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The study of the physiology of differences between the two sexes is of much interest from a theoretical approach and often of considerable economic value. In beef cattle bulls usually gain faster and require less feed per unit gain than genetically similar heifers under identical conditions. Three trials with beef cattle were conducted, studying the effects of male hormones on feed-lot performance, carcass characteristics, meat characteristics, hormonal activity of the pituitary and thyroid glands, size of certain organs and glands, and development of masculinity. The effects were studied in steers and heifers in two trials and in steers only in one trial. In the 1950-51 trial, three sire progeny groups of four heifers and four steers each were allotted to three groups so that one heifer and one steer from each sire were in each of two treatment groups, and two heifers and two steers from each sire were in the control group. One treatment group received weekly intramuscular injections of 1 mg/kg of body weight of testosterone in acqueous suspension. The second treatment group received weekly intramuscular injections of methyl androstenediol in acqueous suspension at the rate of 1 mg/kg of body weight. In the 1951-52 trial, three sire progeny groups of four heifers and four steers were allotted so that two heifers and two steers from each sire were in the testosterone group and two of each sex were in the control group. Injections were started at a weight of 500 pounds and continued until the animals reached 800 pounds live weight with records kept during this period. Calves were individually fed and feed consumption was recorded. They were slaughtered at 800 pounds and carcass data, and organ and gland weights were collected. The pituitary gland was assayed for content of gonadotropic and thyrotropic hormones and the thyroid gland was assayed for thyroxin content. Observations were made on masculine appearance and behavior. In the third trial methyl testosterone was fed in the concentrate mixture at the rates of 0.00, 0.25, 0.50, and 1.00 mg/kg of animal weight per week. Similar information was taken as in the 1950-51 and 1951-52 trials with testosterone. Physical and chemical tests were run on samples of meat from calves in the 1951-52 trial.

Testosterone, administered under these conditions, increased the average daily gain and decreased the total digestible nutrients required per 100 pounds of gain of steer and heifer calves. The responses were greater in the heifers than in the steers for each of these traits. Testosterone appeared to decrease the percent of fat, the dressing percent, and the percent of hindquarter of heifer calves. It increased the thyrotropic hormone content and apparently decreased the gonadotropic hormone content of the anterior pituitary glands of calves.

Methyl androstenediol at the level used had a depressing effect on average daily feed intake during the last of the trial and may have increased the gonadotropic hormone content of the anterior pituitary gland. There were no other apparent effects on the characteristics of the calves.

Methyl testosterone, orally administered at the levels of 0.25, 0.50, and 1.00 mg/kg body weight per week had no effect on rate of gain and efficiency of gain, increased the thyrotropic activity of the anterior pituitary, decreased percent of fat and increased the percent of lean in the carcass, and increased the size of the seminal vesicles in steer calves.

Testosterone, in increasing daily gain, feed efficiency, and protein content of the carcass may be effective through its action in stimulating the secretion of thyrotropic hormone by the anterior pituitary. This high thyrotropic hormone level results in a stimulation of the thyroid gland to produce more thyroxin thus stimulating the basal metabolic rate which is conducive to fat metabolism and protein anabolism.

THE RESPONSE OF GENETICALLY RELATED GROUPS OF YOUNG BEEF CATTLE TO ADMINISTERED MALE HORMONES

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MARTIN JOE BURRIS

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APPROVED:

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Professor of Animal Husbandry

In Charge of Major

Redacted for privacy

Chairman of Genetics Committee

Redacted for privacy

Chairman of Department of Animal Husbandry

Redacted for privacy

Chairman of School Graduate Committee

Redacted for privacy

Dean of Graduate School

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INTRODUCTION

One of the first differences noticed between animals in a group as the casual observer becomes slightly critical is that between male and female animals. Often there are many traits which make the members of the two sexes a great deal unlike. In many species size alone is a sufficient criterion for differentiation. Among the numerous other sex-influenced traits are behavior, color of hair coat or plumage, voice, activity, external genitalia, appetite, and body form. In addition to these more obvious, outer traits, there are a multitude of less distinct differences concerned with the development and physiology of body function which further act to characterize the particular sex. It is these developmental and physiological characteristics with which one must deal if an accurate recording is to be made of the cause-and-effect mechanisms which are capable of producing sexual dimorphism.

The genetic determination of sex is normally accepted. A quite long breach exists, however, between the union of egg and sperm to form potential male and female zygotes, and the adult animals which make up the reproducing population of the next generation. The study of the secretion, transportation, and action of the so-called "sex hormones" serves to lessen this breach of the unknown and to supply hints toward the knowledge of sex differentiation. The tremendous interplay of sex hormones with glands, organs, enzymes, and other hormones of the body present an intriguing problem in all

phases of development and physiology. What are the limits of sex hormone influences in the body; how does the normal physiology complement, compensate, and nullify the actions of the sex hormones; how much are sex hormones the determiners of differences between sexes; what are the quantitative responses to sex hormones? These are simply a few of the questions which arise as the study of sex characteristics reaches beyond the visible exterior.

From a purely practical viewpoint the differences between sexes of animals become important to the human race. Man, at least many men, have a certain portion of their diet made up of animal products and, often, distinct and noteworthy differences exist between carcasses of animals of the two sexes as to their availability and desirability for use as human food. The question then arises as to the possibility and practicality of changing some characteristics of an animal of one sex whose carcass may be less desirable toward those of the other sex whose carcass may be more desirable by the use of sex hormones. Factors which differentiate the sexes and are important in the supplying of human food are palatability and tenderness of the meat, proportion of waste products, rate of growth of the animal and efficiency of converting feeds into human food. The economics of food production demand that if improvement of this sort is possible, it must be financially profitable if it is to be applied in commercial practice.

The following material is presented with a possibility of contributing somewhat to our general knowledge of sexual differentiation particularly with the use of administered male hormones in

beef cattle and to study the effects on growth of animals under these treatment conditions. The producer of market beef is usually aware of many differences in heifer and steer calves in growth rate, conditioning and other measures of feed-lot performance which have considerable economic importance to him. Less information is available, however, on dressing percent, carcass grade, percent of edible parts, palatability, and tenderness of carcasses of heifers and steers. From the more applied viewpoint a survey will be made as to the possibilities of using male hormones in the commercial production of market beef.

A further aspect under consideration in this work is the study of similarities and differences between animals due to common ancestors; an estimation of the effects of genetics and the interaction of genetics with male hormones and sex. This comparison makes possible a more accurate basis for the recommendation of the uses of male hormones in genetically different groups of animals within a species and also provides a basis for comparing the relative value of genetical improvement and male hormone administration in the production of meat.

REVIEW OF LITERATURE

A review of the literature of some of the pertinent work which has been done with the administration of male hormones is presented in an effort to show the background and theoretical basis for the use of male hormones in growing beef cattle. The difference between males and females, and between gonadectomized and intact animals offers very excellent measures of the effect of hormones at all-or-none levels and many of the conditions which are produced experimentally can be expected to duplicate these differences. The measurement of thyrotropic hormone activity of the pituitary may well serve as an indication of the metabolic activity of the animal. The ability of the male hormones to stimulate the thyrotropic activity of the pituitary may show a possible route of its action on other parts of the animal body. The gonadotropic activity of the anterior pituitary offers a further indication of the action of testosterone on this important gland.

The response to male hormones in laboratory animals

The first experimental demonstration of hormonal action by the testis according to Burrows (15, p.177) was reported by Hunter in 1794 when he showed that the rudimentary spur of a hen would grow into a good masculine spur if transplanted into the leg of a cock, whereas the small spur of a young cock would undergo no such development when implanted into the leg of a hen. The first testicular extracts were probably prepared by Brown-Sequard (108,

p.334) who made extravagant claims of increased vigor and bodily well-being from subcutaneous injections of these extracts. A lipoid concentrate of fresh bull's testes was prepared by McGee in 1927 (108, p.335) which was capable of inducing measurable growth of the capon's comb and of repairing castrate atrophy in the rat and guinea pig. The term, male sex hormone, is used to define the material secreted by the testis which is necessary for the development of the male sex traits (108, p.335). The use of the term, androgen, is preferred by some authors (15, p.121) in that male sex hormone connotates the restriction of material to one sex and its secretion to only the appropriate gonads. The most potent androgen which has been obtained is testosterone which is thought to be very similar, if not structurally identical with, the hormone secreted by the testis (108, p.336).

The male sex hormone present within the normal male organism is derived from the testes although the ovary and the adrenal cortex also seem to be capable of releasing androgenic compounds (23, pp.180-182). The site of secretion of androgenic hormone of the testis is assumed to be the interstitual tissue according to Dorfman (23, p.180) as determined from the lack of effect of atrophy of seminal epithelium in cryptorchidism or under adequate dosage of x-rays. On the other hand, the administration of pitch to rodents caused damage to the interstitual tissue and parallel atrophy of secondary sex glands with seminal epithelium remaining normal. A series of androgenic compounds and related substances have been

reported in the urine (23, p.186) some of which may be considered as normal urinary constituents and some of which are considered artifacts of degradation, substitution or dehydration of secreted androgens.

The activity of the androgens reported by the various workers in the field are discussed under the following groups: sexual activity, sex glands and reproduction, sex accessory glands, secondary sex characters, retention of urinary metabolites and protein anabolism, and enzymes.

The male guinea pig was used by Grunt and Young (38, pp.239-246) to demonstrate the response in sexual behavior to testosterone propionate injections. The following normal sequence of mating behavior of the male was noted: nibbling, nuzzling, mounting, intromission, and ejaculation - these descriptive terms being used to designate the various phases of the courtship procedure. Normal male animals were scored on the basis of activity in each of these phases and each animal on the basis of these scores placed in one of the following groups: high drive, medium drive and low drive. Subsequently the animals were tested for sexual behavior at weekly intervals. Castration of adult males resulted in the loss of seventy-five percent of their sex drive within fourteen weeks. The administration of daily dosages of testosterone propionate at 12.5, 25, 50, 100 gamma led to the demonstration that the strength of sex drive displayed during therapy is similar to that shown prior to castration; high drive animals showing their former characteristic high drive and low drive animals returning to their low level of sex

drive. An increase in the sexual activity of the male rabbit with the daily injection of 0.5 mg. and 3 mg. of testosterone propionate during a ten-day test period was observed by Cheng and Casida (17, pp.40-42). A decrease in reaction time and an increase in number of attempts at ejaculation were shown by the hormone-treated animals both during treatment and during a ten-day posttreatment period. Castration of male rats results in an immediate reduction in the number of animals which will attempt to mate with receptive females according to work by Beach and Levinson (10, p.165). The administration of 75 gamma of testosterone propionate daily was sufficient to maintain the normal copulatory activity for the twenty-eight day test period while the 25 and the 5 gamma dosage levels resulted in a gradual loss of copulatory activity during the twenty-eight day period. The precocious development of sexual maturity in the rhesus monkey was demonstrated by van Wagenen (112, p.544). By treatment of immature female monkeys with 7.5 mg. of testosterone propionate per kilo of body weight per week, the age of first menstruation with subsequent menstrual cycles was reduced from two years to approximately one year.

A definite reduction in the size of the testis of adult rats with the injection of small doses of testosterone propionate (2 mg. per day for twenty days) was found by Selye and Friedman (96, p.130). The injection of large doses (10 mg. daily for twenty days) resulted in no reduction in testis size. In all cases, however, there was atrophy of the Leydig cells. No inhibiting effects of

testosterone propionate was found on the weight of testes of young or adult hypophysectomized male rats receiving 3 mg. of the hormone daily for twenty-four days according to observations by Cutuly and Cutuly (20, p.505). However, there was a marked degeneration of the tubular elements of the testis not found in the hypophysectomized control. The injection of large doses of testosterone and testosterone propionate (0.05 to 20 mg. daily for eighteen to twenty days) resulted in decrease in testis weight and severe damage to the interstitual cells of the testis of male guinea pigs during the peak of the annual sexual cycle, (114, pp.459-461). A pronounced effect of testosterone propionate on the ovaries of young and adult female rats is reported by Laqueur and Fluhmann (62, pp. 98-99). Ovaries of rats which were injected with 4 mg. of testosterone propionate on alternate days beginning during diestrus contained no recent corpora lutea but many follicles at various stages of development or atresia. When the injections were begun during estrus, however, the ovaries were large and contained hypertrophied corpora lutea. Thus there appeared to be a prevention of the formation of corpora lutea but not of follicular growth with the injection of testosterone propionate. However, the injection of testosterone propionate in female rats from birth is reported by Laqueur (61, p.268) to arrest follicular development beyond the antrum stage and results in the complete absence of corpora lutea in the ages studied (from seven to two hundred thirty-two days).

Stimulation of the accessory sex organs by androgens has been

reported frequently and is often used as a measure of the level of physiological dosage of the androgen (115, p.113). The weight of the prostrate gland of the male rat is suggested by Ludwig (72, p.469) as an index of the level of testosterone which has been absorbed particularly in the method of hormone pellet implantation. Increases in the weight of the seminal vesicle of castrated male rats by the injection of 0.5 mg. of testosterone propionate for seven, fourteen and twenty-one days were observed by Almquist and Andrews (5, pp.127,129). However, the seminal vesicles of hibernating castrate male hamsters were dependent upon the resumption of hibernation in their response to androgenic hormones according to Lyman and Dempsey (73, p.648). Hamsters which returned to hibernation after receiving 5 mg. of testosterone had seminal vesicles much smaller than those animals which did not return to hibernation. In either instance of hibernating animals, the response was much less than the response from non-hibernating hamsters. The stimulation of the inguinal bursa of the scrotum of the male rat by testicular secretion is demonstrated by Wells and Overholser (115, p.113) by the method of unilateral castration. Stimulation of contractility and weight of the rat scrotum by the use of testosterone propionate in mature rats is suggested by Almquist and Andrews (5, p.132) as a demonstration of the role of the male hormone in thermoregulation of the testis.

No depressing effect of testosterone propionate on spermatogenesis of male rats receiving 0.05, 1.0, or 3.0 mg. daily

of this hormone for thirty days was found by Ludwig (72, p.458) although in the group getting the dosage of 0.1 mg. daily sperm were present in reduced numbers and were less active. When testicular implants of testosterone were made at the time of beginning of testosterone injection, Ludwig (72, p.472) found local maintenance of spermatogenesis in male rats even when the level of testosterone propionate injection was 0.1 mg. daily. The suggestion is made that low levels of androgens act only through the pituitary resulting in decreased secretion of gonadotropins and thus indirectly injure the testis while large doses are capable of exerting a stimulation to the semiferous tubules directly to permit normal spermatogenesis despite a lowered level of gonadotrophic hormones. The daily subcutaneous injection of from 5 to 20 mg. of testosterone and testosterone propionate did not reduce the number of spermatozoa produced by the testes of male ground squirrels according to observation made by Wells (114, p.461). Local maintenance of spermatogenesis in hypophysectomized male rats is reported by Dvoskin (24, p.112) using intratesticular implants of testosterone pellets which permitted an absorption of an average of 12.5 gamma daily. This evidence indicates a local maintenance of spermatogenesis by the hormone rather than through the pituitary mechanism.

