THE EFFECTS OF DIETHYLSTILBESTROL-METHYLTESTOSTERONE ON PERFORMANCE, CARCASS TRAITS, SERUM AND MUSCLE CHARACTERISTICS OF SWINE

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ABSTRACT

THE EFFECTS OF DIETHYLSTILBESTROL-METHYLTESTOSTERONE ON PERFORMANCE, CARCASS TRAITS, SERUM AND MUSCLE CHARACTERISTICS OF SWINE

by Thomas Dean Bidner

Two experiments involving 40 barrows and 40 gilts were conducted to study the effects of a combination of diethylstilbestrol (DES) plus methyltestosterone (MT) upon performance, carcass traits, muscle composition and serum components. In experiment 1, 16 barrows and 16 gilts of Yorkshire breeding were assigned to a 2 x 2 factorial experiment at 49 kg. The factorial design consisted of sex (barrows and gilts) and dietary hormone (with and without 2.2 mg DES plus 2.2 mg MT per kilogram of ration). Forty-eight pigs weighing 23 kg were randomly assigned to a second experiment with a 2 x 3 factorial design consisting of sex (gilts and barrows) and dietary hormone (0 DES + MT, 2.2 mg DES + MT per kilogram of ration from 23 kg live weight and 2.2 mg DES + MT per kilogram of ration from 45 kg live weight). Two pigs were removed from each of the lots (8 pigs in experiment 1 and 12 pigs in experiment 2) when they averaged approximately 95 kg. Blood samples were drawn from the anterior vena cava at four time periods in experiment 1 and three time periods in experiment 2 for the determination of serum free fatty acids (FFA), serum growth hormone (PGH) levels and electrophoresis of serum proteins. A 20 minute postmortem sample was taken from the right longissimus muscle and frozen in liquid nitrogen. A block of this frozen muscle was taken for histochemical analysis and the remaining muscle was powdered for determination of muscle pH, protein fractionation and succinic dehydrogenase (SDH) activity.

A significant interaction between treatment and sex was noted in experiment 2 for daily gain, as the DES + MT treatment stimulated the growth rate of gilts and depressed that of barrows. The DES + MT treatment had no significant effect upon carcass traits in experiment 1. One possible explanation of these results could have been the heat stress effects during the summer months. Pigs that received DES + MT from 45 kg in experiment 2 had significantly less backfat than controls (2.45 vs 2.74 cm) but percent fat trim was similar for all groups. Pigs which received DES + MT from 23 kg had larger longissimus muscle areas than controls (35.2 vs 31.6 cm^2) but the weight of the longissimus muscle for treated pigs was not significantly different than that of controls. There were no significant interactions between sex and treatment for any of the carcass traits; thus, DES + MT exerted a similar effect upon gilts and barrows. Gilts had 2.5 cm^2 larger longissimus muscle areas and 0.9% higher ham and loin percentages than barrows in experiment 1, while in experiment 2 gilts had 3.4 cm^2 larger longissimus muscle areas than barrows but percentage of ham and loin was not significantly different. Barrows also were 2.2 cm longer than gilts in experiment 2.

The longissimus and quadriceps femoris muscles of gilts were heavier and they constituted a higher percentage of total side weight than those of barrow carcasses. The DES + MT treatment had no significant influence upon any of the protein fractions of the longissimus muscle and the protein fractions were similar for barrows and gilts. The hormone combination did not alter the area of red or intermediate muscle fiber types and likewise had no influence on the percentage of red, white or intermediate muscle fibers (based upon stain for succinic dehydrogenase activity).

Thus, DES + MT did not alter the muscle protein fractions or the size and type of muscle fibers.

Electrophoresis of serum proteins indicated that DES + MT tended to increase the percentage of albumin (28 days) and decrease the percentage of β-globulin (28 days) and γ-globulins (56 days). Feeding DES + MT had no significant effect upon FFA levels after 7, 28 or 56 days of treatment. The hormone combination tended to increase ovarian follicle size and at least one of the treated gilts (23 to 95 kg) had a cystic ovary.

In experiment 1, DES + MT treatment had no effect upon serum PGH at 7 or 28 days of the trial but the treatment significantly ($P < .01$) increased PGH levels at 56 days. In experiment 2, pigs fed DES + MT from 45 kg also had significantly ($P < .02$) higher serum GH levels at 13 weeks than control pigs while the pigs receiving DES + MT from 23 kg had GH values similar to the control pigs.

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By

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INTRODUCTION

The swine industry of today is oriented toward efficient production of lean heavy muscled carcasses that will yield pork products which are very acceptable to the consumer. It has been well documented that feed efficiency, daily gain and meatiness can be improved through selective breeding but it is less well established that these same criteria can be consistently improved by nutritional means. However, it is generally accepted that energy restriction during the finishing phase and elevated dietary protein will improve carcass leanness.

Recently there has been considerable interest in feeding a combination of diethylstilbestrol (DES) and methyltestosterone (MT) to pigs during the finishing period. Jordan et al. (1965) as well as others have reported that oral administration of this hormone combination increases feed efficiency and muscling and decreases amount of backfat especially in barrows. Other workers have found that DES + MT treatment had similar effects on the carcasses of gilts and barrows. In all of these trials the pigs were individually removed from experiment when they reached a constant final weight. This procedure favors the treated barrows since they are older than controls at final weight because of growth suppressing effects of this hormone combination upon barrows.

Baker et al. (1967) concluded that DES + MT had an anabolic effect in swine when fed from 45 to 95 kg. Among these anabolic observations were a reduction in bodyfat and an increase in area of longissimus muscle. Hypertrophied muscles of 'doppelender' cattle showed altered proportions

of the various protein fractions (Lawrie et al.. (1964). In his classical work on pig compositional studies, McMeekan (1940) showed that muscle mass increased most rapidly during the early stages of growth while fat synthesis increased later in the growth phase. To date no experiments have been reported in which DES + MT was fed to pigs during both the growing and finishing phases.

A study was undertaken to observe the effects of DES + MT in swine with the following specific objectives:

1. To observe the effects of a combination of DES + MT on performance, carcass traits, some muscle properties and serum components.
2. To determine the effects of feeding these hormones from 23 to 95 kg compared to feeding them from 45 to 95 kg.
3. To ascertain possible differences in response between barrows and gilts to the hormonal treatment.

REVIEW OF LITERATURE

The effects of diethylstilbestrol (DES) and methyltestosterone (MT) or combinations of these compounds on various characteristics of swine have been reported and will be presented in the following review of the literature.

Performance and Carcass Merit

Numerous studies have been conducted with swine to determine if implantation or feeding of compounds exhibiting estrogenic activity improved gains, feed efficiency, or carcass traits. These experiments have yielded variable results.

Woehling et al. (1951) observed no significant differences in rate of gain, feed intake and efficiency or carcass quality from stilbestrol implants; but the reproductive organs showed definite evidence of hormonal stimulation. Similar results were observed by Dinusson et al. (1951) except that the non-treated gilts required 5.2 to 13.7% more feed per hundred pounds of gain than the treated pigs. Pearson et al. (1952) conducted three separate experiments and concluded that stilbestrol implants did not materially affect the gains of either gilts or barrows but apparently caused growth depression in young boars. The stilbestrol implants had no influence on organoleptic ratings of loin roasts.

Perry et al. (1954) fed pigs 2.5 mg of stilbestrol daily from 45 lb to 125 lb and then increased the level to 5 mg daily; however, no significant improvement on growth rate or feed efficiency over that exerted by antibiotic feeding was observed. This treatment resulted in enlarged teats in both males and females and swelling of the vulva in females.

Beeson et al. (1955) reported similar findings when pigs were fed 2 mg of stilbestrol daily. The latter authors stated that there was a trend toward leaner carcasses in the stilbestrol treated animals although this effect was not significant. Taylor et al. (1955) fed 0, 5, 10, 20, 40, 80, 160, 320, 640 and 1280 µg of stilbestrol per pound of ration but none of these levels had an effect upon rate of gain or feed efficiency. Additionally, differences in live probe and carcass measurements were small and not significant. Those pigs which were fed 320 µg and higher levels of stilbestrol showed teat enlargement and swelling of the external genitalia of gilts. In a similar experiment, Sewell et al. (1957) fed 0.5, 2.0 and 2.5 mg of stilbestrol per pound of feed with no consistent growth stimulatory effect. A trend toward more efficient feed utilization was noted in the pigs receiving the combination of high levels of stilbestrol and antibiotics. Teat enlargement was apparent among both barrows and gilts in all lots receiving stilbestrol. Heitman and Clegg (1957) found that when 30 mg implants of stilbestrol were given to light weight pigs (58 to 73 lb) growth rate was reduced and carcasses were leaner with less backfat and higher percentage of lean cuts. When the implants were given at heavier weights (108 to 131 lb) there was no reduction in gain and no increase in carcass leanness.

Tribble et al. (1958) used intact and castrated males and females to determine the effects of feeding 0.25 mg of stilbestrol per pound of feed from 44 to 200 lb. Their data revealed that this level of stilbestrol had no effect upon feedlot performance or carcass characteristics. However, they observed a sex-stilbestrol interaction in that males increased while females decreased in rate of gain when stilbestrol was fed. When

pigs received 2 mg of DES per day in high and low energy rations, Hale et al. (1960) found that stilbestrol exerted no effect upon either feedlot performance or carcass characteristics. Cahill et al. (1960) implanted gilts and barrows with stilbestrol pellets of 1.5, 3.0 and 6.0 mg at 150 lb. Stilbestrol implants retarded the growth rate of barrows while the gilts that received 3 mg implants gained more rapidly and consumed less feed per unit of gain than control gilts. No significant differences were noted for any of the carcass data but a positive trend existed between amount of stilbestrol implanted and size of the longissimus muscle. Day et al. (1960) reported that stilbestrol implants had no significant effect upon growth rate of barrows, in fact high levels of stilbestrol tended to reduce growth rate, but they did significantly decrease backfat thickness. Beacom (1963) also reported that a single 12 mg stilbestrol implant had no influence on rate of gain among barrows. These hormone-treated barrows had 0.52 lb less average daily feed consumption when protein level of the ration was increased from 14% to 16%. Treated barrows had less backfat, larger loin eye areas and increased net returns than control pigs. Gorrill et al. (1964) also implanted pigs with 12 mg of stilbestrol and observed that average daily gains among barrows were reduced from 1.53 to 1.36 lb, but gains of gilts increased from 1.26 to 1.34 lb. Daily feed intake of the barrows was reduced while that for gilts was increased. Stilbestrol implants had no apparent effect upon carcass traits but mammary development of both sexes was stimulated.

Numerous research studies have been conducted with androgenic compounds to observe their effects upon performance and carcass traits of swine. Woehling et al. (1951) implanted a 15 mg testosterone pellet in

the hind flank of pigs at 43 lb and again at 12 weeks of age. There were no significant differences in feed lot performance or carcass quality characteristics among any of the pigs. Sleeth et al. (1953) conducted two trials in which pigs were injected with 1 mg of testosterone propionate per kilogram of body weight once weekly for six weeks and then semi-weekly for 115 days. Treatment reduced daily gain but had little effect upon feed efficiency. The testosterone-treated pigs had less backfat which the authors attributed to the slower gains.

Perry et al. (1954) fed 20 mg of testosterone daily from 45 to 125 lb liveweight and then 40 mg daily to the finish of the test. No significant improvement in growth rate or feed efficiency was noted over that exerted by antibiotic feeding alone. In a similar experiment, Beeson et al. (1955) observed that when 20 mg of testosterone was fed throughout the experiment, rate of gain decreased but feed efficiency was not affected. The latter authors also found that testosterone treatment had no undesirable side effects and in fact appeared to make pigs trimmer and heavier muscled. Perry et al. (1956) fed 9, 17, 27, 34, 47, 52 and 62 mg of testosterone daily and observed that the 9 mg level had no effect on growth rate but higher levels reduced the growth rate. The pigs that received 17 mg of testosterone or more per day consumed less feed than those on lower levels of the hormone and were more efficient. The latter authors also observed that vulvae of gilts receiving the higher levels of testosterone assumed a fishhook shape. Additionally testosterone levels of 9 mg or more significantly decreased backfat thickness, but the degree of muscling was not significantly affected among any of the levels of treatment. In a summary of five experiments, Johnston et al. (1957) reported

that there were no differences between levels for any of the parameters studied when pigs were fed either 9 mg or 15 mg of MT per pound of feed. Both levels of MT decreased rate of gain, daily feed consumption, feed efficiency and backfat thickness. However, Noland and Burris (1956) found no apparent effect upon weight gain, feed consumption or feed utilization for either intact males and females or castrated males and females when MT was fed at rates of 0, 0.015, 0.15 and 1.5 mg per kilogram of body weight. When pigs received 1.5 mg of MT per kilogram of body weight they produced leaner carcasses as indicated by less backfat and higher percentages of primal cuts.

Thrasher et al. (1959) reported that feeding pigs various testosterone analogs had no apparent effect upon feedlot performance. However, they found that 5.0 mg of MT or 0.9 mg of 11 β-hydroxy-17 alpha-methyltestosterone per pound of ration tended to increase carcass leanness. Whiteker et al. (1959) found that providing 20 mg of MT per head daily had no significant effect upon rate of gain or daily feed intake. Treatment significantly increased lean cut yields from 56.26 to 59.06%. Hale et al. (1960) showed that feeding 20 mg of MT per day to barrows from 60 to 205 lb reduced gains on high energy rations but no effect was observed on low energy rations. While MT decreased average backfat thickness on all rations, it had no effect on carcass length or area of the longissimus muscle. Henry (1962) reported that feeding 3 levels (2, 4 and 8 mg/lb) of 4-hydroxy-17-alpha methyltestosterone had no effect upon feedlot performance.

Combinations of estrogenic and androgenic compounds and their effects upon performance and carcass merits of swine have also been studied. Sleeth

et al. (1953) injected pigs with both 1.0 mg of estradiol benzoate and 0.5 mg of testosterone propionate per kilogram of body weight. Average daily gain of the treated pigs was reduced by 0.2 lb and backfat thickness was decreased by 0.14 in. Both treated barrows and gilts exhibited abnormal sexual behavior and their reproductive tracts showed the effects of marked hormonal stimulation. Thrasher et al. (1959) compared various combinations of stilbestrol and testosterone which were either fed or implanted, but none of the treatments had a significant effect upon growth rate. In their studies pigs were removed from the trial and slaughtered when they reached 205 lb in experiment 1 and 210 lb in experiment 2. Although a trend toward increased leanness was observed among the pigs fed the hormone combination, treatment had no significant effect upon carcass characteristics. Genital and mammary stimulation was greatest when the pigs were implanted with stilbestrol and testosterone propionate.

In a more recent experiment, Jordan et al. (1965) fed a combination of 2.2 mg of DES + MT per kilogram of ration from 48.8 to 99.8 kg. The test was terminated as each pig reached 99.8 ± 2.27 kg. Average daily gain of the treated barrows was significantly reduced while treated gilts gained faster than control gilts. In addition, hormone treatment significantly reduced backfat thickness, percent fat trim and percentage of lean cuts was increased but no effect upon loin eye size or carcass length were observed. Waitt et al. (1967) studied the effects of oral DES + MT on reproductive performance of gilts and they observed that when the combination of these hormones at levels of either 2.2 or 4.4 mg per kilogram of ration was fed, during a finishing period of 60 days, breeding difficulty was encountered even though the hormones were removed 47 days prior

to breeding. The treated gilts that did conceive had 2.2 fewer pigs per litter than controls. Gilts that were fed 4.4 mg of DES + MT per kilogram of ration throughout the finishing, prebreeding and breeding periods failed to exhibit estrus and did not conceive. Only one fourth of the gilts on the 2.2 mg hormone level conceived. Following withdrawal of the hormone combination, 2/3 of the remaining gilts were bred in two subsequent estrus cycles. In a similar experiment, Thrasher et al. (1967) fed 2 g of DES + MT per ton of feed from 45 kg live weight and they removed the pigs from test at 95 kg. Hormone treatment significantly reduced feed intake, daily gain and backfat thickness and increased the percentage of lean cuts especially among the barrows. While the treatment had no effect on loin eye size or carcass length, it tended to increase feed efficiency. In a second experiment conducted by these same authors, gilts were fed 2 g of DES + MT per ton of feed from 45 to 93 kg and then they were bred 8 weeks after removal from experiment. Only four out of ten treated gilts became pregnant, four had cystic ovaries and two others failed to conceive after two services. Eight out of ten control gilts settled on the first service and none had cystic ovaries.

Baker et al. (1967) utilized 448 pigs in three experiments to evaluate the effects of feeding 2.2 mg of DES + MT per kilogram of ration from 50 to 95 kg of live weight. In each experiment the pigs were removed from test at 95 kg. In experiment 1, combination of DES + MT reduced gains and feed consumption of barrows but not among gilts. Carcasses from pigs fed DES + MT had significantly less backfat and percent fat trim, and they had significantly higher lean cut yields as well as larger loin eye areas.

In experiment 2, the authors found that the biggest response to MT + DES was obtained when the crude protein content of the ration was 16 percent. But in experiment 3, the barrows on the DES + MT-16% protein ration had smaller loin eye areas than the untreated control barrows. In the latter experiment, carcasses of pigs fed DES + MT also had decreased backfat thickness and percent fat trim and increased percentages of lean cuts. No visible signs of androgenic or estrogenic side effects were noted in pigs fed this hormone combination. Wallace and Lucas (1969) also conducted 3 experiments to study the influence of feeding either 1 or 2 mg of MT + DES per pound of ration. While these authors observed that the gains were less among hormone treated pigs than controls, differences were not significant. The hormone treated barrows showed a marked feed intake reduction, and DES + MT significantly reduced backfat thickness in all 3 experiments and increased lean cuts in experiments 2 and 3 only. However, neither loin eye area nor carcass length was significantly influenced by hormone feeding. Bidner (1969) fed 2.2 mg of DES + MT per kilogram of ration from 45 to 95 kg and the pigs were removed from test individually at 95 kg. The DES + MT treatment had little effect upon feedlot performance when the combined data of the barrows and gilts were considered; however, hormone treatment significantly reduced daily gain among barrows. Hormone treated pigs also had significantly less backfat and fat trim, larger longissimus muscle areas and higher percentages ham and loin.

In summarizing the literature reviewed, it is obvious that the response to the administration of either estrogenic or androgenic hormones to pigs is quite variable. In most studies growth rate was depressed and

feed efficiency, either unchanged or slightly increased. Backfat thickness was reduced especially if accompanied by a decrease in growth rate. In a few studies, loin eye area was increased, but in these instances the pigs were usually older due to growth depression of the hormones. Several studies have shown that undesirable side effects accompanied feeding or implants of high levels of these hormones.

Some performance and compositional differences between barrows and gilts

As early as 1940, McMeekan (1940) reported that intact females (gilts) had less fat and more bone and muscle than barrows. Comstock et al. (1944) found that barrows grow faster than gilts and that the differences in growth rate increased with age. Bruner et al. (1958), Bowland and Berg (1959), Cameron (1960), Mulholland et al. (1960), Wagner et al. (1961), Crum et al. (1964), Waldren (1964), McCampbell and Baird (1965), Hale and Southwell (1966), Hines (1966), and Brooks (1967) found that barrows grow faster than gilts, while Zobrisky et al. (1959), Blair and English (1965) and Hale et al. (1968) found no difference in rate of gain between barrows and gilts. Bell et al. (1958), Cameron (1960), Blair and English (1965), Hines (1966) and Hale et al. (1968) reported that barrows consumed more feed per day than gilts. Bowland and Berg (1959), Wagner et al. (1961), Crum et al. (1964), Brooks (1967), Hale et al. (1968) also reported that gilts required less feed per pound of gain than barrows. However, Hines (1966) noted no differences between barrows and gilts in feed efficiency.

Self et al. (1957) summarized data from 584 gilt and barrow carcasses and found that gilt carcasses contained more muscle and less fat than

barrows. Additionally, gilt carcasses had significantly larger longissimus muscles than barrows (3.81 and 3.49 in^2, respectively). Bruner et al. (1958) published data that were collected on full-sib pairs (barrows and gilts) at the Ohio Swine Evaluation Station over a period of five seasons. They reported that gilt carcasses had 2.3% more lean cuts, 0.41 in. greater length, 0.51 in^2 larger longissimus muscles and 0.1 in less backfat than littermate barrows. Kropf et al. (1959) also concluded that gilt carcasses contained more muscle and less fat than barrow carcasses. The latter authors noted that gilt carcasses had greater specific gravity values, higher percentages of lean cuts and larger longissimus muscle areas than barrows. In addition chemical analysis of a carcass composite sample showed that gilt carcasses contained less fat, more protein and moisture than barrows. Zobrisky et al. (1959) reported that barrows were the most highly finished of four sex groups followed in order by spayed gilts, gilts and boars. Cahill et al. (1960) obtained similar results and concluded that the differences in leanness became more obvious after pigs had reached 150 lb. Handlin et al. (1961) also reported that gilts were superior to barrows for most carcass traits. They found that gilts had higher carcass or ham specific gravity values than barrows.

Charette (1961) found that boars had larger loin eye areas than barrows regardless of when they were castrated. He also reported that gilts had larger loin eye areas and less backfat than barrows. Cox (1963) noted that barrows had slightly higher proportions of fat over the shoulder and less over the loin than gilts. Salmela et al. (1963) and Cahilly et al. (1963) concluded that gilts were superior to barrows in all measures of carcass leanness.

Fletcher et al. (1963) compared barrow and gilt carcasses on the basis of wholesale cuts, edible portion, fat and bone. Their data showed that gilts had significantly more edible portion from the ham and loin as well as higher percentages of total edible portion. The latter authors also found that gilts possessed significantly higher percents of bone and less fat than barrows. Beacom (1964) found that gilts had 0.25 to 0.44 in^2 larger loin eye areas and their carcasses graded superior to those of barrows. Waldren (1964) reported that gilts had significantly less shoulder and middle cuts, less backfat and larger longissimus muscle areas than male carcasses. Judge (1964) found that weight of the edible portion of hams was significantly greater in gilts than barrows. Crum et al. (1964) reported similar results, and noted that barrows had more marbling than gilts. However Rahnefeld (1965) reported results summarizing the effects of breed and sex on carcass composition and contrary to most other findings he found no breed or sex differences in backfat thickness. Blair and English (1965), Hale and Southwell (1966) and McCampbell and Baird (1966) concluded that gilt carcasses were leaner and heavier muscled than barrows. Hale and Southwell (1966) also reported that gilts had significantly higher dressing percentages compared to barrows.

Hines (1966) showed that gilt carcasses had less backfat (0.11 in), larger longissimus muscle areas (0.52 in^2) and greater length (0.2 in) than barrows when slaughtered at similar weights. In addition, gilts had higher percentages of ham and loin (1.7%) as well as lean cuts (1.8%) than barrows. Dressing percentage usually favored barrows which was consistent with the greater backfat measurement among barrows.

Muscle Composition

Meat and meat products consist primarily of moisture, lipid substances, proteins, other nitrogenous compounds and inorganic salts (Doty and Maroney, 1960). Consequently, gross analysis of meat and meat products include determinations of moisture, crude protein, fat and ash.

Clegg and Carroll (1956) showed that rib steaks of DES implanted cattle had significantly higher percent moisture and less ether extract than controls. Ogilvie et al. (1960) observed a significant increase in percent protein and moisture and a decrease in the fat content of carcass composite samples from steers fed either 10 or 30 mg of DES per day. Wallentine et al. (1961) obtained similar results from steers that received 10 mg of stilbestrol per day.

Henry (1962) observed that protein content of untrimmed boneless wholesale cuts of swine carcasses were significantly increased when pigs received 4-hydroxy-17-alpha-methyltestosterone. However, Whiteker et al. (1959) reported that the protein content of pork loins was not significantly affected by feeding methylandrostenediol, methyltestosterone or thyroprotein, but in fact these compounds tended to decrease muscle protein levels. Bidner (1969) reported that DES + MT significantly increased the percentages of moisture and protein and decreased the percentage of fat in the untrimmed right ham. Friend and Cunningham (1967) reported that gilt carcasses had higher percentages of protein and ash and a lower percentage of fat and dry matter than barrows.

