	82^{abc}	82^{abc}
	Plus	6	76^{b}	71^{abc}	88^{ab}	81^{abc}	81^{abc}
8	Nil	6	79^{ab}	71^{abc}	88^{ab}	82^{abc}	81^{abc}
	Plus	6	76^{b}	69^{abcd}	85^{b}	79^{c}	79^{c}

Figures, in columns, having the same superscript are not significantly ($P > 0.05$) different.

Table 21. Summary of the effect of rations on various digestibility coefficients.

Rations	No. of Pigs	Mean Apparent Digestibility Coefficients (Dry Matter Basis)				
		Crude Protein	Ether Extract	Total Carbo-hydrate	Dry Matter	Gross Energy
1	12	79[a]	70[ab]	88[ab]	81[ab]	82[a]
2	12	78[a]	64[c]	86[b]	80[ab]	80[a]
3	12	80[a]	67[bc]	87[ab]	82[ab]	82[a]
4	12	81[a]	69[abc]	89[a]	84[a]	83[a]
5	12	80[a]	70[ab]	87[ab]	81[ab]	81[a]
6	12	77[a]	74[a]	87[ab]	80[ab]	80[a]
7	12	78[a]	71[ab]	89[a]	82[ab]	81[a]
8	12	77[a]	70[ab]	87[ab]	80[b]	80[a]

Figures, in columns, having the same superscript are not significantly ($P > 0.05$) different.

Table 22. Summary of the effect of androgen on the cumulative digestibility coefficients.

Androgen	No. of Pigs	Mean Apparent Digestibility Coefficients (Dry Matter Basis)				
		Crude Protein	Ether Extract	Total Carbo-hydrate	Dry Matter	Gross Energy
Nil	48	79[a]	70[a]	88[a]	82[a]	82[a]
Plus	48	78[a]	69[a]	87[a]	81[a]	81[a]
Average	96	79[a]	69[a]	88[a]	81[a]	81[a]

Figures, in columns, having the same superscript are not significantly ($P > 0.05$) different.

or lower in the apparent digestibility of any of its definable components.

c. Nitrogen Balance Trial

The percentage of crude protein in the rations fed are given in Appendix Table LIII. The percentages of nitrogen retained from the ration, retention of absorbed nitrogen, nitrogen excreted in the feces and nitrogen excreted in the urine are given in Appendix Tables LIV to LVII, respectively. The analyses of variance on these data are shown in Appendix Tables LVIII to LXI.

The main treatment effects on the criteria tested are summarized in Tables 23 and 24.

From Appendix Tables LVIII to LXI it is seen that the presence of androgen in the ration had no effect on

Table 23. Summary of the effect of androgen at different stages of growth on the criteria tested.

Criterion Tested	Androgen	No. of Pigs	Stages of Pig Growth			
			Early Weaning	Growing	Finishing	Average
% Nitrogen Retained from feed	Nil	6	44.0[a]	29.0[a]	26.5[a]	33.1[a]
	Plus	6	43.7[a]	31.9[a]	24.0[a]	33.2[a]
% Retention of Absorbed Nitrogen	Nil	6	51.3[a]	37.6[a]	32.7[a]	40.6[a]
	Plus	6	50.8[a]	41.0[a]	31.4[a]	41.0[a]
% Nitrogen in feces	Nil	6	26.9[a]	33.1[a]	27.7[a]	29.2[a]
	Plus	6	25.1[a]	33.1[a]	32.2[a]	30.1[a]
% Nitrogen in urine	Nil	6	73.1[a]	67.0[a]	72.4[a]	70.8[a]
	Plus	6	75.0[a]	66.9[a]	67.8[a]	69.9[a]

Comparison between Nil and Plus for each criterion tested, in each stage. Figures having the same superscript are not significantly ($P > 0.05$) different.

the retention or the excretion of nitrogen. As the animals increased in age, however, there was a decrease in the amount of nitrogen retained from the feed, this decrease being highly significant ($P < 0.01$) between the early-weaning and the subsequent stages. A consequence of this was a highly significant ($P < 0.01$) increase in the amount of nitrogen excreted in the urine.

Table 24. Summary of the effect of the stages of growth on the cumulative criteria tested.

Criterion Tested	No. of Pigs	Stages of Pig Growth			
		Early Weaning	Growing	Finishing	Average
% Nitrogen Retained from feed	12	43.9^{a}	30.4^{bc}	25.2^{c}	33.2^{b}
% Retention of Absorbed Nitrogen	12	51.0^{a}	39.3^{bc}	32.0^{c}	40.8^{b}
% Nitrogen in feces	12	26.0^{c}	33.1^{a}	29.9^{b}	29.7^{b}
% Nitrogen in urine	12	74.0^{a}	67.0^{c}	70.1^{b}	70.4^{b}

Figures, in rows, having the same superscript are not significantly ($P > 0.05$) different.

d. Muscle Fibre Measurement

Two samples from the longissimus dorsi muscle of each pig were placed on separate slides and the muscle fibres carefully teased apart. Fifty microscopic measurements of muscle fibre diameters, 25 from each slide, were made for each pig. Table 25 shows the effect of methandrostenolone on the distribution of muscle fibres of various diameters within the longissimus dorsi muscle of 200-pound pigs.

Tables 26 and 27 show that when androgen was fed there was a tendency for the muscle sample to contain a higher percentage of muscle fibres of smaller diameter.

Table 25. The effect of methandrostenolone on muscle fibre diameters in the longissimus dorsi of 200-pound pigs.

Androgen	No.of Pigs	Muscle Fibre Diameters in Microns										
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	over 100
Nil	6	-	1	36	42	58	49	44	41	23	5	2
Plus	6	-	1	31	53	93	64	35	16	7	1	-

Table 26. The effect of methandrostenolone on the occurrence of muscle fibres of specific diameters within the longissimus dorsi of 200-pound pigs.

Androgen	% Muscle Fibres at Various Measurements										
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	over 100
Nil	-	0.33	11.96	13.95	19.27	16.28	14.62	13.62	7.64	1.66	0.66
Plus	-	0.33	10.30	17.61	30.90	21.26	11.63	5.32	2.33	0.33	-

Table 27. The effect of methandrostenolone on the occurrence of muscle fibres of more or less than 60 microns within the longissimus dorsi of 200-pound pigs.

Androgen	% Muscle Fibres	
	Under 60 microns	60 microns and over
Nil	45.5	54.5
Plus	59.1	40.9

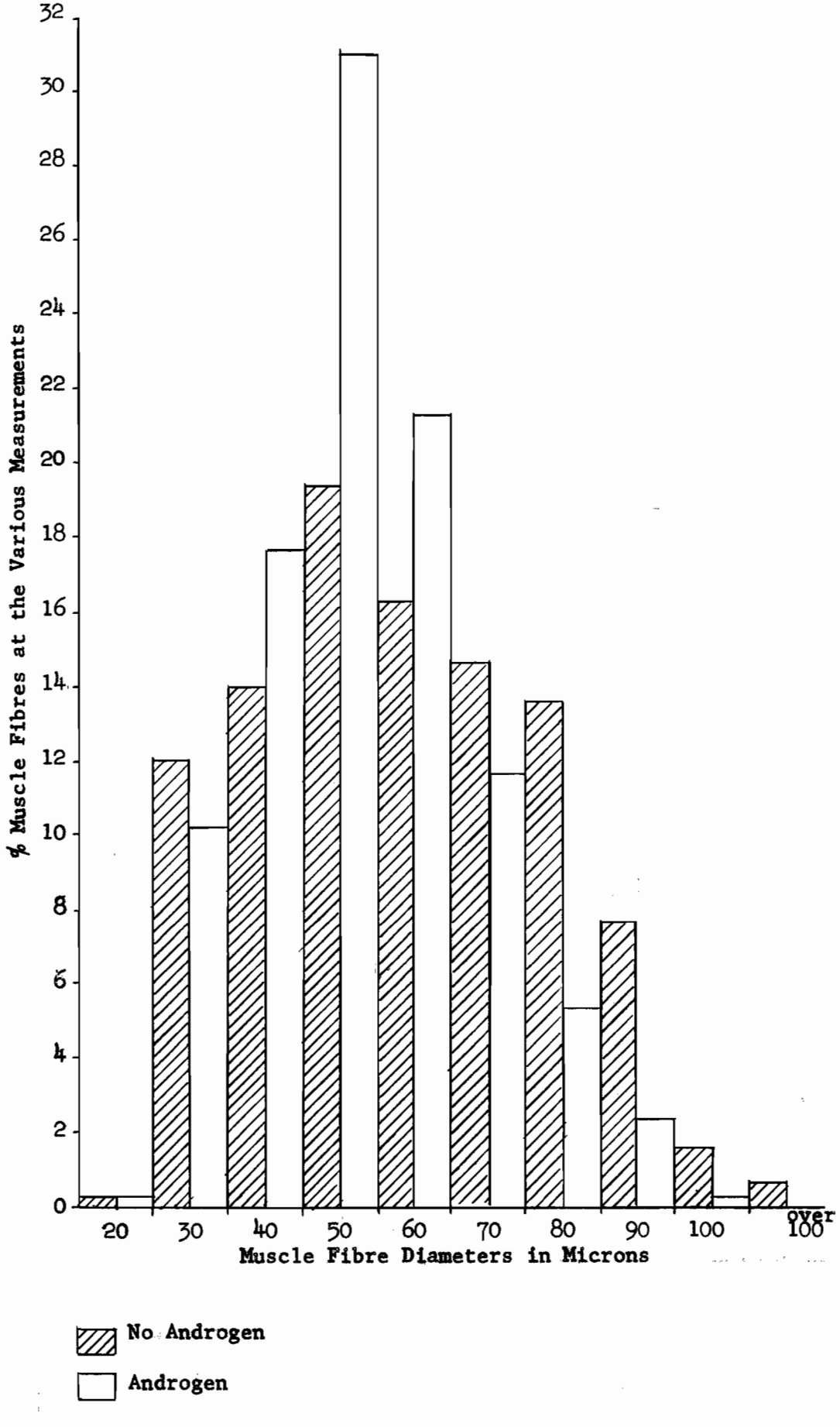
In the androgen-fed pigs 59.1% of the muscle fibres were below 60 microns in diameter as compared with 45.5% for the control animals (Table 27). The effect of methandrostenolone on muscle fibre diameters is illustrated graphically in Figure 5.