Effects of androgens on glands other than the pituitary and gonads and on various organs of the body are extremely significant in studying the role of these hormones. Chronic treatment of male rats with large doses of methyl testosterone was found by Selye,

Rowley and Hall (97, p.143) to produce changes in the adrenal cortex characterized by an involution of the glomerulosa, marked thickening of the connective tissue and deposition of coarse fat granules in the cells of the fasiculata and reticularis. Although the adrenals of rats lose weight and atrophy after hypophysectomy (102, p.222), the injection of 1.25 mg. of testosterone propionate daily in hypophysectomized rats gave a partial maintenance in adrenal weight for a ten day period (70, p.303). A slight involution of the cortex of the adrenal of rats following the daily injection of 2 mg. of testosterone propionate was found to result in reduction of adrenal weight (77, p.392). The injection of 5 mg. of testosterone propionate in immature rats was found to increase the number of mitoses in the thyroid and parathyroid gland and also to increase the functional activities of these glands as indicated by histological examination (83, p.738).

Daily administration of 5 mg. of testosterone propionate to adult mice during a period of twenty days was found to have very pronounced results upon several organs and glands according to observations made by Selye (95, p.213). The thyroids of these treated mice were larger (about twenty percent) than the controls and histologically appeared to show some increase in the height of follicular epithelium and some colloid absorption. The adrenals of testosterone-treated mice were about two-thirds as heavy as adrenals from control mice. Atrophy of the entire gland was present although due chiefly to involution of the cortical cells. The liver and

spleen of these mice showed no significant histological changes due to the treatment with male hormone. The kidneys of mice receiving the testosterone propionate were greatly enlarged due to the hypertrophy of the cells of the proximal and distal convoluted tubules and of the parietal lamina of Bowman's capsules. Korenchevsky and coworkers (60, p.398) reported that androsterone and testosterone propinate produced hypertrophy both in actual and in relative weights of the liver and heart in young male and female rats after two months when these hormones were injected at the rate of 5 to 25 and 1 to 10 mg. per week respectively. The male hormones had a masculinizing effect reflected in the weight of liver and heart of female rats which approached that of normal males. Slight hypertrophy of liver cells in both sexes and of heart muscle fibers in males resulted from these treatments. No alterations in the weights of the adrenals or thyroids were found by Leathem (67, p.142) due to the tri-weekly injections of 1.25 mg. of testosterone propionate for twenty or thirty days into male rats forty and one hundred fifty days of age. No effects of testosterone propionate on the weight of the thyroid gland of mature male rats receiving .5 mg. of the hormone daily were found by Leathem (64, pp.30,31) either when injected into normal rats or rats on a ration including .5% of thiourea or thiouracil. A synergistic activity was found by Grad and Leblond (36, p.261) between the male hormone and thyroxine in the proliferation of the serous tubules of the submaxillary glands of the rat. This synergism resulting from the injection of both

testosterone (twice daily injections of .25 mg. for forty-seven days) and thyroxine (twice daily injections of 3 micrograms of DL-sodium thyroxine) also resulted in an increased weight of the heart and kidney in hypophysectomized, castrated male rats.

The injection of male hormone into normal male and female rats produced a depressing effect on the gonads of both sexes by Moore and Price (79, p.52) and this effect is interpreted by these workers as due to the decrease in secretion of gonadotropic hormones by the hypophysis caused by the male hormone injection. Degranulation of the basophil cells of the anterior pituitary was found in immature female rats receiving 2 to 8 mg. of testosterone propionate daily for ten or twenty days by Wolfe and Hamilton (119, p.583). However, after chronic administration of this hormone for ninety days the weights and number of eosinophiles and granular basophiles of the anterior pituitary of these immature female rats were more comparable to the glands of litter mate brothers than of litter mate sisters. The gonad-stimulating content of the anterior pituitary of castrate female rats was found to increase directly with the time of autopsy after castration by Lauson, Golden and Sevringhaus (63, p.51). Their animals were twenty-four weeks old at autopsy and the pituitaries of animals which had been castrated sixty days prior had a gonad-stimulating content of 52.7 times that of normal intact females. In the bird, Payne (87, p.512) reported that there is a general enlargement and increase in number of the basophiles and a degranulation and regression of the acidophiles of

castrate male and female White Leghorn fowls.

The injection of male hormone extracted from urine into castrate dogs was found to cause a marked drop in urinary nitrogen and a slight subsequent rise both due to changes in urea nitrogen by Kochakian and Murlin (57, p.457). Accompanying this change in nitrogen excretion was an increase in fat metabolism, a decrease in protein metabolism, and a slight increase in body weight. The administration of androstenedione (58, p.656) and later testosterone and testosterone acetate (52, p.751) were found to produce nearly identical effects on urinary nitrogen retention in castrate male dogs to those observed due to injection of urinary male hormone. In none of these studies with castrate dogs was there found an effect on the basal metabolic activity to indicate a calorigenic effect of the male hormones. A demonstration of a similar effect of male hormones in the human was given by Kenyon (50, p.133) who reported that the prolonged administration of 25 mg. of testosterone propionate daily to eunuchoids resulted in marked increase in body weight in addition to stimulation of the genitalia. In a later paper (51, p.152) the effect of testosterone propionate upon the nitrogen, electrolyte, water and energy metabolism of these patients is discussed. A consistent decline in urinary nitrogen, a decline in urinary sodium, usually a retention of chloride and a weight gain due largely to water held in association with sodium and nitrogen were striking effects of this hormone. The decrease in urinary total nitrogen is reflected completely in the urinary urea and is unaccompanied by

any regular change in the urinary creatinine or by increase in the non-protein nitrogen, plasma proteins, or hemoglobin of the blood. Work by Papanicolaou and Falk (86, p.239) demonstrated a definite proliferation of the temporal muscle of the guinea pig due to the prolonged administration of testosterone propionate. The muscular development of females and castrate males was said to approach that of the normal male, which is described as being rounded and protrubant as compared to the small, flat musculature of non-masculine animals. The fat content of the carcass of young Angora female rabbits on a wet weight basis was 5.8 percent while the fat content of young Angora male rabbits was 1.7 percent according to observations made by Wilson and Norris (117, p.457).

A consistent increase in the basal metabolic rate of all patients receiving methyl testosterone was reported by McCullagh and Rossmiller (75, p.506). This increase in metabolic activity was accompanied by gains in weight in nearly all of these clinical cases. With the withdrawal of therapy the basal metabolic rate dropped off abruptly. The development of prominent musculature was found to accompany the increase in body weight of eunuchoid patients maintained for several months on orally administered methyl testosterone according to observations of McCullagh and Rossmiller (76, p.507). These workers were also able to stimulate growth in a dwarf patient through the use of methyl testosterone (76, p.510). Increased rate of growth was reported by Webster and Hoskins (113, p.74) in hypogonadal boys receiving from 75 to 125 mg. of

testosterone propionate per week. The therapeutical use of methyl testosterone and testosterone propionate are discussed by Goldzieher (35, p.927) in the stimulation of growth and increase of body weight in humans. The suggestion is made that a substance capable of producing the proliferation of cells involving epithelium, stroma, and muscle tissue, consistent with the androgenic activity of the male hormones, actually represents a general growth-stimulating factor, having a special affinity for, but not restricted to the genital organs.

The administration of testosterone propionate to castrate male rats (54, p.262) produces an effect on urinary nitrogen similar to that observed in dogs except that about one week after the beginning of injections, the nitrogen excretion gradually returns to normal despite continued injections. The replenishment of protein in starved castrate rats was found to be materially increased by the injection of 2.5 mg/day of testosterone propionate. However, in intact male rats, Geiger and El Rawi (34, p.147) were unable to show a significant effect of 2 mg. of testosterone propionate injected on alternate days in either protein depletion on a fifteen day test period or in protein repletion in a subsequent sixteen day test period. A prolonged retention of nitrogen resulted from the intravenous injection of 150-200 mg. of testosterone to normal young men (116, p.840). A maximum nitrogen retention occurred during the second day and a positive nitrogen balance was maintained for about eight days. A retention of phosphorus and water accompanied the nitrogen retention. Within twenty-four hours after injection, seventy to

eighty percent of the administered hormone had been accounted for as excess 17-ketosteroids in the urine.

The demonstration of the renotropic effect of many of the male hormones has been accompanied by a demonstration of increase in body weight in many cases (54, pp.297-301). The anabolism of protein is not confined to one type of tissue but is associated with many or all parts of the body. The increase in weight of the assessory sex organs account for a portion of this increase (51, p.147) but only a relatively small percent of the total gain. The effect of male hormones on muscular development was first reported in the guinea pig by Papanicolaou and Falk (86, p.238) and verified later by several workers in other species. The excessive stimulation of the levator ani muscle which has an anatomical association with the penis was noted by Scow (94, p.50) when testosterone injections were given to gonadectomized male mice. There were no differences found in the percentage of carcass protein due to the injection of testosterone.

Studies have been made on the protein constituents of the blood in an attempt to obtain information concerning the protein fabrication processes apparently stimulated by the steroid hormones. The increase in plasma globulin observed in castrate male rats was found to be prevented by the administration of 0.1 mg. of testosterone propionate daily (65, p.463). However, the increased level of plasma globulin and plasma non-protein nitrogen associated with hypothyroidism resulting from antithyroid drugs was not influenced by the use of testosterone propionate (66, p.1286). In the trials, there was also

no effect of testosterone propionate upon the protein and water content of the liver of the hypothyroid rat. Subnormal plasma protein levels of rats caused by feeding high protein diets were not affected by the administration of 1.25 mg. of testosterone propionate three times weekly according to the further work of Leathem (68, p.76). However, the slight increase in liver protein induced by high protein levels tended to be counteracted by this dosage of androgen.

The administration of testosterone propionate in weekly amounts of 0.2 mg., 0.8 mg., and 3 mg. in immature mice was reported by Silberberg and Silberberg (98, pp.98-107) to accelerate ageing of the epiphyseal cartilage of the upper end of the tibia. This ageing was manifested by inhibition of proliferation and increasing regressive changes. Castration resulted in a delay in growth, and was also followed by a reduction in the rate of proliferation. The use of testosterone therapy in small doses in these castrate mice resulted in a restoration of both development and growth of the epiphyseal cartilage. The response to androgens of endochondral ossification in males is less marked than in females. Except for the earlier appearance of the os penis and the ischial tuberosity, Turner, Lachmann and Hellbaum (111, p.426) found no changes in the time of appearance of the ossification centers of a great number of bones in rats injected from time of birth with 0.25 to 2.0 mg. per day of testosterone propionate. No apparent effect on the time of appearance of ossification centers of the several bones of

the rat was found by Noback and associates (84, p.60) after the injection of 125 micrograms of testosterone propionate daily from birth to ten days of age.

The action of androgens in hemopoiesis of rats is discussed by Crafts (19, pp.405-411). The castration of the normal male results in a temporary drop in hemoglobin, slight decrease in total erythrocyte count, slight hypochromia and microcytosis. The administration of 2.0 mg. of testosterone propionate daily for 50 days to castrate males resulted in a significant hyperplasia of the bone marrow with an increase of erythroid elements to 63.6 percent of all cells counted as compared with 58.1 percent for normal controls and 61.6 percent for castrate controls. The injection of 2.0 mg. of testosterone propionate daily to hypophysectomized male rats prevented the decrease in total erythrocyte count, the increase in total white cell count, and the hypoplasia of the bone marrow normally following hypophysectomy.

The injection of 250 micrograms of testosterone twice daily for 42 to 47 days in hypophysectomized, castrated male rats was reported by Eartly, Grad and Leblond (26, pp.680-683) to increase both the Malphigian and cornified layers of the integuement and to increase the number of mitoses per unit length of the basement membrane of the integument. The regression of number of mitoses on epidermal thickness was highly significant indicating that the effect of these hormones on thickness of the epidermis may be mediated by way of their action on cell production. A study of

the tensile strength of whole skin of the leg of chickens by Herrick (45, p.146) revealed that skin from chickens receiving 5 mg. of testosterone propionate on alternate days for ten days had a much greater (two times) breaking strength than did non-treated controls. A higher amount of collagen nitrogen was found in the skin of the hormone-treated birds. The skin of the hormone-treated birds also had more abundant and more completely differentiated fibers. The measure of the tensile strength of the gastrocnemius muscle of these birds gave a similar response to that of the skin; the hormone-treated chickens have a great deal stronger gastrocnemius muscle.

When either normal or castrate male mice were treated for thirty-five or one hundred fifteen days with a subcutaneous pellet of testosterone propionate (6-12 mg. absorbed), Kochakian and Fox (56, p.670) found a decrease in total "alkaline" (pH9.8) phosphatase and an increase in "acid" (pH 5.4) phosphatase of the kidneys, however similar enzymes of the liver and intestine were apparently not affected. This response of the enzymes to the male hormones continued for a considerable time after the nitrogen retention response had passed, perhaps indicating a closer association with protein anabolism than nitrogen retention as such. As in the case of phosphatases the arginase contents of the liver and intestine of mice were not affected by the androgens, while the arginase content of the kidney was found to be quite sensitive according to observations by Kochakian (53, pp.116-122). The level of arginase of the kidneys of castrated mice was found to vary

directly with the amount of androgen absorbed in a thirty-day period. Variable responses from different androgens were noted, the less active of the steriods actually resulting in decreased arginase content of the kidney. The level of nutrition was not found to interfere with the determination of arginase content of the kidney by the various steroids. In a summary of work done with the phosphates and arginases of the kidney, liver, and intestines, Kochakian (55, p.212) concludes that the metabolic effects of protein anabolic steroids are mediated at least in part through the kidneys since the enzyme activities of this tissue are markedly altered by the various steroids while the enzyme activities of the liver and intestine are not. The ability of testosterone propionate to stimulate the kidney arginase activity of rats was not apparently inhibited by the experimental production of phlorizin or alloxan diabetes (59, pp.226-227). Testosterone propionate was found by Grunt and Leathem (37, p.220) to definitely increase the cytoplasmic alkaline phosphatase in the follicular cells of the mouse thyroid when daily dosages of 0.5 mg. or more were used. It is significant that although testosterone was not effective in altering alkaline phosphatase of the thyroid in the presence of thiouracil or thyroglobulin, the thiouracil (.25%) virtually eliminated alkaline phosphatase whereas thyroglobulin caused a follicular cell atrophy without loss of the enzyme.

The response to male hormones in farm animals

In addition to the effect of male hormones on sexual behavior of breeding males, the administration of male hormones has been used in farm animals for the purpose of increasing gains in body weight, efficiency of feed utilization, and carcass quality. The intramuscular injection to weanling pigs with 1 mg/kg. of body weight weekly of testosterone propionate for six weeks and then biweekly resulted in an increased gain of 0.15 pounds per day during a one hundred fifty day feeding period, according to the work by Sleeth and coworkers (99, p.801). The carcasses from treated pigs showed no significant differences from control pigs in average thickness of backfat, tenderness, and carcass scores. The organoleptic ratings of roasts from treated animals indicated that the levels of testosterone injection used did not measurably affect the palatability. In a second trial by Sleeth and associates (99, p.801), the pigs weighing forty six pounds at the beginning of treatment received 0.5 mg. of testosterone propionate biweekly. After thirty nine days the average daily gain of the testosterone propionate and the control groups were practically identical. Rate of gain, feed efficiency, and several carcass characteristics were not significantly affected by the implantation of two 15 mg. pellets of testosterone at twelve week intervals in growing-fattening pigs according to work by Woehling and coworkers (118, pp.890-891). Weight gains of the pigs during successive growth periods indicated no significant difference between treatment groups.