It is well recognized (Denny-Brown, 1929; Ogata, 1958; Dubowitz and Pearse, 1960a; Brooke, 1966) that two basic types of fibers occur in skeletal

muscle. These muscle fibers have been described as being either slow or fast. However, Henneman and Boeson (1965) concluded that the gastrocnemius muscle of the cat could be divided into 3 basic types of fibers. These were large pale "A" or white fibers, small dark "C" or red fibers and "B" or intermediate fibers. While some disagreement exists with respect to identification and nomenclature, most myologists agree that there are three basic muscle fiber types.

Lawrie (1966) categorized "white" muscles as those which operate in short bursts of activity. These muscles have broad fibers that are lacking myoglobin and are high in glycogen. Beatty et al. (1963) also stated that immediately after slaughter glycogen content was higher in white than red areas of the adductor muscle. The latter authors concluded that lactate production was higher in white than red muscles. Blanchaer et al. (1963) stated that the higher rate of lactate production in white fibers and their greater phosphorylase, α-glycerophosphate dehydrogenase and lactate dehydrogenase activity suggests that their superior anaerobiosis is based on greater glycolytic capacity. Ogata (1960) showed by biochemical assay that white muscle fibers of the rabbit had higher anaerobic glycolytic activity than red muscle fibers. Lawrie (1966) also stated that white muscle fibers have a high content of phosphorylase, high ATP splitting capacity and little capacity for respiratory activity. On the other hand, "red" muscle fibers are narrow, and each is surrounded by several capillaries as well as having an auxiliary oxygen reserve in the form of high myoglobin concentrations. While stores of phosphocreatine, glycogen, phosphorylase and capacity for splitting ATP are relatively low, the respiratory capacity is high. The "intermediate" muscle fibers are

usually intermediate in size and enzyme activity when compared to red and white muscle fiber types.

Close (1964) stated that in some mammals, all the limb muscles are slow at birth, whereas in the adult animal they are differentiated into fast and slow muscles. He showed that the differences between fast and slow types were brought about by a relative increase in the speed of shortening of the fast type while the slow type remained essentially unchanged after birth. Several research studies have shown that characteristic properties of the muscle types can be partially reversed by cross-innervation. This suggests that the differentiation of fiber types into slow and fast muscles may be due to neural influence.

Recently, it has been found that type of exercise had an effect upon muscle fiber types. Kendrick-Jones and Perry (1965) found that when rats were subjected to short-term exercise on a treadmill creatine-phosphokinase levels increased in the leg muscles over that of controls. Peter et al. (1968) subjected guinea pigs to a single bout of exercise and found an increase in hexokinase activity in both red and white muscles. Holloszy (1967) reported that when rats were given a strenuous program of running on the treadmill several oxidative enzymes in the hind limb muscles increased 2-fold. Among these enzymes were succinate dehydrogenase (SDH), succinate oxidase and cytochrome oxidase.

Beecher et al. (1965) classified several muscles of the pig as either red or white and they observed close agreement between muscle fiber type and SDH activity with red muscle fibers having higher SDH activity than white fibers. Muscle fibers of mammals show a reciprocal relationship between phosphorylase and oxidative enzyme activity, with red muscles

being high in oxidative enzymes and low for phosphorylase and white muscles having the opposite relationship (Dubowitz and Pearse, 1960b; Padykula and Gauthier, 1963; Ogata and Mori, 1963; Romanul, 1964).

Dawson and Romanul (1964) obtained good correlations between histochemical and biochemical activity for the following enzymes: phosphorylase, isocitric dehydrogenase, malic dehydrogenase and cytochrome oxidase. They did not include SDH activity in their study. Beatty et al. (1966) studied several muscles from the rat and rhesus monkey to compare histochemical and biochemical methods of fiber type classification. They reported that a direct correlation existed between the qualitative histochemical classification (staining intensity for SDH) and the quantitative measurement of SDH activity of the quadratus femoris (red), soleus (red), sartorius (predominately red) and the superficial portion of the brachioradialis (predominately white) muscles of the rhesus monkey.

Koch (1969) categorized fiber types from pig longissimus muscles as red, white or intermediate on the basis of their staining reaction for SDH activity. He found that Poland Chinas had larger red areas (expressed as a percent of total fiber area) and smaller white areas than Chester White or Landrace pigs. He also observed a significant difference with a biochemical assay of SDH between breeds. The longissimus muscle of Landrace had the highest activity and Poland Chinas the lowest SDH activity.

The sarcoplasmic and myofibrillar proteins are removed from muscle by varying the extraction procedure, especially the ionic strength of the extracting solution. Helander (1957) found that when finely subdivided

muscle was extracted with distilled water, about one-third of the total protein content was solubilized. This soluble protein fraction includes the sarcoplasmic proteins plus non-protein nitrogen (NPN). Sarcoplasmic proteins have a number of physical and chemical properties in common including low molecular weight, low viscosity, easy extractability and a globular structure (Helander, 1957). Dickerson and Widdowson (1960) stated that the sarcoplasmic fraction consisted of proteins found in the sarcoplasm including the enzymes of the glycolytic cycle and most of the ribonucleoproteins. Hill (1962) reported that sarcoplasmic proteins of the longissimus muscle accounted for 23.64% of the total nitrogen on a fat free basis. However, Randall (1969) found that sarcoplasmic protein nitrogen fraction represented 18.09% of the total nitrogen in longissimus muscles of pigs when expressed on a dry, fat free basis.

Dickerson and Widdowson (1960) stated that NPN has been assumed to represent the nitrogen in tissues which is present in true solution. The latter authors reported that the NPN fraction is separated from total nitrogen by its solubility in trichloroacetic acid. Besides urea, creatine and purines, the NPN fraction includes amino acids and some polypeptides. Hill (1962) reported that the NPN fraction was 12.41% of the total nitrogen while Randall (1969) found that the NPN fraction accounted for 11.89% of the total nitrogen.

Helander (1957) found that myofibrillar proteins remained in the muscle tissue during the extraction of sarcoplasmic and NPN fractions. The myofibrillar protein fraction includes myosin, actin, tropomyosin troponin and several other proteins. Dickerson and Widdowson (1960) reported that the fibrillar fraction contains the true fibrillar proteins

and their denatured products and also mucopolysaccarides and deoxyribonucleoproteins. These proteins differ from the sarcoplasmic fraction in that they have a fibrous nature, high viscosity, high molecular weight and low solubility. Randall (1969) stated that the fibrillar nitrogen represented 47.57% of the total nitrogen while Hill (1962) found that the fibrillar fraction was 56.71% of the total.

Dickerson and Widdowson (1960) reported that the stroma proteins include the extracellular proteins, collagen, elastic and reticulin. Hill (1962) found that 7.24% of the total nitrogen was stroma protein and Randall (1969) reported that stroma nitrogen represented 22.26% of total nitrogen.

Dickerson and Widdowson (1960) observed that the NPN fraction remained relatively constant from the 46th day of fetal life to the adult pig. On the other hand they found that sarcoplasmic proteins were high in the 46 day old fetus but decreased until birth and then increased thereafter until maturity. While the fibrillar proteins of the pig increased from the 46 day fetus to maturity, the biggest increase occurred between day 46 and day 90 of fetal life.

Partmann (1963) found that extractability of fish muscle proteins decreased very slowly with time when the muscle was frozen and stored below -18°C. Borchert and Briskey (1965) reported that freezing muscle in liquid nitrogen did not significantly effect protein extractability. Khan et al. (1963) stored chicken muscles at different temperatures up to 100 weeks and he observed that when samples were stored at -18°C or below, the total extractability changed very little until about 50 weeks. The loss of protein extractability resulted in a decrease of the actomyosin fraction

while the stroma fraction remained unchanged and the sarcoplasmic fraction decreased only after long storage. Sayre and Briskey (1963) found that protein solubility of pig muscle was grossly altered by the conditions of both temperature and pH existing at the onset of rigor mortis or during the first few hours after death. In a similar experiment, Sayre et al. (1966) reported that when the pH of postmortem porcine muscle dropped to 5.8 or lower while muscle temperature remained above 35°C, solubility of the muscle proteins was markedly reduced. They observed that the sarcoplasmic proteins were not affected to as great an extent as the myofibrillar proteins by the early postmortem high temperature-low pH conditions.

Scopes (1964) found that myofibrillar proteins are soluble only in high ionic strength solutions and that pH has a great effect upon the quantity of myofibrillar protein that can be extracted. Sarcoplasmic proteins are denatured readily at pH values below 6.0 at 37°C. Scopes and Lawrie (1963) stated that as a result of the postmortem conversion of glycogen to lactic acid, muscle pH falls from its in vivo value of about 7.3 to about 5.5 depending upon such factors as physiological state of the animal before death, type of muscle and temperature during glycolysis. It has been shown that postmortem rate of pH fall of porcine muscle is relatively fast, thus low pH values may be attained while temperature is still high resulting in considerable denaturation and precipitation of the muscle proteins (Sayre and Briskey, 1963; Sayre et al. (1966); Borchert and Briskey, 1965). Bendall and Wismer-Pedersen (1962) concluded that under these conditions porcine fibrillar proteins are not denatured or aggregated in the usual sense, but are probably covered by a layer of denatured

sarcoplasmic protein that is firmly bound to the surface of the myofilaments. This phenomenon results in reduced extractability of the myofibrillar proteins.

Lawrie (1960) studied the effect of hexoestrol implants upon the muscle composition of Friesian steers and found essentially no difference between the treated and control steers for any of the nitrogen fractions. Kochakian (1966) also concluded that the weight changes observed in rats from the administration of androgens did not alter the composition of the muscles. However, Lawrie et al. (1964) compared muscles from a 'doppelender' (hypertrophied) heifer with those of a normal half sister and found that the nitrogen content of the muscles increased by 5% while the hydroxyproline content was decreased by 40% in muscles of the 'doppelender' heifer. Additionally, muscles of the 'doppelender' heifer also had higher levels of sarcoplasmic proteins and lower quantities of stroma proteins than the normal heifer.

Most anatomists subscribe to the theory that the number of muscle fibers is fixed at birth. This theory has recently been challenged but no conclusive evidence to the contrary is available to date. Thus, if fiber number is essentially fixed at birth, the only increase in muscle quantity that can occur would be by hypertrophy or the enlarging of individual muscle fibers. In this perspective fiber diameter can be a useful measure of hypertrophy. Livingston et al. (1966) correlated muscle fiber diameter with total lean content of the pig but his correlations were poor. Joubert (1956) reported that weight of muscle had the highest relationship to fiber size with larger muscles having larger fiber diameters. Swanson

et al. (1965) found considerable variation in muscle fiber size at different positions along the longissimus muscle and at different locations within each position.

Carrow et al. (1967) reported that both forced and voluntary exercise increased muscle size in the hind limb of rats; however, the cross-sectional area of the red fibers showed a greater increase than those of white fibers. Edgerton et al. (1969) revealed that the plantaris muscle of moderately and heavily exercised rats showed a greater proportion of fibers with high malate, succinate dehydrogenase and nicotinamide adenine denucleotide diaphorase activity than sedentary rats. They concluded from these observations that muscle types can be changed in non-pathologic conditions.

MacDonald and Slen (1959) injected ewes and wethers with either estradiol cylcopentylpropionate or testosterone, but neither of these hormones had a significant effect upon fiber diameter of the longissimus muscle. Everitt and Carter (1961) reported that 60 mg implants of hexoestrol likewise had no effect upon fiber diameter of the semitendinosus muscle of steers.

Bone and Blood Components

Turner et al. (1941) found that even with prolonged injections of large amounts of testosterone propionate the skeletal structure of rats was not affected. O'Mary et al. (1952) observed that stilbestrol treated western lambs had higher percentages of bone plus connective tissue, although there was no significant difference in percent bone alone. Although

the differences were not significant, Clegg and Carroll (1956) found a trend toward increased percentages of bone in stilbestrol implanted cattle. Bell et al. (1957) fed lambs 4 mg of stilbestrol daily and showed that treatment increased body retention of calcium, phosphorus and nitrogen. Wallentine et al. (1961) found that bone from stilbestrol fed steers contained less ether extract and a higher percentage of ash than untreated controls. Bidner (1969) found that DES + MT treated pigs had heavier and larger femurs than untreated controls, but the hormone combination had no effect upon bone calcium, phosphorus, percent ash or bone strength. Femurs from the treated pigs also had increased moments of inertia, maximum load and bending moments but no differences in breaking stress were observed. Thus, DES + MT treatment increased bone size without influencing its composition.

Gardner and Pfeiffer (1943) observed that the injection of estrogenic hormones increased levels of serum calcium and accelerated the rate of bone formation in birds. Whitehair et al. (1953) noted that lambs implanted with stilbestrol retained 60% more calcium, 30% more phosphorus and 83% more nitrogen than the control group. Shroder and Hansard (1958) observed that lambs fed 2 mg of stilbestrol per day had reduced fecal endogenous calcium with little apparent influence upon calcium absorption. While the latter authors reported that phosphorus absorption was increased, fecal endogenous phosphorus was only slightly decreased by hormone treatment.

Wilkinson et al. (1954) reported that lambs treated with stilbestrol had significantly lower hematocrit values than controls. The latter authors also observed that treated lambs had significantly higher levels of plasma globulins and total proteins than controls. Baker et al. (1968) reported that DES + MT

decreased serum triglycerides and cholestrol levels among gilts but had no influence upon free fatty acid levels. Bidner (1969) observed that DES + MT had no influence upon hematocrit, hemoglobin, total serum proteins, serum calcium or phosphorus in the pig. He also reported that although DES + MT altered percentages of the serum protein fractions, it had no significant effect on the total amount of serum proteins. The hormone combination significantly decreased the β-globulin and increased the albumin fractions.

Kotik (1966) reported that Large White gilts had higher serum levels of albumin and α-globulin, lower levels of β- and α-globulins and less total serum protein than barrows.

Serum Growth Hormone

Growth hormone (sometimes referred to as somatotropic hormone) activity exerts a regulatory influence on skeletal growth and protein biosynthesis. Pituitary extracted growth hormone (GH) has been shown to stimulate growth, nitrogen retention and protein synthesis in animals (Young, 1945; Evans et al., 1948; Thurman and Andrews, 1955; Knobil, 1961; Youself and Johnson, 1966; Wheatley et al., 1966; Emerson and Emerson, 1969).

Hunter (1967) stated in a review article that the only well established function of growth hormone is its maintainance of tissue fuel supplies by means of increasing lipolysis. Blood glucose level is closely related to GH output. While secretion of human GH is greater in children than in adults, the secretion pattern is similar. Goldberg (1969) reported that muscles of rats treated with pituitary GH were indistinguishable in gross observations other than size from those of control rats. These results indicate that unlike work induced

hypertrophy which causes an increase in synthesis and a decrease in degradation, GH increased protein synthesis in muscle without changing protein degradative rates.

Prior to the development of assays for measuring blood hormone levels, a number of attempts were made to associate growth rate with pituitary GH activity. The rat tibia test has been used until very recently to indirectly measure the amount of GH activity in the pituitary gland. Baird et al. (1952) studied two lines of pigs, a fast and slow growing line. They found that the fast growing line had heavier pituitary weights and rat tibia assay indicated these pigs also had higher GH levels than the slow growing line. Armstrong and Hansel (1956) found a positive correlation between growth rate and anterior pituitary GH concentration in Holstein heifers. Baker et al. (1956) also found a positive relationship between weight of the dry anterior pituitary and GH activity in pigs. Gerrits (1968) measured pituitary gland GH content of a fat and lean line of Duroc pigs by the rat tibia test. He found no difference in GH content between the two lines and concluded that genetic selection for high and low backfat probably altered the ability of the tissues to respond to GH rather than influence the secretory mechanism.

Clegg and Cole (1954), Cahill et al. (1956), Shröder and Hansard (1958), and Preston and Burroughs (1958) have all reported that stilbestrol increased the weight of the anterior pituitary in ruminants. Clegg and Cole (1954) also found that the heavier pituitary glands contained larger amounts of GH among heifers but not in steers. The latter authors also observed that the steers showed a marked increase in growth due to stilbestrol while the heifers exhibited only a slight growth response. Schroder and Hansard (1958) reported that heavier

pituitary glands from DES treated lambs contained significantly higher GH levels than untreated controls. In a similar experiment, Struempler and Burroughs (1959) observed that pituitary GH content increased with increasing levels of DES. Bidner (1969) found that DES + MT treated pigs also had larger pituitary glands than untreated controls.

Radioimmunoassay techniques have recently been developed as a quantitative measure of hormone levels in body fluids. Siers (1968) used an antibody-charcoal radioimmunoassay technique to measure porcine plasma growth hormone (PGH). He failed to find any positive relationships between plasma PGH levels and meat characteristics. Machlin et al. (1968) developed a double antibody radioimmunoassay procedure to determine plasma PGH levels. The latter authors reported that plasma basal levels of PGH were 5.8 ± 0.8 ng/ml for pigs (45 to 75 kg) which had been fasted overnight. Stress and exercise provoked significant increases in plasma PGH levels but these authors concluded that changes are less dramatic compared to those seen in the normal weight man. Greenwood (1967) stated that higher than normal levels of plasma GH could be produced in men and postmenopausal women following the administration of stilbestrol. Trenkle (1970) reported that stilbestrol fed steers had increased plasma GH levels as well as pituitary glands which were 15% heavier than controls. However, Purchas (1970a) found that jugular GH levels were higher in Holstein-Friesian heifers (4 to 10 months of age) on a normal level of nutrition than similar animals on a high level of nutrition or on a high level of nutrition plus MGA (melengestrol acetate).

Protein Biosynthesis

Androgens, usually C_{19} steroids, are responsible for the normal development of male reproductive organs and secondary sexual characteristics. Eberlin et al. (1967) stated that in addition to the growth stimulatory effects on particular structures, androgens exert a generalized anabolic effect, causing increased protein formation, particularly in muscle and bone, resulting in increased rates of linear growth in immature animals. Bradford (1967) also concluded that androgens have a profound effect on protein anabolism. Simpson et al. (1944) showed that body weight gains and skeletal growth in hypophysectomized male rats injected with pituitary hormones were augmented by the simultaneous injection of testosterone propionate.. Saunders and Drill (1957) showed an anabolic effect in rats as measured by weight of levator ani muscle. Hershberger et al. (1953) also used the levator ani muscle to observe the myotrophic effects of androgens. These authors concluded that 19-nortestosterone had high myotrophic activity and low androgenic activity in rats. In a review article, Kochakian (1966) summarized several papers dealing with the effects of androgens upon regulation of muscle growth in the dog, rat and guinea pig. He and others have shown a positive nitrogen balance in castrated dogs with exogenous androgens. He also reported that the simultaneous administration of GH and testosterone propionate to the castrated rat resulted in an additive effect upon nitrogen balance and body weight. Age and weight, at which androgens were injected were critical parameters for the observation of a positive response to body weight and protein content. In contrast to the rat, Kochakian (1966) showed that certain muscles of the guinea pig were dependent on androgens for their development. He concluded that androgens stimulated increases in

body weight, with the concomitant synthesis of protein in skeletal muscles and these events were accompanied by a decrease in body fat. Fujii and Villee (1968) reported that a single injection of 1 mg of testosterone stimulated the synthesis of ribonucleic acids (RNA) in the ventral prostate, seminal vesicles and liver of immature rats. Kochakian (1966) also reported that testosterone induced an early and rapid increase in the RNA content of the temporal and massster muscles of castrated rats. Hancock et al. (1962) found that the administration of androgens to castrated rats greatly increased the incorporation of ^{32}P labeled CTP into RNA on aggregate preparations isolated from the ventral prostate gland. Wicks and Kenny (1964) revealed that within 70 minutes after the administration of testosterone to rats, castrated 12 to 15 hours previously, the rate of synthesis of RNA in the seminal vesicles increased by 50% and continued to rise until approximately 50 minutes after injection.

Liao (1965) found that prostatic nuclei and ribosomes isolated from testosterone-treated animals are richer in template RNA than those obtained from control rats. Silverman (1963) reported testosterone governs the level of template RNA associated with prostatic ribonucleoprotein particles. These authors also suggested that testosterone governs synthesis or utilization of messenger RNA (MRNA) in the ventral prostate. Bruckovsky and Wilson (1968) reported that 1 minute after administration of testosterone to rats it was taken up by the prostate and at least 90% was converted to 3 products: androstandiol, dihydrotestosterone (DHT) and androsterone. They also found that in the presence of NADPH generating system, nuclei isolated from the prostate converted testosterone to DHT. Bashirelahi and Villee (1970) showed that DHT and not testosterone was effective in increasing in vitro RNA synthesis in the

nuclei of the prostate gland. Anderson and Liao (1968) found that nuclear chromatin of the prostate contained an androgen receptor which selectively retained DHT. The presence of a highly tissue-specific receptor for DHT in the prostatic nuclear chromatin material indicates that this hydrogenated testosterone derivative may be the active form of androgen in prostatic nuclei.

Liao et al. (1965) measured the RNA polymerase activity of purified nuclei from the prostate of castrated rats shortly after testosterone injection. They found a significant enhancement of RNA polymerase activity within a few hours after a single injection of testosterone. Widnell and Tata (1966) reported that testosterone stimulated the Mg^{2+}-activated RNA polymerase reaction in liver cells of castrated rats. Bradfield (1967) stated in a review article that the administration of testosterone propionate to rats in small doses enhances RNA polymerase activity resulting in increased RNA synthesis.

Breuer and Florini (1965) demonstrated that castration of immature male rats reduced the protein synthetic activity of isolated muscle ribosomes by one-half within 9 days. They further observed from sucrose gradient centrifugation studies that the level of protein synthetic activity was correlated with the polyribosome profile. Additionally, the castrated rats had a decreased percentage of ribosomes sedimenting as polyribosomes. Androgen replacement brought the activity of the castrated rats back to that of the control male rats. These authors concluded that androgens probably stimulate the synthesis of mRNA, since they increased the muscle polyribosome content. Actinomycin D prevented androgens from stimulating the muscle ribosomes which may also indicate that androgens are enhancing mRNA synthesis.

In a later experiment, Breuer and Florini (1966) studied the effects of a single injection of testosterone propionate, growth hormone or a combination

of the hormones on aggregated RNA polymerase and chromatin activity in femoral muscles. Both testosterone propionate and growth hormone increased RNA polymerase activity but the effect of testosterone was masked when the assay was performed in ammonium sulfate medium. Testosterone also increased the priming activity of muscle chromatin while growth hormone did not stimulate the template efficiency of chromatin. They concluded that testosterone but not growth hormone stimulated RNA synthesis in muscle by increasing the priming activity of deoxyribonucleic acid (DNA). Growth hormone, on the other hand, may act directly by affecting RNA polymerase activity.

More recently Florini (1970) investigated the pattern of protein synthesis in the intact soleus muscle of testosterone-treated and control rats by disc-gel electrophoresis and isoelectric focusing in polyacrylamide gels. He found no detectable differences in protein composition even when testosterone injection had stimulated both RNA and protein synthesis by 60%. Gross examination of the soleus muscles indicated that androgens did not cause any major change in the structure or function of skeletal muscle.

Estrogens are responsible for the development of sex organs, secondary sexual characteristics and maintainance of the menstrual cycle and pregnancy in females. O'Donnell and Preedy (1967) stated that it has become increasingly clear in recent years that the effects of estrogens on physiological processes are in fact widespread. The treatment of an animal with estradiol-17β causes stimulation of various synthetic pathways in the isolated uterus including protein synthesis. Many research studies have shown that estrogens and estrogenic like compounds have an anabolic effect in ruminants. Andrews et al. (1954) compared steers which had been implanted with either testosterone or

stilbestrol and they observed that testosterone did not affect growth or feed efficiency while stilbestrol increased both growth rate and feed efficiency. Perry et al. (1955) found that steers fed 10 mg of stilbestrol daily had increased gain and feed efficiency while Clegg and Carroll (1956) reported that stilbestrol implants increased growth rate and feed efficiency of both steers and heifers. The latter authors also observed that hormone treatment significantly increased loin eye size. Ogilvie et al. (1960) found that steers implanted with DES had increased growth rates and improved appetite. Trenkle (1970) reported that live weight gains of steers fed DES were 12% greater than controls and as mentioned previously, the treated steers had increased plasma GH levels and heavier pituitary glands. He concluded that DES could be stimulating the pituitary gland to release increased quantities of GH into the plasma. Clegg and Cole (1954) found that DES implants increased nitrogen retention in both lambs and steers. The increased retention was mainly due to decreased urinary nitrogen output. Struempler and Burroughs (1959) also found that DES increased nitrogen retention in lambs. Whitehair et al. (1953) reported that DES implanted lambs had a 68% increase in growth rate over that of controls. In a similar experiment, Whanger et al. (1964) found that DES increased the retention of absorbed nitrogen in lambs.