C. DISCUSSION

a. Growth, Feed Consumption and Digestibility

When considering individual rations, the presence of the androgen, methandrostenolone, resulted in most cases in a nonsignificant reduction in the daily intake of feed. In spite of this, however, there was no real difference in gains between the animals fed the rations with or without the androgen. This resulted in noticeably higher, though not significantly different, feed efficiency values for the androgen-fed pigs. It may be concluded,

FIGURE 5. The effect of methandrostenolone on muscle fibre diameters in 200 lb. pigs.



therefore, that the feed utilization exhibited by those animals on androgen was slightly better than that for the pigs receiving no hormone. This observation is in agreement with the work done on steers and heifers by Bogart et al. (1951) and Burris et al. (1952). However, most of the trials conducted with pigs have shown that androgen had no effect on either the rate of gain or the efficiency of feed utilization (Bratzler et al., 1954; Beeson et al., 1955; Noland and Burris, 1956; Semprini and Rappini, 1958; Thrasher et al., 1959; Whitaker et al., 1959; Hale et al., 1960). Growth depression has also been observed (Perry et al., 1956; Johnston et al., 1957).

Shay et al. (1941) reported a significant difference in growth response between the sexes to injections of testosterone propionate. They found that whereas female rats showed an increase in liveweight gains, males failed to respond to androgen treatment. In this trial no differential growth due to sex was displayed by the androgen-fed animals.

Although a higher efficiency of feed utilization was generally observable for those animals on the androgen-containing rations, these values were rarely significantly different within the same ration. In contrast, significant differences in weight gains ($P < 0.01$) and in feed consumption ($P < 0.05$) were noted between rations. Under the circumstances, therefore, a comparison between rations is highly justified.

One purpose of this trial was to attempt to increase the intake of rations that were already proven capable of inducing high levels of feed conversion when fed to early-weaned pigs. In previous trials, although these rations effected highly favourable feed efficiency values, they did not bring about adequate liveweight gains as their overall intake was lower than that for the control ration they were tested against. To increase their acceptability, and at the same time maintain high feed efficiency values, modifications were made in the amount of sweetening agents added. These factors were supposed to improve the acceptability by improving the flavour and/or the physical characteristics of the feed - for example, decreasing dustiness by the use of high levels of molasses. Ten per cent of molasses was included in the control ration as compared with the test rations, each of which contained one or other of the following sweetening agents - 5%, 10% molasses, 5% molasses + 5% sucrose.

The results of this experiment showed that, although animals on the 5% sucrose ration consumed significantly less feed than animals on the other treatments, the liveweight gains made by these animals, although less, were not significantly different from those for animals on the other rations. Since all the rations used in this trial were computed to contain the same quantities

of all the nutrients that are known to be required by the early-weaned pig, any differences observed might be ascribed to differences in the quantity of sweetening agents present in the ration.

Many workers (Lewis et al., 1955; Jensen et al., 1955; Aldinger et al., 1959; Kruger et al., 1960; Grinstead et al., 1961) have reported a preference by the baby pigs for rations containing a sweetening agent. In trials conducted by Hanson et al. (1954), in which pigs were fed rations containing various levels of sucrose and saccharin, they reported that pigs preferred a ration containing 10% sucrose. Previous to this Willett et al. (1946) noted no significant difference between a control ration containing 10% raw cane sugar and one containing 10% molasses. Above 20% of molasses they observed a lowered consumption which they attributed to the resulting taste and the physical nature of the food. From the results of the trial conducted by Willett and his associates (1946) one may conclude that 10% of cane sugar in the ration was equivalent to 10% of molasses. If this presumption is correct, a 5% sucrose + 5% molasses ration may also be equivalent to a 10% molasses or a 10% sucrose ration. Granting that this statement is also true, the reason why no differences were noted between the 10% molasses and the 5% molasses + 5% sucrose rations would be because they were equivalent to one another in degree

of sweetness, which resulted in similar intakes and hence similar liveweight gains. Also, since pigs preferred a 10% sucrose ration (Hanson et al., 1954) and according to the findings of Willett et al. (1946), there are no significant differences between a ration containing 10% of sucrose and one containing 10% of molasses, and if the presumption that these two rations are equivalent is correct, then the findings of this trial are in agreement with those of Hanson et al. (1954). In this experiment both the 10% molasses and the 5% molasses + 5% sucrose rations were consumed to a greater extent than the 5% sucrose rations.

In spite of this, it is well to remember that although the highest gains were made by those animals in the 5% molasses + 5% sucrose rations (Table 18), the liveweight gains on all treatments were statistically similar. Despite the fact that the degree of sweetness apparently contributed to the significant reduction recorded in the intake of the rations containing 5% of molasses, differences between rations may have also been due to the type and/or amount of specific feed ingredients in their composition.

A closer look at the composition of the rations fed shows that the major differences between the control and the test rations were that the former contained a higher percentage of skim milk powder, and 5% brewer's

yeast was included. Also noticeable was the higher percentage of animal protein contained in the control ration as compared with the test rations. It should be noted, again, that the test rations were computed for least cost and hence the higher proportion of the cheaper plant proteins.

Hays et al. (1959) reported that when dry skim milk served as the source of protein, the digestibility of dry matter and protein remained relatively constant as pigs increased in age from two to five weeks; but with soybean protein the digestibility increased with increasing age. Combs et al. (1963) noted that, when pigs were early-weaned, the maximum digestion of soybean meal, fish meal and dried skim milk occurred during the seventh to the eighth week of life. However, during the third to the fourth week and the fifth to the sixth week period, the digestibility of all fractions except ether extract was higher with the dried skim milk ration than either the soybean or fish meal ration. The ether extract digestibility during these periods was similar for the milk and fish meal rations.

According to the findings of Combs et al. (1963) it would be expected that animals on a skim milk ration would have a faster rate of growth during the early periods than those fed rations containing proteins from other sources. Also, since there are no significant

differences in the digestibility of proteins from different sources after the seventh week (Combs et al., 1963), the end result would be that pigs fed rations containing a high percentage of skim milk would be heavier at the end of an eight-week period than those on other types of rations. As the control ration contained a higher percentage of skim milk and less soybean oilmeal than the test rations did, it would be expected therefore, as did occur, that the animals on this ration would gain more weight than the animals on the test rations. In spite of the fact that the difference in liveweight gain between the rations based on the No. 2 formula and those based on the No. 5 formula was not significant, the numerical difference in favour of the No. 5 formula was probably due to the increased number of ingredients used in its computation and later preparation.

These differences in weight gain occurred even though the theoretical requirements of the pig were met in all rations that were fed. We may conclude from this that where early-weaning pig rations are to be computed electronically, it is necessary to provide the machine with information not only on the amount of nutrients that are required, but also on the type and/or amount of specific feed ingredients that should be supplied. This can be done by specifying minimum or maximum levels for such ingredients.

The inclusion of brewer's yeast in the control ration may have played some significant part in the superior performance of the animals on this feed.