The subcutaneous implantation of a 10 mg. pellet of testosterone in wether lambs was found by Andrews and associates (7, pp.579-582) to increase the average daily gain and efficiency of feed utilization of wether lambs during a sixty eight day feeding period. Lambs receiving an additional 10 mg. pellet of testosterone forty three days after the first implantation, however, were not significantly different from control lambs in average daily gain in body weight. The quality of carcass of the testosterone-treated lambs appeared to be higher than that of control lambs. Testosterone had no significant effect on the daily feed consumption of treated lambs as compared with that of control lambs. The implantation of a 12 mg. pellet of testosterone in ewe and wether lambs resulted in no significant change in rate of gain or feed efficiency when compared with control lambs under similar feeding conditions according to work by O'Mary and coworkers (85, p.667). In a second trial, O'Mary and associates (85, p.667) found that weekly injections of 20 mg. of testosterone significantly increased the average daily feed consumption and average daily gain of ewe and wether lambs. A significant interaction existed between the hormone treatment and the sex of the lambs, the treated wethers (20.2 gms.) having slightly more external fat than control wethers (19.2 gms.) while the treated ewes (21.6 gms.) having considerable less external fat than control ewes (27.2 gms.), in a representative meat sample. The subcutaneous implantation of pellets containing a total of 30 mg. of testosterone into lambs weighing seventy four pounds and

eighty one pounds at beginning of the test period resulted in increased rate of gain and feed efficiency during ten and twelve week feeding period according to work done at the Purdue station (78, p.179).

A temporary growth stimulus and increased daily feed consumption was reported by Dinusson, Andrews and Beeson (22, pp.323-325) in beef heifers receiving an intramuscular injection of 50 mg. of testosterone propionate in oil, followed by a second injection of 32.5 mg. of testosterone propionate fifty six days later. However, average daily gain and efficiency of feed utilization were not significantly different from those of control calves. In a second trial by Dinusson, Andrews and Beeson (22, pp.324,325) the subcutaneous implantation of a 50 mg. pellet of testosterone propionate in beef heifers had no significant effect on rate of gain, efficiency of feed utilization, or average daily feed intake. A short growth stimulus also resulted in the second trial with beef heifers, but the overall growth rate, carcass quality and dressing percentage were apparently not affected by that treatment of testosterone propionate. Yearling steers receiving a 180 gm. pellet of testosterone implanted subcutaneously at the beginning of the test period were found by Andrews, Beeson and Johnson (8, p.677) to not differ significantly from control steers in growth rate, efficiency of feed utilization, or carcass grade.

The thyrotropic activity of the anterior pituitary gland

A direct association of the thyroid gland with the anterior pituitary gland was suggested by the demonstration of atrophic changes in the thyroid gland after removal of the anterior pituitary in two species of frogs, Rana boylei (101, p.63) and Rana pipiens (4, p.486). The overall size of the thyroid gland was markedly reduced as was the size and number of colloid masses present in the gland. Metamorphosis in the axolotl larva of the Mexican salamander was induced by Spaul (105, p.430) using an acetic acid extract of the anterior pituitary of the ox. Extracts of the posterior lobe of the oxwere found to retard or to have little effect on the metamorphosis of the larva. Hypertrophy of the thyroid gland in guinea pigs was produced by Loeb and Bassett (71, p.861) using injections of alkaline extracts of bovine pituitary. With this hypertrophy of the thyroid gland there was an accompanying loss of weight in the heavier animals and absence of weight increases in all animals treated. The injection of acid extract of the anterior pituitary of the bovine was found by Thurston (107, p.77) to produce parallel effects in several species of animals including hypertrophy of acinar epithelium, the proliferative activity as indicated by the number of mitoses, the absorption of colloid, and the change in size and shape of the acini. The effects of the acid extract were in principle the same in all species studied, but the intensity of effects varied a great deal. The following species are arranged

in order of increasing thyroid response: (1) mouse, (2) rat, (3) rabbit, (4) cat, (5) pigeon, and (6) guinea pig. Many methods have been suggested for the measurement of relative capacity of anterior pituitary material or extracts to produce thyroidal stimulation. Many of the early methods were dependent on histological examination and were based on the guinea pig since it had been found to be most responsive to treatment. Rabinovitch (88, p.602) made a quantitative estimate of the degree of hypertrophy by a numerical determination of the mitosis present in the stimulated thyroid glands. The hypertrophy of the thyroid is correlated with a marked increase in the number of mitoses. Direct measurement of the increased height of acinar epithelium of the stimulated guinea pig thyroid was proposed by Rawson and Starr (90, p.729) as a quantitative measurement of thyrotropic activity of anterior pituitary gland material. Hypophysectomized rats were used for assay of thyrotropic hormone in body fluids by Hertz and Oastler (46, p.525) who observed that the administration of thyrotropic hormone prevents the atrophy in cell histology following hypophysectomy. Administration of thyrotropic hormone in hypophysectomized rats is followed immediately by the formation of colloid droplets in the thyroid, however, according to Dvoskin (25, p.68) toxic dosages of typhoid vaccine, histamine and pilocarpine and dosages of human blood sera gave numerous positive responses quite unrelated to the thyrotropic activity of the material used.

Stimulation of metabolic rate in rats by the injection of a thyrotropic extract of the anterior pituitary was observed by Anderson and Collip (6, p.680). These workers used as a unit the smallest amount of hormone which given to a hypophysectomized rat will give a twenty percent increase in metabolism in ninety-six hours when administered twice daily. Stimulation of time of metamorphosis in the frog tadpole has been suggested by D'Angelo, Gordon and Charipper (21, p.224) who described a tadpole unit of thyrotropic activity as the minimal amount of hormone which when given to the totally starved, non-metamorphosing animal in 5 intraperitoneal injections on alternate days will stimulate the thyroid gland, increase the hind-limb length and cause a body weight loss fifty percent greater than that in water-injected controls.

The loss of iodine from the thyroid following the administration of the thyrotropic hormone was found to be a suitable method of bioassay according to Stimmel, McCullagh and Picha (106, p.52) using guinea pigs weighing between two hundred twenty five and two hundred seventy five grams. The use of radio-active iodine (49, p.148) may provide a much more efficient method for the measurement of iodine loss under thyrotropic hormone injection and the uptake of iodine by the depleted thyroid. An increased content of radio-active iodine was observed by Leblond (69, p.287) in rats receiving anterior pituitary extract within fifteen hours after the administration of radio-active iodine. This qualitative test may

have definite quantitative applications under controlled conditions. Rawson (89, p.494) observed the following effects, in the order given, in thyroids of cockerels treated with thyroid-stimulating hormone: loss of thyroid iodine, increase in thyroid-acinar-cell height, increase in thyroid weight, and finally an increased capacity to concentrate radio-active iodine. The determination of uptake of radio-active phosphorous by the thyroid of guinea pigs following administration of varying amounts of thyrotropic hormone was found by Borell and Holingren (12, p.340) to be a very sensitive measure of activity since the amount of phosphorous taken up by the gland increased ten-fold with a doubling in cell height due to thyrotropic stimulation.

The gravimetric method based on the increase in weight of the thyroid gland accompanying thyrotropic stimulation was suggested by Rowlands and Parkes (92, p.1831) as a possible method of bio-assay of this hormone. The response curve of weight of thyroid gland to dosage level in guinea pigs did not deviate greatly from a straight line when transformed on the logarithmic scale. The thyrotropic unit suggested by Reece and Turner (91, p.12) was that amount of hormone which would elicit a fifty percent increase in the weight of thyroid glands of four male guinea pigs weighing between one hundred forty and one hundred seventy grams when injected subcutaneously daily for four days and the animals sacrificed on the fifth day. The extensive use of the weight of the guinea pig thyroids as a basis for thyrotropic activity brought about the

definition of a guinea pig unit (11, p.661) as the total amount of hormone administered over a five day period, with subcutaneous injection once each day which will cause a mean weight increase of fifty percent (to about 26.4) in the thyroids of ten male guinea pigs weighing an average of 155 gms. The response to increasing dosage was found most sensitive in the region of fifty percent response. The thyroids of day-old chicks were found to be very sensitive to the thyrotropic hormone by Smelser (100, p.435) who reported that the thyroid gland of the chick responds by an increase in weight to one-tenth the amount of material necessary to produce hypertrophy in the guinea pig. Furthermore the assay range, based on chick thyroid weight, is much longer, the maximum response obtainable with one hundred times the minimal stimulating dose. The chick thyroid is capable of a weight increase of ten to eleven times in a five day injection period while the guinea pig thyroid increased only four to five times in weight under similar conditions. The work of Bergman and Turner (11, p.664) also demonstrated the efficiency of the day-old chick as an assay animal for thyrotropic hormone. The Bergman-Turner male chick unit was defined as the total amount of hormone, administered over a four day period with subcutaneous injection once each day which will cause a mean weight increase of fifty percent (to about 5.4 mg.) in the thyroids of twenty chicks weighing an average of fifty five grams. This chick unit was found to be about one-quarter as much as the Bergman-Turner guinea pig unit.

The methods of bioassay described are based either on the direct or indirect action of the hormone upon the thyroid gland. The direct methods have as their criteria of activity alterations in histological appearance of the thyroid glands, changes in iodine content of the thyroid and increases in weight of the thyroid under stimulation by the thyrotropic hormone. The indirect methods of assay involve measurement of effects produced through the mediation of the thyroid gland. These effects may include increased uptake of iodine and phosphorous, increased metabolic rate, and inducement of precocious metamorphosis in the larve of amphibia after the injection of certain amounts of thyrotropic hormone. Many of these indirect effects illustrate very specifically the dependence of thyroid function on a supply of thyroid stimulating hormone.

The relative potency of thyrotropic hormone in the anterior pituitary of a large number of species has been estimated by Adams (1, p.6) in a review article. The following animals are listed in order of decreasing potency per given amount of tissue according to this order: "bull-frog, leopard frog, chicken (age?), sole, rat, mouse, dog, pig, sheep, toad, cattle (beef), turkey, man, horse, rabbit, cat, pigeon, young chick, guinea pig, hen". This author also indicates that the thyroids of animals low in thyrotropic hormone are most responsive to low levels of thyrotropic hormone dosage and therefore the most desirable assay animal from this viewpoint. The variation of thyrotropic potency of the anterior pituitary between species of animals appear to have no

fundamental relation to the phylogenetic position of the animal. Variations in thyrotropic activity of cattle between age groups, sex groups, and between beef and dairy cattle were found by Reece and Turner (91, p.96) using the guinea pig as the assay animal. They report that the thyrotropic potency in cattle increases from 26.40 guinea pig units in one gm. of fresh gland from calves to 32.13 and 38.36 units in four to ten month old heifers and bulls, respectively, and then drops at eleven-twenty three months to 24.59 units in open heifers and 35.02 units in bulls. A similar change in the anterior pituitary of the rat is indicated by Turner and Cupps (110, p.652) who indicate that the potency of the thyrotropic hormone per gram of fresh pituitary tissue reaches a maximum in both males and females between one hundred thirty and one hundred eighty days of age and rapidly falls off after that age. During this period of rapid growth, the glands of female rats were much lower in thyrotropic hormone per unit of fresh tissue than were those of male rats. The thyrotropic activity per pituitary in rabbits was found to decrease from young immature females (ten-seventy days) to young mature females and still further in old mature females (Saxton and Greene, 93, p.502). In albino mice Adams and Mothes (2, p.31) have found an increase in thyrotropic hormone of the pituitary gland from pre-puberty to puberty in both males and females with a subsequent reduction with the establishment of sexual maturity. The thyrotropic hormone of the female mice was greater than that of the male at pre-puberty

and puberty but became less that that of the male upon nearing sexual maturity. In a discussion Adams and Mothes (2, p.31) indicate that the rapid increase of thyrotropic activity found with the onset of puberty and then subsequent decline with maturity found in their albino mice has been reported for several other species: rabbits (93, p.502), rats (110, p.652), and cattle (91, p.96).

The influence of the various sex hormones on the thyrotropic activity of the anterior pituitary is suggested by the assay of pituitaries of cattle by Bates, Riddle and Lahr (9, p.261) who found that the thyrotropic activity of adult bull pituitaries is much greater than that of adult steer pituitaries. Equivalent amounts of extract of bull and steer anterior pituitaries increased the weight of thyroid glands of doves ninety three percent and sixty one percent respectively. Anterior pituitary lobe tissue of bulls was found to contain fifty percent more of the thyrotropic hormone per unit weight than similar tissue from steers (91, p.60). Castration of young rats was reported by Turner and Cupps (109, p.1043) to reduce thyrotropic activity of males forty seven percent and females eighteen percent by twenty days post-operative and ninety three percent in males and one hundred percent in females by sixty six day post-operative. When these castrate rats were given two hundred gamma of testosterone propionate daily for twenty days, the female rapidly regained a normal level of thyrotropic hormone while the thyrotropic hormone content of the

castrate male pituitary apparently was not affected by this dosage. Stimulation of the thyroid gland by the injection of five mg. of testosterone propionate to immature female mice has been reported by Nathanson, Brues and Rawson (83, p.738) who indicated that this stimulation may be due to stimulation of the anterior pituitary by the male hormone.

Methods of assay of thyrotropic hormone in body fluids are at present very unreliable according to Albert (3, p.474). This worker reports that methods of assay suitable for determining thyrotropic hormone levels in the anterior pituitary are entirely inadequate for determining the urine or blood content where the hormone is present in very minute amounts and in many cases may be entirely lacking.

The gonadotropic activity of the anterior pituitary gland

The extensive investigations of Smith and Engle (103, p.212) definitely established the presence of specific gonad-stimulating materials in the anterior pituitary tissue of several species. By the implantation of anterior pituitary glands into sexually immature mice and rats of both sexes, these workers were able to induce precocious sexual maturity in the female as evidenced by the changes characteristic of sexual maturity in normal animals and to induce similar changes to a lesser degree in male animals. The Third International Conference on Standardization of Hormones held in Geneva in 1938 adopted the term gonadotropin or gonadotropic hormones for substances which have specific gonad-stimulating effects.

The gonadotropic hormones which are produced by the anterior pituitary gland are termed hypophyseal gonadotropins. According to much existing evidence hypophyseal gonadotropin is not a single factor but is composed of at least three hormones: (1) a hormone stimulating the growth of follicles in the ovary and the germinal epithelium in the testis - the gametokinetic or follicle-stimulating hormone (FSH); (2) a hormone responsible for thecorpus luteum development and stimulating the interstitial testicular tissue - the luteinizing hormone (LH); (3) a luteotrophic hormone maintaining the function of the corpora lutea (39, p.175). Thus the extraction of two gonadotrophic hormones from dried anterior pituitary tissue was accomplished by Fevold, Hisaw and Leonard (32, p.293) by the use of acqueous pyridine - one having a follicular growth stimulating capacity, the other stimulating lutein growth.