Aizawa and Mueller (1961) concluded that the action of estradiol on the uterus was primarily concerned with the induction of conditions favorable to protein synthesis. Gorski and Nicolette (1963) reported that injection of estradiol-17β stimulated the in vivo incorporation of orthophosphate-^{32}P into RNA of immature and ovariectomized rat uteri within one hour. They also showed that this effect of estrogen was similar in all subcellular fractions which may indicate that the influence on protein synthesis occurs at some common

site. In another experiment Gorski (1964) revealed that nuclear preparations of uteri, from rats which were treated in vivo with 17β-estradiol 1 and 2 hours earlier had higher polymerase activity than preparations from controls. This reaction could be blocked by high ionic strength media and puromycin. This observation indicates that estrogen is apparently causing the synthesis of some protein which increases RNA polymerase activity.

EXPERIMENTAL PROCEDURE

Two experiments involving 40 barrows and 40 gilts were conducted to observe the effects of a combination of DES + MT on various characteristics of swine. Yorkshire pigs, except for three Yorkshire-Hampshire crossbreds in experiment 2, were randomly alotted to treatments from weight, sex and litter outcome groups. In both experiments, gilts and barrows were fed in separate lots, each containing self feeders and automatic water fountains.

In experiment 1, 16 barrows and 16 gilts of Yorkshire breeding were randomly assigned to a 2 x 2 factorial design (sex group and with or without DES + MT). Thus eight barrows and eight gilts served as controls and an additional eight barrows and eight gilts were fed 2.2 mg of DES and 2.2 mg of MT per kilogram of ration from approximately 49 to 95 kg of body weight. Composition of the rations is shown in table 1. The experiment was started June 4, 1969 and the last group of hogs was removed from the trial August 22, 1969. Two pigs were removed from each of the four lots when they averaged approximately 95 kg. Approximately 20 ml of blood were withdrawn from the anterior vena cava at the initiation of the experiment and again after 7, 28 and 56 days on the DES + MT treatment for the determination of serum free fatty acids (FFA), serum GH levels and electrophoresis of the serum proteins. The blood samples were collected at approximately the same time (8:00 a m) on each bleeding day.

TABLE 1. COMPOSITION OF THE RATIONS

Ingredients	Experiment 2 16.0% Protein		Experiment 2 16.0% Protein	
Ground shelled corn	77.50	77.50	77.25	77.25
Soybean meal (49%)	18.00	18.00	18.00	18.00
Salt	0.50	0.50	0.50	0.50
Limestone	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.00	1.00	1.00	1.00
MSU VTM premix[a]	0.50	0.50	0.50	0.50
Vitamin E premix[b]	0.25	0.25	0.50	0.50
DES + MT - Tylan premix[c]	--	1.25	--	1.25
Tylan premix[d]	1.25	--	1.25	--
Total	100.00	100.00	100.00	100.00
Chemical Analysis				
Crude protein, %	16.20		15.22	
Calcium, %	0.74		0.78	
Phosphorus, %	0.49		0.51	

[a]The vitamin-trace mineral premix supplied the following (per kg of feed): Vitamin A-3,307 IU; Vitamin D_3-661 IU; Pantothenic acid-13.2 mg; Niacin-17.6 mg; Riboflavin-3.3 mg; Choline chloride-110 mg; Vitamin B_{12}-19.8 µg; Zinc-75 mg; Manganese-37.5mg; Iodine-2.75 mg; Copper-9.92 mg; Iron-59.5 mg and BHT-49.6 mg.
[b]Experiment 1 - 110 IU Vitamin E/kg of feed and Experiment 2 - 220 IU/kg.
[c]Supplied 2.2 mg DES, 2.2 mg MT, and 11 mg Tylosin/kg of feed.
[d]Furnished 11 mg Tylosin/kg of feed.

Table 2 shows the design of experiment 2 and the number of pigs remaining per lot at the end of the trial. During the course of this experiment 10 pigs were removed from the experiment because of disease or other

factors which affected their performance. Twenty-four barrows and 24 gilts weighing approximately 23 kg were randomly assigned to the six treatment groups of experiment 2 on Nov. 3, 1969. One Yorkshire-Hampshire crossbred gilt was assigned to each of the three gilt lots. The two lots which received DES + MT at 45 kg were fed the control ration until Dec. 5, 1969, at which time they were switched to the ration containing DES + MT. Composition of these rations is shown in table 1.

TABLE 2. EXPERIMENTAL DESIGN OF EXPERIMENT 2.

	Number of pigs per lot			
	Barrows		Gilts	
Treatment	Start Exp.	End Exp.	Start Exp.	End Exp.
No DES + MT	8	5	8	6
DES + MT from 45 kg[a]	8	7	8	6
DES + MT from 23 kg[a]	8	7	8	7

[a]2.2 mg of diethylstilbestrol plus 2.2 mg methyltestosterone per kilogram of ration.

Blood samples (10 ml) for GH assays were taken at the start of the experiment (23 kg) and at 5 and 13 weeks after being placed on the DES + MT treatment at approximately the same time of morning (8:00 a m) on each sampling period. Two pigs were removed for slaughter when they averaged approximately 95 kg. The last group of pigs was removed for slaughter on Feb. 20, 1970. The hormones (DES + MT) were withdrawn approximately 90 hours prior to slaughter.

Slaughter Procedure

The pigs were slaughtered in the University Meats Laboratory and dressed essentially packer style. The hams were faced and leaf fat was loosened during slaughter but the facing and leaf fat were left attached and removed after chilling. At 20 min postmortem, a cross-sectional sample approximately 3 cm thick was excised from the right longissimus muscle adjacent to the 1st and 2nd lumbar vertebrae. The adhering fat and connective tissue were removed and the muscle was cut into four equal sized pieces. These muscle sections were then frozen in liquid nitrogen.

Three samples for histochemical analysis were also taken at this time and frozen in liquid nitrogen. After removing the frozen muscle samples from the liquid nitrogen, they were placed in sterile polyethylene bags and held in a container of dry ice until they were transferred to a -29°C freezer. Two pigs were slaughtered at one time allowing a span of 10 min between each animal to accommodate the sampling procedure.

Cutting Procedure

The carcasses were chilled at 1.1 to 4.4°C for 24 hr. Prior to cutting the carcasses, length and backfat thickness (avg of three measurements) were measured as described by the Pork Carcass Evaluation Committee (1952). The wholesale cutting procedure followed was that described by the Pork Carcass Evaluation Committee (1952) except that the anterior portion of the left longissimus muscle was excised from the shoulder before the shoulder was separated from the loin and belly. Area of the right longissimus muscle was recorded at the 10th rib.

Longissimus and Quadriceps Femoris Muscles

The entire left longissimus muscle was removed and then freed of adhering surface fat before it was weighed. The entire longissimus muscle was ground twice through a 1.8 mm plate and thoroughly mixed. A 50 to 75 g sample of the muscle was placed in polyethylene bags and stored at -29°C for subsequent protein, fat and moisture determinations.

The quadriceps femoris muscle includes the following individual muscles: rectus femoris, vastus intermedius, vastus lateralis and vastus medialis which were removed as a group from the left ham, freed of surface fat and then weighed.

Right ham and loin muscles were subjectively evaluated for marbling, color, firmness and wateriness on a 0 to 5 scale for each of these characteristics. Values of 5 were assigned to those hams and loins with the highest degrees of marbling, most desirable color and the firmest and driest muscles. Ham and loin muscles which were devoid of visible marbling, very pale in color and very soft and watery were assigned scores of 0 for each of the quality characteristics. The Wisconsin quality scoring system was used as a reference (Wisconsin quality standards, 1963).

Moisture, Fat and Protein

Duplicate composite samples of approximately 5 g were placed in disposable aluminum dishes and dried at 100°C for 18 to 24 hr for moisture determination. After cooling in a desiccator, weight loss was recorded as moisture. Fat content was determined by extraction of the above dried samples with anhydrous ether for 3 1/2 to 4 hr in a Goldfisch Fat Extractor

as outlined in A.O.A.C. (1965). A micro-Kjeldahl technique (American Instrument Company, 1961) was used to determine total nitrogen in approximately 1/2 g samples. It was assumed in the protein calculations that muscle protein contains 16% nitrogen.

Powdered Frozen Muscle

The muscle samples previously frozen in liquid nitrogen for the determination of the protein fractions were powdered in a -29°C room as described by Borchert et al. (1965). Chipped dry ice and shattered pieces of frozen muscle were pulverized in a Waring Blendor jar for approximately 30 to 45 sec. The muscle powder was sifted and the coarse material remaining on the sieve was again placed in the blendor and the process repeated. After the second pulverization and sifting was completed, the coarse material was discarded. The powdered muscle samples were stored in polyethylene bags which were not sealed until 12 hr after filling to allow for the escape of CO_2.

Muscle pH

Five grams of powdered frozen muscle (frozen in liquid nitrogen at 20 min postmortem) were suspended in 25 ml of 0.005 M sodium iodoacetate by gentle agitation with a magnetic stirrer. A Corning Model 12 expanded scale pH meter was used for the pH determinations. Beckman 3581 buffer solution pH 7.0 was diluted 25-fold and used to standardize the pH meter.

Blood Preparation

Following withdrawal, the blood was placed in centrifuge tubes, allowed to clot and the clot was freed from the side of the tubes. The cells and serum were then spun at 2000 x g for 15 min in a model 5 International Centrifuge. The decanted serum was placed in vials and an aliquot taken for protein electrophoresis. The remaining portion of the serum was frozen and stored at -29°C.

Electrophoresis of Serum Protein

Electrophoretic separation of serum proteins was accomplished on agar gel in a modified Durrum cell (Cawley and Eberhardt, 1962). Four ml of warm 1% agar solution in barbital buffer pH 8.6 were applied to a 32 mm, 16 cm film leader. Three lambda of serum were streaked on the agar gel using a 10 lambda graduated pipette. The electrophoretic separation procedure was allowed to proceed for 45 min at 200 volts D C and a current of 75 milliamps in the modified Durrum cell filled with barbital buffer at pH 8.6. The film leader strips were attached to a staining rack and oven dried at 110°C. After the strips had thoroughly dried, they were placed in thiazine red solution (0.2% Thiazine Red R in 10% glacial acetic acid) for at least 10 min. The strips were then put through two decolorizing baths of 5% acetic acid for another 10 min or more. Quantitation was accomplished with a Beckman RB analytrol densitometer.

Serum Free Fatty Acids

A colorimetric method for the determination of free fatty acids (FFA) in porcine serum was developed from a modification of the methods of Duncombe (1963), Itaya and Ui (1965) and Weenick (1969). Three-tenths of a ml of serum was added to a glass-stoppered test tube containing 2 ml of phosphate buffer pH 6.1 and 6 ml of chloroform. The mixture was shaken 30 times and allowed to separate for at least 15 min. After separation, most of the upper layer was removed with a disposable Pasteur pipette. Three ml of copper-triethanolamine reagent (equal volumes of 6.45% Cu $(NO_3)_2 \cdot 3$ H_2O and 1 M triethanolamine, final pH 7.8) were added and again the mixture was shaken 30 times and the upper layer removed. The chloroform solution of copper-fatty acid soaps was filtered through Whatman No. 4 filter paper to remove trace amounts of copper in the aqueous solution. Three ml of the filtrate were mixed with 0.5 ml of color reagent (0.1% diethyldithiocarbomate in n-butanol, prepared fresh daily) and read immediately at 440 nm on a Bausch & Lomb Spectronic 20 Colorimeter against a blank of 3 ml of chloroform and 0.5 ml of color reagent. The optical density reading of a chloroform blank which was carried through the procedure was subtracted from all values. Amount of FFA was quantitated with the aid of a standard curve (prepared with a solution of palmitate in chloroform).

Protein Fractionation

The protein fractionation procedures used were similar to those of Helander (1957) and Borton (1969). All fractionation procedures were carried out at 4°C with cold extracting solutions. Details of this method are outlined in figure 1.

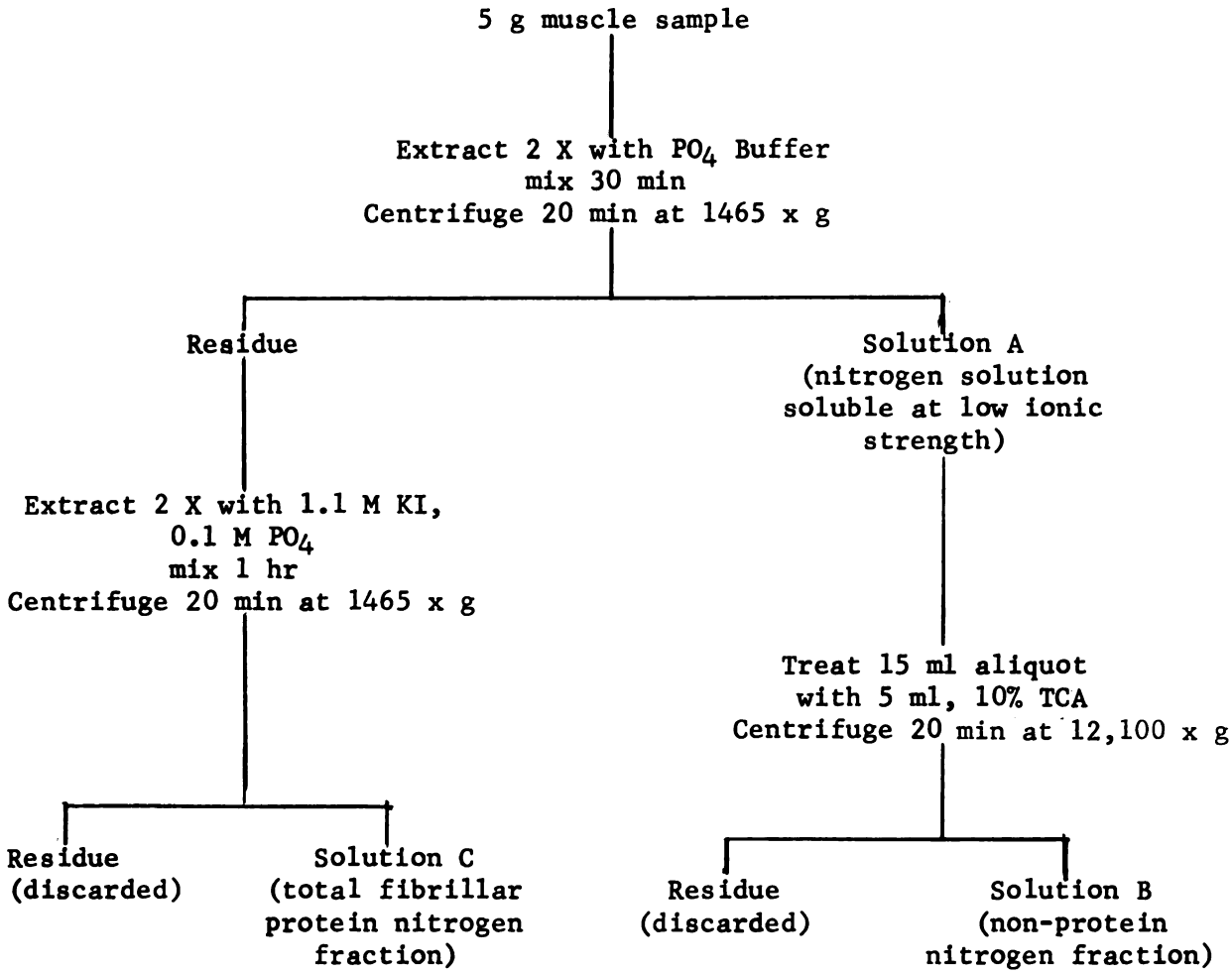

Figure 1. Outline of the protein fractionation procedure.

Five grams of powdered frozen muscle were weighed into 250 ml autoclavable polypropylene wide mouth bottles equipped with screw covers. Fifty ml of 0.05 M phosphate (PO_4) buffer were added to the 5 g of powdered muscle. The bottles were placed on a magnetic stirrer and gently agitated for 30 min. The mixture was centrifuged at 1465 x g for 20 min in a Sorvall superspeed RC2-B automatic refrigerated centrifuge. The supernatant was filtered through eight layers of cheese cloth into a 100 ml graduated cylinder. The residue was resuspended in 50 ml of 0.05 M PO_4 buffer, stirred, centrifuged and filtered as described above. The volume of the combined supernatants was recorded and designed as solution A. A 15 ml aliquot of solution A was used for nitrogen analysis for nitrogen soluble at low ionic strength. A second 15 ml aliquot of solution A was mixed with 5 ml of 10% trichloracetic acid (TCA). After 3 hr, the mixture was centrifuged at 12,100 x g for 20 min with the supernatant being designed as solution B (NPN).

The residue remaining after the 0.05 M PO_4 buffer extraction was suspended in 50 ml of 1.1 M KI and 0.1 M PO_4 buffer, pH 7.4. The mixture was stirred gently for 1 hr on a magnetic stirrer and centrifuged at 1465 x g for 20 min. The supernatant was collected and the extraction procedure was repeated. The volume of combined supernatants was recorded and designed as solution C (total fibrillar nitrogen fraction).

Total nitrogen was determined on 0.5 g of frozen powdered muscle. Fifteen ml fractions were used to determine the nitrogen in solutions A, B and C and the results were designed as nA, nB, nC and nT (as total nitrogen content of the muscle sample) respectively.

These symbols represent the following nitrogen fractions:

nA = nitrogen extractable at low ionic strength

nB = non-protein nitrogen (NPN)

nA - nB = sarcoplasmic protein nitrogen

nC = fibrillar protein nitrogen

nT - (nA + nC) = stroma protein nitrogen

Succinic Dehydrogenase Activity

The procedure followed was that described by Bonner (1955).

Approximately 4 g of powdered frozen muscle were extracted for 30 min with 15 ml 0.02 M phosphate buffer, pH 7.2. The resultant mixture was centrifuged at 1500 x g for 20 min and the supernatant (3°C) was adjusted to pH 5.7 with 1 N acetic acid. This mixture was again centrifuged at 1500 x g for 15 min and the precipitate suspended in 3 ml of 0.1 M PO_4 buffer (pH 7.2).

A 0.3 ml aliquot of the buffered suspension was added to a tube containing 1.9 ml of 0.15 PO_4 buffer pH 7.2, 0.3 ml of 0.1 M KCN, 0.3 ml of 0.01 M $K_3Fe\ (CN)_6$ and 0.2 ml of sodium succinate. Reduction of $K_3Fe\ (CN)_6$ was read spectrophotometrically at 420 nm with a Beckman DU Spectrophotometer. Absorbance was obtained initially and again after 30 min of incubation at 35°C against a blank, which was identical to sample tubes except distilled water replaced $K_3Fe\ (CN)_6$. Results were expressed as millimicromoles of succinate oxidized per minute per gram of muscle.

Determination of Red, White and Intermediate Fiber Types

Fresh-frozen blocks of the longissimus muscle which were removed and frozen in liquid nitrogen for histochemical analysis of fiber types were sectioned (8 to 10 μ) on a Slee Freeze microtome. The sections were mounted on coverslips and stained for SDH activity according to the procedure of Nachlas et al., (1957). The tissue sections were incubated in a stock PO_4-succinate buffer (equal volumes of 0.2 M PO_4 buffer, pH 7.6 and 0.2 M sodium succinate) mixed 1 to 1 with an aqueous solution of nitro-2,2:5,5'-tetraphenyl-3,3'-(3,3'-dimethoxy-4,4'-biphenylene ditetrazolium chloride, 1 mg/ml). After incubation for 45 min to 1 hr, the tissues were washed in a saline solution composed of 8.5 g NaCl, 0.2 g $CaCl_2$ and 0.1 g KCl in 1000 ml of distilled water. Next the sections were fixed in a 10% formal saline solution for 10 min and rinsed in 15% alcohol for 5 min. The coverslips were then mounted on slides with glycerine jelly.

Eight by 10 inch photographs (1/4 inch margins) of the slides were taken with a magnification of approximately 375 X. Three photographs were taken of each slide for the determination of red, white or intermediate fiber types. The total area of red, white and intermediate fibers was obtained on the photographic prints with a compensating polar planimeter. The individual fiber areas of red and intermediate fibers were obtained by dividing the total area of each fiber type by the number of fibers per picture. Since some white fibers stained too faintly to distinguish the sarcolemma, individual areas of white fibers could not be obtained.

Growth Hormone Assay

Porcine growth hormone antibody was obtained from Dr. Allen Trenkle, Iowa State University. The antiserum had been produced in guinea pigs by repeated subcutaneous injections of porcine growth hormone (PGH), obtained from Nutritional Biochemical Corporation, Cleveland, Ohio. Each animal received six injections over a five month period, the first three injections with complete Freund's adjuvant and the last three without adjuvant (Siers, 1968). Anti-guinea pig gamma globulin was obtained by repeated immunization of sheep with guinea pig gamma globulin emulsified in Freund's adjuvant.

A sample of 2 mg purified PGH (P 522 A) was procured from Dr. Wilhelmi, Emory University, Atlanta, Georgia, for use as standards and for iodination.

The methods of Greenwood (1963) and Purchas (1970b) were used for iodination of the PGH and involved the following steps:

(1) A total of 25 µl 0.5 M phosphate buffer was added to a 1 ml glass vial containing 5 µl of PGH (1 µg/µl, P 522 A).

(2) One mc of ^{125}I [(specific activity, 50 mc/ml) Isoserve Division of Cambridge Nuclear Corporation, Cambridge, Massachusetts] was transferred to the vial with a microsyringe (Hamilton Company, Whittier, California).

(3) An aliquot of 25 µl chloramine T (3.5 mg/ml) was added and the contents mixed for 40 sec. Then a 100 µl aliquot of sodium metabisulfite (2.4 mg/ml) was added to reduce excess chloramine T and to convert the remaining free iodine to iodate. Chloramine T and sodium metabisulfite reagents were prepared within 1/2 hr of use in 0.075 M barbital buffer, pH 8.6 (Herbert, 1965).

(4) Then a total 25 µl of 2.5% bovine serum albumin [(BSA), Nutritional Biochemical Corporation, Cleveland, Ohio] in 0.075 M barbital buffer, pH 8.6 was added.

(5) A quantity of 100 µl transfer solution (1% KI, 0.01% bromphenol blue and 16% sucrose) was added and the contents of the vial were layered under 0.075 M barbital buffer on a 1 x 12 cm glass column using a disposable pipette. The column was packed with Bio-Gel P 60, 50 to 100 mesh, (Biorad Laboratories, Richmond, California) and washed with 0.075 M barbital buffer, pH 8.6. The vial was immediately rinsed with 70 µl of rinse solution (1% KI, 0.01% bromphenol blue and 8% sucrose) and applied to the column. The column had been charged with 1 ml of 5% BSA in 0.075 M barbital buffer, pH 8.6 to saturate protein binding sites on the glass.

(6) Elution was carried out with 0.25% BSA 0.075 M barbital buffer, pH 8.6. One ml aliquots were collected in 15 tubes containing 1 ml of 1% BSA 0.075 M barbital buffer, pH 8.6.

(7) The protein bound ^{125}I peak and the free ^{125}I peak were located by counting aliquots of each tube in a Gamma Counter (Nuclear Chicago). An example of an iodination for PGH is shown in figure 2. The first peak represents the iodinated PGH. Tubes containing GH-^{125}I with the highest counts were stored at 4°C for later use.

The PGH iodinated for more than 10 to 14 days was repurified by passing it through a 1 x 12 cm Sephadex G-100 column (Pharmacia Fine Chemicals Inc., Piscataway, New Jersey). Procedures were the same as for iodination. A typical elution pattern is shown in figure 3. The first peak was determined to be damaged material while the third peak was assumed to be free iodine.