Many workers (Hutchinson, 1952; Gard et al., 1955; Noland et al., 1955; Jeter et al., 1960; Plumlee et al., 1960; Gage et al., 1961), have recognized the presence of "Growth Promoting Factors" (GPF) in some constituents of livestock feed. The exact nature of these factors is not known. They may be trace elements, vitamins, or other factors as yet unknown which are necessary for satisfactory animal growth. Brewer's yeast, long recommended for addition to pig rations to supply "good" protein and B vitamins (Hupka, 1941), has been named as a possible source of GPF. However, Gard et al. (1955) reported that there was no clear cut evidence to support this claim. Jeter et al. (1960) observed that both brewer's yeast and the ash of brewer's yeast along with 3 p.p.m. selenium or 24 p.p.m. strontium improved the feed efficiency but had no effect on growth rate when a nutritionally adequate diet was fed. This observation may support the theory that GPF may be specific trace elements, possibly in ideal combinations, which effect improved performances in animals.

The results of this trial tend to suggest that brewer's yeast may have some effect, as yet unknown, on the liveweight gains of early-weaned pigs. However, it would be necessary for this substance to be further

investigated before definite conclusions may be reached.

The findings of Maner et al. (1962) show that when soybean protein was fed to four-week-old pigs it caused a buffering action which delayed the activation of pepsinogen secreted by the gastric glands. The buffering action also delayed or prevented the aggregation of the protein, which is believed involved in proper digestion by the pig (Braude et al., 1958). Along with this, the distinctly shorter time which diets containing soybean protein spend in the gastro-intestinal tract of young pigs, as compared with casein (Maner et al., 1961; 1962) leads to the possibility of inefficient digestion and hence utilization of this material. Since the test rations contained large quantities of soybean, the resulting inefficient utilization of this substance would have reduced the early growth of animals on these rations and this in turn would be reflected by their lower total weight gains.

Combs et al. (1963) reported no significant differences in the apparent digestibility of dry matter, protein, ether extract and calories in the pig after the seventh week of age. Since in this trial digestibilities were determined during the ninth week of age, no differences between the rations, according to Combs et al. (1963), would be expected in view of the fact that all rations contained the same level of all nutrients.

No differences between rations were observed for

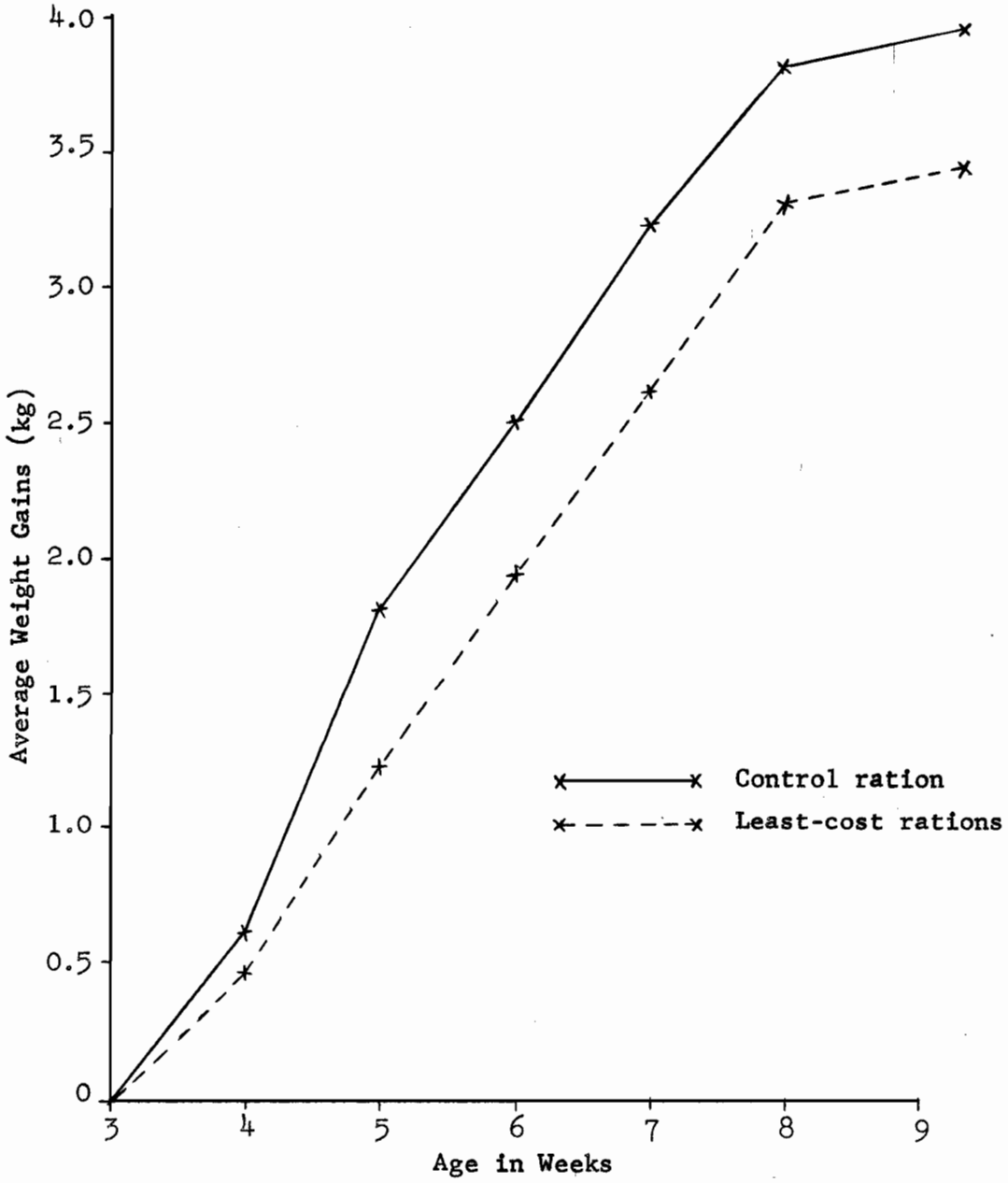
the apparent digestibility of crude protein or calories, but significant differences were noted for ether extract, total carbohydrate and dry matter. Except for Ration No. 2, these differences were not consistent for any other ration. Low digestibility values for ether extract and total carbohydrate fractions were reflected in the overall low total gains made by the animals on this ration. These findings are in agreement with those of Combs et al. (1963) since, on the whole, differences in the apparent digestibilities of the nutrients for the different rations were practically non-existent, during the ninth week stage. Therefore, any differences in the final weights of animals fed the various rations must have been due to differential digestibilities and hence growth rates which occurred prior to the seventh week.

This is illustrated graphically in Figure 6. This figure shows that animals on the control ration made faster gains than those on the least-cost rations between the ages of three and five weeks. Following this period the rates of gain made by both groups of animals were similar.

b. Nitrogen Balance Trial

The administration of androgens to rats has been claimed to promote anabolism and fat metabolism, but when used on pigs the results have been disappointing. In these trials the use of the androgen, methandrostenolone,

FIGURE 6. The effect on the weekly weight gain of early-weaned pigs fed a control ration high in animal protein sources as compared to those fed rations high in sources of plant protein (least-cost rations).



had no apparent effect on the retention of nitrogen from the feed during any of the growth periods - early-weaning, growing, finishing. This is not what was expected as one of the qualities of an androgen is its ability to bring about protein anabolism. The androgen used was claimed to have increased anabolic activity and reports on its effect when used on both human subjects and rats have been very satisfactory in this respect.

In this trial, stage of growth, and therefore the age of the animal, was the only factor which influenced the retention of nitrogen. This, of course, is expected, for as the animal grows older the biological value of protein decreases. However, the addition of 1.0 mg. methandrostenolone per kilogram feed did not enhance the retention of nitrogen by pigs during three different stages of growth.

c. Muscle Fibre Measurement

The findings of Papinicolaou and Falk (1938) show that the administration of an androgen to laboratory animals induces a general muscular hypertropy. As an increase in the body size of most animals is believed due to an enlargement of existing muscle fibres, the sheep being an exception, androgen treatment would be expected to exert its influence on muscle fibre size. The results obtained in this trial, however, are not in agreement with this. Pigs fed the ration containing the androgen,

methandrostenolone, tended to have a larger number of small-sized muscle fibres than did the animals on the control ration.

Several workers (Hammond and Appleton, 1932; McMeekan, 1940, 1941; Joubert, 1956; Tuma et al., 1962) have reported an increase in fibre size with age of the animal. In this trial, however, there was no difference in the ages of pigs of either group at the time of slaughter, so that this factor played no significant part in the size of fibres observed.

Since the only difference between the two groups was the feeding of androgen to one group, it is possible that this substance may have influenced muscle fibre development in those animals to which it was fed. In spite of the apparent contradictions of previous findings, (Brady, 1937; Satorius and Child, 1938; Hiner et al., 1953), it may be concluded that, because of the larger number of muscle fibres of small diameter, the meat produced by the androgen-fed animals had a finer texture and would be more tender than that of the control animals.