Accurate biological assay of gonadotropic hormones is complicated by several conditions which modify the actions of the hormones and, hence, interfere with determinations of their presence and potency. These conditions include the synergism or interaction between certain gonadotrophins, the augmentation of the gonadotropic effect exerted by non-hormonal substances, and the instability of gonadotropic solutions. An instance of synergism between the follicle stimulating hormone and the luteinizing hormone was found by Fevold and Hisaw (31, p.665) who showed that these two hormones are dependent on the action of each other in producing

effects on the weight and appearance of the ovary which are much greater than the results expected on the basis of injecting each hormone individually into different animals. Further synergistic activity was observed by Fevold (30, p.36) who found that, while luteinizing hormone was unable to stimulate the ovaries to form estrogen, in the presence of follicle stimulating hormone the addition of luteinizing hormone in very small amounts greatly increase the output of estrogen by the ovary. A similar synergism was found in their experiment between the gonadotrophic hormones in the effect on the weights of the ovary and uterus. Augmentation of the hypophyseal gonadotrophic effects is discussed by Casida, Meyer, and McShan (16, p.89) who list numerous materials having an augmentative effect but which apparently have no common chemical characteristics. Examples of these materials are tannic acid, copper and zinc salts, male urine, egg albumin, merthiolate, blood serum, and recrystallized heme. Apparently this augmentation is dependent, in some cases, upon a delayed absorption of the hormone by the target tissues. A third condition affecting the complexity of gonadotrophic hormone assay is treated by Maddock and Heller (74, p.181) who illustrate the rapid loss of gonadotropic activity from solution due to shaking or normal temperatures of 37°C. These workers have found the addition of "protectors" such as whole blood, egg white, testis slices or aluminum hydroxide prevents the inactivation of rat pituitary gonadotrophin which often occurs from shaking at 37°C. for 2.5 hours.

The biological assay of gonadotrophins is normally based on the effect on the gonads as the target organ or in some cases on the secondary effect on the accessory organs (seminal vesicles, prostrate, uterus, vagina, etc.). Normal intact adult animals are not often suitable for the assay of gonadotropic hormones since their reproductive organs are already under heavy stimulation of gonadotrophin from the animal's own hypophysis. Exceptions to this are those animals ovulating only after copulation or those animals which exhibit a seasonal quiessence during time the reproductive organs receive little or no hypophyseal stimulation. The induction of ovulation in the estrus rabbit was used by Hill, Parkes, and White (47, p.358) to measure the potency of the ovulation producing hormone present since in the presence of adequate amounts of follicle stimulating hormone, the luteinizing hormone causes ovulation. A method of approximate assay of the amounts of follicle stimulating hormone and luteinizing hormone is suggested by Fevold (29, p.443) based on the observation that increase in ovarian weight of rats with only a follicular response is due chiefly to follicle stimulating hormone, while increase in weight of the seminal vesicles is due chiefly to stimulation of luteinizing hormone when the unextracted pituitary material is injected. The use of acqueous suspensions of anterior pituitary tissue was preferred by Heller, Lauson and Sevringhaus (44, p.366) over the implantation of pituitary sections in obtaining a more accurate and uniform absorption by the test animal. By using the increase

in weight of the uterus of immature female rats, these workers were able to attain an increase in sensitivity about eight times that of the ovarian weight method. Because of the rapid increase to a maximum weight, the uterine assay is restricted in use to quite a narrow range of dosages.

The use of hypophysectomized animals has been recommended for gonadotrophic assays because the animal's own hypophysis is thereby ruled out as a possible secretor of active gonadotrophins. In this manner the stimulus to the target organs is entirely of an outside source assuming no other organ of the body is secreting gonad-stimulating materials. The use of female rats hypophysectomized at twenty six to twenty eight days and used six to eight days postoperative, is described by Evans and coworkers (27, p.529). The rats are injected daily for three days and observation made on the resumption of follicular growth for follicle stimulating activity and on the repair of deficient interstitual tissue of the ovary for luteinizing activity of the injected material. These workers (27, p.537) also reported a synergistic activity between the two hormones in their effects on ovarian tissue. The use of hypophysectomized cocks has been indicated by Nalbandov, Meyer, and McShan (82, p.103) who were able to assign specific responses of the cock to each of the two hormones. Pure follicle stimulating hormone produced only increase in testis size while pure luteinizing hormone produced both comb growth and testis growth. If the follicle stimulating hormone is contaminated by only a small amount of

luteinizing hormone both comb growth and testicle growth result, the two materials acting synergistically.

The physiological hypophysectomy of the cock with implanted stilbestrol pellets results in a complete inactivation of the anterior pituitary gland to produce gonadotrophic hormones according to Nalbandov and Baum (81, p.378). These workers suggest this experimental animal for the biological assay of gonadotrophic hormones. The estrogenized cock is as sensitive as the hypophysectomized cock and the operation is much simpler in the case of estrogen implantation.

By the implantation of ovaries into the spleen so that estrogen produced was secreted into the portal circulation and thus pass directly to the liver and undergo inactivation there, Jungck, Heller and Nelson (48, p.151) were able to demonstrate a normal level of gonadotrophic hormones in the anterior pituitary of female rats in the absence of circulating estrogen. These workers have suggested that the normal levels of gonadotropins are maintained by a constant inactivation by the ovaries rather than the accepted explanation of estrogenic control of the pituitary. These implanted ovaries increased three-fold in weight after thirty - fifty seven days transplantation over their original weight at the time of operation. This development is interpreted by Heller and Jungck (43, p.154) to result from the lack of estrogen inhibition rather than the usual concept of gonadotrophic hormone stimulation for ovarian growth. This interpretation is substantiated by the decrease

in weight resulting from injection of estradiol benzoate. The unilateral-castration of the male chick was reported by Breneman (13, p.128) to produce no effect on the weight of the pituitary gland when compared with normal male chicks until ninety five days post operative. After ninety five days, the pituitary of the unilateral-castrated chick was slightly larger than the normal male. The pituitary of caponized chicks was consistently larger than either the normal male chick or the unilateral-castrated chick. The administration of 0.05 mg. of testosterone propionate daily for ten days to caponized male chicks resulted in a marked reduction in pituitary size but the similar treatment of unilaterally-castrated chicks and normal male chicks had no effect on pituitary size (14, p.404). At a daily injection of fifty gamma of testosterone propionate daily, the gonadotropic hormone content of these caponized chicks appeared to be completely inhibited.

The pituitary glands of castrate rats are reported by Hellbaum and Greep (41, p.298) to stimulate the development of corpora lutea in the ovaries of normal or hypophysectomized rats in addition to stimulating follicular development while pituitaries from normal males are capable of only follicular stimulation. A similar phenomena was found in the horse by Hellbaum (40, p.156) who reported that the pituitaries of stallions stimulated follicular development while the pituitaries of geldings and young non-pregnant adult females produced luteinized ovaries in assay rats. Ovaries of assay animals injected with pituitary powder from young female

horses and geldings were about four times as large as ovaries of assay animals receiving stallion pituitary powder. Immature female rats receiving 1 mg. of testosterone propionate on alternate days and autopsied on the tenth day of treatment showed follicular stimulation of the ovaries but there were no corpora lutea present in either treated or control groups (18, p.591). Using both hypophysectomized and intact female rats as assay animals, Hellbaum and Greep (42, pp.34-35) found that the pituitaries of castrated male rats receiving 0.5 mg. of testosterone propionate daily for thirty - forty five days failed to produce corpora lutea in the ovaries of over eighty percent of the test animals. Pituitaries from untreated castrate male rats induced the formation of corpora lutea in ovaries of all the assay animals. The content of follicle-stimulating hormone in the blood sera of these testosterone-treated castrate males was about half as concentrated as the hormone in the sera of untreated castrate males. The relative luteinizing activity of sera of the castrate, normal male, and testosterone propionate-treated castrate was calculated from a measure of the number of corpora lutea present after the injection of a given amount of follicle stimulating hormone and a given quantity of blood sera. The amount of luteinizing hormone in the blood sera appeared to be increased by the injection of testosterone propionate after fifteen and thirty days of treatment by not after forty five days of treatment. The pituitaries of normal male rats were found to contain primarily follicle-stimulating hormone while the blood serum of these

animals contains luteinizing hormone and small amounts of follicle-stimulating hormone. Following castration, the luteinizing hormone, as well as follicle-stimulating hormone, are markedly increased in the pituitary; the follicle-stimulating hormone in the blood stream is also present in large amounts whereas the luteinizing hormone appears to be decreased.

MATERIALS AND METHODS

Three trials were conducted in an effort to determine the effects of administered male hormones in beef cattle with special emphasis being placed on rate and efficiency of production and changes in body form and function. These trials were: (1) the 1950-1951 trial; (2) the 1951-1952 trial and (3) the methyl testosterone trial.

The 1950-1951 trial

Twenty-four grade Hereford calves were fed out in the 1950-1951 trial. This group of calves were made up of progeny groups of four heifers and four steers each from three purebred Hereford sires - Sire 14, Sire 17 and Sire 71. These three bulls were half-brothers, being out of the same sire. The dams of these calves were from a herd of seventy-five cows at the Northrup Experimental Area (Oregon). These calves were born in the spring and summer of 1950 and raised until weaning at the Northrup Experimental Area. At weaning the calves were moved to the Oregon Agricultural Experiment Station, Corvallis, Oregon, where they remained during the trial period. From weaning until the calves reached five hundred pounds, they were kept in the feeding pens (described below) and trained to being tied during feeding.

The following treatment groups were established: methyl androstenediol, testosterone and control. Calves were randomly allotted to each treatment group from the sex and sire groups.

One heifer and one steer from each sire progeny were placed in the methyl androstenediol group and received weekly intramuscular injections of 1 mg. per kg. of body weight of methyl androstenediol in acqueous suspension (Methostan, Schering Corporation). One heifer and one steer from each sire progeny group were placed in the testosterone treatment group and received weekly intramuscular injections of 1 mg. per kg. of body weight of testosterone in the form of acqueous suspension of micropellets (Oreton - F, Schering Corporation). Both treatments were injected intramuscularly beginning when the calf reached five hundred pounds and continuing throughout the feeding period until the calf reached eight hundred pounds. Two heifers and two steers from each sire progeny group were placed in the control group and received no injections or other treatments in addition to routine feeding and care.

The feeding trial began when each calf reached five hundred pounds. At this time the calf was weighed, photographed and scored on body conformation by a committee of five scorers. The calf was then placed on individual feed test and records kept of feed consumption. The calves were restricted to pens in groups of six during the entire feeding period - steers and heifers were fed in separate pens. The calves were fed twice daily, at 7 A.M. and 2 P.M. approximately. Before feeding each calf was tied to his compartment at the manger and remained tied for about three hours, or until the majority of calves had finished eating. When the calf was untied, it was allowed the freedom of its pen and access to water at all

times, but to no feed. The grain was fed to all calves and then the hay was fed, each being weighed for individual animals. Refused feed was stored in burlap bags in front of each calf and weighed back at seven day intervals, both for the purpose of correcting feed consumption records and as a basis for increasing the daily ration. Live weights of all calves were taken at fourteen day intervals between 10 and 11 A.M. on alternate Saturdays. Feed and consumption and gains were summated for each period on individual record forms and entered into the master record for each two week period.

The test ration consisted of roughage and a grain concentrate. The roughage fed was high-quality alfalfa hay, chopped to facilitate weighing and to avoid waste. The concentrate mixture consisted of the following ingredients: rolled barley, 60%; ground oats, 20%; dried beet pulp, 10%; wheat bran, 5%; soybean meal, 2.5%; linseed meal, 1%; dried skim milk, .5%; bone meal, .5%; salt, .45% and irradiated yeast, .05%. The plan of feeding was to maintain a ratio of one pound concentrate to three pounds of hay in the ration of calves during the five hundred to six hundred pound weight period; a ratio of one pound concentrate to two pounds hay in the ration of calves during the six hundred to seven hundred pound weight period; and a ratio of one pound concentrate to one pound hay in the ration of calves during the seven hundred to eight hundred pound weight period. Since a portion of the roughage was refused more frequently than the grain, the roughage consumption usually determined the total

daily ration. Hay was fed slightly in excess of consumption in order for calves to show the ability to utilize large quantities of feed particularly roughage.

At eight hundred pounds body weight, the calf was taken off the feeding trial. Again it was photographed and scored by the scoring committee.

During the following week, the animal was taken to a nearby slaughterhouse and slaughtered after a twenty-four hour shrink period. The animals were usually slaughtered on the Wednesday following their being taken off the feeding test. At the time of slaughter the following glands and organs were taken out, trimmed, and weighed: pituitary, thyroid, adrenals, liver and heart. A measurement was taken of the length of the extended small intestine after adhering fat and connective tissue had been separated away. Sections of the thyroid, adrenals, and small intestine were taken for histological observation and fixed in Bouin's fixative. After fixation the samples of tissue were washed, dehydrated in alcohol and dioxan, cleared in xylol, infiltrated and imbedded in paraffin. Sections were cut at 10 micro thickness and mounted on micro slides. The sections were stained with Harris' haematoxylin and eosin. Linear measurements of thyroid colloid dimensions were made with a micrometer eyepiece calibrated with a micrometer slide. The pituitary gland was placed in the freezing compartment of a refrigerator for biological assay.

Weights were taken on the cold carcass after the animal had

been hanging in the cooler for approximately five days. The left side of the carcass was then cut into the wholesale market cuts and weights of these parts taken. Measurement was taken of the widest width and the length of the rib eye muscle at the twelfth rib on the prime rib cut.

The individual feed consumption, pounds gain, and days on feeding test were computed on the basis of the master record. Average daily gain is computed as the total weight gain divided by the number of days on test. Feed efficiency is expressed as the pounds of total digestible nutrients consumed per one hundred pounds gain and is computed from the total digestible nutrients consumed divided by the total gain in pounds divided by one hundred. Total digestible nutrients of the feed was computed from Morrison's tables of feed composition (80, pp.1086-1130).

The 1951-1952 trial

The trial conducted in 1951-1952 was quite similar to the trial conducted in 1950-1951. The following conditions are notable exceptions. A portion of the cows were bred to Sire 15 and Sire 71 was not used at the Northrup Experimental Area in that year. Thus the sire progeny groups are from Sire 14, Sire 15 and Sire 17. The calves and their dams were moved to the Camp Adair area near Corvallis about August 1, 1951 and remained there until they were weaned. The methyl androstenediol treatment group was discontinued and the twenty-four calves divided into two treatment groups of

of twelve animals each, one receiving the described testosterone treatment and the other serving as a control group. Again, however, calves from the sire progeny and sex groups were randomly allotted to the treatment groups.

At the time of slaughter the ovaries were dissected out and placed in Bouin's fixative. Observations were taken at time of slaughter on follicular and luteal development and these were confirmed by later dissection and examination. The size and number of follicles and corpora lutea in the ovaries were determined by observation of the preserved specimens after all the organs had been collected. The seminal vesicles were dissected out at the time of slaughter and weighed; specimens were fixed in Bouin's fixative for histological study and references. A representative sample of the thyroid gland tissue was secured and placed in the freezing compartment of a refrigerator for biological assay. The diameter of the penis at the attachment of the penis retractor muscle was also taken.

In addition to the carcass data taken in the hormone trial in 1950-1951, the prime rib was secured for chemical analysis and evaluation of quality. A one-half inch thick slice was taken from between the twelfth and thirteenth rib for protein, water, fat, and ash determination. The 10-11-12 rib roast cut was cooked and analysis and scoring made on the cooked meat. The 6-7-8-9 rib roast cut was boned out and weights taken on the relative amounts of bone and flesh.