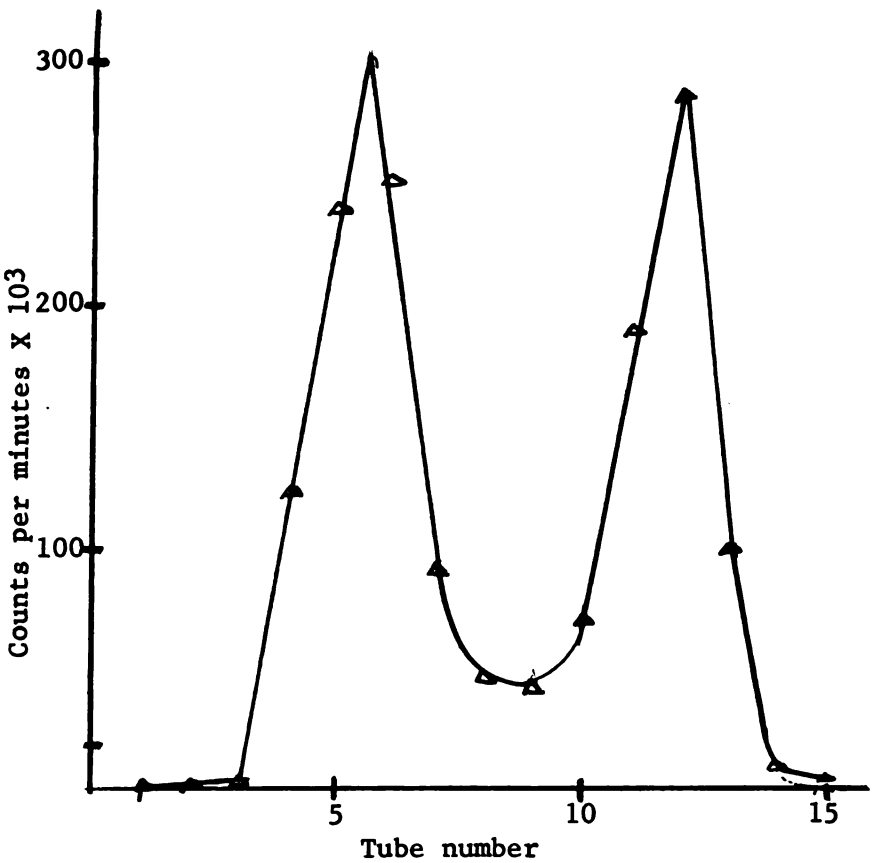

Figure 2. The elution pattern from Bio-Gel P 60 after iodination of PGH.

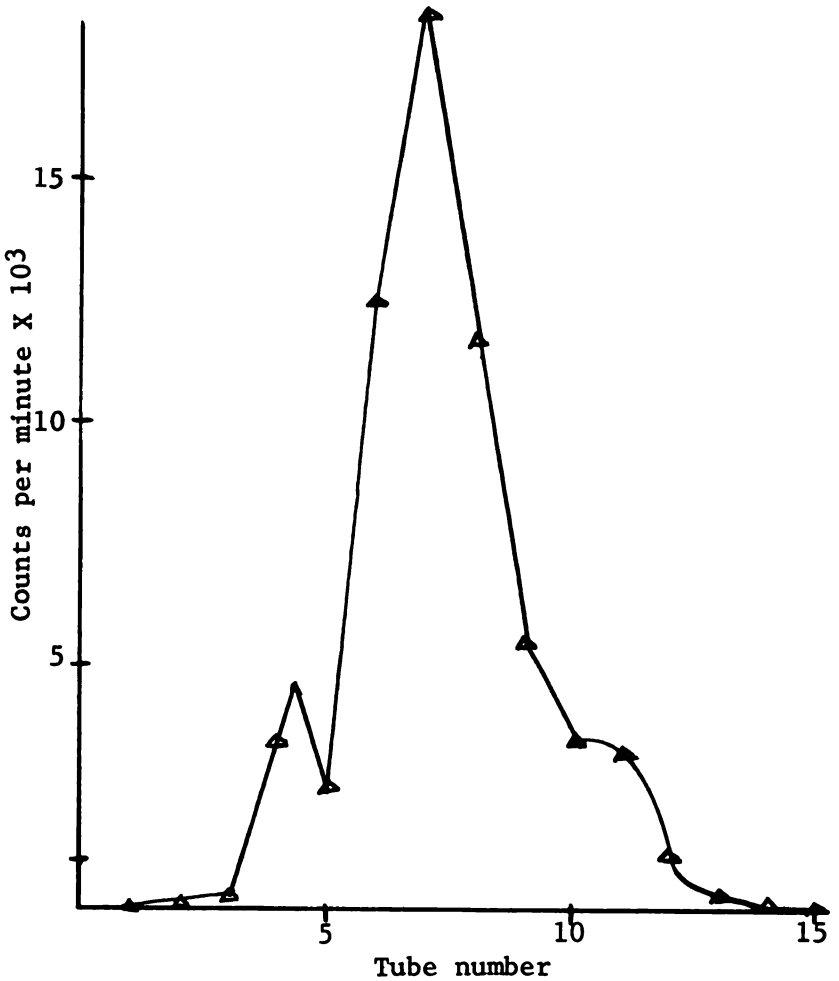

Figure 3. The elution pattern of Sephadex G-100 showing purification of PGH-^{125}I 12 days after iodination.

PGH standards containing 0.1, 0.3, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0 and 5.0 ng of PGH (P 522 A) per 400 µl were prepared. The purified PGH was weighed on a Cahn Electro Balance (Model G1). The PGH was initially dissolved in basic H_2O at a concentration of 1 µg/µl and a portion was dispensed in 5 µl quantaties for iodination. The remainder was brought to proper concentration with 0.25% BSA barbital buffer, pH 8.6, for use as standards. Each standard was prepared individually from the stock solution of PGH and then dispensed in glass tubes, frozen in a dry ice-alcohol bath and stored at -20°C.

The assay procedure was as follows:

(1) On day zero, 0.25% BSA barbital buffer, pH 8.6 and standard PGH or serum to be assayed were added to 12 x 75 mm disposable round bottom glass tubes to make a total volume of 400 µl. At least three sets of standard PGH were a part of every assay. An aliquot of 100 µl anti-PGH, diluted to a final concentration of 1:10,000 with 1:400 normal guinea pig serum (NGPS) in PBS-EDTA, pH 7.0, was added to all tubes containing standards or serum. The anti-PGH was initially diluted to 1:400 with PBS-EDTA. Total precipitate tubes contained 400 µl of 0.25% BSA barbital buffer and 100 µl of 1:400 NGPS in PBS-EDTA, pH 7.0 (0.14 M NaCl, 0.01 M $NaPO_4$, 0.05 M EDTA with 1:10,000 merthiolate) in place of anti-PGH.

(2) A quantity of 100 µl iodinated PGH diluted with 0.25% BSA barbital buffer, pH 8.6 to approximately 25,000 cpm/100 µl was added on day one.

(3) On day two, a total of 100 µl anti-gamma globulin (SAGPGG) diluted 1:4 in PBS-EDTA, pH 7.0 was added. Each day after adding the various components, tubes were gently mixed on a Vortex Mixer and stored at 4°C.

(4) On day five, a portion of 3 ml PBS (0.14 M NaCl, 0.01 M $NaPO_4$, pH 7.0) was added to each tube before centrifugation at 4,470 x g for 30 min in a Sorvall Centrifuge (RC-3 automatic refrigerated). The supernatant was carefully decanted and the tubes were inverted for 1/2 hr to dry. The remaining liquid was removed by blotting before the precipitate was counted for 10 min or 10,000 counts. Data from the average of three sets of tubes containing standard PGH constituted the standard curve. A typical standard curve is presented in figure 4. The percent of iodinated PGH bound to the antibody was plotted versus the log of the quantity of PGH standard added. The guinea pig anti-PGH antibody was titered to a dilution which would bind approximately 30% of the PGH-^{125}I while the SAGPGG antibody was titered to yield optimal precipitation.

For the serum assays, 50 µl and 100 µl samples were used and the concentration of PGH (ng/ml) was calculated as an average of these two samples. Average values for several serum dilutions for one pig (approximately 90-100 kg live weight) are shown in figure 5. A quantity of 200 µl or more of serum decreased the ng PGH recovered.

Cross reactivity with bovine prolactin was tested at levels of 10, 100, 1000 and 10,000 ng per tube. Only small decreases in the amount of bound PGH-^{125}I occurred at 1000 and 10,000 ng prolactin per tube. Porcine hormones were not available to check for cross reactivity.

To obtain recovery estimates, varying amounts of standard PGH were added to tubes containing 100 µl of serum. Recovery averaged 116% when 0.5 ng to 3 ng PGH were added (figure 6).

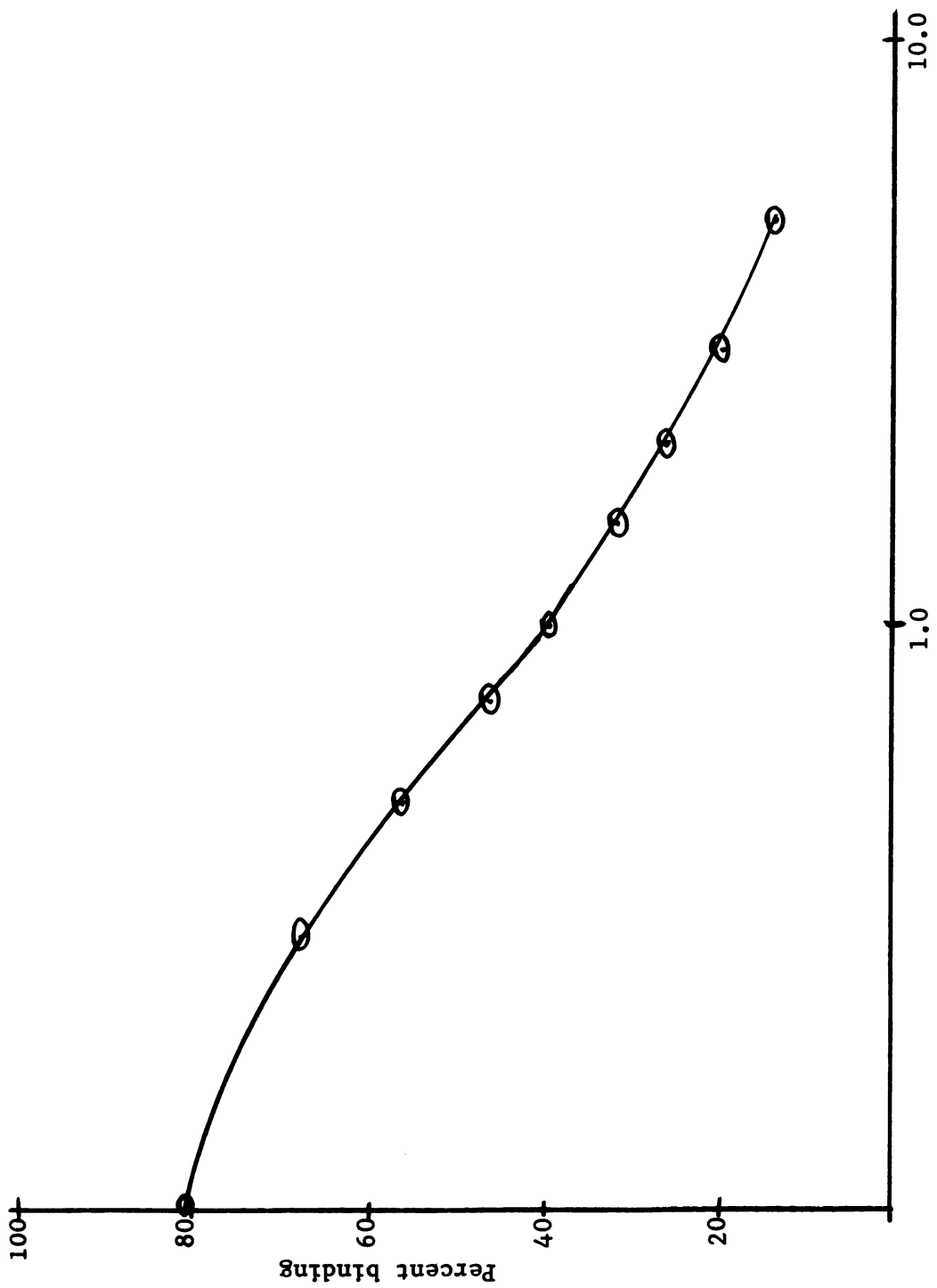

Figure 4. Standard curve for PGH.

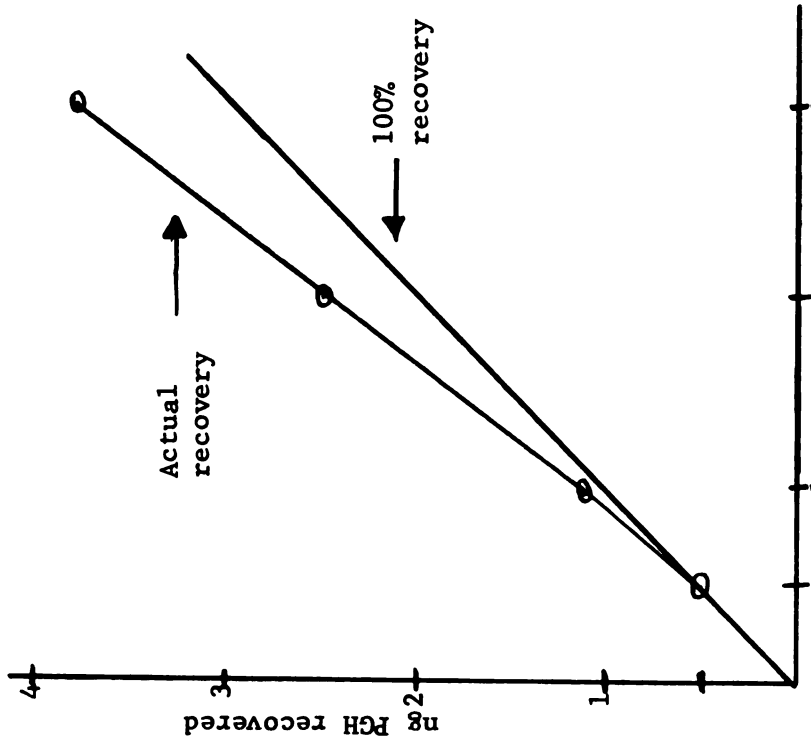

Figure 6. Recovery of PGH (P 522 A) added to 100 µl of porcine serum.

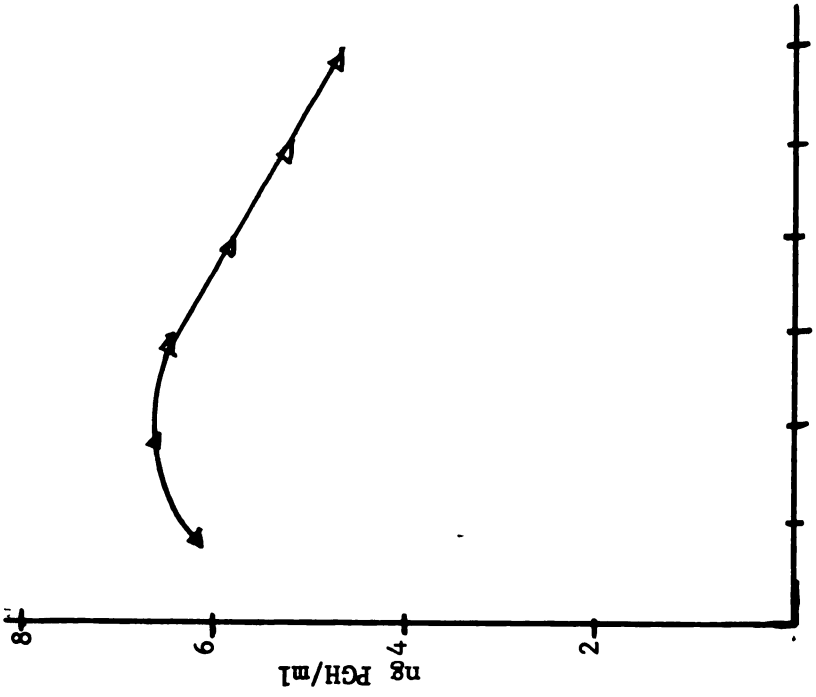

Figure 5. Serum dilution values for one pig.

Statistical Analyses

Data were analyzed on the 3600 Computer at the Michigan State University Computer Laboratory. Analysis of variance and simple correlation coefficients were determined and the more important correlations are listed in Appendix V and VI. Duncan's New Multiple Range procedure was used when significant differences were observed (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Feedlot Performance Data

An equal number of pigs were removed from each treatment at a final weight of 95 kg over a three week period; thus, total days on feed for each lot were held constant. In all previous experiments with DES + MT, the pigs were individually removed from test when they reached a set final weight. With such an experimental design, days on feed were seldom equal. In most of these experiments, the DES + MT treated barrows had reduced rates of gain and thus they were older than the control barrows when fed to constant final weights.

Means of the feedlot performance data for experiments 1 and 2 are shown in table 3. In experiment 1, there was a significant ($P < .01$) sex x DES + MT treatment interaction for final weight. The oral hormone treatment decreased final weight of barrows while the final weight of treated gilts was higher than that of control gilts. This difference was also reflected in gain per day but none of the values was significant. Baker et al. (1967) and Wallace and Lucas (1969) reported that DES + MT treatment seemed to depress the gain of barrows but the effect was not significant.

In experiment 2 the interaction between sex and treatment for daily gain was significant ($P < .05$). Again DES + MT treatment reduced barrow daily gains while gilt gains were stimulated. This was especially true for the gilts that received the hormones from 45 to 95 kg. These results agree with the findings of Baker et al. (1967) and Bidner (1969).

TABLE 3. FEEDLOT PERFORMANCE DATA[a]

Trait	Sex and level of DES + MT[b]									
	Barrows			Gilts				Level of significance		
	0	DES+MT from 23 kg	DES+MT from 45 kg	0	DES+MT from 23 kg	DES+MT from 45 kg	S.E.[c]	Trt	Sex	Sex x Trt
Experiment 1										
Beginning weight, kg	49.4	--	47.0	49.5	--	52.1	0.77	0.75	0.28	0.22
Final weight, kg	99.1^{A}	--	91.4^{B}	92.9^{B}	--	97.6^{A}	0.92	0.43	0.98	0.00
Gain/day, kg	0.749	--	0.673	0.650	--	0.704	0.01	0.61	0.97	0.09
Daily feed, kg	2.39	--	2.08	2.25	--	2.26	--	--	--	--
Gain/feed	0.309	--	0.318	0.287	--	0.307	--	--	--	--
Experiment 2										
Beginning weight, kg	22.3	23.2	23.4	23.1	23.1	23.9	0.63	--	0.27	--
Final weight, kg	96.2^{BC}	96.4^{BC}	94.2^{B}	90.8^{A}	89.2^{A}	96.6^{C}	0.58	--	0.01	--
Gain/day, kg	0.778^{C}	0.734^{B}	0.734^{B}	0.664^{A}	0.684^{A}	0.727^{B}	0.00	0.58	0.30	0.02
Daily feed, kg	2.16	2.18	2.15	2.03	2.18	2.04	--	--	--	--
Gain/feed	0.333	0.319	0.313	0.326	0.313	0.331	--	--	--	--

[a]Means having different superscripts are significantly different ($P < .01$).
[b]2.2 mg of DES + 2.2 mg of MT per kilogram of feed.
[c]Standard error of the means.

The DES + MT treatment depressed the daily feed intake of barrows in experiment 1 but this observation was not found in experiment 2. Hormone treatment apparently increased the gain per unit of feed in experiment 1 of both gilts and barrows. These results were not repeated in experiment 2. In experiment 1, DES + MT seemed to have a depressing effect on growth of the barrows due to a reduction in daily feed intake. This adverse effect was especially noticeable in two of the barrows (numbers 2-4 and 6-4) as they became very lean and gaunt during the later portion of the trial. These results may or may not have been due to the hormonal treatment but they directly affected the carcass data, especially those characteristics related to quantity of fat.

Carcass Traits

In experiment 1 treatment with DES + MT had no significant effects upon any of the carcass traits measured (table 4). These results are contrary to all those reported in the literature on the effects of orally administered DES + MT (2.2 mg/kg of feed) upon carcass traits. The DES + MT treatment has been shown to consistently reduce backfat thickness, fat trim and increase ham and loin percent (Jordan et al., 1965; Baker et al., 1967; Wallace and Lucas, 1969; Bidner, 1969). Baker et al. (1967) and Bidner (1969) also found that these hormones increased longissimus muscle area at the 10th rib. In all of these experiments the pigs were individually removed from test at a constant final weight. The results of the present study in all probability are attributable to the fact that the number of days on feed was held constant for each lot; whereas, in the previous experiments DES + MT reduced the gain of the barrows and thus,

TABLE 4. SUMMARY OF THE CARCASS TRAITS - EXPERIMENT 1[a]

Trait	Sex and level of DES + MT[b]: Barrows 0	Barrows DES+MT from 45 kg	Gilts 0	Gilts DES+MT from 45 kg	S.E.[c]	Level of significance: Trt	Sex	Sex x Trt
Carcass length, cm	78.5	76.1	77.1	78.2	0.34	0.64	0.57	0.67
Backfat, avg, cm	3.15	2.87	3.14	2.82	0.07	0.14	0.83	0.06
Longissimus area, cm^2	31.7^{B}	28.9^{C}	31.6^{B}	33.9^{A}	0.56	0.89	0.04	0.58
Ham and loin, %	39.3^{B}	39.7^{AB}	40.3^{A}	40.5^{A}	0.22	0.45	0.04	0.94
Lean cuts, %	56.6	57.5	57.2	58.4	0.32	0.23	0.18	0.64
Primal cuts, %	67.0	67.3	67.6	68.1	0.45	0.54	0.58	0.16
Fat trim, %	19.0	18.9	19.1	18.0	0.37	0.14	0.83	0.06
Dressing percent	72.3	70.8	72.2	72.0	0.31	0.20	0.41	0.54

[a]Means having different superscripts are significantly different ($P < .01$).
[b]2.2 mg of DES + 2.2 mg of MT per kilogram of feed.
[c]Standard error of the means.

these pigs were older than untreated controls at the time of slaughter. Numerous workers (Greer et al., 1965; Hines, 1966; Wallace, 1968; Klay et al., 1969) have shown that limited fed pigs tended to have less fat and more muscle than control pigs. These limited feeding results have been, at least, partially attributed to the fact that the restricted pigs were older than full fed controls at slaughter weights.

The present trial was conducted during the summer months and the pigs were housed in open fronted units on a concrete slab. Heat stress seemed to more severely affect the treated barrows than controls in as much as one barrow from the DES + MT lot died during a period of extended high ambient temperature. Ray et al. (1969) found a significant seasonal difference in steers fed DES at Yuma, Arizona. Gains during the winter months were 14 and 24% greater than those in the summer months.

Gilt carcasses had significantly ($P < .05$) larger longissimus muscle areas and higher ham and loin percentages than barrows. These findings agree with those of Kropf et al. (1959), Hines (1966), Hale et al. (1968) and others. There was essentially no difference in backfat thickness between barrows and gilts which agrees with the findings of Rahnefeld (1965) but disagrees with most of the reported literature comparing barrow and gilt carcasses.