VI. INTEGRATING DISCUSSION: CHAPTERS IV AND V

An investigation was carried out to test the effect of four levels of androgen on the growth of early-weaned pigs. None of these was found to be statistically different, although the gains made by animals on the 1.0 mg. per kilogram of feed level were numerically superior to those of animals on the other levels. On the whole, androgen had no effect on the apparent digestibility of nutrients, but it tended to reduce the feed consumption, and this is believed to be the reason for the differences in liveweight gains when the 0.5 or 1.5 mg. levels were fed. Whether the reduction in feed consumption was due to biological stresses set up within the animal by the androgen or to its effect on the flavour of feed is not known.

The same effect was noticeable on the growth rate of pigs kept to 200 pounds liveweight.

The method used for androgen dosage in this trial was questionable. Apart from the possibility that the

dosage levels may have been too small, pigs in the same dosage group, depending on their feed consumption, would have had differential intakes of the androgen. The level to be applied to a feed could have been more satisfactorily established by a determination of the amount per kilogram of body weight that is necessary to bring about an increase in weight gain over a period of time. This value could then have been equated so that when placed in a feed the animal would consume the established amount of androgen over the given period. However, the differential feed consumption by animals of different weights may have in part overcome this problem.

Because of the relatively good results obtained in the dosage trial, the 1.0 mg. level of androgen was used in the main growth trial. In this trial, sweetening agents were also added to the test rations in an effort to improve their acceptability and therefore their intake.

The opinion was that the reduced intakes recorded when these rations were fed previously was due to their lower content of molasses which may have caused an increase in dustiness of the feed or affected some of the other physical characteristics of a ration, i.e. sweetness.

As in the preliminary trial, the results indicated that the androgen tended to reduce the consumption of feed. In spite of this, there was no difference in weight gains between the androgen-fed pigs and the

controls within the same ration. This indicated a better utilization of feed by those animals fed the androgen. In general, though, the use of androgen had no effect on either the apparent digestibility of nutrients or the weight gains.

A significant decrease in the feed consumption was noted for the animals on the 5% molasses ration. However, the reduced consumption was apparently not large enough to affect significantly their total weight gains. On the whole, gains made by animals on rations containing different degrees of sweetness were approximately the same.

The only factor contributing to differences in gain was the ration fed. Although the apparent digestibility of the ether extract fraction was significantly different between rations, in general, all of the other nutrients were digested equally as well. In spite of this, it is believed that differences in the total gains were due to differences in digestibility of certain components of the rations prior to seven weeks of age. Rations containing a large quantity of plant proteins, as did the test rations, would have been less digestible during this period than one containing a relatively large amount of skim milk powder as did the control ration. The lowered digestibility would have caused a reduced rate of growth of the animals on the test rations during the early stages, and this was reflected in their lower total weight gains.

It was believed, too, that the brewer's yeast may have supplied to the control ration some unspecified factors which would have been absent in the test rations. For lack of a better name these may be called "Growth Promoting Factors".

The inability of the young pig to utilize rations containing large quantities of plant protein as efficiently as rations containing skim milk powder, for the first three to four weeks following early-weaning, seems to be the main limiting factor in the use of least-cost computation in the formulation of early-weaning rations. Since these animals are not able to effectively utilize plant protein before the seventh week of age (Combs et al., 1963) it may be necessary to divide the early-weaning stage into two periods. One period lasting from three to seven weeks, when a skim-milk ration is used and a period from seven weeks on, when a ration containing predominantly plant proteins is substituted. Where this "two-period" early-weaning system complicates management procedures, an alternative would be to require a fixed minimum amount of skim milk powder when rations are computed electronically. However, until some method is developed to improve the digestibility of plant proteins by early-weaned pigs, there will remain the necessity of restricting the use of large quantities of such feed ingredients in pig rations, at least prior to seven weeks of age.

In the nitrogen balance trials it was observed that nitrogen retention decreased with age of the animal. Although one of the properties of androgenic compounds is the ability to increase protein anabolism, in this trial the presence of the androgen in feed did not increase the retention of nitrogen. However, since the androgen was not observed to have any significant effect on weight gains, it was extremely unlikely that it would have effected any increases in nitrogen retention in the animals to which it was fed.

Muscle samples taken from the longissimus dorsi showed that the androgen-fed pigs tended to have a greater number of muscle fibres of small diameter measurements than did the controls. In view of the findings of Papinicolaou and Falk (1938) and since differences in the ages of the animals was not a factor (Tuma et al., 1962), it may be speculated that, in this trial, the androgen was responsible for a depression in the development of muscle fibres. In addition, according to the report of Hiner et al. (1953), the conclusion may be drawn that the tendency of the androgen-fed animals to have muscle with a larger number of fibres of small diameter measurements may reflect a finer texture and greater tenderness than that of the controls.

VII. SUMMARY

1. In a preliminary trial, four levels of the androgen, methandrostenolone - 0, 0.5, 1.0, 1.5 mg. per kilogram feed - fed to early-weaned pigs had no effect on the apparent digestibility of nutrients or on the growth rate of these pigs. The highest daily gains were made by animals on the 1.0 mg. level of treatment. No differences in the rate of growth were observed in the pigs that were fed through to 200 pounds liveweight on rations with and without methandrostenolone.

2. The inclusion of 1.0 mg. methandrostenolone per kilogram of feed, in the main growth trial, had no effect on the apparent digestibility, the growth rate or the nitrogen retention of early-weaned pigs. When pigs were kept to 200 pounds liveweight it was observed that with increase of age there was a decrease in the rate of nitrogen retention. The presence of androgen in the ration did not influence its retention.

Microscopic examination of the longissimus dorsi of these animals after slaughter revealed that those pigs fed rations containing androgen tended to have a larger number of muscle fibres of small diameter measurement than did the controls.

3. In both trials, the presence of androgen tended to reduce the feed consumption. However, gains were equal in magnitude to those of the controls and this reflected a slightly better utilization of feed by animals fed the androgen.

4. Of the three sweeteners used - 5% and 10% molasses, and 5% molasses + 5% sucrose - only one, the 5% molasses ration, caused a significant reduction in feed consumption. However, gains were equal for the three sweetener levels.

5. Differences in weight gains resulted from the kind of ration fed. The highest gains were made by animals on the control ration. This was presumed to be due to the presence of skim milk powder which is more readily digested by early-weaned pigs, prior to seven weeks of age, than are plant proteins, which were present at higher levels in the test rations. Except for the ether extract fraction, there was no difference in the apparent digestibility of nutrients between rations. In spite of this, the differences

in the total weight gains were believed to be due to differences in digestibility between the rations prior to seven weeks of age.

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APPENDIX

Preliminary Trial . . Tables I to XXXI

Main Trial . . . . . Tables XXXII to LXI

APPENDIX

Procedure for collection from metabolism crates.

1. Feed pigs.
2. Spray cage lightly with hose.
3. Collect urine and measure total volume.
4. Take 1% of total volume and place in sample bottle containing 50 ml. toluene.
5. Add 50 ml. of 50% H_2SO_4 to urine bucket.
6. Collect sample of day's feces in DIXIE cup.

Typical Time-table Throughout Collection Period of Nitrogen Retention Studies.

Start of Period

Monday:	Clean cage and put empty bucket underneath.
	Collect Day 1 feces throughout day.
Tuesday:	Collect and sample Day 1 urine.
	Collect Day 2 feces throughout day.
Wednesday:	Collect and sample Day 2 urine.
	Collect Day 3 feces throughout day.
Thursday:	Collect and sample Day 3 urine.
	Collect Day 4 feces throughout day.
Friday:	Collect and sample Day 4 urine.
	Collect Day 5 feces throughout day.
Saturday:	Collect and sample Day 5 urine.

End of Period.