The meat was cooked in the following way. The roasts were placed in individual, uncovered pans and a thermometer inserted with the bulb centered in the rib eye muscle. The roasts were seared at an oven temperature of 200°C. for twenty minutes. The temperature was then lowered to 125°C. for the remainder of the cooking period. The roasts were cooked for three and one half to four hours, until an interior temperature of 73°C. was reached. At this temperature, and with this method of cooking, the meat was medium-rare in degree of doneness. When sliced, each roast appeared to be uniformly cooked. Weights were taken of meat and pan before and after cooking. Drip and evaporation losses were calculated from these weights as a percent of the weight of the raw meat. Samples of the rib eye muscle were used for judging, press fluid and shearing strength determinations. The judging panel was composed of faculty and advanced students in the Departments of Animal Husbandry and Home Economics. The press fluid determinations were made by subjecting a sample of cooked lean meat to a pressure of eight thousand pounds per square inch at 40°C. for five minutes and measurement made of the amount of juice pressed out of the sample. Shearing strength determinations were calculated by the force required to shear a one-inch sample of cooked meat when a uniform shearing speed of twenty inches per minute was applied.

The methyl testosterone trial

Twenty-four grade Hereford steer calves with an average weight

of four hundred fifty pounds at the beginning of the trial were randomly allotted to four treatment groups. These groups received the following amount of methyl testosterone per one hundred pounds of concentrate mixture; none, 1.5 grams, 3.0 grams, and 6.0 grams. The concentrate mixture was fed at the rate of 0.8 pounds per day per hundred pounds of body weight and as much good quality alfalfa hay was fed as the calves would consume. The calves were all individually fed under the same conditions described for the 1950-51 and 1951-52 trials. The concentrate feed consumed resulted in the following average weekly intakes of methyl testosterone per one hundred pounds live weight for the four treatment groups: none, 0.25 mg., 0.50 mg., and 1.00 mg. The calves in this study were fed to a weight of nine hundred fifty pounds and then slaughtered at a nearby slaughterhouse. Weights were taken of the pituitary, thyroid, and adrenal glands and the heart and liver. The pituitary glands of these calves also were bioassayed for thyreotropic and gonadotropic hormone content. One steer in the treatment group receiving 3.0 grams methyl testosterone per one hundred pounds feed was a chronic bloater and did not finish the test, therefore the 3.0 gram group contains only five animals.

Biological assay for gonadotropin and thyrotropin content of the anterior pituitary

A very short time after the calves had been slaughtered, the pituitary glands were placed in the freezing compartment of a

refrigerator and kept frozen until shortly prior to the assay period. On the day before injections were to start the pituitary glands, each handled individually, were taken from the cold storage and weighed. The pituitary was then divided into two approximately equal halves by a longitudinal section to aid in mechanical separation. The posterior pituitary and that portion of the dura mater covering the anterior pituitary were dissected away from each half leaving the anterior pituitary with a minimum amount of external fibrous covering. The anterior pituitary of each calf was ground in a mortar with a pestle until thoroughly macerated and then distilled water was added to the tissue until a volume of 12.5 cubic centimeters was attained. This water was added as a series of two rinses of the grinding apparatus in order to remove all possible tissue from the motar and pestle. By this procedure it was possible to grind the pituitary tissue into small particles which would remain suspended in the water solution for several hours. The acqueous solution was placed in the freezing compartment of the refrigerator until used.

The calves in the 1950-51 hormone trial were divided into groups of four each as follows. All animals of one sex from one sire were placed together in one group. Thus one group would include four heifers from one sire, one of which received testosterone treatment, one received methostan treatment and two were controls The four animals in each of these groups and a bull calf were then assigned to the sub-lots of twenty chicks.

The procedure was very similar in the testosterone trial in 1951-52 with the exception that the groups of calves consisted of four animals from one sire, two heifers and two steers, one of each sex having been treated with testosterone and one of each sex having been a control animal.

The procedure for the steers receiving methyl testosterone in their feed during 1951-52 was also very similar with the exception that the groups of calves each consisted of four animals, one being selected from each of the treatment groups: 6.0 grams, 3.0 grams, 1.5 grams and control.

The assay animals used in this experiment were White Leghorn cockerel chicks from commercial flocks. These were supplied by the Heisdorf Nelson Farms at Kirkland, Washington, who had chicks available from weekly hatches continuously throughout the year. The chicks were removed from the incubator on the twenty-second day of incubation, sexed, packaged and delivered to the college usually on the twenty-third day. The chicks were thus on the average two days old when delivered. They were immediately placed in a room with temperature controlled at 24°C. and a three hundred watt bulb with reflector suspended about fourteen inches above the floor. The chicks were allowed feed (commercial chick mash) and water at all times throughout the assay period.

Lots of chicks of approximately one hundred each were found to be the most desirable number to work with from the standpoint of equipment available, time available for treatment and time

available for autopsy. These hundred chicks were banded with wing tags numbered consecutively. Numbers were randomly allotted to each chick. Each lot of one hundred chicks was divided into five equal sub-lots each composed of twenty chicks consecutively numbered. Thus numbers one to twenty inclusive were in sub-lot I, twenty-one to forty were in sub-lot II, forty-one to sixty were in sub-lot III, sixty to eighty were in sub-lot IV, and eighty-one to one hundred were in sub-lot V. Those chicks having numbers ending in one, two and three received daily injections of 0.02 cc. of the acqueous anterior pituitary solution described above, numbers ending in four, five and six received doses of 0.04 cc., and numbers ending in seven, eight and nine received doses of 0.08 cc. daily. Thus of each sub-lot of twenty chicks six received the 0.02 cc. dosage, six received the 0.04 cc. dosage and six received the 0.08 cc. dosage. The above dosage levels were given by subcutaneous injection in the breast area for four consecutive days beginning when the chicks were four days old. This method is an adaption of that given by Evans for gonadotropin assay (27, p.1006), and that for thyrotropin assay (9, p.664).

The acqueous solution of the anterior pituitary of the calf assigned to each sub-lot was injected in the chicks in that sub-lot. Thus the response of each pituitary was measured in eighteen chicks. All chicks having numbers ending in 0 and those in excess of one hundred birds served as a negative control and were not injected with any material.

Approximately twenty-one hours after the last injection the chicks were weighed; weights being taken to the nearest gram. Chicks were then killed by chloroform in groups of about ten each, the order of killing and autopsy apparently random. The thyroid glands were dissected out onto micro slides and then the testes were dissected away as soon as the thyroids had been removed from each chick. Attempts were made to remove a large portion of the non-glandular material which tended to adhere to these glands before weighing. The glands were weighed very quickly after separation in order that loss due to evaporation be kept to a minimum. Weights were taken on a Roller-Smith tension balance which is to be recommended for this type of work because of the speed which is essential and a degree of accuracy which is quite acceptable. All chicks were autopsied twenty-one to twenty-eight hours after the last injection.

The chicks used in this trial were sexed cockerels and a very small percentage of them were pullets. The measurements on the thyroids of pullets were discarded since there was considerable evidence that there was a differential response to thyrotrophic hormone due to sex differences. There was also a very low death loss during the various treatment period among the chicks. Thus the average number of chicks per sub-lot receiving injections is slightly less than the eighteen allotted to each sub-lot. At the time of slaughter, the chicks were approximately eight days old and none were less than seven days old, the exact age being

dependent on the differences between individuals in the group, purely a chance condition which may or may not have significance.

Biological assay of thyroid hormone content in the thyroid gland

The sample of thyroid gland of calves in 1951-52 trial was placed in the freezing compartment of a refrigerator and stored at freezing temperatures until it was to be used. Samples of thyroid tissue from all calves in the progeny group of Sire 14 were macerated in a Waring blender for approximately ten minutes and the material diluted with distilled water to a volume of 7.5 cc. for each gram of tissue. The mixture was thoroughly mixed in the blender and strained through a doubled cheese cloth. This material was then placed in the freezing compartment of a refrigerator and held until used (up to a week). This material was then injected into mice ten weeks of age which had been on a ration of 0.1 percent thiouracil in the feed for the previous four weeks. The thyroid material from each calf was injected subcutaneously into three male and four female mice. One injection of 0.2 cc. of the thyroid suspension was given and the mice killed thirty-six hours post-injection. The mice were asphyxiated in one-half pint jars sealed with mason lids. The time required for complete asphyxiation and death was recorded for each individual mouse. The time required for asphyxiation is used as an indication of oxygen consumption and respiration rate.

Statistical treatment of data

The analysis of variance described by Snedecor (104, pp.214, 253) was used to determine the significance of treatment means. The following sequence of testing for significance was used throughout the various trials. When F values exceeded those given by Snedecor for the F distribution at the .05 level, the differences were deemed significant. The error mean square was used to test the second order interaction. If the second order interaction was significant, it was used to test all first order interactions. If the second order interaction was not significant, the error and second order interaction sums of squares and degrees of freedom were pooled to give the new Pooled error (1) which was used to test all first order interactions. If any first order interactions were significant they were used to test their main effects. The non-significant interactions were then pooled with the error to give Pooled error (2) which was used to test the main effects. The analysis of covariance was used to adjust the sums of squares of deviations of total digestible nutrients per one hundred pounds gain for the effects of average daily gain (33, p.270).

EXPERIMENTAL RESULTS

In determining the response of beef calves to administered male hormones, several characteristics must necessarily be observed, measured and recorded. Some of the various factors which have been recorded are feedlot performance, carcass characteristics, meat characteristics, glandular size and activity and induced sexual development. Many of these traits will have definite physiological implications which will aid in explanation of the various other treatment effects. Some will possibly have value chiefly from the economical aspect. The careful integration of these results is necessary before comprehensive and accurate conclusions can be made.

Measures of feedlot performance

Average daily gain, total digestible nutrients required per one hundred pounds gain, and total digestible nutrients consumed per day are important measures of feedlot performance. These three factors - rate of gain, efficiency of gain and feed intake, are very important considerations in determining whether the producer of market beef will make money year after year. The following results are given to demonstrate the effects of genetic and environmental conditions on the ability of beef calves to grow rapidly, gain efficiently, and consume amounts of feed adequate for these purposes.

Average daily gain

The average daily gains in pounds per day during the entire test period for calves in the various treatments, sire and sex groups and subgroups in the 1950-51 trial are given in Table 1. Similar information is presented in Table 5 for calves in the 1951-52 trial. The analysis of variance of the effects of these sources of variation is shown in Table 2 for the 1950-51 trial and in Table 6 for the 1951-52 trial. The average daily gain during the 675 to 800 pound weight period is presented in Table 3 for calves in the various treatments, sire and sex groups and subgroups in the 1950-51 trial. Similar information is given in Table 7 for calves in the 1951-52 trial. Analysis of variance of the effects of these sources of variation is given in Table 4 for the 1950-51 trial and in Table 8 for the 1951-52 trial.

Effect of methyl androstenediol

The weekly intramuscular injection of 1 mg/kg of body weight of methyl androstenediol during the test period had no significant effect upon the average daily gain during the entire test period (Table 2) as is shown by the analysis of variance.

Table 1. The effect of methyl androstenediol and testosterone treatments, sire, and sex upon the average daily gain of calves in the 1950-51 trial

Sire and sex groups	Treatment groups			Sire and sex Averages
	Control	Testosterone	Methyl Androstenediol	
	Average daily gain (pounds)			
Sire 14				
Heifers	2.03	2.63	2.00	2.17
Steers	2.24	2.66	1.86	2.25
Average	2.13	2.64	1.93	2.21
Sire 17				
Heifers	2.01	2.73	1.95	2.17
Steers	2.68	2.91	2.36	2.66
Average	2.35	2.82	2.16	2.42
Sire 71				
Heifers	1.99	2.26	1.88	2.03
Steers	2.26	2.48	2.44	2.36
Average	2.12	2.37	2.16	2.19
Treatment Averages				
Heifers	2.01	2.54	1.94	2.12
Steers	2.39	2.68	2.22	2.42
Average	2.20	2.61	2.08	2.27

Table 2. Analysis of variance of the effect of methyl androstenediol and testosterone treatments, sire and sex upon the average daily gain of calves in the 1950-51 trial

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	2	.4836	10.21*
Testosterone vs. others	1	.9106	19.22*
Methostan vs. control	1	.0566	1.20
Sires	2	.1240	2.62
Sexes	1	.5296	11.18*
Treatments x sires	4	.0384	.82
Treatments x sexes	2	.0286	.61
Sires x sexes	2	.0852	1.81
Treatments x sires x sexes	4	.0254	.41
Error	6	.0617	
Pooled error (1)	10	.0472	
Pooled error (2)	17	.0474	

* Indicates statistical significance at .05

Table 3. The effect of methyl androstenediol and testosterone treatments, sire, and sex upon the average daily gain during 675-800 pound weight period of calves in the 1950-51 trial

Sire and sex groups	Treatment groups			Sire and sex Averages
	Control	Testosterone	Methyl Androstenediol	
	Average daily gain (pounds)			
Sire 14				
Heifers	2.29	3.07	1.98	2.41
Steers	2.36	2.90	1.94	2.39
Average	2.32	2.98	1.96	2.40
Sire 17				
Heifers	2.21	2.57	1.98	2.24
Steers	3.32	3.64	2.55	3.21
Average	2.77	3.11	2.27	2.73
Sire 71				
Heifers	2.23	2.50	1.98	2.23
Steers	2.33	3.51	2.53	2.68
Average	2.28	3.01	2.26	2.46
Treatment Averages				
Heifers	2.24	2.71	1.98	2.30
Steers	2.67	3.35	2.34	2.76
Average	2.46	3.03	2.16	2.53

Table 4. Analysis of variance of the effect of methyl androstenediol and testosterone treatments, sire and sex upon the average daily gain during 675-800 pound weight period of calves in the 1950-51 trial

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	2	1.1967	7.70*
Testosterone vs. others	1	2.0466	13.17*
Methostan vs. control	1	.3467	2.23
Sires	2	.2566	1.65
Sexes	1	1.2765	8.22*
Treatments x sires	4	.0566	.37
Treatments x sexes	2	.0334	.22
Sexes x sires	2	.4893	3.21
Treatments x sexes x sires	4	.0854	.43
Error	6	.1971	
Pooled error (1)	10	.1525	
Pooled error (2)	18	.1554	

* Indicates statistical significance at .05

Table 5. The effect of testosterone treatment, sire and sex upon the average daily gain of calves in the 1951-52 trial

Sire and sex groups	Treatment groups		Sire and sex averages
	Control	Testosterone	
	Average daily gain (pounds)		
Sire 14			
Heifers	2.21	2.61	2.41
Steers	2.44	2.94	2.69
Average	2.32	2.78	2.55
Sire 15			
Heifers	2.09	2.79	2.44
Steers	2.91	2.58	2.74
Average	2.50	2.68	2.59
Sire 17			
Heifers	1.99	2.44	2.21
Steers	2.61	2.70	2.66
Average	2.30	2.57	2.44
Treatment averages			
Heifers	2.09	2.61	2.35
Steers	2.65	2.74	2.70
Average	2.37	2.68	2.52

Table 6. Analysis of variance of the effect of testosterone treatment, sire and sex of calf upon the average daily gain of calves in the 1951-52 trial

Source of variation	Degrees of Freedom	Mean Square	F.
Treatment (Testosterone vs. control)	1	.5597	5.49*
Sires	2	.0514	.50
Sexes	1	.7056	6.92*
Treatments x sires	2	.0375	.22
Treatments x sexes	1	.2780	4.68
Sires x sexes	2	.0150	.09
Treatments x sires x sexes	2	.1651	4.11*
Error	12	.0402	
Pooled interaction error	7	.1019	

* indicates statistical significance at .05

Table 7. The effect of testosterone treatment, sire and sex upon the average daily gain during the period from 675-800 pounds live weight of calves in the 1951-52 trial

Sire and sex groups	Treatment groups		Sire and sex averages
	Control	Testosterone	
	Average daily gain (pounds)		
Sire 14			
Heifers	2.37	3.04	2.71
Steers	2.80	3.19	2.99
Average	2.58	3.12	2.85
Sire 15			
Heifers	2.24	3.06	2.65
Steers	2.99	3.23	3.11
Average	2.62	3.15	2.88
Sire 17			
Heifers	2.17	2.35	2.26
Steers	2.61	3.15	2.88
Average	2.39	2.75	2.57
Treatment averages			
Heifers	2.26	2.82	2.54
Steers	2.80	3.19	2.99
Average	2.53	3.00	2.77

Table 8. Analysis of variance of the effect of testosterone treatment, sire and sex upon the average daily gain during the period from 675-800 pounds live weight of calves in the 1951-52 trial

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	1	1.3485	26.76*
Sires	2	.2410	4.78*
Sexes	1	1.2545	24.89*
Treatments x sires	2	.0202	.37
Treatments x sexes	1	.0424	.77
Sires x sexes	2	.0555	1.02
Treatments x sires x sexes	2	.1134	2.54
Error	12	.0447	
Pooled error (1)	14	.0545	
Pooled error (2)	19	.0504	

* Indicates statistical significance at .05

The average daily gain of calves receiving methyl androstenediol was slightly lower than that of the control calves (Table 9).