The carcass data of experiment 2 are presented in table 5. In this experiment DES + MT significantly ($P < .05$) reduced backfat thickness which was opposite to the findings in experiment 1 but in agreement with Baker et al. (1967) and the other experiments in which DES + MT was fed from 45 to 95 kg. The pigs that received DES + MT from 45 to 95 kg had

TABLE 5. SUMMARY OF THE CARCASS TRAITS - EXPERIMENT 2[a]

Traits	Sex and level of DES + MT[b]: Barrows 0	Barrows DES+MT from 23 kg	Barrows DES+MT from 45 kg	Gilts 0	Gilts DES+MT from 23 kg	Gilts DES+MT from 45 kg	S.E.[c]	Level of significance: Trt	Sex	Sex x Trt
Carcass length, cm	78.2^{BC}	79.1^{C}	77.3^{AB}	75.1^{A}	75.7^{AB}	77.2^{AB}	0.27	0.48	0.01	0.28
Backfat, avg, cm	2.82^{B}	2.67^{AB}	2.48^{A}	2.65^{AB}	2.68^{AB}	2.42^{A}	0.07	0.04	0.35	0.21
Longissimus area, cm^2	29.8^{A}	33.8^{C}	30.8^{AB}	33.1^{BC}	36.5^{D}	35.1^{CD}	0.65	0.06	0.00	0.98
Ham and loin, %	40.0	41.3	41.3	41.9	42.9	42.0	0.29	0.29	0.13	0.95
Lean cuts, %	58.4	60.2	60.1	60.1	61.5	61.3	0.40	0.22	0.30	0.90
Primal cuts, %	69.4	70.9	70.9	70.8	72.1	72.0	0.35	0.28	0.11	0.99
Fat trim, %	16.3	14.2	14.2	15.9	15.4	14.3	0.47	0.30	0.64	0.72
Dressing percent	71.8^{AB}	72.9^{CD}	71.2^{A}	72.5^{BCD}	73.4^{D}	72.1^{ABC}	0.24	0.03	0.10	0.98
Marbling score[d]	2.2	1.9	1.7	1.3	1.5	1.5	0.15	0.80	0.29	0.71
Color score[d]	3.9	4.0	4.3	3.8	3.9	4.3	0.13	0.50	0.81	0.97
Firmness score[d]	4.1	4.1	3.9	3.3	3.7	3.6	0.16	0.67	0.34	0.78
Wateriness score[d]	3.7	3.7	3.9	3.2	3.6	3.6	0.14	0.77	0.55	0.76
Total quality score[e]	13.9	13.9	13.8	11.8	13.0	12.6	0.50	0.91	0.47	0.87

[a]Means having different superscripts are significantly different ($P < .01$).
[b]2.2 mg of DES + 2.2 mg of MT per kilogram of feed.
[c]Standard error of the means.
[d]Based on Wisconsin scoring system of 5 possible scores for the ham and loin.
[e]20 possible scores, 5 points each for marbling, color, firmness and wateriness (Wisconsin system).

less backfat thickness than those that received the hormones from 23 to 95 kg. Gilts treated from 45 to 95 kg had significantly ($P < .05$) less backfat thickness than gilts treated from 23 to 95 kg or the controls. The effect of hormone treatment upon longissimus muscle area approached significance ($P < .06$). The longissimus muscle area of pigs receiving DES + MT from 23 kg was significantly larger than untreated controls. This effect was similar for both treated gilts and barrows. The pigs receiving DES + MT from 23 to 95 kg had significantly ($P < .05$) greater dressing percents than control pigs or those receiving DES + MT from 45 to 95 kg.

The carcass and feedlot performance data were similar for treated pigs whether they received DES + MT at 23 kg or 45 kg, but the pigs fed DES + MT from 23 kg had significantly ($P < .01$) larger longissimus muscle areas than controls while the pigs on DES + MT from 45 kg had less ($P < .01$) backfat than controls. Thus, the pigs that received DES + MT during the growing period had larger longissimus muscle areas while those pigs that received DES + MT during the finishing period were trimmer (less backfat) than controls.

As in experiment 1, there were no significant interactions between sex and treatment for any of the carcass traits studied. These results agree with the observations of Bidner (1969) but disagree with the findings of Baker et al. (1967) and Wallace and Lucas (1969). The latter two groups of authors found that DES + MT treatment had a more pronounced effect upon barrow carcasses than those of gilts.

In experiment 2, gilts had significantly ($P < .01$) larger longissimus muscle areas while barrows were longer than gilts. Contrary to the results

observed in the first experiment, ham and loin percent was not significantly different between gilts and barrows. The differences in carcass traits between barrows and gilts in both of the present experiments were less than those reported in the literature. It should be recalled that Yorkshire pigs of essentially the same genetic makeup were used in both experiments and perhaps this could have influenced the results obtained from their carcasses.

Longissimus and Quadriceps Femoris Muscles

Longissimus and quadriceps femoris muscles were chosen to study the effects of DES + MT upon some muscle properties. The longissimus is a large late maturing loin muscle and the quadriceps femoris is an early to intermediate maturing, easily accessible group of ham muscles (Berg, 1968; Cuthbertson and Pomeroy, 1962). Bidner (1969) found that DES + MT treatment increased the percentage of protein and moisture and decreased the percentage of fat in composite ham samples. Thus, the longissimus and quadriceps femoris muscles were selected to observe if the hormone treatment increased their weight or percent of left side weight and if the total grams of protein in the longissimus muscle differed from the untreated control values. The DES + MT treatment significantly ($P < .05$) increased the quadriceps femoris muscles when expressed as a percentage of left side weight but had no effect upon the weight of the quadriceps femoris muscles (table 6) per se. The percentage of total protein in the longissimus muscle was significantly ($P < .05$) reduced by the hormonal treatment which is similar to the findings of Whiteker et al. (1959). The

TABLE 6. SUMMARY OF SOME LONGISSIMUS AND QUADRICEPS FEMORIS MUSCLE DATA - EXPERIMENT 1[a]

Trait	Sex and level of DES + MT[b]: Barrows, 0	Barrows, DES+MT from 45 kg	Gilts, 0	Gilts, DES+MT from 45 kg	S.E.[c]	Level of significance: Trt	Sex	Sex x Trt
Weight longissimus, g	1773.5^{B}	1601.5^{A}	1815.2^{BC}	1866.5^{BC}	28.57	0.55	0.01	0.94
Weight quadriceps femoris, g	963.8^{B}	915.7^{C}	969.4^{B}	1027.5^{A}	10.45	0.54	0.01	0.43
Longissimus[d], %	4.93^{B}	4.92^{B}	5.32^{A}	5.30^{A}	0.07	0.90	0.01	0.91
Quadriceps[d], %	2.59^{B}	2.83^{A}	2.88^{A}	2.91^{A}	0.03	0.05	0.00	0.44
Protein longissimus, g	394.1^{A}	349.5^{B}	407.2^{A}	411.8^{A}	6.85	0.32	0.01	0.98
Protein longissimus[d], %	0.0112^{AB}	0.0108^{A}	0.0119^{B}	0.0118^{B}	0.00	0.52	0.02	0.77
Moisture longissimus, %	73.80	74.16	73.81	73.79	0.12	0.63	0.45	0.87
Protein longissimus, %	22.21^{BC}	21.81^{A}	22.43^{C}	22.05^{AB}	0.08	0.04	0.17	0.70
Fat longissimus, %	2.88	2.70	2.04	2.58	0.17	0.53	0.17	0.64

[a]Means having different superscripts are significantly different ($P < .01$).
[b]2.2 mg of DES + 2.2 mg of MT per kilogram of feed.
[c]Standard error of the means.
[d]Expressed as a percentage of left side weight.

DES + MT treatment had no apparent effect upon muscle weight or percent as well as the grams of protein in the longissimus muscles in either experiment 1 or 2 (tables 6 and 7, respectively). In contrast to the observations of experiment 1, DES + MT had no influence upon the quadriceps femoris muscle in experiment 2.

As shown in table 6, gilts had significantly ($P < .01$) heavier longissimus and quadriceps femoris muscles, higher percentages of longissimus and quadriceps femoris muscles (expressed as percent of the left side weight) and total grams of protein in the longissimus muscle than barrows. When compared to barrows, gilts also had significantly ($P < .05$) more protein in the longissimus muscle when the data were expressed as percent of the left side weight. These results agree with other carcass observations in experiment 1 since gilts had larger longissimus muscle areas and higher ham and loin percentages than barrows. In the second experiment, similar results were obtained for the longissimus muscle since gilts were superior to barrows in weight and percent of longissimus but not in weight or percent of the quadriceps femoris muscle. The barrows in experiment 2 had significantly ($P < .01$) higher percentages of fat in the longissimus muscle than gilts. Barrows also tended to have more marbling in the loin and ham than gilts (table 5). These findings correspond with that of Crum et al. (1964) who reported that barrow carcasses had more marbling than gilt carcasses.

There were no significant interactions between treatment x sex for any of the traits studied in the longissimus and quadriceps femoris muscles. In both trials, the DES + MT treatment had little or no effect upon the

TABLE 7. SUMMARY OF SOME LONGISSIMUS AND QUADRICEPS FEMORIS MUSCLE DATA - EXPERIMENT 2[a]

Trait	Sex and level of DES + MT[b]							Level of significance		
	Barrows			Gilts						
	0	DES+MT from 23 kg	DES+MT from 45 kg	0	DES+MT from 23 kg	DES+MT from 45 kg	S.E.[c]	Trt	Sex	Sex x Trt
Weight longissimus, g	1816.0^{A}	2018.1^{B}	1826.0^{A}	1970.8^{B}	2078.6^{B}	2131.7^{B}	34.87	0.17	0.01	0.85
Weight quadriceps femoris, g	959.0	1025.0	976.4	993.7	993.6	1035.0	15.93	0.50	0.07	0.65
Longissimus[d], %	5.22^{A}	5.81^{BC}	5.44^{AB}	6.04^{D}	6.22^{CD}	6.02^{CD}	0.10	0.35	0.03	0.64
Quadriceps[d], %	2.75	2.93	2.78	3.04	3.09	2.93	0.57	0.51	0.10	0.85
Protein longissimus, g	399.9^{A}	457.3^{B}	409.2^{A}	441.4^{B}	466.0^{BC}	488.7^{C}	7.62	0.09	0.00	0.67
Protein longissimus[d], %	0.0116^{A}	0.0136^{B}	0.0122^{A}	0.0135^{B}	0.0139^{B}	0.0139^{B}	0.00	0.17	0.05	0.26
Moisture longissimus, %	73.65	73.68	73.99	74.16	74.16	73.63	0.08	0.96	0.91	0.50
Protein longissimus, %	22.03	22.67	22.39	22.46	22.42	22.92	0.09	0.27	0.11	0.37
Fat longissimus, %	2.87^{D}	2.46^{C}	2.19^{C}	1.59^{A}	1.83^{AB}	2.09^{BC}	0.10	0.90	0.01	0.13

[a]Means having different superscripts are significantly different ($P < .01$).
[b]2.2 mg of DES + 2.2 mg of MT per kilogram of feed.
[c]Standard error of the means.
[d]Expressed as a percentage of left side weight.

longissimus or quadriceps femoris muscle properties of either barrows or gilts.

Longissimus Muscle Protein Fractionation

The oral feeding of DES + MT to pigs has been shown to increase the area of the longissimus muscle above that of untreated controls (Baker et al., 1967; Bidner, 1969). Lawrie et al. (1964) reported that in hypertrophied muscle of 'doppelender' cattle the sarcoplasmic protein fraction was increased and the stroma protein fraction was correspondingly decreased. Thus if DES + MT treatment was in fact resulting in muscle hypertrophy it could possibly alter the various muscle protein fractions. With this thought in mind, protein fractionation was performed on samples of longissimus muscles to determine if any of the protein fractions were altered by the DES + MT treatment. Hormone treatment had no significant influence upon any of the protein fractions (table 8). The effects of DES + MT upon NPN approached significance ($P < .06$). No differences in any of the protein fractions were noted between barrows and gilts and there were no significant treatment x sex interactions. These findings agree with the work of Lawrie (1960) for cattle and the results of Kochakian (1966) and Florini (1970) with rats. None of these workers found any differences in protein fractions between hormone treated and control animals.

Since Sayre and Briskey (1963), Bendall and Wismer-Pedersen (1962) and Borchert and Briskey (1965) have reported that high muscle temperatures accompanied by low pH during the first 2 hr postmortem significantly decreased protein solubility in pigs, pH of the longissimus muscle was

TABLE 8. LONGISSIMUS MUSCLE PROTEIN FRACTIONATION DATA - EXPERIMENT 2

Trait	Sex and level of DES + MT[a]							Level of significance		
	Barrows			Gilts						
	0	DES+MT from 23 kg	DES+MT from 45 kg	0	DES+MT from 23 kg	DES_MT from 45 kg	S.E.[b]	Trt	Sex	Sex x Trt
pH	5.97	5.94	6.04	6.01	5.96	5.88	0.02	0.65	0.20	0.58
Nitrogen,[c] %	14.73	15.04	15.26	15.26	14.81	15.14	0.11	0.49	0.99	0.36
Sarcoplasmic N[d]	27.09	27.88	27.29	28.24	27.97	27.83	0.515	0.99	0.85	0.84
Fibrillar N[d]	42.42	42.20	42.74	41.91	43.75	42.34	0.540	0.80	0.69	0.60
NPN[d]	12.16	12.81	13.62	13.67	13.79	14.28	0.184	0.06	0.09	0.65
Stroma N[d]	18.38	17.11	16.35	16.17	13.79	15.34	0.649	0.55	0.29	0.99

[a]2.2 mg of DES + 2.2 mg of MT per kilogram of feed.
[b]Standard error of the means.
[c]Percent nitrogen expressed on a dry, fat free basis.
[d]Expressed as a percent of total nitrogen on a dry, fat free basis.

determined at 20 min postmortem. No significant differences in pH were found between any of the treatment or sex groups as well as for the sex x treatment interactions in the present experiment.

Red, White and Intermediate Muscle Fibers

Carrow (1967) concluded that both forced and voluntary exercise in rats resulted in muscle hypertrophy and increased the area of red and white muscle fibers. It has also been found that muscle fiber types of rats can be changed in a nonpathologic condition (Edgerton et al., 1969). Thus, histological slides were prepared to determine the relative areas and percentages of red, white and intermediate fibers. Individual muscle fiber types were determined by using a stain specific for SDH activity. The DES + MT treatment had no apparent influence upon the areas of red or intermediate fibers or the percentages of red, white and intermediate fiber types in either experiment (table 9). These results are consistent with the protein fractionation data. MacDonald and Slen (1959) and Everitt and Carter (1961) reported that neither testosterone nor hexoestrol had any influence upon muscle fiber diameter.

In experiment 1, barrows had significantly ($P < .05$) higher percentages of red fibers than gilts but these findings were not repeated in experiment 2. In the second trial, there was a significant ($P < .01$) interaction between treatment and sex for area of red fibers. Barrows that received DES + MT from 23 kg had significantly ($P < .05$) larger red fiber areas than all other groups. This corresponds with the fact that barrows treated from 23 kg had larger longissimus muscle areas than control barrows or barrows which received DES + MT from 45 kg.

TABLE 9. RED, WHITE AND INTERMEDIATE FIBER TYPES IN THE LONGISSIMUS MUSCLE[a]

Trait	Sex and level of DES + MT[b]							Level of significance		
	Barrows			Gilts						
	0	DES+MT from 23 kg	DES+MT from 45 kg	0	DES+MT from 23 kg	DES+MT from 45 kg	S.E.[c]	Trt	Sex	Sex x Trt
Experiment 1										
Area red fibers[d]	0.79	--	0.88	0.96	--	0.83	0.03	0.79	0.39	0.12
Area intermediate fibers[d]	1.00	--	1.13	1.15	--	1.04	0.04	0.83	0.70	0.14
Red fibers[e], %	18.60^{Bg}	--	20.34^{Bh}	18.24^{Bg}	--	15.83^{A}	0.58	0.73	0.05	0.22
Intermediate fibers[e], %	6.65	--	7.10	7.07	--	5.53	0.34	0.50	0.41	0.13
White fibers[e], %	74.76	--	72.56	74.69	--	78.65	0.78	0.57	0.07	0.12
Experiment 2										
Area red fibers[d]	0.72^{A}	0.87^{Bg}	0.70^{A}	0.74^{A}	0.70^{A}	0.82^{Bh}	0.02	0.55	0.46	0.01
Area intermediate fibers[d]	0.85	1.16	1.03	0.92	1.00	1.06	0.04	0.11	0.35	0.21
Red fibers[e], %	19.07	17.85	15.69	17.64	16.10	15.62	0.61	0.20	0.62	0.99
Intermediate fibers[e], %	8.89	7.14	8.03	8.36	8.52	7.76	0.39	0.62	0.54	0.62
White fibers[e], %	71.89	74.80	75.62	74.31	75.99	76.72	0.88	0.40	0.38	0.93
SDH activity[f]	33.78	37.00	37.54	44.03	41.50	36.77	1.54	0.74	0.12	0.32

[a]Means having different superscripts are significantly different, AB ($P < .01$), gh ($P < .05$), respectively.
[b]2.2 mg of DES + 2.2 mg of MT per kilogram of feed.
[c]Standard error of the means.
[d]Expressed as area of picture per individual fiber.
[e]Area of fiber type expressed as a percentage of total area per picture.
[f]Millimicromoles of succinate oxidized per minute per gram of muscle.

The chemical SDH activity of the longissimus muscle was not significantly influenced by DES + MT treatment, sex or an interaction of treatment x sex.

Serum Protein Electrophoresis

Results of serum protein electrophoresis of blood samples taken at the start of experiment 1 and 7 days, 28 days and 56 days after DES + MT treatment are presented in table 10. The DES + MT treatment significantly ($P < .05$) decreased the percent β-globulins at 28 days and the percent γ-globulins at 56 days. The effect of DES + MT upon percent albumin at 28 days approached significance ($P < .07$). Percent albumin of treated barrows at 28 days was significantly ($P < .01$) greater than all the other groups. These results agree with the findings of Bidner (1969) who reported that DES + MT treatment increased the percent albumin and decreased the percentage of serum globulins.

As shown in table 10, barrows had significantly higher percentages of albumin initially ($P < .02$) at 28 ($P < .01$) and 56 days ($P < .05$) than gilts, while gilts had significantly ($P < .04$) higher percentages of α-globulins at the start of the experiment and percentages of γ-globulin at 28 days than barrows ($P < .01$). These results are in partial disagreement with the observations of Kotik (1966) since he reported that barrows had more β- and γ-globulins than gilts while gilts had higher albumin and α-globulin levels than barrows. Bidner (1969) found no differences in the electrophoretic patterns of serum proteins for gilts and barrows.

TABLE 10. SUMMARY OF THE SERUM PROTEIN ELECTROPHORESIS DATA - EXPERIMENT 1[a]

Trait	Sex and level of DES + MT[b]: Barrows 0	Barrows DES+MT from 45 kg	Gilts 0	Gilts DES+MT from 45 kg	S.E.[c]	Level of significance: Trt	Sex	Sex x Trt
Albumin, % initial	45.2^{C}	41.4^{B}	37.5^{A}	43.1^{BC}	0.66	0.47	0.02	0.00
α-globulin, % "	23.1^{Ad}	24.8^{ABe}	26.2^{B}	25.5^{B}	0.49	0.61	0.04	0.21
β-globulin, % "	11.3	11.1	11.5	10.9	0.21	0.41	0.97	0.88
γ-globulin, % "	20.3^{Ad}	22.8^{ABe}	24.8^{Bf}	20.5^{ABd}	0.62	0.38	0.34	0.01
Albumin, % 7 days	46.6	46.6	48.6	49.8	0.77	0.41	0.09	0.10
α-globulin, % 7 days	20.6	21.5	20.9	20.4	0.47	0.99	0.71	0.16
β-globulin, % "	11.0	11.0	10.8	11.3	0.24	0.48	0.71	0.39
γ-globulin, % "	21.8	21.0	19.7	18.6	0.63	0.23	0.06	0.18
Albumin, % 28 days	44.7^{Bd}	49.5^{C}	40.6^{A}	41.5^{ABe}	0.94	0.07	0.00	0.59
α-globulin, % 28 days	21.4	19.0	21.8	22.1	0.59	0.22	0.15	0.69
β-globulin, % "	10.7^{B}	9.4^{Ae}	11.3^{Bd}	10.4^{ABf}	0.25	0.03	0.12	0.64
γ-globulin, % "	23.2^{B}	22.0^{B}	26.2^{A}	26.0^{A}	0.66	0.52	0.01	0.83
Albumin, % 56 days	44.1^{B}	47.7^{A}	42.7^{B}	42.4^{B}	0.81	0.18	0.05	0.80
α-globulin, % 56 days	20.4	20.9	21.1	24.4	0.65	0.26	0.12	0.87
β-globulin, % "	11.9	11.2	11.9	11.3	0.19	0.12	0.89	0.77
γ-globulin, % "	23.6^{A}	19.8^{B}	24.4^{A}	22.3^{A}	0.63	0.02	0.20	0.91

[a]Means having different superscripts are significantly different, ABC ($P < .01$), def ($P < .05$), respectively.
[b]2.2 mg of DES + 2.2 mg of MT per kilogram of feed.
[c]Standard error of the means.

Serum Free Fatty Acids

Results of the analysis of serum free fatty acids (FFA) in experiment 1 are shown in table 11. The DES + MT treatment had no significant effect upon the serum FFA levels at any of the sampling times. At 56 days, treatment effect was approaching significance ($P < .08$). The FFA levels of the treated gilts and barrows were higher than control levels at 56 days. Barrows and gilts had comparable FFA levels and there was no significant interaction between treatment and sex. These results are similar to the findings of Baker et al. (1968) who found that neither DES + MT treatment nor sex had any influence upon FFA levels of pigs.

Weights and Some Gross Ovarian Observations

The DES + MT treatment did not have a significant effect upon ovarian weights in either experiment 1 or 2, but the hormone combinations increased the number of large follicles (> 5 mm) in the ovaries which were examined at the time of slaughter (table 12). While the latter observation occurred in both experiments, the gilts of experiment 2 which were treated from 23 kg had larger follicles than those fed DES + MT from 45 kg live weight. Four of the seven gilts from this latter group (23 to 95 kg) had follicles greater than 10 mm while none of the gilts from the other groups had follicles this large. One gilt from this treatment group had a polycystic ovary with 14 follicles greater than 35 mm and an ovary weight of 250 gm. Two other gilts from this same group had follicles greater than 15 mm and could have been classified as having cystic ovaries. These results agree

TABLE 11. SUMMARY OF THE SERUM FREE FATTY ACID LEVELS - EXPERIMENT 1

Trait	Sex and level of DES + MT[a]: Barrows 0	Barrows DES+MT from 45 kg	Gilts 0	Gilts DES+MT from 45 kg	S.E.[b]	Level of significance: Trt	Sex	Sex x Trt
Free fatty acids[c], initial	1.3	1.4	1.5	1.3	0.33	0.96	0.97	0.88
Free fatty acids[c], 7 days	5.0	4.7	4.2	3.7	0.45	0.73	0.20	0.71
Free fatty acids[c], 28 days	7.6	7.7	6.3	6.3	0.62	0.31	0.98	0.47
Free fatty acids[c], 56 days	2.8	5.1	2.8	3.8	0.47	0.08	0.48	0.47

[a]2.2 mg of DES + 2.2 mg of MT per kilogram of feed.
[b]Standard error of the means.
[c]μeq/100 ml.

with the observations of Thrasher et al. (1967) who found that four out of 10 gilts receiving 2.2 mg of DES + MT per kilogram of feed from 45 to 93 kg had cystic ovaries. Waitt et al. (1967) also reported breeding difficulty in gilts that received a combination of DES + MT (2.2 mg or 4.4 mg each per kilogram of ration).

TABLE 12. OVARY WEIGHTS AND SOME GROSS OVARIAN OBSERVATIONS

	Sex and level of DES + MT		
		Gilts	
Trait	0	DES+MT from 23 kg	DES+MT from 45 kg
	Experiment 1		
Ovary weight, g	5.80	--	6.50
Follicles, < 5 mm	36.3	--	11.7
Follicles, > 5 mm	6.3	--	22.1
Corpora lutea, < 5 mm	--	--	0.4
Corpora lutea, > 5 mm	--	--	--
Corpora albicantia	12.1	--	12.1
	Experiment 2		
Ovary weight, g	8.04	10.27	49.15
Follicles, < 5 mm	75.8	4.3	36.7
Follicles, > 5 mm	0.80	20.9	11.3
Corpora lutea, < 5 mm	--	--	--
Corpora lutea, > 5 mm	--	1.6	2.0
Corpora albicantia	--	1.4	3.0

Several corpora albicantia were recorded for both groups of gilts in experiment 1 (a summer trial) while very few corpora albicantia were noted in experiment 2 (a winter trial). Since the gilts were of similar breeding and age at the time of slaughter, it could be that the gilts in the summer trial reached sexual maturity earlier than those in the winter trial.