Table I. Average Daily Gains (gms.), 32 Pigs - 3-9 weeks. (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	257	373	436	335
	436	206	406	364
	395	336	402	331
	375	432	376	407
F	427	408	406	271
	381	375	365	350
	390	343	420	387
	282	296	376	405

Table II. Average Daily Feed Consumption (gms.), 32 Pigs - 3-9 weeks. (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.15	1.0	1.5
M	607	812	895	799
	792	417	755	761
	739	760	804	610
	713	690	604	712
F	925	846	831	643
	863	696	760	630
	823	569	620	729
	575	561	599	739

Table III. Analysis of Variance of Average Daily Gains (y), 32 Pigs - 3-9 weeks. (Preliminary Trial)

Source	D/F	$S(y-\bar{y})^2$	Variance	Variance Ratio		
				F. (Obs.)	F.(Nec.) P=0.05	F.(Nec.) P=0.01
All causes	31	95,044.2				
Androgen (A)	3	12,291.1	4,097.03	1.21	3.01	4.72
Sex (S)	1	7.0	7.0	0.002	4.26	7.82
A x S	3	1,155.4	385.13	0.11	3.01	4.72
Error	24	81,590.7	3,399.61			

Table IV. Analysis of Variance of Average Daily Feed Consumption (x), 32 Pigs - 3-9 weeks. (Preliminary Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F.(Nec.) P=0.05	F.(Nec.) P=0.01
All causes	31	404,448.97				
Androgen (A)	3	33,495.27	11,165.09	0.77	3.01	4.72
Sex (S)	1	116.28	116.28	0.008	4.26	7.82
A x S	3	24,091.17	8,030.39	0.56	3.01	4.72
Error	24	346,746.25	14,447.76			

Table V. Average Daily Gains (gms.), 16 Pigs - 3-9 weeks. (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	438	373	436	331
	395	206	406	407
F	391	408	420	271
	282	375	376	387

Table VI. Average Daily Feed Consumption (gms.), 16 Pigs - 3-9 weeks. (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	792	812	895	610
	739	417	755	712
F	823	846	620	643
	575	696	599	729

Table VII. Average Daily Gain (lbs.), 16 Pigs - 9 weeks to 120 pounds. (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	1.11	1.40	1.50	1.34
	1.22	1.11	1.51	1.52
F	1.38	1.30	1.34	1.11
	0.99	1.12	1.35	1.39

Table VIII. Average Daily Feed Consumption (lbs.), 16 Pigs - 9 weeks to 120 pounds. (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	3.48	3.70	4.41	4.05
	3.95	3.62	4.43	4.24
F	3.98	3.81	3.80	3.49
	3.49	3.73	3.35	3.86

Table IX. Average Daily Gain (lbs.), 16 Pigs - 120-200 pounds. (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	2.00	1.78	1.90	1.78
	2.00	1.82	1.36	1.74
F	1.95	1.63	1.78	1.90
	1.63	1.18	1.78	1.95

Table X. Average Daily Feed Consumption (lbs.), 16 Pigs - 120-200 pounds. (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	7.35	5.78	6.86	6.22
	7.75	8.48	5.92	5.85
F	7.71	5.63	5.49	6.64
	7.61	5.47	5.80	6.83

Table XI. Average Daily Gain (lbs.), 16 Pigs - 3 weeks to 200 pounds. (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	1.31	1.34	1.45	1.30
	1.34	1.13	1.27	1.40
F	1.39	1.30	1.36	1.18
	1.08	1.07	1.33	1.40

Table XII. Average Daily Feed Consumption (lbs.) 16 Pigs - 3 weeks to 200 pounds. (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	4.04	3.80	4.41	3.94
	4.33	4.23	4.24	3.96
F	4.44	3.86	3.61	3.77
	4.10	3.88	3.52	4.06

Table XIII. Analysis of Variance of Average Daily Gain (y), 16 Pigs - 3-9 weeks. (Preliminary Trial)

Source	D/F	$S(y-\bar{y})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	15	62,955.75				
Androgen (A)	3	11,634.75	3,878.25	0.96	4.07	7.59
Sex (S)	1	479.27	479.27	0.12	5.32	11.26
A x S	3	18,453.73	6,151.24	1.52	4.07	7.59
Error	8	32,388.00	4,048.50			

Table XIV. Analysis of Variance of Average Daily Feed Consumption (x), 16 Pigs - 3-9 weeks. (Preliminary Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	15	224,440.94				
Androgen (A)	3	8,121.69	2,707.23	0.15	4.07	7.59
Sex (S)	1	2,525.06	2,525.06	0.14	5.32	11.26
A x S	3	73,454.69	24,484.90	1.40	4.07	7.59
Error	8	140,339.50	17,542.44			

Table XV. Analysis of Variance of Average Daily Gain (y), 16 Pigs - 9 weeks to 120 pounds. (Preliminary Trial)

Source	D/F	$S(y-\bar{y})^2$	Variance	Variance Ratio		
				F. (Obs.)	F.(Nec.) P=0.05	F.(Nec.) P=0.01
All causes	15	0.41				
Androgen (A)	3	0.15	0.05	1.67	4.07	7.59
Sex (S)	1	0.04	0.04	1.33	5.32	11.26
A x S	3	0.02	0.007	0.23	4.07	7.59
Error	8	0.20	0.03			

Table XVI. Analysis of Variance of Average Daily Feed Consumption (x), 16 Pigs - 9 weeks to 120 pounds. (Preliminary Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F.(Nec.) P=0.05	F.(Nec.) P=0.01
All causes	15	1.60				
Androgen (A)	3	0.23	0.08	1.60	4.07	7.59
Sex (S)	1	0.35	0.35	7.00*	5.32	11.26
A x S	3	0.60	0.20	4.00	4.07	7.59
Error	8	0.42	0.05			

*Significant ($P<0.05$)

Table XVII. Analysis of Variance of Average Daily Gain (y), 16 Pigs - 120-200 pounds. (Preliminary Trial)

Source	D/F	$S(y-\bar{y})^2$	Variance	Variance Ratio		
				F. (Obs.)	F.(Nec.) P=0.05	F.(Nec.) P=0.01
All causes	15	0.76				
Androgen (A)	3	0.21	0.07	1.75	4.07	7.59
Sex (S)	1	0.02	0.02	0.05	5.32	11.26
A x S	3	0.23	0.08	2.00	4.07	7.59
Error	8	0.30	0.04			

Table XVIII. Analysis of Variance of Average Daily Feed Consumption (x), 16 Pigs - 120-200 pounds. (Preliminary Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F.(Nec.) P=0.05	F.(Nec.) P=0.01
All causes	15	13.72				
Androgen (A)	3	5.85	1.95	3.61	4.07	7.59
Sex (S)	1	0.57	0.57	1.06	5.32	11.26
A x S	3	2.98	0.99	1.83	4.07	7.59
Error	8	4.32	0.54			

Table XIX. Analysis of Variance of Average Daily Gain (y), 16 Pigs - 3 weeks to 200 pounds. (Preliminary Trial)

Source	D/F	$S(y-\bar{y})^2$	Variance	Variance Ratio		
				F. (Obs.)	F.(Nec.) P=0.05	F.(Nec.) P=0.01
All causes	15	0.20				
Androgen (A)	3	0.05	0.002	0.1	4.07	7.59
Sex (S)	1	0.01	0.01	0.005	5.32	11.26
A x S	3	0.00	0.00	0.00	4.07	7.59
Error	8	0.14	0.02			

Table XX. Analysis of Variance of Average Daily Feed Consumption (x), 16 Pigs - 3 weeks to 200 pounds. (Preliminary Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F.(Nec.) P=0.05	F.(Nec.) P=0.01
All causes	15	1.11				
Androgen (A)	3	0.25	0.08	2.67	4.07	7.59
Sex (S)	1	0.19	0.19	6.33*	5.32	11.26
A x S	3	0.42	0.14	4.67*	4.07	7.59
Error	8	0.25	0.03			

*Significant ($P<0.05$)

Table XXI. Chemical Composition of Rations Fed (3-9 weeks of age) (Dry Matter Basis). (Preliminary Trial)

Nutrient	Sex	mg. methandrostenolone per kg. feed			
		0	0.5	1.0	1.5
Crude Protein	M.;F.	27.56	27.23	27.39	27.52
Ether Extract	M.;F.	3.77	3.77	3.83	3.87
Total Carbohydrate	M.;F.	50.26	51.96	51.69	50.27
Dry Matter	M.;F.	90.46	91.43	91.59	90.41
Gross Energy Value (Cals./gm.)	M.;F.	4.30	4.35	4.31	4.36

Table XXII. Apparent Digestibility Coefficients of Crude Protein (Pigs Fed Early-weaning Ration from 3-9 weeks of age). (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	80*	76	83	76
	81	57	77	73
	73	65	79	73
	78	81	84	80
F	80	82	80	62
	73	81	79	83
	81	76	84	80
	79	74	77	77

*Calculated value.

Table XXIII. Apparent Digestibility Coefficients of Ether Extracts (Pigs Fed Early-weaning Ration from 3-9 weeks of age). (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	69*	60	76	79
	70	58	67	74
	68	60	73	66
	64	66	78	77
F	70	67	72	58
	55	75	65	71
	71	57	86	76
	67	74	65	78

*Calculated value.

Table XXIV. Apparent Digestibility Coefficients of Total Carbohydrates (Pigs Fed Early-weaning Ration from 3-9 weeks of age). (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	90*	89	89	90
	88	79	89	88
	87	85	88	88
	89	89	90	88
F	89	89	88	81
	87	89	90	89
	90	87	87	90
	90	86	89	87

*Calculated value.

Table XXV. Apparent Digestibility Coefficients of Dry Matter (Pigs Fed Early-weaning Ration from 3-9 weeks of age). (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	82*	80	83	78
	82	66	81	77
	77	73	81	77
	81	82	84	81
F	81	82	82	69
	77	82	77	82
	83	79	83	82
	81	78	81	78

*Calculated value.