Table 9. The effect of methyl androstenediol on the average daily gain (in pounds) of heifers and steers

Treatment	Heifers	Steers	Both sexes
Methyl androstenediol	1.94	2.22	2.08
Control	2.01	2.39	2.20
Advantage of control	0.07	0.17	0.12

The average daily gain of steers receiving methyl androstenediol was reduced somewhat more than the average daily gain of heifers receiving methyl androstenediol when these groups are compared with the control group. During the period of gain from 675 to 800 pounds the average daily gain of the methyl androstenediol-treated calves was not significantly different from the control calves (Table 4). The methyl androstenediol-treated calves gained less per day during the period from 675 to 800 pounds live weight than did the control calves (Table 10).

Table 10. The effect of methyl androstenediol on average daily gain (in pounds) during the period from 675-800 pounds live weight

Treatment groups	Heifers	Steers	Both sexes
Methyl androstenediol	1.98	2.34	2.16
Control	2.24	2.67	2.46
Advantage of control	0.26	0.33	0.30

Heifers receiving methyl androstenediol gained 0.26 pounds per day less than control heifers in this period, while steers receiving methyl androstenediol gained 0.33 pounds per day less than control steers. The average daily gain in weight during consecutive two-week periods after the beginning of the feed test is given in Table 11 for heifers and steers in the control and methyl androstenediol-treatment groups. The trend of these average daily gains is shown graphically in Figure 1. The average daily gain of steers receiving methyl androstenediol appears to follow very closely the average daily gain for control steers for consecutive two-week periods. The heifers in these two groups, however, show rather wide fluctuations in daily gain in corresponding two-week periods.

Table 11. The effect of methyl androstenediol and testosterone treatments on the average daily gain (in pounds) of steers and heifer calves in the 1950-51 trial

Weeks after beginning of test	Treatment groups					
	Control		Methyl androstenediol		Testosterone	
	Heifers	Steers	Heifers	Steers	Heifers	Steers
2	1.76	1.82	2.12	1.88	2.50	2.33
4	2.01	2.69	1.02	2.26	2.83	2.02
6	2.58	2.43	1.41	2.05	1.79	2.74
8	1.30	1.91	2.41	1.93	3.40	2.60
10	1.64	2.07	2.05	2.24	2.55	2.10
12	1.80	2.35	2.14	2.43	1.43	3.10
14	2.31	3.08	2.19	2.95	3.14	2.57
16	1.99	2.88	2.14	1.86	2.86	3.83

Effect of testosterone

The weekly intramuscular injection of 1 mg/kg of body weight of

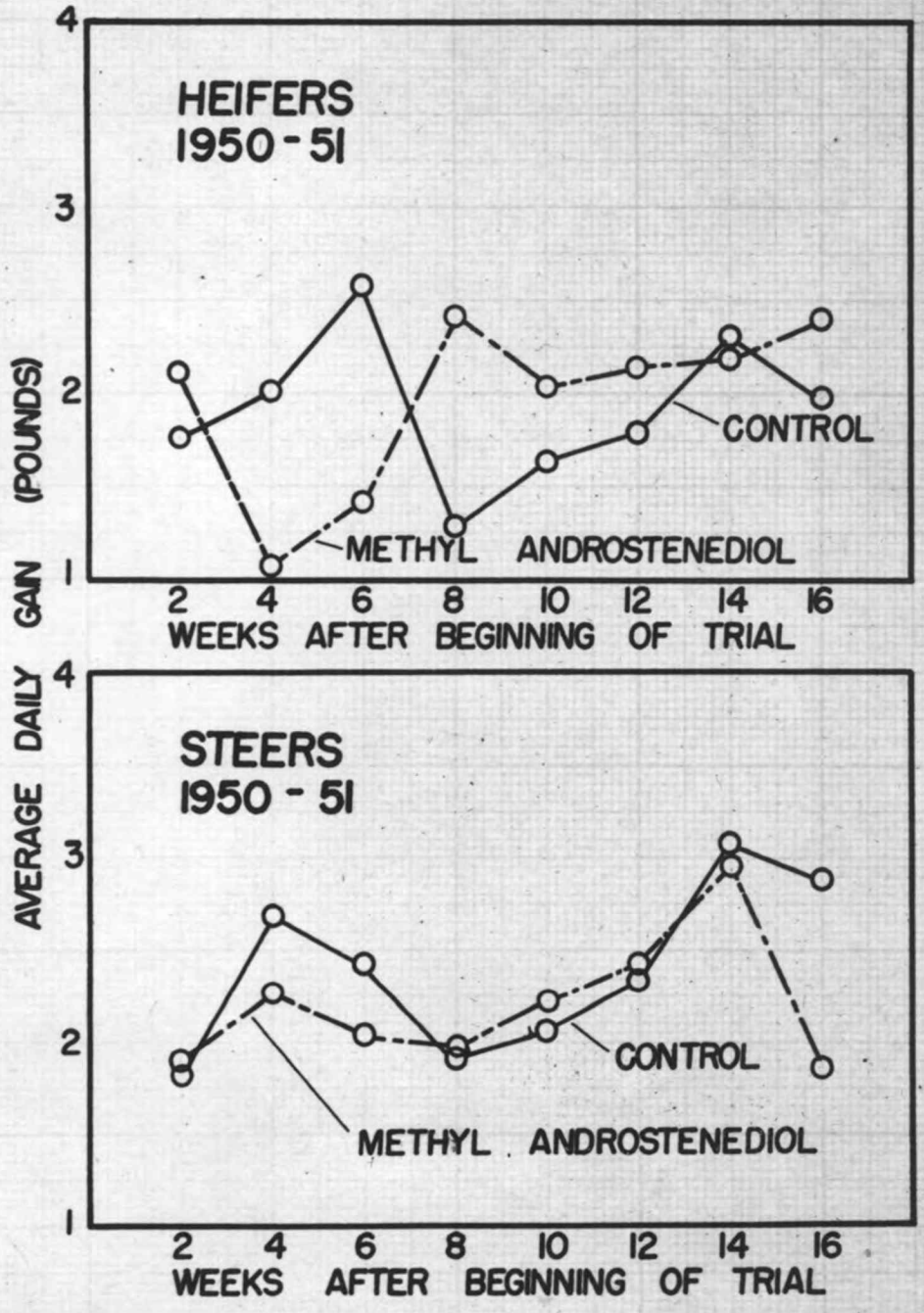


FIGURE 1. THE EFFECT OF METHYL ANDROSTENEDIOL ON AVERAGE DAILY GAIN.

testosterone during the test period had statistically significant effects on average daily gain during the entire test period in both years in which the trials were conducted (Tables 2 and 6). Control calves (heifers and steers combined) gained 2.20 pounds per day during the entire test period, while calves receiving testosterone injections gained on the average 2.61 pounds per day during the entire test period in the 1950-51 trial (Table 12).

Table 12. The effect of testosterone on average daily gain (in pounds) of heifers and steers in the 1950-51 trial

Treatment groups	Heifers	Steers	Both sexes
Testosterone	2.54	2.68	2.61
Control	2.01	2.39	2.20
Advantage of testosterone	0.53	0.29	0.41

The heifers receiving testosterone gained 0.53 pounds more per day than did control heifers while the testosterone-treated steers gained 0.29 pounds more per day than did control steers. In 1951-52 the testosterone-treated calves gained 2.68 pounds per day on the average while the control calves gained 2.37 pounds per day, an advantage in favor of the testosterone calves of 0.31 pounds in average daily gain (Table 13). The testosterone-treated heifers gained 0.52 pounds more per day than did control heifers, while testosterone-treated steers gained 0.09 pounds more per day than control steers. The much greater response of the heifers as compared to steers to the injection of testosterone propionate suggests an interaction

Table 13. The effect of testosterone on average daily gain (in pounds) of heifers and steers in the 1951-52 trial

Treatment groups	Heifers	Steers	Both sexes
Testosterone	2.61	2.74	2.68
Control	2.09	2.65	2.37
Advantage of testosterone	0.52	0.09	0.31

between the sexes and the hormone treatment. This interaction was not statistically significant in either the 1950-51 (Table 2) or 1951-52 trials (Table 6).

The average daily gain in weight during consecutive two-week periods after the beginning of the feed test is given in Table 11 for heifers and steers in the control and testosterone-treated groups in the 1950-51 trial and in Table 14 for heifers and steers in the 1951-52 trial. The trend of these average daily gains is plotted in Figures 2 and 3 for the 1950-51 and 1951-52 trials, respectively.

Table 14. The effect of testosterone on the average daily gains (pounds) in weight of steer and heifer calves in the 1951-52 trial

Weeks after beginning of test	Treatment groups			
	Control		Testosterone	
	Heifers	Steers	Heifers	Steers
2	1.93	2.57	2.38	1.98
4	1.79	2.27	2.29	1.91
6	1.74	2.36	2.10	2.45
8	1.96	2.91	2.71	2.75
10	2.81	2.50	3.31	3.06
12	1.77	2.60	2.42	2.94
14	1.89	2.85	2.66	2.93