Since the treated gilts had larger follicles than controls in both experiments, and gilts that received the DES + MT from 23 kg had some large follicles, it could be concluded that DES + MT was possibly effecting the output of pituitary follicle-stimulating hormone (FSH) and the production of luteinizing hormone (LH). A stimulation of FSH and a reduction in LH could account for the large follicles and the lack of corpora lutea and corpora albicantia noted in some of the ovaries from treated gilts (23 to 95 kg) in experiment 2, but these conclusions are mere speculation at the present time.

Serum Growth Hormone

Bidner (1969) found that DES + MT treated pigs had significantly larger pituitary glands than untreated control pigs. Thus, a radioimmunoassay for PGH was developed to determine the serum GH levels of the treated and control pigs. Blood samples were taken from the anterior vena cava at the start of experiment 1 and after 7, 28 and 56 days of DES + MT treatment. In the second experiment, blood samples were drawn at the start of the experiment and after 5 and 13 weeks of the trial. The pigs were caught and restrained in order to obtain the blood samples; therefore, each animal was subjected to a certain amount of stress. Machlin et al. (1968) reported that plasma PGH levels were elevated by stress. The mean serum GH level for each sample time (table 13) was lower than the value (5.8 ± 0.8 ng/ml) reported by Machlin et al. (1968) for 45 to 75 kg pigs which were fasted overnight. The mean GH values were also lower than the plasma GH levels (21.0 ± 2.7 ng/ml) of cattle (Trenkle, 1970) and (approximately 5 ng/ml) sheep (Hertelendy et al., 1969).

TABLE 13. THE MEAN SERUM GROWTH HORMONE LEVEL FOR EACH TIME PERIOD

Time of sample	Average test weight, kg	Average level PGH, ng/ml
	Experiment 1	
Start of experiment	49	2.70 ± 1.32
7 days	57	2.65 ± 1.03
28 days	70	3.46 ± 1.29
56 days	89	3.17 ± 1.69
	Experiment 2	
Start of experiment	23	2.39 ± 1.09
5 weeks	45	2.14 ± 1.32
13 weeks	84	2.23 ± 1.35

Average serum GH levels of control and treated pigs (experiments 1 and 2) are presented in table 14. After seven days of DES + MT treatment there was no apparent influence upon the GH values. In experiment 1, a significant ($P < .05$) sex x treatment interaction was observed after DES + MT had been fed for 28 days. The GH level of treated barrows after 28 days was significantly higher than control barrows while the opposite response was found for the gilts. After 56 days of DES + MT treatment, serum GH values of both treated gilts and barrows were significantly ($P < .01$) higher than control pigs. At the corresponding time period in experiment 2 (13 weeks), serum GH levels of treated barrows (DES + MT from 45 kg) were also significantly higher than controls; however, gilts GH levels were not significantly affected by treatment. Thus, at 85 to 90 kg serum GH levels of pigs fed DES + MT from 45 kg were higher than untreated control pigs. These results agree with the findings of Trenkle (1970) for beef cattle since he found that DES treated cattle had elevated plasma GH levels after 50 days on test.

TABLE 14. SERUM GROWTH HORMONE LEVELS[a]

Trait	Sex and level of DES + MT[b]: Barrows 0	Barrows DES+MT from 23 kg	Barrows DES+MT from 45 kg	Gilts 0	Gilts DES+MT from 23 kg	Gilts DES+MT from 45 kg	S.E.[c]	Level of significance: Trt	Sex	Sex x trt
Experiment 1										
GH, initial, ng/ml	2.51	--	3.60	1.97	--	2.75	0.23	0.08	0.17	0.95
GH, 7 days, ng/ml	2.69	--	2.27	3.21	--	2.93	0.19	0.69	0.41	0.15
GH, 28 days, ng/ml	2.67^{A}	--	4.18^{B}	3.80^{B}	--	2.86^{A}	0.19	0.83	0.71	0.05
GH, 56 days, ng/ml	2.47^{A}	--	4.70^{C}	2.11^{A}	--	3.59^{B}	0.25	0.00	0.16	0.82
Experiment 2										
GH, initial, ng/ml	2.87^{B}	2.71^{B}	3.04^{B}	1.88^{A}	2.03^{A}	1.77^{A}	0.17	0.98	0.01	0.90
GH, 5 weeks[d], ng/ml	2.19	1.88	1.95	1.94	2.93	1.88	0.22	0.55	0.44	0.36
GH, 13 weeks[d], ng/ml	1.72^{B}	1.78^{B}	4.14^{A}	1.70^{B}	2.20^{B}	1.85^{B}	0.18	0.02	0.10	0.04

[a]Means having different superscripts are significantly different ($P < .01$).
[b]2.2 mg DES + 2.2 mg of MT per kilogram of feed.
[c]Standard error of the means.
[d]DES + MT was added to the ration of pigs treated from 45 kg at 5 weeks.

The pigs receiving DES + MT from 23 kg (experiment 2) had serum GH levels similar to the untreated control pigs (table 14 and figure 8). In experiments 1, the GH levels of the pigs treated from 45 kg decreased initially and then increased throughout the remainder of the trial while the GH values of untreated controls increased during the first 28 days and then decreased. The GH levels of the control pigs in experiment 2 declined during the trial (table 14 and figure 8).

At the start of experiment 2, the serum GH level of the barrows was significantly higher than that of the gilts. Trenkle (personal communication) also noted that bulls and steers tended to have higher plasma GH levels than heifers.

Correlation coefficients were calculated from a summary of the 31 pigs in experiment 1 and the 38 pigs in experiment 2. Some simple correlations for PGH are presented in table 15. In experiment 1, the correlation between gain per day and PGH level at 56 days was significant ($P < .05$, -.37). This agrees with the results of Purchas (1970a) who found a correlation of -.36 between gain per day and bovine GH level. However, this observation was not obtained in experiment 2 since no correlation was found between gain per day and PGH level at 13 weeks.

The PGH levels at 28 days in experiment 1 were negatively correlated with area of the longissimus muscle (-.4) and backfat thickness (-.38). A highly significant ($P < .01$, -.47) negative correlation was obtained between backfat thickness and PGH at 56 days of DES + MT treatment. In experiment 1, there were several significant correlations between PGH

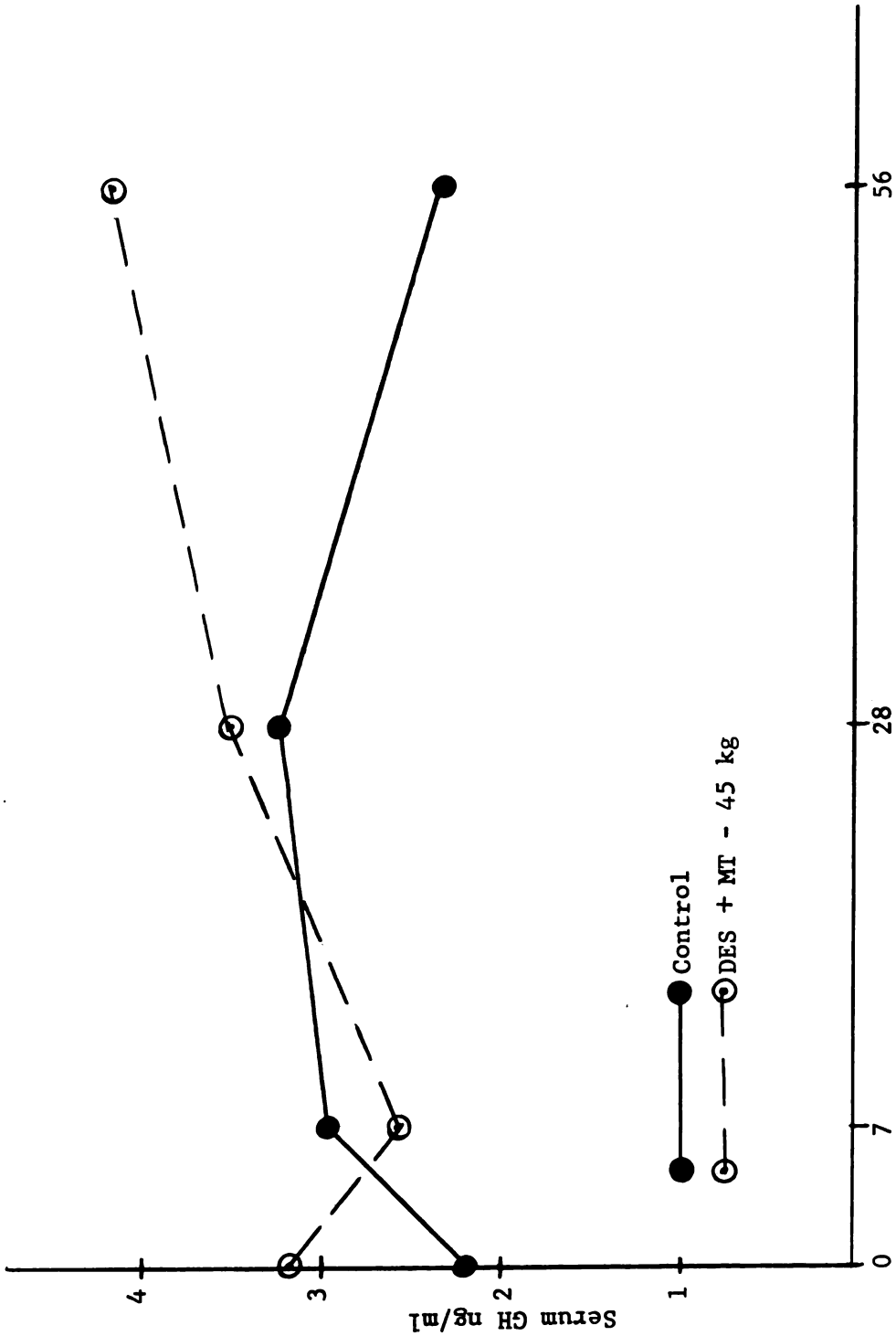

Figure 7. Serum growth hormone levels for treated and control pigs in experiment 1.

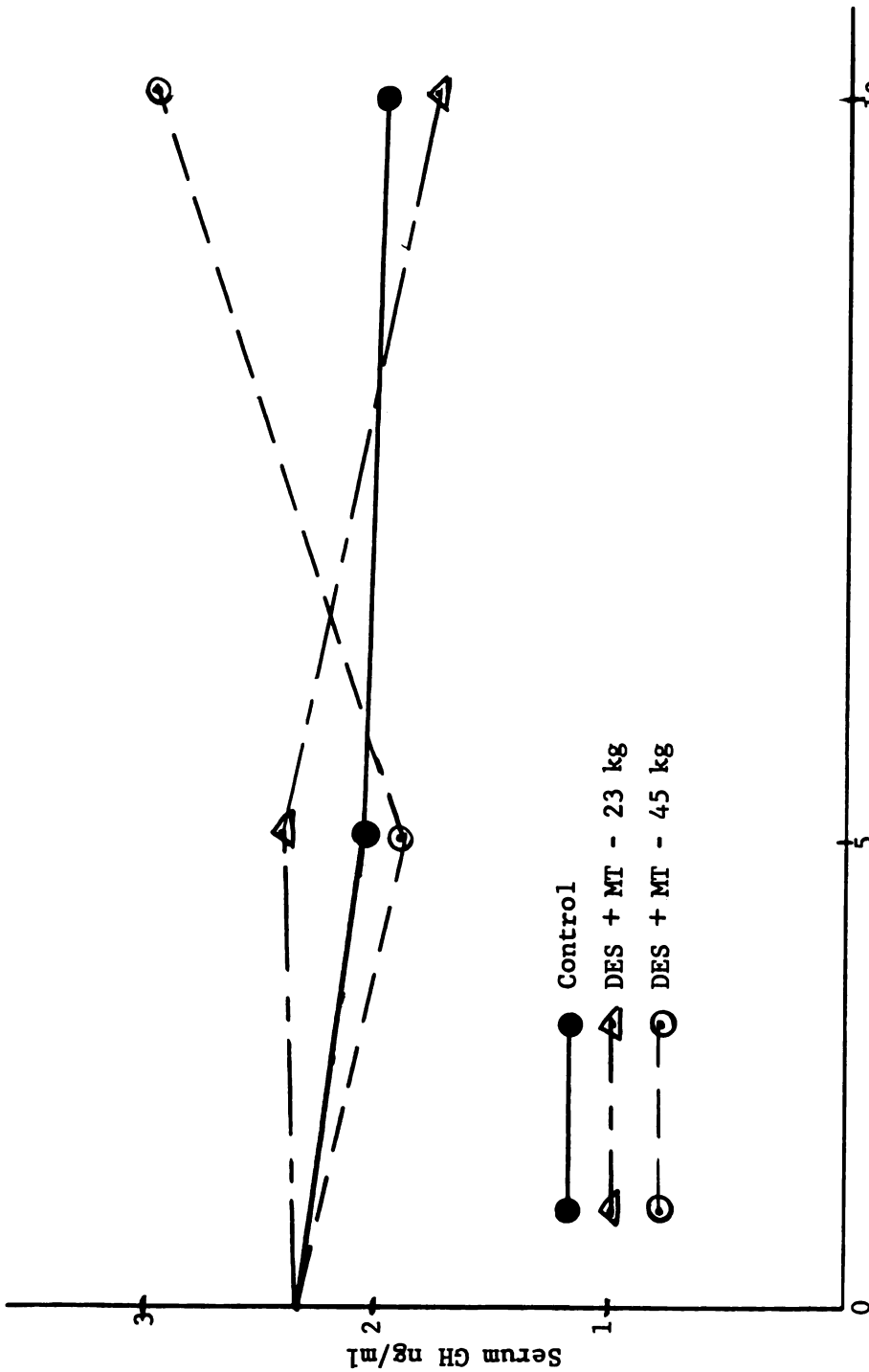

Figure 8. Serum growth hormone levels for treated and control pigs in experiment 2.

levels and gain or carcass traits but none of the corresponding correlations for PGH level in experiment 2 were significant. These latter results agree with the findings of Siers (1968) who studied PGH levels in pigs.

TABLE 15. SIMPLE CORRELATION COEFFICIENTS BETWEEN SERUM GROWTH HORMONE LEVELS AND SOME FEEDLOT AND CARCASS DATA

	Gain/ day, kg	Longissimus area, cm^2	Ham & loin, %	Backfat, cm	Fat trim, %
		Experiment 1			
PGH, initial	-.12	-.08	0.21	-.35*	-.31
PGH, 7 days	-.05	-.17	0.21	-.31	-.35*
PGH, 28 days	-.32	-.41*	0.31	-.38*	-.33
PGH, 56 days	-.37*	-.05	0.24	-.47**	-.32
		Experiment 2			
PGH, initial	0.20	-.10	-.04	0.03	-.24
PGH, 5 weeks	0.05	0.18	-.04	0.30	0.12
PGH, 13 weeks	0.00	-.04	0.11	-.17	-.12

*P < .05
**P < .01

SUMMARY

Forty barrows and 40 gilts were included in two experiments designed to study the effects of DES + MT upon performance, carcass traits, muscle composition and serum components of barrows and gilts. In experiment 1, 32 pigs weighing 45 kg were randomly assigned to four lots. One lot of eight barrows and one lot of eight gilts were fed 2.2 mg of DES and 2.2 mg of MT per kilogram of feed. The other barrow and gilt lots of eight pigs each received no DES + MT and served as controls. Eight pigs (two per treatment group) were removed from test when they averaged approximately 95 kg. At 23 kg live weight, 48 pigs (24 barrows and 24 gilts) were allotted to six treatment groups in experiment 2. Each lot consisted of eight pigs with gilts and barrows being fed separately. One lot of gilts and one of barrows were fed DES + MT from 23 to 95 kg while two additional lots (1 gilt and 1 barrow) received the hormones from 45 to 95 kg. The pigs were removed from this experiment for slaughter as described in experiment 1.

The DES + MT treatment stimulated daily gains of gilts and depressed the gains of barrows in both experiments. The hormone combination reduced daily feed intake of barrows in experiment 1 but this result was not repeated in experiment 2. Treated pigs also had higher gains per unit of feed in the first experiment but not in experiment 2.

The combination of DES + MT had no significant effect upon carcass traits in experiment 1. One possible explanation of these results could

have been the effects of heat stress during the summer months upon treated pigs. In experiment 2, pigs receiving DES + MT from 45 kg had less backfat than controls while those that received DES + MT from 23 kg had larger longissimus muscle areas than control pigs. Gilts had larger longissimus muscle areas and higher percentages of ham and loin than barrows in experiment 1. Gilts also had larger longissimus muscle areas and less backfat than barrows in experiment 2 but in contrast to the first trial percentages of ham and loin were not significantly different. The hormone combination had similar effects upon the carcass characteristics of gilts and barrows in both experiments. The DES + MT treatment increased quadriceps femoris muscle (expressed as a percentage of left side weight) in experiment 1 but this observation was not repeated in experiment 2. As was expected from the area data, gilts had larger longissimus muscles when expressed on a weight or percent basis and they also had more grams of protein in the longissimus muscle than barrows. In addition, the gilts in experiment 1 had larger quadriceps femoris muscles, whether expressed as weight or percent, than barrows.

Hormone treatment had no significant effect upon any of the muscle protein fraction or pH values of the longissimus muscle. This corresponds with the fact that DES + MT treatment did not alter the mass of the longissimus muscle. Area of red and intermediate fibers were similar for treated and control pigs in both experiments. Feeding DES + MT had no apparent effect on the percentages of red, white or intermediate fiber types. Thus, the hormone treatment did not alter muscle protein fractions or fiber types.

As shown in previous work, electrophoretic separation of serum proteins revealed that DES + MT tended to increase percent albumin and decrease the percent globulin. The hormone combination had no significant effect upon FFA levels at 7, 28 or 56 days. The DES + MT treatment tended to increase ovarian follicle size of treated gilts and at least one of the treated gilts (experiment 2, 23 to 95 kg) had a cystic ovary.

In both experiments 1 and 2, the pigs fed DES + MT from 45 kg had significantly higher serum GH levels at 90 kg than the untreated control pigs. Pigs that received DES + MT from 23 kg had serum GH values similar to control pigs.

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APPENDIX

APPENDIX I. RAW DATA EXPERIMENT 1 - GILTS

Pig No	Beginning weight kg	Final weight, kg	Gain/ day, kg	Days on feed	Serum FFA, µeq/100 ml Initial	7 days	28 days	56 days	Length, cm	Longissimus area, cm^2
					Lot 1[a]					
2-10	52.6	89.4	0.635	58	2.7	8.5	7.4	5.8	75.3	30.0
2-11	48.1	90.7	0.540	79	3.3	7.6	5.4	0.4	73.9	31.7
9-12	45.4	96.6	0.649	79	0.4	5.4	4.7	1.1	79.0	34.8
20-6	46.7	93.9	0.694	68	-	0.5	3.8	6.9	79.9	31.0
30-11	58.5	94.3	0.558	64	-	1.6	5.1	1.8	78.7	37.1
52-8	47.6	91.2	0.640	68	0.4	4.5	10.5	-	76.2	31.6
55-16	46.7	93.9	0.812	58	1.4	3.3	8.4	3.3	77.1	24.5
301-10	50.3	93.0	0.667	64	4.0	2.2	5.4	2.9	76.8	32.3
Mean	49.5	92.9	0.650	67.3	1.5	4.2	6.3	2.8	77.1	31.6
					Lot 2[b]					
2-8	47.2	92.5	0.576	79	-	2.4	10.2	6.9	74.4	35.5
6-7	47.2	88.5	0.608	68	0.5	5.1	8.2	5.6	78.7	31.9
9-8	59.0	106.6	0.821	58	1.8	4.2	3.8	3.3	78.6	34.8
20-1	52.6	101.6	0.844	58	-	4.5	9.4	3.6	81.3	33.9
30-9	57.6	103.9	0.721	64	-	0.7	5.3	2.7	81.0	36.8
30-12	49.4	97.5	0.708	68	3.3	6.9	7.3	6.2	77.7	33.2
52-7	54.4	92.5	0.599	79	5.1	1.8	0.9	2.4	77.7	29.7
55-11	49.0	97.5	0.758	64	-	4.0	5.1	-	76.2	35.5
Mean	52.1	97.6	0.704	67.3	1.3	3.7	6.3	3.8	78.2	33.9

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg

APPENDIX I. RAW DATA EXPERIMENT 1 - GILTS (continued)

Pig No	Ham & loin, %	Lean cuts, %	Primal cuts, %	Fat trim, %	Dressing percent	Backfat cm	Longissimus % 1. side	Quadriceps femoris, % 1. side
				Lot 1[a]				
2-10	39.7	56.8	66.7	18.7	69.0	2.97	4.99	3.00
2-11	39.6	57.3	66.5	20.2	73.5	3.25	5.44	2.99
9-12	41.3	59.1	68.4	18.5	72.8	3.30	5.32	2.84
20-6	40.3	57.3	67.6	19.7	72.2	3.05	5.49	2.80
30-11	42.0	60.4	70.6	14.6	74.3	2.62	6.17	3.19
52-8	40.4	57.5	68.2	19.7	74.6	2.85	5.25	2.89
55-16	38.8	55.2	66.5	21.1	69.8	3.38	4.61	2.82
301-10	39.9	56.2	65.9	20.3	71.2	3.68	5.32	2.51
Mean	40.3	57.2	67.6	19.1	72.2	3.14	5.32	2.88
				Lot 2[b]				
2-8	38.8	56.8	66.3	20.6	74.5	3.25	5.35	2.90
6-7	42.8	61.0	70.1	15.1	69.7	2.46	4.90	2.82
9-8	40.2	57.5	68.2	19.3	71.9	3.30	4.69	2.97
20-1	40.0	57.6	67.3	19.0	70.1	3.30	5.36	2.76
30-9	40.1	58.3	68.1	19.2	72.9	2.84	5.66	2.91
30-12	39.4	55.6	65.9	19.8	74.9	3.12	5.19	2.87
52-7	41.0	59.2	68.6	15.0	71.1	2.03	5.50	2.99
55-11	41.4	60.9	70.0	15.7	70.7	2.29	5.72	3.08
Mean	40.5	58.4	68.1	18.0	72.0	2.82	5.30	2.91

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg

APPENDIX I. RAW DATA EXPERIMENT 1 - GILTS (continued)

Pig No	Longissimus, g	Quadriceps femoris, g	Moisture, %	Protein, %	Fat, %	Protein long, g	Protein g long, % 1. side	Area red fibers
				Lot 1[a]				
2-10	1540	925	74.04	22.62	0.97	348.3	.0113	0.79
2-11	1805	1000	73.80	22.86	1.65	412.6	.0109	0.74
9-12	1960	1000	73.02	21.90	2.50	429.2	.0122	1.22
20-6	1870	955	73.39	22.58	2.98	422.2	.0124	0.94
30-11	2177	1125	74.16	22.90	1.96	498.5	.0141	0.84
52-8	1790	985	72.90	22.69	3.17	406.2	.0119	1.04
55-16	1480	910	73.73	22.36	2.42	330.9	.0103	0.69
301-10	1900	855	75.46	21.58	0.64	410.0	.0121	1.41
Mean	1815.2	969.4	73.81	22.43	2.04	407.2	.0119	0.96
				Lot 2[b]				
2-8	1810	985	73.99	22.17	2.48	401.3	.0118	0.88
6-7	1760	1015	73.56	21.65	3.32	381.0	.0121	0.84
9-8	1695	1070	73.60	22.12	2.48	374.9	.0099	0.63
20-1	1900	980	73.86	22.00	2.66	418.0	.0118	0.84
30-9	2177	1120	73.78	22.33	1.82	486.1	.0126	1.01
30-12	1940	1075	73.56	22.69	2.26	440.2	.0118	1.03
52-7	1800	975	73.68	22.08	2.64	397.4	.0121	0.57
55-11	1850	1000	74.28	21.36	2.96	395.2	.0123	--
Mean	1866.5	1027.5	73.79	22.05	2.58	411.8	.0118	0.83

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg

APPENDIX I. RAW DATA EXPERIMENT 1 - GILTS (continued)