Table XXVI. Apparent Digestibility Coefficients of Gross Energy (Pigs Fed Early-weaning Ration from 3-9 weeks of age). (Preliminary Trial)

Sex	mg. methandrostenolone per kg. feed			
	0	0.5	1.0	1.5
M	79*	81	85	79
	83	65	81	79
	79	73	82	78
	82	84	86	83
F	83	84	82	69
	78	84	83	84
	85	80	85	84
	83	80	81	81

*Calculated value.

Table XXVII. Analysis of Variance of the Apparent Digestibility Coefficients of Crude Protein (Pigs Fed Early-weaning ration from 3-9 weeks of age). (Preliminary Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F.(Nec.) P=0.05	F.(Nec.) P=0.01
All causes	31	1,186.83				
Androgen (A)	3	186.13	62.04	1.67	3.03	4.76
Sex (S)	1	28.69	28.69	0.77	4.28	7.88
A x S	3	117.61	39.20	1.06	3.03	4.76
Missing value	1					
Error	23	854.40	37.15			

Table XXVIII. Analysis of Variance of the Apparent Digestibility Coefficients of Ether Extract (Pigs Fed Early-weaning ration from 3-9 weeks of age). (Preliminary Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F.(Nec.) P=0.05	F.(Nec.) P=0.01
All causes	31	1,639.64				
Androgen (A)	3	394.14	131.38	2.71	3.03	4.76
Sex (S)	1	0.26	0.26	0.005	4.28	7.88
A x S	3	130.43	43.48	0.90	3.03	4.76
Missing value	1					
Error	23	1,114.81	48.47			

Table XXIX. Analysis of Variance of the Apparent Digestibility Coefficients of Total Carbohydrate (Pigs Fed Early-weaning ration from 3-9 weeks of age). (Preliminary Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	31	186.14				
Androgen (A)	3	25.04	8.35	0.14	3.03	4.76
Sex (S)	1	0.13	0.13	0.002	4.28	7.88
A x S	3	19.55	6.52	0.11	3.03	4.76
Missing value	1					
Error	23	141.42	61.49			

Table XXX. Analysis of Variance of the Apparent Digestibility Coefficients of Dry Matter (Pigs Fed Early-weaning ration from 3-9 weeks of age). (Preliminary Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	31	492.22				
Androgen (A)	3	71.44	23.81	1.52	3.03	4.76
Sex (S)	1	5.28	5.28	0.34	4.28	7.88
A x S	3	55.26	18.42	1.18	3.03	4.76
Missing value	1					
Error	23	360.24	15.66			

Table XXXI. Analysis of Variance of the Apparent Digestibility Coefficients of Gross Energy (Pigs Fed Early-weaning ration from 3-9 weeks of age). (Preliminary Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	31	610.95				
Androgen (A)	3	87.23	29.08*	1.47	3.03	4.76
Sex (S)	1	17.40	17.40	0.88	4.28	7.88
A x S	3	51.37	17.12	0.87	3.03	4.76
Missing value	1					
Error	23	454.95	19.78			

Table XXXII. Average Daily Gain (gms.). (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M	1	485	133	399	367	333	154	310	230
		2	389	374	540	407	392*	374	380	382
		3	202	298	272	281	173	175	261	242
	F	1	510	195	271	189	433	395	260	411
		2	470	373	299	378	381	257	367	481
		3	306	225	217	174	338	270	196	303
Plus	M	1	355	250	352	452	190	202	396	287
		2	433	383	448	421	311	376	490	477
		3	256	152*	232	257	146	129	323	123
	F	1	421	269*	246	204	302	314	444	346
		2	431	367	448	496	445	435	305	285
		3	286	210	260	255	227	292	232	346

*Calculated values.

Table XXXIII. Average Daily Feed Consumption (gms.). (Main Trial)

Hormone	Sex	Replicate	Rations							
			1	2	3	4	5	6	7	8
Nil	M	1	948	355	911	632	582	442	514	385
		2	878	782	1183	982	816*	860	857	671
		3	496	589	825	665	307	527	653	499
	F	1	1002	368	509	485	828	751	516	788
		2	1014	791	885	735	711	527	805	905
		3	593	588	338	462	700	511	540	594
Plus	M	1	564	540	637	801	376	445	840	539
		2	787	653	755	854	700	926	814	887
		3	400	352*	463	472	255	281	922	385
	F	1	793	552*	582	479	670	583	865	609
		2	802	905	859	1003	784	986	675	513
		3	1044	420	576	520	483	673	795	609

*Calculated values.

Table XXXIV. Average Daily Gains (gms.) Adjusted to Equal Feed Intake. (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M	1	400	226	325	377	358	221	355	314
		2	325	339	384	312	346*	315	322	380
		3	152	320	224	281	280	216	264	291
	F	1	409	284	317	243	384	369	304	374
		2	365	335	233	357	367	298	325	409
		3	327	248	315	235	327	316	233	233
Plus	M	1	385	287	360	411	276	268	343	324
		2	396	386	421	364	300	297	445	410
		3	335	246*	292	315	269	244	246	207
	F	1	382	303*	271	259	300	338	384	362
		2	390	295	389	394	409	338	302	330
		3	172	283	286	298	281	289	193	362

*Calculated values.

Table XXXV. Analysis of Variance of Average Daily Gains (y). (Main Trial)

Source	D/F	$S(y-\bar{y})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	95	973,280.99				
Androgen (a)	1	31.51	31.51	0.007	4.04	7.19
Sex (b)	1	3,396.26	3,396.26	0.76	4.04	7.19
Rations (c)	7	96,289.07	13,755.58	3.09**	2.21	3.04
Replications (d)	2	412,474.08	206,237.04	46.34**	3.19	5.08
Interactions: ab	1	810.84	810.84	0.18	4.04	7.19
ac	7	43,602.24	6,228.89	1.40	2.21	3.04
ad	2	4,316.08	2,158.04	0.48	3.19	5.08
bc	7	125,087.81	17,869.69	4.01**	2.21	3.04
bd	2	15,551.58	7,775.79	1.75	3.19	5.08
cd	14	58,074.59	4,148.19	0.93	1.90	2.48
Missing values	3					
Error	48	213,646.93	4,450.98			

**Highly significant ($P < 0.01$).

Table XXXVI. Analysis of Variance of Average Daily Feed Consumption (x). (Main Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	95	3,884,413.8				
Androgen (a)	1	8,011.8	8,011.8	0.37	4.04	7.19
Sex (b)	1	30,780.9	30,780.9	1.41	4.04	7.19
Rations (c)	7	425,912.1	60,844.6	2.79*	2.21	3.04
Replications (d)	2	1,287,068.1	643,534.1	29.50**	3.19	5.08
Interactions: ab	1	67,468.9	67,468.9	3.09	4.04	7.19
ac	7	209,169.4	29,881.3	1.37	2.21	3.04
ad	2	79,862.1	39,931.1	1.83	3.19	5.08
bc	7	408,182.6	58,311.8	2.67*	2.21	3.04
bd	2	58,163.2	29,081.6	1.33	3.19	5.08
cd	14	262,830.8	18,773.6	0.86	1.90	2.48
Missing values	3					
Error	48	1,046,963.9	21,811.7			

*Significant ($P < 0.05$)

**Highly significant ($P < 0.01$)

Table XXXVII. Analysis of Variance of Average Daily Gains (y) Adjusted to Equal Feed Intake (x). (Main Trial)

Source	D/F	$S(y-\bar{y})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	95	354,282.24				
Androgen (a)	1	2,635.51	2,635.51	0.40	4.04	7.19
Sex (b)	1	41.34	41.34	0.006	4.04	7.19
Rations (c)	7	21,667.49	3,095.36	0.47	2.21	3.04
Replications (d)	2	120,842.89	60,421.45	9.15**	3.19	5.08
Interactions: ab	1	2,573.01	2,573.01	0.39	4.04	7.19
ac	7	12,260.40	1,751.49	0.27	2.21	3.04
ad	2	3,905.15	1,952.58	0.30	3.19	5.08
bc	7	33,402.24	4,771.75	0.72	2.21	3.04
bd	2	2,830.57	1,415.29	0.21	3.19	5.08
cd	14	35,254.61	2,518.19	0.38	1.90	2.48
Missing values	3					
Error	48	118,869.03	6,603.84			

**Highly significant ($P<0.01$)

Table XXXVIII. Percentage Crude Protein in Rations Fed (Dry Matter Basis). (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M.;F.	1	28.10	28.68	28.53	28.62	30.69	29.43	28.59	30.38
		2	27.44	28.46	28.03	26.81	28.80	28.15	27.73	28.73
		3	28.10	26.95	28.67	29.04	30.41	30.23	28.51	29.70
Plus	M.;F.	1	27.77	28.96	28.62	28.14	29.76	30.07	28.95	29.87
		2	29.29	29.34	27.56	26.64	29.45	28.41	27.76	28.58
		3	28.10	29.62	28.57	26.81	30.26	29.28	28.14	31.86