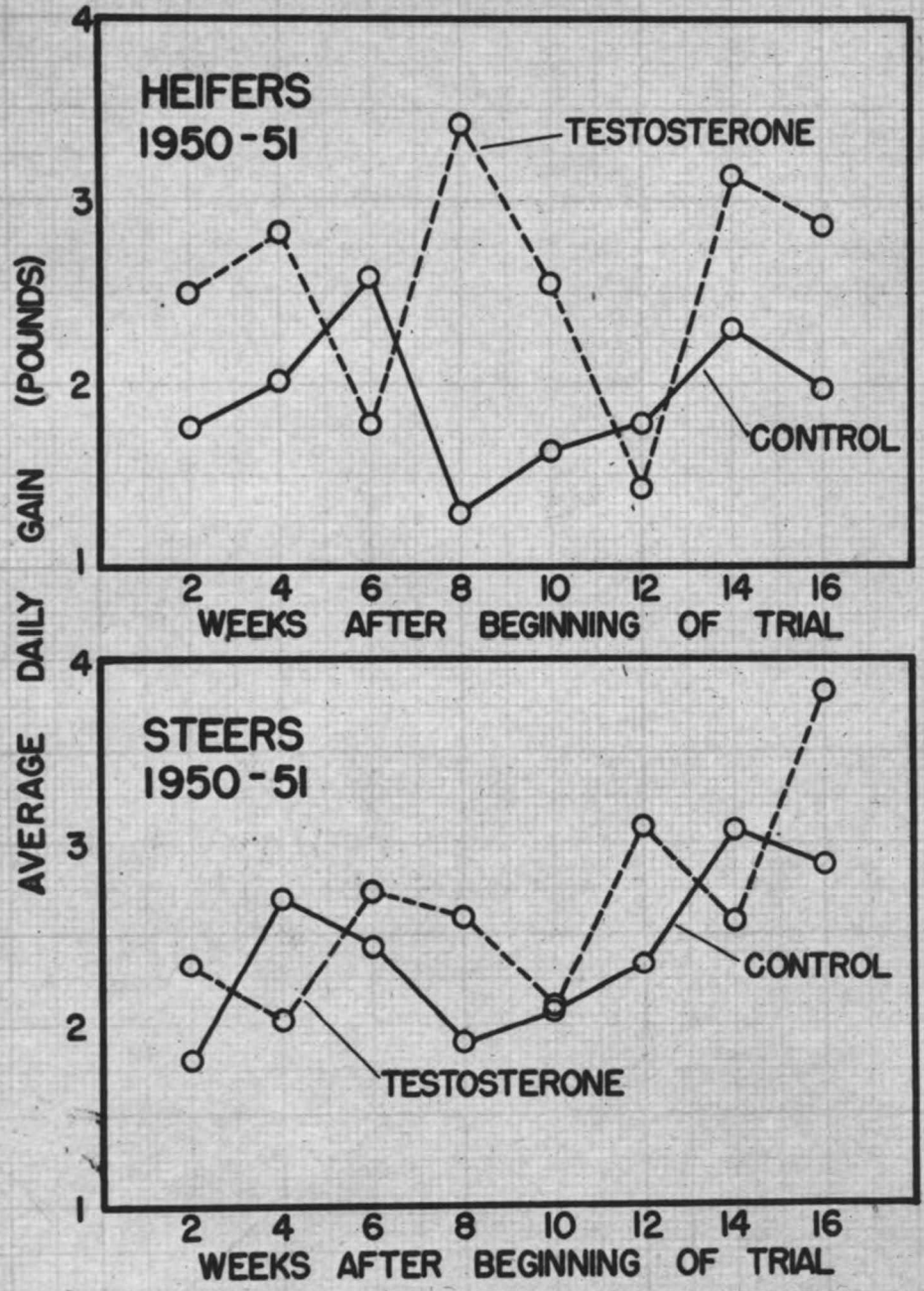


FIGURE 2. THE EFFECT OF TESTOSTERONE ON AVERAGE DAILY GAIN

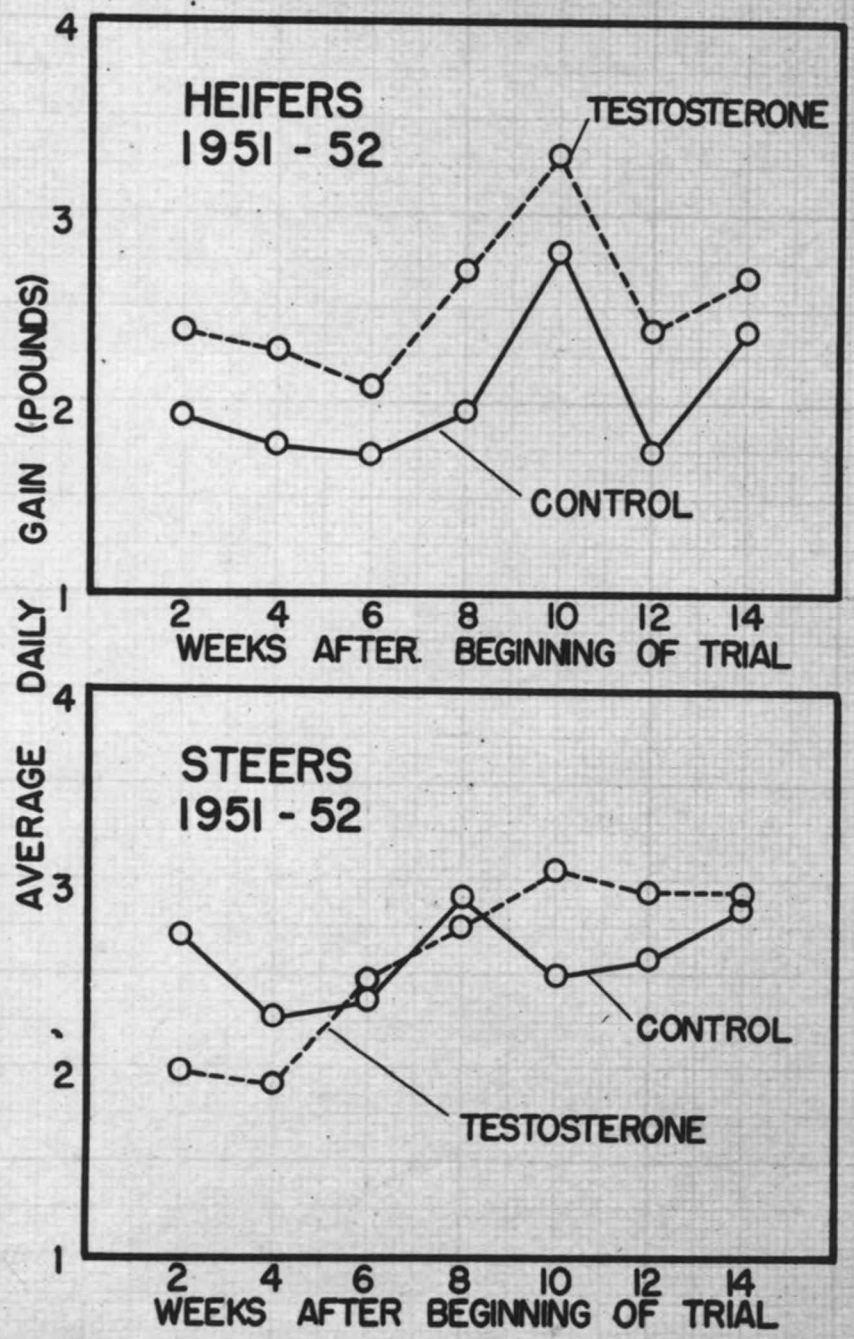


FIGURE 3. THE EFFECT OF TESTOSTERONE ON AVERAGE DAILY GAIN.

The heifers receiving testosterone treatment showed rather consistently greater gains than control heifers during consecutive two-week periods. This trend was particularly well illustrated by the heifers in the 1951-52 trial (Figure 3). The steers receiving testosterone showed considerable fluctuation in rate of gain and were not consistently higher in average daily gains in successive two-week periods. During the 675-800 pound gain period, the testosterone-treated calves gained more rapidly than control calves in both the 1950-51 trial and the 1951-52 trial (Tables 4 and 8). In the 1950-51 trial, steer calves receiving testosterone treatment gained 0.68 pounds more per day than did control calves during this period, while the heifer calves receiving testosterone gained 0.47 pounds more per day than control heifers, Table 15. The average daily gains of nearly all calves was higher

Table 15. The effect of testosterone on average daily gain (in pounds) during the period from 675-800 pounds live weight in the 1950-51 trial

Treatment groups	Heifers	Steers	Both sexes
Testosterone	2.71	3.35	3.03
Control	2.24	2.67	2.46
Advantage of testosterone	0.47	0.68	0.57

during this period than the average daily gains for the entire feeding period (Tables 1 and 3). The testosterone-treated steers were gaining 0.68 pounds per day more than the control steers

during this period compared with a corresponding advantage of 0.29 pounds per day for the entire feeding period (Table 12) indicating that the response during this period was greater than during the earlier part of the test for the steer calves. In the 1951-52 hormone injection trial (Table 16) the testosterone-treated heifers and steers gained faster during the 675 to 800 pound gain period than did the corresponding control calves. The steers receiving testosterone gained 0.39 pounds more than control steers, whereas the advantage of testosterone steers over the control steers for the entire feeding period was 0.09 pounds per day (Table 13).

Table 16. The effect of testosterone on average daily gain (in pounds) during the period from 675 to 800 pounds live weight in the 1951-52 trial

Treatment groups	Heifers	Steers	Both sexes
Testosterone	2.82	3.19	3.00
Control	2.26	2.80	2.53
Advantage of testosterone	0.56	0.39	0.47

Effect of methyl testosterone

The feeding of methyl testosterone at the rate of 0.25 mg., 0.50 mg., or 1.00 mg. per kg. of body weight per week had no significant effect on the average daily gain of steer calves (Table 18). The average daily gain for calves in the methyl testosterone trial is given in Table 17. The average daily gain for each of the methyl

Table 17. The effect of various levels of methyl testosterone on the average daily gain (in pounds) of steers

Individual Averages	Weekly intake of hormone (mg/kg body weight)			
	0.00	0.25	0.50	1.00
	2.91	2.12	2.87	2.30
	2.24	2.10	2.40	2.14
	2.18	2.03	2.23	1.93
	2.30	1.94	2.03	2.42
	2.14	2.14	2.33	2.09
	2.50	2.75	- -	2.20
Treatment Averages	2.38	2.18	2.37	2.18
Advantage of the Control Group	- -	0.20	0.01	0.20

Table 18. The analysis of variance of the effect of various levels of methyl testosterone on the average daily gain of steers

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	3	774.07	1.08
Error	19	718.02	

testosterone-fed groups was slightly less than the average daily gain of the control group. No tendency toward increased or decreased gains was present, with the increasing levels of methyl testosterone in the ration.

Effect of sires

The average daily gains of the three sire-progeny groups in the hormone trials conducted in 1950-51 (Table 2) and in 1951-52 (Table 6) were not significantly different. A range of 0.23 pounds in

average daily gain occurred in the 1950-51 hormone trial between the sire progeny groups; in the 1951-52 trial the range in average daily gain between the fastest and slowest gaining groups was 0.15 pounds (Table 19). Although there were no significant differences in average daily gain during the period from 675-800 pounds live weight in the 1950-51 trial among the three sire progeny groups (Table 4), a significant difference occurred among these groups in the 1951-52 trial (Table 8). During this growth period a range of 0.33 pounds in average daily gain existed between the fastest and slowest gaining sire groups in the 1950-51 hormone trial; while in the 1951-52 trial the range in average daily gain was 0.31 pounds (Table 20).

Table 19. The effect of sire of calves on average daily gain (pounds)

Year of hormone trial	Sire 14	Sire 15	Sire 17	Sire 71
1950-51	2.21	- - -	2.42	2.19
1951-52	2.55	2.59	2.44	- - -

Table 20. The effect of sire on average daily gain in body weight (pounds) during the period from 675-800 pounds live weight

Year of hormone trial	Sire 14	Sire 15	Sire 17	Sire 71
1950-51	2.40	- - -	2.73	2.46
1951-52	2.85	2.88	2.57	- - -

Effect of sex

Steer and heifer calves were significantly different in average

daily gain in the 1950-51 hormone trial (Table 2) and in the 1951-52 hormone trial (Table 6). The increase in average daily gain in heifers and steers produced by testosterone injection is shown in Tables 12 and 13 and is discussed in the section on the effects of testosterone on average daily gain. Steer calves gained 0.30 pounds and 0.35 pounds more per day in the 1950-51 and 1951-52 trials, respectively, than did heifer calves (Table 21).

Table 21. Average daily gain (pounds) of heifers and steers

Sex	1950-51 trial	1951-52 trial	Both trials
Heifers	2.12	2.35	2.24
Steers	2.42	2.70	2.56
Advantage of steers	0.30	0.35	0.32

The control steers had a much higher average daily gain than the control heifers (Tables 12 and 13), while a relatively smaller difference was found between the testosterone-treated heifers and steers. During the 675-800 pound gain period, the steers made significantly greater daily gains than the heifers in both the 1950-51 trial (Table 4) and the 1951-52 trial (Table 8).

Table 22. Average daily gain (pounds) of heifers and steers during the period from 675-800 pounds live weight

Sex	1950-51 trial	1951-52 trial	Both trials
Heifers	2.30	2.54	2.42
Steers	2.76	2.99	2.88
Advantage of steers	0.46	0.45	0.46

Although the average daily gain of all calves during the 675-800 pound gain period was somewhat greater in 1951-52 than in 1950-51, the superiority of steers over heifers was practically the same in both years (Table 22).

Total digestible nutrients required per 100 pounds gain

The average amount of total digestible nutrients required for one hundred pounds gain in live weight during the entire test period is given in Tables 23 and 27 for calves in the various treatment, sire and sex groups and subgroups in the 1950-51 and 1951-52 trials respectively. Analysis of variance of the effect of these sources of variance is given in Table 24 for the 1950-51 trial and in Table 28 for the 1951-52 trial. The average amount of total digestible nutrients required for one hundred pounds gain during the period from 675-800 pounds live weight in the 1950-51 trial is shown in Table 25 for calves in the various treatment, sire and sex groups and subgroups in the 1950-51 trial. Analysis of variance of the effects of these sources of variation is presented in Table 26 for the 1950-51 trial and in Table 30 for the 1951-52 trial.

Effect of methyl androstenediol

The injection of methyl androstenediol had no significant effect on the total digestible nutrients required for each 100 pounds gain in body weight during the overall test period (Table 24). The heifer calves receiving methyl androstenediol were only slightly

Table 23. The effect of methyl androstenediol and testosterone treatments, sire, and sex upon the total digestible nutrients required per 100 pounds gain of calves in the 1950-51 trial

Sire and sex groups	Treatment groups			Sire and sex Averages
	Control	Testosterone	Methyl Androstenediol	
	Total digestible nutrients per 100 pounds gain (pounds)			
Sire 14				
Heifers	491	376	480	459
Steers	458	362	512	448
Average	475	369	496	453
Sire 17				
Heifers	515	376	502	477
Steers	389	357	418	388
Average	452	366	460	433
Sire 71				
Heifers	514	429	523	495
Steers	443	376	430	423
Average	478	402	477	459
Treatment Averages				
Heifers	507	393	501	477
Steers	430	365	453	420
Average	468	379	477	448

Table 24. Analysis of variance of total digestible nutrients required per 100 pounds gain of calves in the 1950-51 trial

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	2	19,334	13.32*
Testosterone vs. others	1	38,351	26.43*
Methostan vs. control	1	317	.22
Sires	2	1,560	1.08
Sexes	1	19,832	13.67*
Treatments x sires	4	358	.23
Treatments x sexes	2	1,254	.80
Sires x sexes	2	3,268	2.09
Treatments x sires x sexes	4	800	.39
Error	6	2,073	
Pooled error (1)	10	1,564	
Pooled error (2)	18	1,451	

* Indicates statistical significance at .05

Table 25. The effect of methyl androstenediol and testosterone treatments, sire, and sex upon the total digestible nutrients required per 100 pounds gain from 675 to 800 pounds of calves in the 1950-51 trial

Sire and sex groups	Control	Testosterone	Methyl Androstenediol	Sire and sex Averages
	Total digestible nutrients (pounds) per 100 pound gain			
Sire 14				
Heifers	512	376	521	480
Steers	485	370	547	472
Average	498	373	534	476
Sire 17				
Heifers	530	419	559	510
Steers	371	322	416	370
Average	451	371	487	440
Sire 71				
Heifers	554	433	562	526
Steers	469	302	447	422
Average	512	367	504	474
Treatment Averages				
Heifers	532	409	547	505
Steers	442	331	470	421
Average	487	370	508	463

Table 26. Analysis of variance of total digestible nutrients required per 100 pounds gain from 675 to 800 pounds of calves in the 1950-51 trial

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	2	35,472	8.99*
Testosterone vs. others	1	69,111	17.52*
Methostan vs. control	1	1,833	.47
Sires	2	3,277	.83
Sexes	1	42,428	10.76*
Treatments x sires	4	980	.20
Treatments x sexes	2	118	.02
Sires x sexes	2	9,135	1.88
Treatments x sires x sexes	4	747	.10
Error	6	7,596	
Pooled error (1)	10	4,857	
Pooled error (2)	18	3,944	

* Indicates statistical significance at .05

Table 27. The effect of testosterone treatment, sire and sex upon the total digestible nutrients required per 100 pounds gain of calves in the 1951-52 trial

Sire and sex groups	Treatment groups		Sire and Sex Averages
	Control	Testosterone	
	Total digestible nutrients (pounds) per 100 pound gain		
Sire 14			
Heifers	481	360	421
Steers	414	352	383
Average	448	356	402
Sire 15			
Heifers	493	373	433
Steers	372	383	378
Average	432	378	405
Sire 17			
Heifers	521	402	462
Steers	407	371	389
Average	464	387	425
Treatment averages			
Heifers	498	379	438
Steers	398	369	383
Average	448	374	411

Table 28. Analysis of variance of total digestible nutrients required per 100 pounds gain of calves in the 1951-52 trial

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	1	3308.5	2.66
Sires	2	130.0	1.30
Sexes	1	1832.7	1.47
Treatments x sires	2	71.0	.66
Treatments x sexes	1	1242.7	11.50*
Sires x sexes	2	61.6	.57
Treatments x sires x sexes	2	67.8	.59
Error	12	114.8	
Pooled error (1)	14	108.1	
Pooled error (2)	18	99.8	

* Indicates statistical significance at .05

Table 29. The effect of testosterone treatment, sire and sex upon the total digestible nutrients required per 100 pounds gain during the period from 675-800 pounds live weight of calves in the 1951-52 trial

Sire and Sex Groups	Treatment groups		Sire and Sex Averages
	Control	Testosterone	
	Total digestible nutrients (pounds) per 100 pound gain		
Sire 14			
Heifers	504	357	431
Steers	411	356	384
Average	458	357	407
Sire 15			
Heifers	519	391	455
Steers	395	348	372
Average	457	370	413
Sire 17			
Heifers	525	463	494
Steers	463	358	411
Average	494	410	452
Treatment averages			
Heifers	516	404	460
Steers	423	354	389
Average	470	379	424

Table 30. Analysis of variance of total digestible nutrients required per 100 pounds gain from 675-800 pounds live weight of calves in the 1951-52 trial

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	1	49,286	41.88*
Sires	2	4,779	4.06*
Sexes	1	30,246	25.70*
Treatments x sires	2	157	.13
Treatments x sexes	1	2,856	2.30
Sires x sexes	2	888	.71
Treatments x sires x sexes	2	2,731	2.74
Error	12	996	
Pooled error (1)	14	1,244	
Pooled error (2)	19	1,177	

* indicates statistical significance at .05

more efficient than control heifers, Table 31, while methyl androstenediol-treated steers were slightly less efficient than control steers. During the 675-800 pound gain period, the heifers as well as the steers receiving methyl androstenediol were slightly less efficient in converting feed intake to body weight than were the corresponding heifer and steer control groups, Table 32. As is indicated in Table 27, this difference between the control and methyl androstenediol-treated groups was not statistically significant.