Pig No	Area intermediate fibers	Red, fibers, %	Intermediate fibers, %	White, fibers, %	Electrophoresis of serum proteins, initially			
					Albumin, %	Globulin		
						α, %	β, %	γ, %
			Lot 1[a]					
2-10	0.89	19.65	4.71	75.65	41.2	26.1	10.9	21.8
2-11	1.05	17.49	7.91	74.60	43.3	21.6	12.4	22.7
9-12	1.46	17.60	9.83	72.57	38.5	25.3	12.3	24.0
20-6	1.08	17.84	6.23	75.94	50.7	21.2	11.3	16.7
30-11	1.20	16.43	5.57	78.00	48.0	21.0	10.2	20.7
52-8	1.08	14.62	5.90	79.46	49.5	19.9	14.6	16.0
55-16	0.98	16.70	9.76	73.53	46.0	28.2	9.3	16.5
301-10	1.46	25.62	6.63	67.75	44.5	21.8	9.5	24.3
Mean	1.15	18.24	7.07	74.69	45.2	23.1	11.3	20.3
			Lot 2[b]					
2-8	1.08	14.97	6.68	78.34	46.5	22.0	11.0	20.5
6-7	1.11	18.28	7.65	74.07	31.3	24.3	10.6	33.8
9-8	0.66	15.70	6.17	78.12	48.7	20.9	11.1	19.4
20-1	1.20	17.18	6.11	76.71	42.2	23.8	10.7	23.3
30-9	1.14	15.92	4.62	79.47	41.4	27.2	12.6	18.8
30-12	1.50	12.27	4.30	83.42	41.7	28.3	9.3	20.7
52-7	0.63	16.37	3.21	80.42	42.8	26.2	11.7	19.3
55-11	--	-	--	lost	36.6	25.3	11.8	26.2
Mean	1.04	15.83	5.53	78.65	41.4	24.8	11.1	22.8

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg

APPENDIX I. RAW DATA EXPERIMENT 1 - GILTS (continued)

Pig No	Electrophoresis of serum proteins, 7 days				Electrophoresis of serum proteins, 28 days				Electrophoresis of serum proteins, 56 days			
	Albumin, %	Globulin α, %	Globulin β, %	Globulin γ, %	Albumin, %	Globulin α, %	Globulin β, %	Globulin γ, %	Albumin, %	Globulin α, %	Globulin β, %	Globulin γ, %
					Lot 1[a]							
2-10	45.6	22.1	10.1	22.1	35.3	32.4	10.8	21.6	40.0	23.5	12.3	24.2
2-11	44.1	19.0	11.6	25.4	40.5	22.6	10.3	26.6	41.8	26.0	10.0	22.2
9-12	39.7	22.1	12.0	26.2	48.1	18.0	9.9	23.9	44.6	12.5	11.9	31.0
20-6	40.7	19.5	12.3	27.5	48.3	15.2	9.9	26.5	41.2	19.9	12.5	26.3
30-11	49.0	21.4	11.0	18.6	46.8	23.4	11.0	18.8	38.3	20.9	13.0	27.8
52-8	49.3	20.7	12.7	17.3	48.7	19.7	12.0	19.6	50.9	20.1	12.6	16.5
55-6	50.3	23.8	8.8	17.1	39.4	18.2	12.7	29.7	49.3	18.4	11.9	20.4
301-10	54.0	16.5	9.5	20.0	50.8	21.6	8.7	18.9	46.5	22.0	11.1	20.3
Mean	46.6	20.6	11.0	21.8	44.7	21.4	10.7	23.2	44.1	20.4	11.9	23.6
					Lot 2[b]							
2-8	50.8	18.6	10.7	19.8	55.5	20.2	9.2	15.0	53.5	14.5	11.6	17.5
6-7	38.0	22.7	11.2	28.1	48.6	19.8	11.3	20.3	47.2	22.1	11.1	19.7
9-8	54.2	18.2	10.0	17.4	57.1	12.1	7.9	22.9	51.8	19.2	11.0	18.1
20-1	47.8	17.4	11.3	23.5	53.9	16.4	8.7	20.9	48.6	20.8	11.6	18.9
30-9	47.5	23.2	12.5	16.9	54.5	18.8	5.8	20.8	48.7	19.6	11.5	20.2
30-12	50.8	22.1	9.8	18.1	48.6	18.5	9.6	23.3	45.7	20.0	10.9	23.5
52-7	37.6	28.6	12.8	20.9	42.8	21.0	11.1	25.0	36.6	30.4	12.1	20.8
55-11	46.3	21.3	9.4	23.1	35.0	25.5	11.8	27.6	49.3	20.5	10.1	19.9
Mean	46.6	21.5	11.0	21.0	49.5	19.0	9.4	22.0	47.7	20.9	11.2	19.8

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg

APPENDIX I. RAW DATA EXPERIMENT 1 - GILTS

Pig No	Follicles <5 mm	Follicles >5 mm	Corpora lutea <5 mm	Corpora lutea >5 mm	Corpora albicantia	Ovary weights	Growth hormone, ng/ml Initial	7 days	28 days	56 days
				Lot 1[a]						
2-10	50	-	-	-	10	5.78	1.23	1.96	4.72	2.50
2-11	40	6	-	-	5	5.81	2.12	1.50	3.19	1.58
9-12	45	16	-	-	20	5.26	1.90	2.56	4.95	2.31
20-6	15	10	-	-	10	5.86	2.21	2.93	3.37	1.56
30-11	75	-	-	-	15	4.20	1.96	2.80	4.69	1.58
52-8	-	13	-	-	15	4.39	2.40	2.59	3.55	1.64
55-16	15	-	-	-	-	10.63	1.91	7.01	1.45	3.57
301-10	50	5	-	-	10	4.58	2.04	4.33	4.48	2.13
Mean	36.3	6.3			12.1	5.80	1.97	3.21	3.80	2.11
				Lot 2[b]						
2-8	40	35	-	-	12	6.94	1.55	1.93	2.78	4.34
6-7	4	18	-	3	8	5.60	2.13	5.54	3.94	5.67
9-8	-	14	-	-	10	5.81	0.96	1.85	1.82	2.07
20-1	12	13	-	-	15	7.92	1.56	2.70	1.50	1.88
30-9	-	28	-	-	25	5.83	2.92	3.80	3.52	2.67
30-12	-	15	-	-	25	5.39	2.13	1.77	2.34	3.33
52-7	28	41	-	-	4	7.99	6.88	4.08	3.75	5.65
55-11	10	13	-	-	6	tumor (1 ovary)	3.86	1.74	3.19	3.14
Mean	11.7	22.1			13.1	6.50	2.75	2.93	2.86	3.59

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg

APPENDIX II. RAW DATA EXPERIMENT 1 - BARROWS

Pig No	Beginning weight kg	Final weight, kg	Gain/ day, kg	Days on feed	Serum FFA, μeq/100 ml Initial	7 days	28 days	56 days	Length, cm	Longissimus area, cm^2
					Lot 3[a]					
2-2	56.2	98.9	0.735	58	-	8.4	1.8	0.4	74.8	35.8
20-10	54.0	105.2	0.753	68	3.3	5.1	10.5	6.4	81.3	31.6
20-11	50.8	103.4	0.821	64	2.2	3.3	14.2	3.3	79.9	32.3
30-1	43.1	86.2	0.544	79	2.0	7.6	7.6	0.4	75.9	24.2
30-3	51.7	97.5	0.676	68	-	2.4	2.9	7.3	79.6	31.3
52-2	46.3	96.6	0.640	79	-	5.1	8.7	0.7	81.3	28.7
55-6	45.8	98.9	0.916	58	-	2.0	9.4	1.4	77.2	35.5
55-7	47.6	105.7	0.907	64	2.9	6.4	5.8	2.7	77.7	34.5
Mean	49.4	99.1	0.749	67.3	1.3	5.0	7.6	2.8	78.5	31.7
					Lot 4[b]					
2-4	49.4	87.5	0.481	79	1.8	10.2	8.2	1.8	75.2	32.3
2-5	44.5	88.5	0.649	68	0.5	3.6	lost	3.6	73.7	30.8
6-4	44.5	88.0	0.553	79	0.4	4.5	lost	9.8	76.7	25.5
20-13	51.7	100.7	0.844	58	-	3.4	5.1	5.4	79.4	31.0
30-2	48.5	91.6	0.671	64	-	1.6	5.1	5.1	76.2	32.6
55-3	46.3	92.5	0.798	58	2.4	8.4	10.9	7.6	74.5	25.8
55-4	44.0	90.7	0.730	64	6.2	5.3	5.4	2.7	76.7	24.2
Mean	47.0	91.4	0.673	67.1	1.4	4.7	7.7	5.1	76.1	28.9

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg

APPENDIX II. RAW DATA EXPERIMENT 1 - BARROWS (continued)

Pig No	Ham & loin, %	Lean cuts, %	Primal cuts, %	Fat trim, %	Dressing percent	Backfat cm	Longissimus % 1. side	Quadriceps femoris, % 1. side
				Lot 3[a]				
2-2	40.2	58.5	69.0	17.5	70.9	2.92	5.47	2.80
20-10	40.4	57.6	67.6	17.8	72.6	3.23	4.61	2.69
20-11	39.2	57.0	68.0	19.2	72.0	3.25	5.07	2.63
30-1	37.7	55.1	65.9	20.1	73.7	2.92	4.57	2.71
30-3	38.7	56.3	67.0	17.6	71.2	2.92	4.86	2.76
52-2	40.7	58.5	68.8	16.9	72.3	2.46	5.17	2.24
55-6	38.9	55.7	65.9	21.4	74.1	3.61	5.01	2.54
55-7	37.6	54.3	63.9	21.6	71.7	3.89	4.67	2.38
Mean	39.3	56.6	67.0	19.0	72.3	3.15	4.93	2.59
				Lot 4[b]				
2-4	40.0	58.5	67.2	17.5	71.2	2.34	5.31	3.09
2-5	40.6	58.8	68.9	17.9	70.0	2.87	5.07	2.91
6-4	41.0	59.4	68.6	16.4	68.6	2.03	5.06	2.92
20-13	39.4	56.7	66.2	21.1	72.7	3.68	5.12	2.64
30-2	40.9	58.8	68.9	16.9	70.0	2.67	5.14	2.84
55-3	37.6	54.2	63.5	22.5	71.3	3.38	4.51	2.70
55-4	38.4	55.9	67.6	19.7	71.8	3.10	4.20	2.71
Mean	39.7	57.5	67.3	18.9	70.8	2.87	4.92	2.83

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg

APPENDIX II. RAW DATA EXPERIMENT 1 - BARROWS (continued)

Pig No	Longissimus, g	Quadriceps femoris, g	Moisture, %	Protein, %	Fat, %	Protein long, g	Protein g long, % l. side	Area red fibers
				Lot 3[a]				
2-2	1925	985	73.82	22.91	4.48	441.0	.0125	0.73
20-10	1828	1060	73.56	22.88	2.42	418.2	.0105	0.79
20-11	1930	995	73.47	22.43	2.78	432.9	.0130	0.78
30-1	1430	850	74.10	22.06	2.40	315.5	.0101	0.84
30-3	1720	975	74.52	22.08	1.89	379.8	.0108	0.73
52-2	1770	1020	74.24	22.09	0.68	391.0	.0114	0.62
55-6	1805	920	74.17	21.60	3.68	389.9	.0108	1.04
55-7	1780	905	72.48	21.60	4.72	384.5	.0112	0.82
Mean	1773.5	963.8	73.80	22.21	2.88	394.1	.0112	0.79
				Lot 4[b]				
2-4	1640	945	75.47	21.36	1.70	350.3	.0114	0.89
2-5	1620	925	73.44	22.26	2.40	360.6	.0114	0.91
6-4	1530	875	73.78	21.11	3.98	323.0	.0108	0.80
20-13	1885	970	73.35	22.02	3.32	415.1	.0113	--
30-2	1725	950	73.90	22.40	2.80	386.4	.0115	1.03
55-3	1485	890	75.15	21.78	1.66	323.4	.0098	0.65
55-4	1325	855	74.06	21.72	3.04	287.8	.0091	1.01
Mean	1601.4	915.7	74.16	21.81	2.70	349.5	.0108	0.88

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg

APPENDIX II. RAW DATA EXPERIMENT 1 - BARROWS (continued)

Pig No.	Area intermediate fibers	Red fibers, %	Intermediate fibers, %	White fibers, %	Electrophoresis of serum proteins, initially			
					Albumin %	Globulin α, %	Globulin β, %	Globulin γ, %
			Lot 3[a]					
2-2	0.95	21.14	7.53	71.33	37.4	23.6	10.8	28.1
20-10	0.86	17.36	5.16	77.48	41.1	22.2	11.4	25.3
20-11	1.23	21.59	11.10	67.31	38.3	27.0	11.8	22.9
30-1	0.85	23.80	6.36	69.84	33.9	28.2	12.1	25.8
30-3	1.07	11.03	4.74	84.23	40.3	25.8	11.9	22.0
52-2	1.00	14.67	4.72	80.60	38.5	26.2	11.9	23.4
55-6	1.06	18.64	7.05	74.30	34.8	28.9	10.2	26.2
55-7	1.00	20.53	6.51	72.96	35.9	27.6	11.5	25.0
Mean	1.00	18.60	6.65	74.76	37.5	26.2	11.5	24.8
			Lot 4[b]					
2-4	1.07	22.18	9.24	68.57	42.9	31.5	10.0	15.8
2-5	1.07	22.67	4.93	72.40	43.4	24.5	10.2	21.9
6-4	0.92	13.80	4.69	81.50	44.2	22.1	11.5	22.1
20-13	--	-	--	lost	42.4	24.5	12.1	21.0
30-2	1.45	19.53	6.41	74.06	44.3	24.7	10.8	20.2
55-3	0.78	22.20	7.27	70.53	40.5	26.1	10.4	23.0
55-4	1.48	21.67	10.04	68.31	40.5	27.5	11.5	20.5
Mean	1.13	20.34	7.10	72.56	43.1	25.5	10.9	20.5

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg

APPENDIX II. RAW DATA EXPERIMENT 1 - BARROWS (continued)

Pig No	Electrophoresis of serum proteins, 7 days				Electrophoresis of serum proteins, 28 days				Electrophoresis of serum proteins, 56 days			
	Albumin, %	Globulin α, %	Globulin β, %	Globulin γ, %	Albumin, %	Globulin α, %	Globulin β, %	Globulin γ, %	Albumin, %	Globulin α, %	Globulin β, %	Globulin γ, %
Lot 3[a]												
2-2	45.3	19.9	9.8	25.1	40.3	21.4	10.3	28.0	40.6	19.8	9.9	29.7
20-10	52.2	17.6	10.3	19.9	41.9	19.4	11.9	26.7	47.3	20.0	13.5	19.2
20-11	52.5	22.0	11.4	14.1	49.2	20.0	11.4	19.5	49.6	19.3	11.5	19.6
30-1	45.2	21.7	9.5	23.5	38.3	21.6	10.1	30.0	38.2	21.3	11.6	28.9
30-3	50.0	22.2	12.1	15.7	38.0	24.6	12.6	24.6	35.3	20.6	14.7	29.4
52-2	50.3	22.0	10.7	17.2	31.3	24.5	12.5	31.9	39.7	24.9	11.6	24.3
55-6	45.7	21.6	10.3	22.4	42.6	20.7	9.2	27.4	45.5	21.3	10.5	22.7
55-7	47.6	20.5	12.6	19.4	43.4	22.4	12.4	21.8	45.3	21.3	12.0	21.3
Mean	48.6	20.9	10.8	19.7	40.6	21.8	11.3	26.2	42.7	21.1	11.9	24.4
Lot 4[b]												
2-4	49.4	19.4	12.6	18.8	43.1	20.9	11.4	24.6	38.5	28.9	11.6	20.9
2-5	48.4	20.7	11.0	19.9	40.1	25.0	9.9	25.0	43.2	20.7	11.7	24.5
6-4	48.0	18.0	11.3	22.7	33.0	23.9	12.2	31.0	34.6	31.8	12.1	21.4
20-13	52.5	18.2	11.8	17.6	45.9	19.7	10.4	24.0	42.4	21.0	11.7	24.9
30-2	48.4	24.9	9.5	17.4	43.1	22.0	10.1	25.0	42.4	26.0	11.3	22.3
55-3	58.3	18.0	10.1	13.6	41.6	22.6	9.3	26.5	47.6	21.2	10.8	21.2
55-4	44.9	24.3	14.2	16.7	43.1	20.4	9.8	26.8	48.4	21.3	10.2	21.2
Mean	49.8	20.4	11.3	18.6	41.5	22.1	10.4	26.0	42.4	24.4	11.3	22.3

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg

APPENDIX II. RAW DATA EXPERIMENT 1 - BARROWS (continued)

Pig No	Growth hormone, ng/ml			
	Initial	7 days	28 days	56 days
		Lot 3[a]		
2-2	1.69	2.96	1.69	2.10
20-10	3.43	1.80	3.66	2.34
20-11	1.96	2.48	2.31	1.99
30-1	2.30	2.69	3.84	1.83
30-3	1.91	5.22	2.78	4.10
52-2	3.09	2.53	2.48	2.48
55-6	2.86	1.61	2.62	3.08
55-7	2.86	2.21	1.96	1.83
Mean	2.51	2.69	2.67	2.47
		Lot 4[b]		
2-4	3.98	2.18	3.84	8.33
2-5	6.33	1.23	4.44	2.64
6-4	2.35	2.75	6.63	5.53
20-13	4.39	2.12	2.31	6.57
30-2	3.63	2.70	4.49	5.00
55-3	1.83	1.66	1.61	2.41
55-4	2.69	3.22	5.91	2.40
Mean	3.60	2.27	4.18	4.70

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg

APPENDIX III. RAW DATA EXPERIMENT 2 - BARROWS

Pig No	Beginning weight, kg	Final weight, kg	Gain/ day, kg	Days on feed	Length, cm	Longissimus area, cm^2	Ham & loin, %	Lean cuts, %	Primal cuts, %
				Lot 1[a]					
5-1	17.2	92.1	.789	95	80.0	32.7	42.9	61.7	72.1
5-2	17.2	95.7	.771	102	78.7	32.3	40.8	58.9	70.8
21-1	23.6	106.1	.939	88	78.4	34.2	38.8	57.3	68.9
28-2	25.4	91.6	.617	107	75.2	21.0	38.5	56.3	64.9
31-4	21.8	95.3	.776	95	78.7	29.1	38.8	58.0	70.4
Mean	22.3	96.2	.778	97.4	78.2	29.8	40.0	58.4	69.4
				Lot 2[b]					
5-4	20.0	97.5	.817	95	77.0	31.5	40.6	58.7	70.3
14-1	20.9	93.9	.767	95	78.5	31.0	41.8	60.3	71.4
21-3	29.0	93.0	.725	88	76.7	33.6	43.0	61.8	72.6
22-2	27.7	97.5	.685	102	77.5	31.0	40.1	59.7	70.0
28-1	23.6	93.9	.798	88	77.7	32.5	42.0	60.8	71.1
39-1	21.8	95.3	.721	102	77.5	32.6	42.9	62.1	72.2
39-3	17.7	88.5	.649	109	76.2	23.9	38.9	57.5	68.7
Mean	23.4	94.2	.734	97.0	77.3	30.8	41.3	60.1	70.9
				Lot 3[c]					
5-3	20.9	93.9	.717	102	81.0	35.2	43.9	64.2	71.2
7-2	29.5	93.0	.621	102	78.0	32.6	42.6	62.2	71.7
14-2	20.0	92.1	.662	109	76.7	36.8	41.6	59.4	69.8
21-5	24.5	98.9	.844	88	78.4	32.3	41.7	60.1	71.5
28-3	25.4	98.0	.762	95	78.5	30.1	37.2	54.1	65.5
31-3	24.5	100.7	.803	95	82.0	32.5	41.0	60.1	71.2
39-4	19.1	98.4	.730	109	78.7	37.1	40.8	61.4	71.9
Mean	23.2	96.4	.734	100	79.1	33.8	41.3	60.2	70.9

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg
[c]Barrows, DES + MT from 23 kg

APPENDIX III. RAW DATA EXPERIMENT 2 - BARROWS (continued)

Pig No	Fat trim, %	Dressing percent	Backfat, cm	Longissimus, % 1. side	Quadriceps femoris, % 1. side	Longissimus, g	Quadriceps femoris, g
				Lot 1[a]			
5-1	12.1	72.7	2.36	5.87	2.87	1980	970
5-2	13.1	73.5	2.29	5.83	3.19	2050	1115
21-1	19.0	72.1	3.68	4.84	2.73	1865	1055
28-2	21.0	67.6	2.92	4.61	2.53	1450	800
31-4	16.1	72.9	2.85	4.96	2.43	1735	855
Mean	16.3	71.8	2.82	5.22	2.75	1816.0	959.0
				Lot 2[b]			
5-4	14.0	71.1	2.62	5.62	2.70	1985	925
14-1	15.3	71.2	2.62	5.33	2.71	1820	950
21-3	12.7	71.3	2.11	5.81	2.31	1925	1065
22-2	14.4	74.7	2.79	5.05	3.04	1800	1085
28-1	12.8	71.5	2.72	5.45	2.93	1805	970
39-1	12.5	69.5	1.98	5.91	3.25	1930	1065
39-3	17.9	69.2	2.54	4.90	2.51	1520	775
Mean	14.2	71.2	2.48	5.44	2.78	1926.0	976.4
				Lot 3[c]			
5-3	8.6	72.2	1.57	6.79	2.99	2260	1000
7-2	12.2	75.9	2.54	5.92	3.50	2025	1200
14-2	17.5	72.9	3.10	6.16	2.63	2052	880
21-5	15.4	71.0	2.79	5.29	2.79	1825	965
28-3	17.3	73.6	3.43	5.07	2.59	1840	945
31-3	13.8	72.9	2.79	5.59	3.01	2065	1130
39-4	14.4	71.9	2.49	5.86	2.97	2060	1055
Mean	14.2	72.9	2.67	5.81	2.93	2018.1	1025

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg
[c]Barrows, DES + MT from 23 kg

APPENDIX III. RAW DATA EXPERIMENT 2 - BARROWS (continued)

Pig No.	Fat (P long.), %	pH of long.	Sacroplasmic N	Fibrillar N	NPN	Stroma N	Moisture (long.), %	Protein (long.), %
				Lot 1[a]				
5-1	1.87	5.68	28.45	42.30	12.70	16.91	74.34	21.74
5-2	2.24	6.06	25.67	43.92	11.69	18.72	74.04	21.92
21-1	3.16	5.88	24.81	47.59	12.21	15.32	73.06	22.66
28-2	3.39	6.15	29.00	42.75	12.76	15.47	73.69	22.24
31-4	3.65	6.09	27.52	35.56	11.45	25.47	73.14	21.58
Mean	2.86	5.97	27.09	42.42	12.16	18.38	73.65	22.03
				Lot 2[b]				
5-4	2.52	5.92	34.86	43.91	12.58	8.65	74.06	22.28
14-1	3.29	5.97	28.56	40.67	13.56	17.21	73.30	22.60
21-3	3.16	6.12	24.90	46.85	13.01	15.24	74.08	22.29
22-2	2.54	6.02	22.54	43.69	15.18	18.59	74.30	23.06
28-1	1.74	6.12	23.12	43.37	12.36	21.15	74.08	21.78
39-1	3.53	5.88	28.52	38.85	13.52	19.11	73.88	22.89
39-3	3.03	6.22	28.53	41.84	15.13	14.50	74.26	21.82
Mean	2.83	6.04	27.29	42.74	13.62	16.35	73.99	22.39
				Lot 3[c]				
5-3	2.11	5.86	25.80	39.04	11.34	23.82	72.98	22.15
7-2	4.89	5.87	34.06	41.17	11.88	12.89	73.68	23.02
14-2	4.67	6.04	24.77	43.50	15.33	16.40	73.48	23.12
21-5	2.98	5.88	23.81	45.65	13.94	16.60	74.08	22.72
28-3	2.05	5.85	27.75	41.15	13.80	17.29	74.24	22.53
31-3	2.56	5.90	30.37	41.31	11.69	16.63	73.42	22.71
39-4	3.15	6.16	28.63	43.59	11.68	16.11	73.06	22.42
Mean	3.20	5.94	27.88	42.20	12.81	17.11	73.68	22.67