Table XXXIX. Percentage Ether Extract in Rations Fed (Dry Matter Basis). (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M.;F.	1	3.78	4.03	4.15	4.10	5.47	5.46	5.16	5.15
		2	3.27	2.58	2.40	2.41	3.79	4.08	3.84	3.58
		3	3.44	2.89	3.12	3.38	4.17	4.50	4.38	4.76
Plus	M.;F.	1	4.27	4.13	4.19	4.12	5.41	5.53	5.11	5.11
		2	3.06	2.46	2.54	1.99	3.61	4.26	3.95	3.75
		3	3.36	3.22	3.04	3.21	4.11	4.22	4.72	4.27

Table XL. Percentage of Total Carbohydrate in Rations Fed (Dry Matter Basis). (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M.;F.	1	58.45	56.41	57.20	56.43	53.71	54.34	55.99	54.25
		2	55.06	58.07	58.58	60.35	53.21	55.48	55.03	57.11
		3	52.25	57.15	53.95	54.90	52.02	52.37	53.47	52.28
Plus	M.;F.	1	55.67	55.75	56.95	57.53	54.47	53.43	55.55	54.11
		2	55.87	56.55	57.44	60.41	56.29	55.23	57.11	54.71
		3	52.83	54.35	55.24	57.31	51.83	52.28	52.65	49.96

Table XLI. Gross Energy Value (Cals./gm.) of Rations Fed (Dry Matter Basis). (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M.;F.	1	4.23	4.37	4.36	4.40	4.54	4.50	4.42	4.47
		2	4.35	4.40	4.42	4.36	4.49	4.40	4.44	4.37
		3	4.32	4.26	4.44	4.39	4.53	4.46	4.48	4.55
Plus	M.;F.	1	4.35	4.38	4.40	4.40	4.53	4.45	4.45	4.50
		2	4.39	4.41	4.37	4.39	4.45	4.45	4.44	4.48
		3	4.32	4.47	4.45	4.43	4.48	4.55	4.39	4.60

Table XLII. Percentage of Dry Matter in Rations Fed. (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M.;F.	1	98.54	95.32	96.95	95.26	96.32	96.20	96.22	96.51
		2	94.73	95.50	96.07	95.84	92.80	95.61	93.52	96.13
		3	93.32	93.56	93.22	94.14	93.41	94.76	94.00	93.68
Plus	M.;F.	1	96.10	95.03	96.59	95.76	96.06	95.95	96.25	95.50
		2	94.85	94.73	94.64	95.26	96.36	95.33	95.88	93.38
		3	93.46	93.49	94.03	93.95	93.58	93.88	93.59	92.75

Table XLIII. Apparent Digestibility Coefficients of Crude Protein. (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M	1	87	80	84	84	82	80*	82	72
		2	80	85	80	84	82*	77	81	81
		3	72	81	76	67	83	64	82	79
	F	1	79	88	84	82	80	83	78	80
		2	74	69	77	82	83	77	81	83
		3	80	79	86	80	77	80	73	69
Plus	M	1	80	88	84	84	82*	76	79	78
		2	77	86	78	85	86	78	83	84
		3	85	75*	65	79	78	75	71	77
	F	1	80	68*	86	84	66	81	79	67*
		2	82	69	83	86	79	71	78	85
		3	72	75	76	80	78	77	67	67

*Calculated Values.

Table XLIV. Apparent Digestibility Coefficients of Ether Extract. (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M	1	75	76	70	78	80	81*	74	74
		2	72	54	65	55	64*	71	67	62
		3	73	54	70	60	73	82	74	70
	F	1	75	77	74	77	73	78	75	76
		2	68	53	42	68	63	70	72	71
		3	78	65	75	70	61	71	64	71
Plus	M	1	71	78	74	74	75*	78	74	71
		2	62	61	59	48	69	73	75	66
		3	76	62*	55	73	69	69	57	77
	F	1	70	58*	80	77	72	75	75	65*
		2	68	55	64	69	70	71	74	69
		3	50	69	70	75	69	70	70	68

*Calculated Values.

Table XLV. Apparent Digestibility Coefficients of Total Carbohydrate. (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M	1	91	88	87	91	89	89*	89	89
		2	89	87	89	90	89*	89	90	89
		3	88	88	88	84	88	81	91	88
	F	1	89	90	87	89	86	89	90	89
		2	83	83	83	90	89	88	89	91
		3	89	88	90	89	89	89	88	84
Plus	M	1	91	89	89	90	87*	83	88	83
		2	86	89	88	91	88	89	91	90
		3	91	85*	82	88	86	88	87	87
	F	1	90	74*	91	90	81	89	89	74*
		2	89	84	88	91	88	87	90	90
		3	84	85	87	88	87	89	84	85

*Calculated Values.

Table XLVI. Apparent Digestibility Coefficients of Gross Energy. (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M	1	86	84	82	87	84	83*	83	82
		2	84	83	83	84	83*	80	84	83
		3	79	81	80	73	83	71	84	82
	F	1	82	87	83	84	80	84	82	82
		2	78	74	77	84	84	81	83	84
		3	83	81	86	82	81	81	79	76
Plus	M	1	84	86	84	86	82*	79	81	78
		2	80	84	82	86	84	82	85	85
		3	86	78*	73	82	79	80	77	80
	F	1	83	69*	86	85	72	82	82	69*
		2	85	76	83	86	81	77	84	85
		3	75	78	80	83	81	81	75	75

*Calculated Values.

Table XLVII. Apparent Digestibility Coefficients of Dry Matter. (Main Trial)

Hormone	Sex	Replicate	RATIONS							
			1	2	3	4	5	6	7	8
Nil	M	1	87	83	83	86	84	83*	84	83
		2	81	83	83	85	83*	81	83	83
		3	77	83	80	74	82	71	83	80
	F	1	83	87	84	84	81	85	83	83
		2	75	74	78	84	84	80	83	85
		3	82	82	86	83	80	81	78	75
	M	1	84	86	86	86	83*	79	83	79
		2	79	85	81	86	84	82	85	85
		3	85	78*	73	82	79	79	76	80
	F	1	83	70*	87	86	73	83	83	70*
		2	82	75	83	86	81	77	83	85
		3	75	78	80	82	80	82	74	74

*Calculated Values.

Table XLVIII. Analysis of Variance of the Apparent Digestibility Coefficients of Crude Protein. (Main Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	95	3,004.15				
Androgen (a)	1	42.40	42.40	1.67	4.06	7.24
Sex (b)	1	74.90	74.90	2.95	4.06	7.24
Rations (c)	7	195.83	27.98	1.10	2.23	3.07
Replication (d)	2	434.98	217.49	8.56**	3.21	5.12
Interactions: ab	1	50.17	50.17	1.97	4.06	7.24
ac	7	116.42	16.63	0.65	2.23	3.07
ad	2	65.00	32.50	1.28	3.21	5.12
bc	7	393.79	56.26	2.21	2.23	3.07
bd	2	60.44	30.22	1.19	3.21	5.12
cd	14	426.79	30.49	1.20	1.92	2.52
Missing values	6					
Error	45	1,143.43	25.41			

**Highly significant ($P<0.01$).

Table XLIX. Analysis of Variance of the Apparent Digestibility Coefficients of Ether Extract. (Main Trial).

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	95	5,710.53				
Androgen (a)	1	18.20	18.20	0.40	4.06	7.24
Sex (b)	1	0.00	0.00	0.00	4.06	7.24
Rations (c)	7	788.24	112.61	2.49*	2.23	3.07
Replications (d)	2	1,518.58	759.29	16.80**	3.21	5.12
Interactions: ab	1	1.98	1.98	0.04	4.06	7.24
ac	7	193.47	27.64	0.61	2.23	3.07
ad	2	116.18	58.09	1.29	3.21	5.12
bc	7	321.29	45.90	1.02	2.23	3.07
bd	2	43.66	21.83	0.48	3.21	5.12
cd	14	675.17	48.23	1.07	1.92	2.52
Missing values	6					
Error	45	2,033.76	45.19			

*Significant ($P<0.05$).