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg
[c]Barrows, DES + MT from 23 kg

APPENDIX III. RAW DATA EXPERIMENT 2 - BARROWS (continued)

Pig No	Marbling	Color	Firmness	Wateriness	Total quality score	Moisture (P long.) %	Nitrogen, % (dry, fat free)
				Lot 1[a]			
5-1	0.5	2.5	3.0	2.5	8.5	75.04	13.89
5-2	1.0	3.5	3.5	3.0	11.0	74.84	15.46
21-1	3.0	4.5	4.5	4.0	16.0	73.03	15.13
28-2	2.5	4.0	4.5	4.0	15.0	73.79	14.81
39-7	4.0	5.0	5.0	5.0	19.0	73.07	14.34
Mean	2.2	3.9	4.1	3.7	13.9	73.95	14.73
				Lot 2[b]			
5-4	0.5	4.0	2.5	2.5	9.5	73.97	14.87
14-1	1.5	4.5	3.5	3.5	13.0	73.11	15.58
21-3	1.0	4.5	4.5	4.0	14.0	73.85	15.26
22-2	1.0	3.0	3.5	3.5	11.0	73.95	15.38
28-1	2.0	5.0	4.5	4.0	15.5	73.55	14.97
39-1	2.5	4.5	4.5	5.0	16.5	73.22	15.50
39-3	3.5	4.5	4.5	4.5	17.0	73.86	15.29
Mean	1.7	4.3	3.9	3.9	13.8	73.64	15.26
				Lot 3[c]			
5-3	1.5	4.0	3.0	3.0	11.5	74.23	15.55
7-2	2.0	4.5	4.0	3.0	13.5	72.30	15.71
14-2	0.5	2.0	2.5	2.5	7.5	73.28	15.33
21-5	2.0	4.5	5.0	4.0	16.0	73.06	14.92
28-3	2.5	4.5	5.0	4.5	16.5	72.25	13.42
31-3	2.5	4.5	5.0	5.0	17.0	73.45	14.75
39-4	2.5	4.0	4.5	4.0	15.0	73.34	15.60
Mean	1.9	4.0	4.1	3.7	13.9	73.13	15.04

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg
[c]Barrows, DES + MT from 23 kg

APPENDIX III. RAW DATA EXPERIMENT 2 - BARROWS (continued)

Pig No	Fat (long.), %	Protein long., g	Protein long, % l. side	Area red fibers	Area intermediate fiber	Red fibers, %	Intermediate fibers, %
				Lot 1[a]			
5-1	2.45	430.5	.0127	0.87	1.08	13.13	9.25
5-2	2.39	449.4	.0148	0.50	0.53	15.83	7.71
21-1	2.73	422.6	.0096	0.76	0.96	25.07	9.22
28-2	2.84	322.5	.0102	0.76	0.83	22.28	9.37
31-4	3.96	374.4	.0107	--	--	---	--
Mean	2.87	399.9	.0116	0.72	0.85	19.07	8.89
				Lot 2[b]			
5-4	1.35	442.3	.0125	0.96	1.64	22.02	10.11
14-1	2.83	411.3	.0120	0.79	0.96	17.02	8.14
21-3	2.00	429.1	.0130	0.65	1.00	19.16	8.60
22-2	1.18	415.1	.0117	0.49	0.76	9.44	6.75
28-1	2.70	393.1	.0119	0.57	1.01	14.51	5.57
39-1	2.23	441.8	.0135	0.65	0.87	13.61	7.86
39-3	3.01	331.7	.0107	0.79	0.94	14.09	9.17
Mean	2.19	409.2	.0122	0.70	1.03	15.69	8.03
				Lot 3[c]			
5-3	2.26	500.6	.0150	0.90	1.09	20.95	9.17
7-2	2.56	466.2	.0136	0.76	1.28	18.49	7.93
14-2	2.18	474.4	.0142	0.88	1.37	11.30	4.52
21-5	2.40	414.6	.0120	0.87	1.03	17.04	9.31
28-3	1.90	414.6	.0144	0.85	1.14	20.91	8.40
31-3	2.69	469.0	.0127	0.81	1.08	18.10	5.09
39-4	3.23	461.9	.0130	1.03	1.15	18.15	5.56
Mean	2.46	457.3	.0136	0.87	1.16	17.85	7.14

[a]Barrows, control
[b]Barrows, DES + MT from 45 kg
[c]Barrows, DES + MT from 23 kg

APPENDIX III. RAW DATA EXPERIMENT 2 - BARROWS (continued)

Pig No	White fibers, %	SDH activity	Growth hormone, ng/ml Initial	5 weeks	13 weeks
		Lot 1[a]			
5-1	77.61	24.88	2.47	2.96	2.12
5-2	75.89	21.35	3.59	2.06	1.06
21-1	65.71	34.54	2.34	1.62	1.59
28-2	68.35	47.65	2.14	2.80	2.05
31-4	---	40.47	3.79	1.49	1.80
Mean	71.89	33.78	2.87	2.19	1.72
		Lot 2[b]			
5-4	65.52	42.22	2.75	1.61	2.31
14-1	74.84	35.84	1.86	1.51	1.85
21-3	72.25	37.32	2.41	1.60	2.83
22-2	81.94	34.74	2.04	1.84	4.53
28-1	79.91	43.72	7.26	2.87	6.24
39-1	78.57	23.42	2.33	2.16	8.12
39-3	76.34	45.50	2.66	2.08	3.10
Mean	75.62	37.54	3.04	1.95	4.14
		Lot 3[c]			
5-3	69.88	29.03	2.27	1.93	1.82
7-2	73.54	30.47	4.97	1.23	1.89
14-2	83.70	27.59	2.33	1.82	1.79
21-5	73.64	29.56	2.42	2.12	1.74
28-3	70.36	39.38	2.88	1.62	1.53
31-3	76.21	42.87	2.39	1.75	1.48
39-4	76.29	60.10	1.71	2.69	2.21
Mean	74.80	37.00	2.71	1.88	1.78

[a]Barrows, Control
[b]Barrows, DES + MT from 45 kg
[c]Barrows, DES + MT from 23 kg

APPENDIX IV. RAW DATA EXPERIMENT 2 - GILTS

Pig No	Beginning weight, kg	Final weight, kg	Gain/ day, kg	Days on feed	Length, cm	Longissimus area, cm^2	Ham & loin, %	Lean cuts, %	Primal cuts, %
					Lot 4[a]				
7-6	27.7	95.3	.767	88	75.4	33.2	41.9	59.6	71.4
28-11	23.6	88.5	.594	109	73.4	28.4	40.3	57.7	69.4
28-12	20.9	91.6	.649	109	74.2	27.4	38.6	55.6	65.9
31-7	26.3	88.5	.608	102	77.2	31.9	41.6	61.6	72.0
39-7	26.8	93.0	.699	95	75.7	38.7	42.6	61.3	71.9
100-6	20.0	88.0	.667	102	74.4	38.8	46.2	64.9	74.4
Mean	23.1	90.8	0.664	100.8	75.1	33.1	41.9	60.1	70.8
					Lot 5[b]				
21-8	27.7	95.3	.662	102	77.0	31.9	40.9	60.7	71.7
28-9	28.1	99.8	.753	95	78.7	36.5	42.3	61.4	72.2
31-9	29.0	96.6	.767	88	80.9	32.6	41.6	60.5	71.4
39-8	23.6	93.0	.680	102	73.9	39.9	42.3	61.3	73.0
39-10	23.1	98.0	.789	95	76.2	40.0	42.1	61.4	72.1
100-9	19.5	96.6	.708	109	76.2	33.2	42.9	62.2	72.2
Mean	23.9	96.6	0.727	98.5	77.2	35.7	42.0	61.3	72.1
					Lot 6[c]				
7-7	24.9	92.1	.708	95	75.7	38.1	44.0	63.3	73.8
24-5	15.4	84.4	.631	109	76.5	31.1	42.8	61.7	72.0
28-13	26.8	85.7	.671	88	75.8	41.3	44.8	64.1	74.4
31-8	27.7	88.5	.690	88	77.7	29.4	40.2	56.5	67.8
39-9	21.8	93.0	.748	95	73.4	39.0	41.0	59.4	70.6
39-12	22.2	88.5	.649	102	73.9	40.3	43.9	63.2	73.4
100-8	17.6	92.5	.690	102	77.0	36.5	43.6	62.2	72.0
Mean	23.1	89.2	0.684	97.0	75.7	36.5	42.9	61.5	72.0

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg
[c]Gilts, DES + MT from 23 kg

APPENDIX IV. RAW DATA EXPERIMENT 2 - GILTS (continued)

Pig No	Fat trim, %	Dressing percent	Backfat, cm	Longissimus, % l. side	Quadriceps femoris, % l. side	Longissimus, g	Quadriceps femoris g
				Lot 4[a]			
7-6	14.7	72.8	2.79	5.70	3.17	1960	1095
28-11	18.3	72.3	2.97	5.18	2.91	1625	920
28-12	22.6	72.8	3.33	5.10	2.41	1640	775
31-7	13.9	72.6	2.24	5.85	3.23	1885	1030
39-7	15.1	72.0	2.79	6.72	3.09	2285	1052
100-6	10.5	72.2	1.78	7.70	3.45	2430	1090
Mean	15.9	72.5	2.65	6.04	3.04	1970.8	993.7
				Lot 5[b]			
21-8	15.1	72.6	2.54	5.43	2.84	2015	980
28-9	14.0	72.5	2.79	6.09	3.01	2255	1110
31-9	15.1	72.6	2.36	5.88	2.78	2000	995
39-8	12.3	72.8	2.18	6.40	3.09	2170	1055
39-10	14.6	71.1	2.72	6.45	3.10	2270	1090
100-9	14.9	70.9	1.96	5.89	2.78	2080	980
Mean	14.3	72.1	2.42	6.02	2.93	2131.7	1035.0
				Lot 6[c]			
7-7	14.0	73.2	2.74	6.30	3.24	2180	1120
24-5	15.0	71.2	2.36	5.64	2.90	1710	885
28-13	18.3	75.4	2.59	6.99	3.04	2275	815
31-8	17.5	73.0	2.74	5.09	2.42	1710	1010
39-9	16.6	73.8	3.56	6.18	2.88	2180	1015
39-12	12.3	73.6	2.21	6.63	4.07	2155	1045
100-8	14.1	73.7	2.59	6.71	3.06	2340	1065
Mean	15.4	73.4	2.68	6.22	3.09	2078.6	993.6

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg
[c]Gilts, DES + MT from 23 kg

APPENDIX IV.. RAW DATA EXPERIMENT 2 - GILTS (continued)

Pig No	Fat (P long.), %	pH of long.	Sacroplasmic N	Fibrillar N	NPN	Stroma N	Moisture (long.), %	Protein (long.), %
				Lot 4[a]				
7-6	2.56	5.93	24.02	43.79	13.38	18.81	73.62	22.72
28-11	2.24	6.18	27.72	42.28	15.91	14.09	74.19	22.50
28-12	2.40	5.93	32.93	43.38	12.41	11.28	73.68	22.88
31-7	2.22	5.92	31.73	41.50	13.76	13.01	73.60	22.71
39-7	2.48	5.95	26.08	35.79	12.93	25.20	74.47	23.00
100-6	1.40	6.15	27.01	44.73	13.63	14.63	75.41	20.93
Mean	2.22	6.01	28.24	41.91	13.67	16.17	74.16	22.46
				Lot 5[b]				
21-8	1.87	5.86	24.40	40.66	15.74	19.20	74.12	23.06
28-9	2.54	5.77	27.12	37.51	13.72	20.38	73.43	22.30
31-9	4.75	5.86	27.21	49.56	12.79	10.45	73.14	22.29
39-8	2.64	5.87	31.66	40.44	14.18	13.73	73.18	23.95
39-10	2.69	5.87	27.08	41.02	13.95	17.95	74.04	23.40
100-9	3.21	6.03	29.55	44.84	15.28	10.33	73.88	22.50
Mean	2.95	5.88	27.83	42.34	14.28	15.34	73.63	22.92
				Lot 6[c]				
7-7	3.14	5.88	26.17	46.97	13.94	12.93	73.37	22.36
24-5	1.74	6.09	28.11	42.20	14.89	14.81	74.46	21.88
28-13	3.24	5.89	23.72	48.98	13.83	11.94	74.60	22.60
31-8	3.68	5.81	28.90	44.26	14.89	11.96	74.16	22.62
39-9	2.14	5.86	29.16	40.54	11.68	18.61	73.92	22.92
39-12	1.28	5.90	29.00	40.82	13.53	16.65	73.83	23.06
100-8	2.44	6.27	30.76	42.45	13.76	13.02	74.79	21.48
Mean	2.52	5.96	27.97	43.75	13.79	13.79	74.16	22.42

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg
[c]Gilts, DES + MT from 23 kg

APPENDIX IV.. RAW DATA EXPERIMENT 2 - GILTS (continued)

Pig No	Marbling	Color	Firmness	Wateriness	Total quality score	Moisture (P long.) %	Nitrogen, % (dry, fat free)
				Lot 4[a]			
7-6	2.0	4.5	4.5	4.0	15.0	72.01	14.81
28-11	1.0	3.0	3.0	3.0	10.0	74.02	14.98
28-12	1.0	3.5	3.0	3.0	10.5	73.55	15.54
31-7	0.5	3.0	2.0	2.5	10.5	74.16	15.57
39-7	2.0	4.5	5.0	4.5	15.0	73.66	16.06
100-6	1.0	4.5	2.0	2.0	9.5	75.64	14.58
Mean	1.3	3.8	3.3	3.2	11.8	73.90	15.26
				Lot 5[b]			
21-8	1.0	4.0	3.0	3.5	11.5	73.76	15.26
28-9	1.0	4.5	2.5	2.5	10.5	72.50	14.14
31-9	2.0	5.0	4.5	4.0	15.5	71.50	14.29
39-8	1.5	4.5	3.5	3.5	13.0	73.26	15.50
39-10	2.0	4.0	4.5	4.0	14.5	72.20	15.04
100-9	1.5	4.0	3.5	4.0	13.0	76.74	16.63
Mean	1.5	4.3	3.6	3.6	13.0	73.25	15.14
				Lot 6[c]			
7-7	3.0	4.0	3.5	3.5	14.0	71.21	14.02
24-5	1.5	4.0	3.5	4.0	13.0	75.08	15.26
28-13	1.0	4.5	4.5	4.0	14.0	72.92	14.86
31-8	2.0	4.0	4.5	4.0	14.5	71.71	13.81
39-9	2.0	4.5	4.5	4.0	15.0	73.81	15.45
39-12	1.0	4.0	4.0	4.0	13.0	74.43	15.50
100-8	0.0	2.0	1.5	1.5	5.0	74.69	14.77
Mean	1.5	3.9	3.7	3.6	12.6	73.41	14.81

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg
[c]Gilts, DES + MT from 23 kg

APPENDIX IV. RAW DATA EXPERIMENT 2 - GILTS (continued)

Pig No	Fat (long.), %	Protein long., g	Protein long, % l. side	Area red fibers	Area intermediate fiber	Red fibers, %	Intermediate fibers, %
				Lot 4[a]			
7-6	2.12	445.3	.0129	0.55	9,27	16.72	7.06
28-11	1.34	365.6	.0117	0.94	1.15	18.55	7.61
28-12	1.53	375.2	.0117	0.68	0.89	16.89	8.98
31-7	2.16	428.1	.0133	0.61	0.67	13.64	4.10
39-7	1.42	525.6	.0154	0.73	0.70	13.84	9.63
100-6	0.94	508.6	.0161	0.92	1.37	26.19	12.76
Mean	1.59	441.4	.0135	0.74	0.92	17.64	8.36
				Lot 5[b]			
21-8	1.30	464.7	.0134	0.96	1.27	17.23	11.56
28-9	2.56	502.9	.0136	0.74	0.76	13.00	6.73
31-9	3.05	445.8	.0124	0.84	1.23	19.42	7.03
39-8	1.82	519.7	.0153	0.79	1.52	12.70	8.17
39-10	1.59	531.2	.0151	0.72	0.83	17.01	7.36
100-9	2.21	468.0	.0133	0.89	0.73	14.33	5.69
Mean	2.09	488.7	.0139	0.82	1.06	15.62	7.76
				Lot 6[c]			
7-7	2.86	487.4	.0141	0.60	0.87	18.51	8.17
24-5	1.60	374.1	.0123	0.71	1.16	19.92	13.82
28-13	1.29	514.2	.0155	0.65	0.92	14.57	11.31
31-8	2.30	386.8	.0115	0.69	0.84	13.55	11.88
39-9	1.90	499.7	.0142	0.68	0.79	12.56	3.10
39-12	1.03	496.9	.0154	0.87	1.37	18.29	6.41
100-8	1.84	502.6	.0144	0.70	1.05	15.31	4.94
Mean	1.83	466.0	.0139	0.70	1.00	16.10	8.52

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg
[c]Gilts, DES + MT from 23 kg

APPENDIX IV. RAW DATA EXPERIMENT 2 - GILTS (continued)

Pig No	White fibers, %	SDH activity	Follicles <5 mm	Follicles >5 mm	Corpora lutea <5 mm	Corpora lutea >5 mm	Corpora albicantia	Ovary weights
				Lot 4[a]				
7-6	76.23	35.07	60	--	--	--	--	9.08
28-11	78.82	60.24	140	--	--	--	--	6.65
28-12	74.14	46.58	100	--	--	--	--	6.30
31-7	79.10	26.06	80	--	--	--	--	8.30
39-7	76.53	52.35	--	--	--	--	--	tumor
100-6	61.05	43.90	75	4	--	--	--	9.85
Mean	74.31	44.03	75.8	0.80	--	--	--	8.04
				Lot 5[b]				
21-8	71.23	39.27	15	4	--	--	--	2.33
28-9	80.28	43.58	120	17	--	--	--	7.10
31-9	74.03	36.71	--	--	--	--	--	tumor
39-8	79.14	31.48	10	27	--	--	5	8.36
39-10	75.64	28.38	--	20	--	--	15	6.85
100-9	79.98	41.19	75	--	--	12	--	26.70
Mean	76.72	36.77	36.7	11.3	--	2.0	3.3	10.70
				Lot 6[c]				
7-7	73.32	37.57	--	17	--	--	4	5.50
24-5	66.26	37.57	--	15>15 mm 8>10 mm	--	--	--	26.98
28-13	74.11	38.78	25	17	--	--	--	7.50
31-8	77.91	52.35	5	17	--	11	--	13.82
39-9	84.82	42.87	--	14>35 mm 7>25 mm	--	--	--	255.90
39-12	75.77	32.54	--	7>15 mm 18>10 mm	--	--	6	23.37
100-8	79.75	48.82	--	8> 5 mm 18>10 mm	--	--	--	10.99
Mean	75.99	41.50	4.3	75 20.9	--	1.6	1.4	49.15

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg
[c]Gilts, DES + MT from 23 kg

APPENDIX IV. RAW DATA EXPERIMENT 2 - GILTS (continued)

Pig No	Growth hormone, ng/ml Initial	5 weeks	13 weeks
	Lot 4[a]		
7-6	1.55	1.44	1.62
28-11	2.20	2.45	1.40
28-12	1.55	1.78	2.27
31-7	1.82	1.85	1.88
39-7	1.99	2.47	1.32
100-6	2.17	1.66	1.71
Mean	1.88	1.94	1.70
	Lot 5[b]		
21-8	1.08	1.40	1.69
28-9	1.21	1.93	1.55
31-9	1.37	2.10	1.72
39-8	2.18	1.95	2.08
39-10	2.31	1.84	2.15
100-9	2.45	2.05	1.91
Mean	1.77	1.88	1.85
	Lot 6[c]		
7-7	2.42	1.13	1.94
24-5	1.55	1.38	1.87
28-13	1.50	2.66	3.84
31-8	1.57	1.68	1.84
39-9	2.34	9.57	2.22
39-12	2.03	1.93	2.01
100-8	2.86	2.17	1.65
Mean	2.03	2.93	2.20

[a]Gilts, control
[b]Gilts, DES + MT from 45 kg
[c]Gilts, DES + MT from 23 kg

APPENDIX V. SIMPLE CORRELATION COEFFICIENTS - EXPERIMENT 1

Variable I	Variable II	r
Gain/day, kg	Backfat thickness, cm	0.50**
Gain/day, kg	PGH, start exp.	-.12
Gain/day, kg	PGH, 7 days	-.05
Gain/day, kg	PGH, 28 days	-.32
Gain/day, kg	PGH, 56 days	-.37*
Carcass length, cm	Longissimus muscle, g	0.46**
Carcass length, cm	Quadriceps femoris, g	0.48**
Longissimus area, cm^2	Ham & loin, %	0.36*
Longissimus area, cm^2	Lean cuts, %	0.36*
Longissimus area, cm^2	Longissimus, %	0.65**
Longissimus area, cm^2	Longissimus, g	0.83**
Longissimus area, cm^2	Area red fibers	0.25
Longissimus area, cm^2	Area intermediate fibers	0.21
Longissimus area, cm^2	Red fibers, %	-.20
Longissimus area, cm^2	White fibers, %	0.20
Longissimus area, cm^2	PGH, 28 days	-.41*
Ham & loin, %	PGH, start exp.	0.21
Ham & loin, %	PGH, 7 days	0.21
Ham & loin, %	PGH, 28 days	0.31
Ham & loin, %	PGH, 56 days	0.24
Lean cuts, %	PGH, start exp.	0.28
Lean cuts, %	PGH, 7 days	0.19
Lean cuts, %	PGH, 28 days	0.28
Lean cuts, %	PGH, 56 days	0.31
Fat trim, %	Backfat thickness, cm	0.84**
Fat trim, %	PGH, start exp.	-.31
Fat trim, %	PGH, 7 days	-.35*
Fat trim, %	PGH, 28 days	-.33
Fat trim, %	PGH, 56 days	-.32
Backfat thickness, cm	Fat, % of longissimus	0.06
Backfat thickness, cm	PGH, start exp.	-.35*
Backfat thickness, cm	PGH, 7 days	-.31
Backfat thickness, cm	PGH, 28 days	-.38*
Backfat thickness, cm	PGH, 56 days	-.47**
% Protein (longissimus)	PGH, 56 days	-.41*

*P < .05
**P < .01

APPENDIX VI. SIMPLE CORRELATION COEFFICIENTS - EXPERIMENT 2

Variable I	Variable II	r
Gain/day, kg	PGH, initial	0.20
Gain/day, kg	PGH, 5 weeks	0.05
Gain/day, kg	PGH, 13 weeks	0.00
Longissimus area, cm^2	PGH, initial	-.10
Longissimus area, cm^2	PGH, 5 weeks	0.18
Longissimus area, cm^2	PGH, 13 weeks	-.04
Ham & loin, %	PGH, initial	-.04
Ham & loin, %	PGH, 5 weeks	-.04
Ham & loin, %	PGH, 13 weeks	0.11
Lean cuts, %	PGH, initial	-.03
Lean cuts, %	PGH, 5 weeks	-.05
Lean cuts, %	PGH, 13 weeks	0.15
Fat trim, %	PGH, initial	-.24
Fat trim, %	PGH, 5 weeks	0.12
Fat trim, %	PGH, 13 weeks	-.12
Backfat, cm	PGH, initial	0.03
Backfat, cm	PGH, 5 weeks	0.30
Backfat, cm	PGH, 13 weeks	-.17
% Protein (longissimus)	PGH, 13 weeks	-.04
Longissimus area, cm^2	Ham & loin, %	0.69**
Longissimus area, cm^2	Lean cuts, %	0.68**
Longissimus area, cm^2	Longissimus, %	0.84**
Longissimus area, cm^2	Longissimus, g	0.90**
Longissimus area, cm^2	Area intermediate fibers	0.18
Longissimus area, cm^2	Red fibers, %	-.14
Longissimus area, cm^2	White fibers, %	0.17
Marbling score	% fat, (longissimus)	0.64**
Marbling score	Backfat, cm	0.27
% fat, (longissimus)	Backfat, cm	0.10

*P < .05
**P < .01

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