**Highly significant ($P<0.01$).

Table L. Analysis of Variance of the Apparent Digestibility Coefficients of Total Carbohydrate. (Main Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	95	927.90				
Androgen (a)	1	25.73	25.73	2.89	4.06	7.24
Sex (b)	1	19.17	19.17	2.21	4.06	7.24
Rations (c)	7	111.33	15.90	1.83	2.23	3.07
Replications (d)	2	24.58	12.29	1.42	3.21	5.12
Interactions: ab	1	8.22	8.22	0.95	4.06	7.24
ac	7	59.90	8.56	0.99	2.23	3.07
ad	2	45.63	22.82	2.63	3.21	5.12
bc	7	78.52	11.22	1.29	2.23	3.07
bd	2	16.32	8.16	0.94	3.21	5.12
cd	14	148.25	10.59	1.22	1.92	2.52
Missing values	6					
Error	45	390.25	8.67			

Table LI. Analysis of Variance of the Apparent Digestibility Coefficients of Gross Energy. (Main Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	95	1,466.95				
Androgen (a)	1	24.80	24.80	1.85	4.06	7.24
Sex (b)	1	29.92	29.92	2.23	4.06	7.24
Rations (c)	7	116.78	16.68	1.24	2.23	3.07
Replications (d)	2	157.50	78.75	5.86**	3.21	5.12
Interactions: ab	1	16.68	16.68	1.24	4.06	7.24
ac	7	68.04	9.72	0.72	2.23	3.07
ad	2	56.47	28.24	2.10	3.21	5.12
bc	7	145.01	20.72	1.54	2.23	3.07
bd	2	41.43	20.72	1.54	3.21	5.12
cd	14	205.46	14.68	1.09	1.92	2.52
Missing values	6					
Error	45	604.86	13.44			

**Highly significant ($P<0.01$).

Table LII. Analysis of Variance of the Apparent Digestibility Coefficients of Dry Matter. (Main Trial)

Source		D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
					F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes		95	1,520.78				
Androgen (a)		1	23.80	23.80	1.84	4.06	7.24
Sex (b)		1	31.74	31.74	2.45	4.06	7.24
Rations (c)		7	109.92	15.70	1.21	2.23	3.07
Replications (d)		2	201.78	100.89	7.80**	3.21	5.12
Interactions:	ab	1	23.21	23.21	1.79	4.06	7.24
	ac	7	73.57	10.51	0.81	2.23	3.07
	ad	2	53.49	26.75	2.07	3.21	5.12
	bc	7	144.14	20.59	1.59	2.23	3.07
	bd	2	37.29	18.65	1.44	3.21	5.12
	cd	14	239.49	17.11	1.32	1.92	2.52
Missing values		6					
Error		45	582.35	12.94			

**Highly significant ($P<0.01$).

Table LIII. Percentage Crude Protein in Rations Fed (Dry Matter Basis). (Main Trial)

Hormone	Sex	Replicate	Growth Stages		
			Early-weaning	Growing	Finishing
Nil	M.;F.	1	28.10	18.97	15.89
		2	27.44	19.18	17.18
		3	28.26	20.13	16.32
Plus	M.;F.	1	27.77	18.80	16.60
		2	27.29	19.65	16.46
		3	28.19	20.39	16.63

Table LIV. Percentage of Nitrogen Retained From Ration. (Main Trial)

Hormone	Sex	Replicate	Growth Stages		
			Early-weaning	Growing	Finishing
Nil	M	1	36.5	27.2	37.9
		2	36.4	22.1	29.1
		3	44.5	37.0	12.6
	F	1	68.8	23.2	23.9
		2	36.3	23.9	38.3
		3	41.4	40.3	16.9
Plus	M	1	35.2	25.1	23.8
		2	40.7	26.5	30.1
		3	52.8	26.8	15.4
	F	1	37.8	32.9	26.8
		2	41.3	35.9	34.8
		3	54.5	43.9	13.2

Table LV. Percentage Retention of Absorbed Nitrogen. (Main Trial)

Hormone	Sex	Replicate	Growth Stages		
			Early-weaning	Growing	Finishing
Nil	M	1	41.8	35.7	45.3
		2	43.0	29.7	34.1
		3	53.7	44.9	17.6
	F	1	77.6	31.2	31.5
		2	41.7	33.9	45.3
		3	50.2	50.3	22.4
Plus	M	1	41.3	30.5	32.2
		2	46.9	35.7	38.1
		3	62.4	37.0	22.0
	F	1	45.1	41.9	35.0
		2	47.2	47.9	42.6
		3	61.6	53.0	18.4

Table LVI. Percentage Nitrogen Excreted in the Feces. (Main Trial)

Hormone	Sex	Replicate	Growth Stages		
			Early-weaning	Growing	Finishing
Nil	M	1	19.8	32.0	26.3
		2	24.2	33.1	20.6
		3	30.7	27.9	32.6
	F	1	36.5	33.3	31.8
		2	20.3	38.6	25.1
		3	30.0	33.4	29.6
Plus	M	1	22.8	23.9	34.2
		2	22.5	34.9	30.3
		3	32.6	37.7	35.6
	F	1	26.0	32.1	32.1
		2	21.0	39.2	28.1
		3	25.4	30.7	32.9

Table LVII. Percentage Nitrogen Excreted in the Urine. (Main Trial)

Hormone	Sex	Replicate	Growth Stages		
			Early-weaning	Growing	Finishing
Nil	M	1	80.3	68.1	73.7
		2	75.8	66.9	79.4
		3	69.3	72.1	67.4
	F	1	63.5	66.8	68.2
		2	79.7	61.4	75.0
		3	70.0	66.6	70.4
Plus	M	1	77.2	76.1	65.8
		2	77.5	65.1	69.8
		3	67.4	62.3	64.4
	F	1	74.0	67.9	67.9
		2	79.0	60.8	71.9
		3	74.6	69.3	67.1

Table LVIII. Analysis of Variance of the Percentage of Nitrogen Retained from the Ration. (Main Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	35	4,861.54				
Androgen (a)	1	0.04	0.04	0.0006	4.49	8.53
Sex (b)	1	153.76	153.76	2.38	4.49	8.53
Stages (c)	2	2,216.71	1,108.36	17.13**	3.63	6.23
Replications (d)	2	0.81	0.41	0.006	3.63	6.23
Interactions: ab	1	6.25	6.25	0.09	4.49	8.53
ac	2	43.17	21.59	0.33	3.63	6.23
ad	2	168.15	84.08	1.30	3.63	6.23
bc	2	49.09	24.55	0.38	3.63	6.23
bd	2	1.89	0.95	0.01	3.63	6.23
cd	4	1,186.50	593.25	9.17**	3.01	4.77
Error	16	1,035.17	64.70			

**Highly significant ($P<0.01$).

Table LIX. Analysis of Variance of the Percentage Retention of Absorbed Nitrogen. (Main Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	35	5,376.83				
Androgen (a)	1	2.20	2.20	0.03	4.49	8.53
Sex (b)	1	200.22	200.22	2.80	4.49	8.53
Stages (c)	2	2,205.90	1,102.95	15.40**	3.63	6.23
Replications (d)	2	2.31	1.16	0.02	3.63	6.23
Interactions: ab	1	1.92	1.92	0.03	4.49	8.53
ac	2	38.37	19.19	0.27	3.63	6.23
ad	2	210.55	105.28	1.47	3.63	6.23
bc	2	67.23	33.62	0.47	3.63	6.23
bd	2	13.31	6.16	0.09	3.63	6.23
cd	4	1,489.17	372.29	5.20**	3.01	4.77
Error	16	1,145.66	71.60			

**Highly significant ($P<0.01$).

Table LX. Analysis of Variance of the Percentage Nitrogen Excreted in the Feces. (Main Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	35	1,029.61				
Androgen (a)	1	7.29	7.29	0.68	4.49	8.53
Sex (b)	1	16.54	16.54	1.55	4.49	8.53
Stages (c)	2	302.38	151.19	1.42	3.63	6.23
Replications (d)	2	74.03	37.02	3.47	3.63	6.23
Interactions: ab	1	40.96	40.96	3.84	4.49	8.53
ac	2	64.82	32.41	3.03	3.63	6.23
ad	2	24.98	12.49	1.17	3.63	6.23
bc	2	13.49	6.25	0.59	3.63	6.23
bd	2	95.85	47.93	4.49*	3.63	6.23
cd	4	218.41	54.60	5.11**	3.01	4.77
Error	16	170.86	10.68			

*Significant ($P<0.05$).

**Highly significant ($P<0.01$).

Table LXI. Analysis of Variance of the Percentage of Nitrogen Excreted in the Urine. (Main Trial)

Source	D/F	$S(x-\bar{x})^2$	Variance	Variance Ratio		
				F. (Obs.)	F. (Nec.) P=0.05	F. (Nec.) P=0.01
All causes	35	1,031.21				
Androgen (a)	1	7.56	7.56	0.71	4.49	8.53
Sex (b)	1	16.67	16.67	1.56	4.49	8.53
Stages (c)	2	301.64	150.82	14.10**	3.63	6.23
Replications (d)	2	74.88	37.44	3.50	3.63	6.23
Interactions: ab	1	40.75	40.75	3.81	4.49	8.53
ac	2	64.38	32.19	3.01	3.63	6.23
ad	2	24.29	12.15	1.14	3.63	6.23
bc	2	13.48	6.74	0.63	3.63	6.23
bd	2	96.28	48.14	4.50*	3.63	6.23
cd	4	220.17	55.04	5.14**	3.01	4.77
Error	16	171.21	10.70			

*Significant ($P<0.05$).

**Highly significant ($P<0.01$).