Table 31. The effect of methyl androstenediol on total digestible nutrients (in pounds) required per 100 pounds gain

Treatment groups	Sex Groups		
	Heifers	Steers	Both Sexes
Methyl androstenediol	501	453	477
Control	507	430	468
Advantage of control	- 6	23	9

Table 32. The effect of methyl androstenediol on the total digestible nutrients (in pounds) required per 100 pounds gain during the period from 675-800 pounds live weight

Treatment groups	Sex Groups		
	Heifers	Steers	Both Sexes
Methyl androstenediol	547	470	508
Control	532	442	487
Advantage of control	15	28	21

The average total digestible nutrients consumed for each 100 pounds gain during consecutive two-week periods after beginning of the test is given in Table 33 for heifers and steers in the control and methyl

androstenediol treatment groups. The trend of these efficiency estimates is shown graphically in Figure 4. The total digestible

Table 33. The effect of methyl androstenediol and testosterone treatments on the average total digestible nutrients (pounds) required for 100 pounds gain in weight of steers and heifers in the 1950-51 trial

Weeks after beginning of test	Treatment Groups					
	Control		Methyl androstenediol		Testosterone	
	Heifers	Steers	Heifers	Steers	Heifers	Steers
2	481	446	382	451	339	357
4	444	327	811	398	306	433
6	354	396	597	432	517	335
8	705	525	359	491	287	364
10	546	485	462	445	399	458
12	532	460	463	410	718	345
14	451	374	481	356	336	424
16	552	414	459	594	386	283

nutrients required per 100 pounds gain of the methyl androstenediol-treated and control steers did not deviate greatly from each other for consecutive two-week periods from the beginning of the trial except during the sixteenth week period. The control and methyl androstenediol-treated heifers, however, deviated greatly between the treatment groups and between consecutive two-week periods in total digestible nutrients required per 100 pounds gain. The resemblance between trends of rate of gain and feed efficiency in these respects are quite striking.

Effect of testosterone

The injection of testosterone resulted in a considerable reduction in feed required per 100 pounds gain as is indicated in Table 34 for

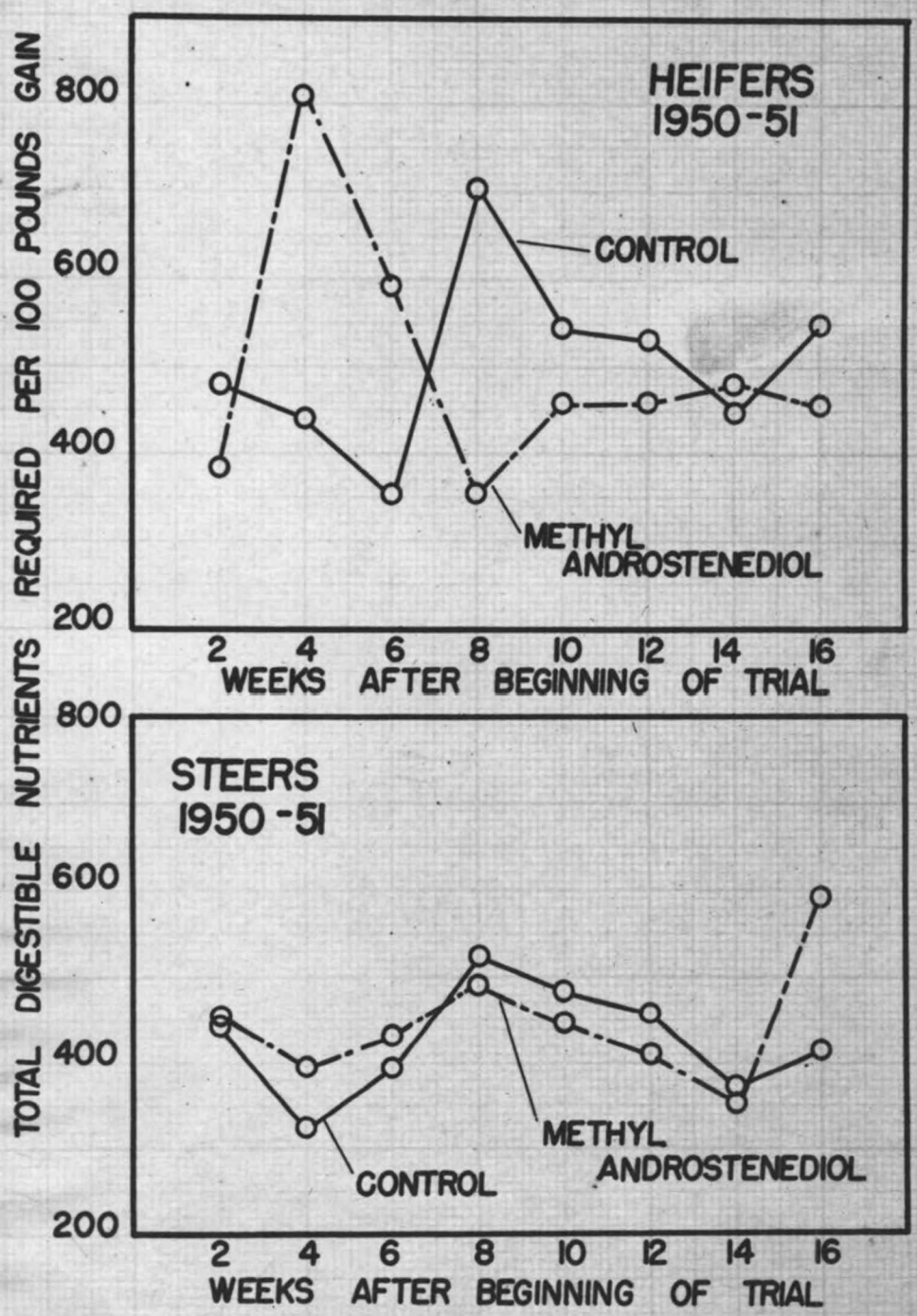


FIGURE 4. THE EFFECT OF METHYL ANDROSTENEDIOL ON TOTAL DIGESTIBLE NUTRIENTS REQUIRED PER 100 POUNDS GAIN.

Table 34. The effect of testosterone on total digestible nutrients (in pounds) required per 100 pounds gain in the 1950-51 trial

Treatment groups	Sex Groups		
	Heifers	Steers	Both Sexes
Testosterone	393	365	379
Control	507	430	468
Advantage of testosterone	114	65	89

the 1950-51 trial and in Table 35 for the 1951-52 trial.

Table 35. The effect of testosterone on total digestible nutrients (in pounds) required per 100 pounds gain in the 1951-52 trial

Treatment groups	Sex Groups		
	Heifers	Steers	Both Sexes
Testosterone	379	369	374
Control	498	398	448
Advantage of testosterone	119	29	74

The testosterone-treated and the control groups were significantly different in the amount of total digestible nutrients required for each 100 pounds gain in body weight in the 1950-51 trial (Table 24). In the 1951-52 trial, a significant interaction of sex and hormone treatment existed in their effects on total digestible nutrients required per 100 pounds gain in body weight (Table 34). In the 1950-51 trial, Table 34, the testosterone-treated calves required 89 pounds less total digestible nutrients than did non-treated control calves for each 100 pounds increase in body weight during the entire test period. Heifers treated with testosterone gained each 100 pounds

on 114 pounds less total digestible nutrients than control heifers, while testosterone-treated steers gained each 100 pounds on 65 pounds less total digestible nutrients than were required by control steers. In the 1951-52 trial, the testosterone-treated calves gained each 100 pounds on 374 pounds of total digestible nutrients while the control calves required 448 pounds for each 100 pounds of gain (Table 35). The heifers receiving testosterone treatment required 119 pounds less total digestible nutrients per each 100 pounds of gain than did control heifers. Steer calves treated with testosterone required 29 pounds less total digestible nutrients than control steers for each 100 pounds increase in body weight. Testosterone-treated steers had an advantage of only 10 pounds of total digestible nutrients on this basis over the testosterone-treated heifers, while control steers had an advantage of 100 pounds over the control heifers.

During the period from 675 to 800 pounds live weight, the calves in the 1950-51 trial which received testosterone required 370 pounds of total digestible nutrients per 100 pounds of gain while the control calves required 487 pounds for an equal gain (Table 36). The advantage of testosterone-treated steers over control steers was 111 pounds of total digestible nutrients required per 100 pounds gain, while the advantage of testosterone-treated heifers over control heifers was 123 pounds. The testosterone-treated steers were more efficient during the period from 675 to 800 pounds live weight than during the entire test period,

Table 36. The effect of testosterone on total digestible nutrients (in pounds) required per 100 pounds gain during the period from 675 to 800 pounds live weight in the 1950-51 trial

Treatment groups	Sex Groups		
	Heifers	Steers	Both sexes
Testosterone	409	331	370
Control	532	442	487
Advantage of testosterone	123	111	117

(Tables 34 and 36), while the other treatment and sex subgroups were less efficient during this period than for the overall test period. The amounts of total digestible nutrients required for each 100 pounds gain in this period for the testosterone-treated and control groups differed significantly in the 1950-51 trial (Table 26) and in the 1951-52 trial (Table 30). Calves receiving testosterone in the 1951-52 trial consumed, on the average, 379 pounds of total digestible nutrients per each 100 pounds gain during the period from 675 to 800 pounds live weight, while the comparative consumption of control calves was 470 pounds (Table 37). The reduction

Table 37. The effect of testosterone on the total digestible nutrients (in pounds) required per 100 pounds gain during the period from 675 to 800 pounds live weight in the 1951-52 trial

Treatment groups	Sex Groups		
	Heifers	Steers	Both Sexes
Testosterone	404	354	379
Control	516	423	470
Advantage of testosterone	112	69	91

of total digestible nutrients required per 100 pounds of gain by testosterone treatment was 69 pounds for steer calves and 112 pounds for heifer calves during the period from 675 to 800 pounds live weight.

The average total digestible nutrients consumed for each 100 pounds gain during consecutive two-week periods after beginning of the feed test period is presented in Table 33 for heifers and steers in the 1950-51 trial and in Table 38 for heifers and steers in the 1951-52 trial. The trend of these feed utilization estimates is shown graphically in Figures 5 and 6 for the 1950-51 and 1951-52 trials, respectively. The total digestible nutrients required per

Table 38. The effect of testosterone on the average total digestible nutrients (pounds) required for 100 pounds gain in weight of steers and heifers in the 1951-52 trial

Weeks after beginning of test	Treatment groups			
	Control		Testosterone	
	Heifers	Steers	Heifers	Steers
2	457	348	361	452
4	529	403	389	461
6	573	404	419	389
8	502	357	344	359
10	368	444	300	342
12	607	440	430	370
14	557	410	425	392

100 pounds gain of the testosterone-treated groups is generally considerably lower than that of comparable control groups. The difference in this trait between the two sexes does not show a consistent upward or downward trend with the successive two-week periods.

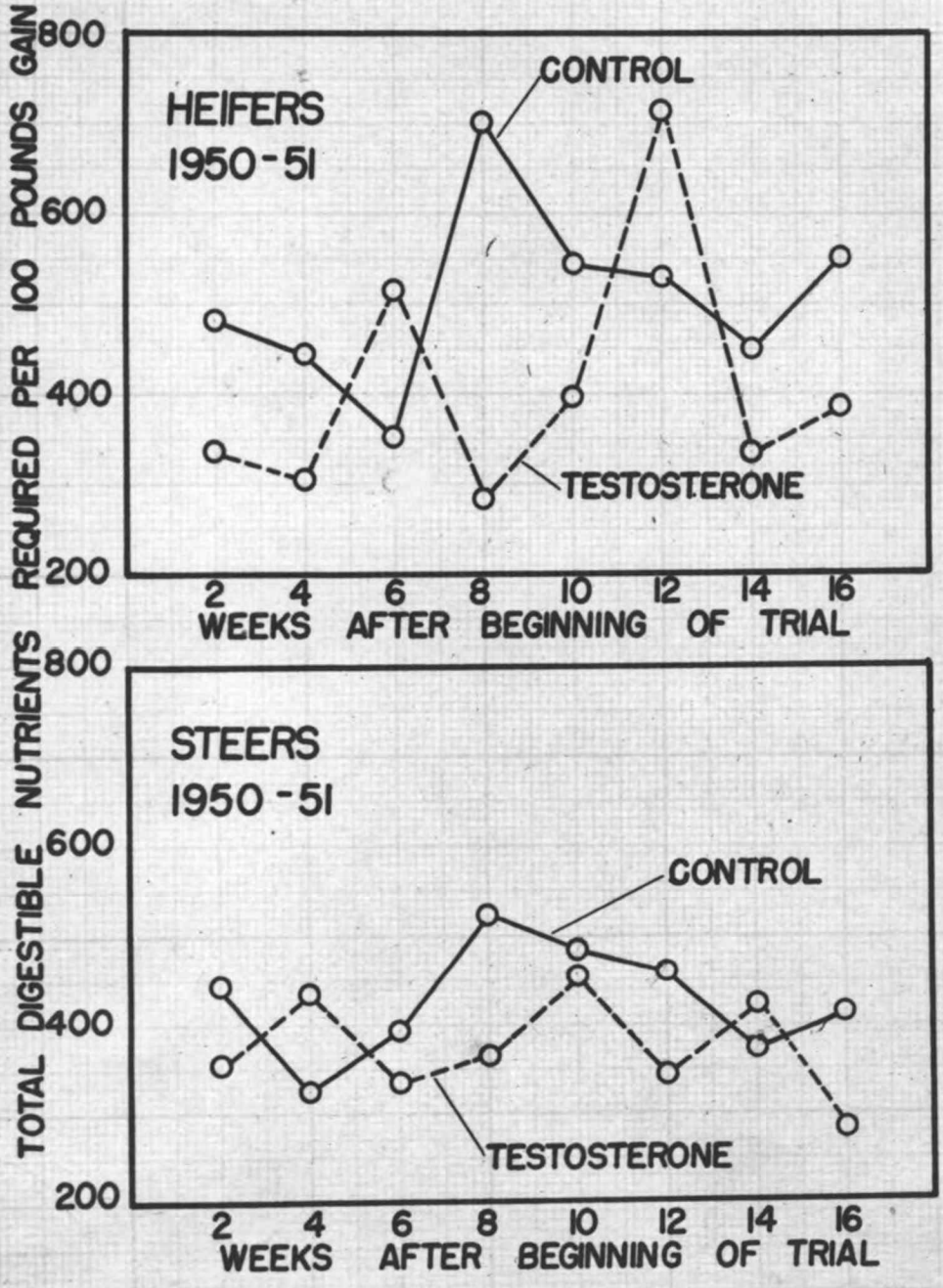


FIGURE 5. THE EFFECT OF TESTOSTERONE ON TOTAL DIGESTIBLE NUTRIENTS REQUIRED PER 100 POUNDS GAIN.

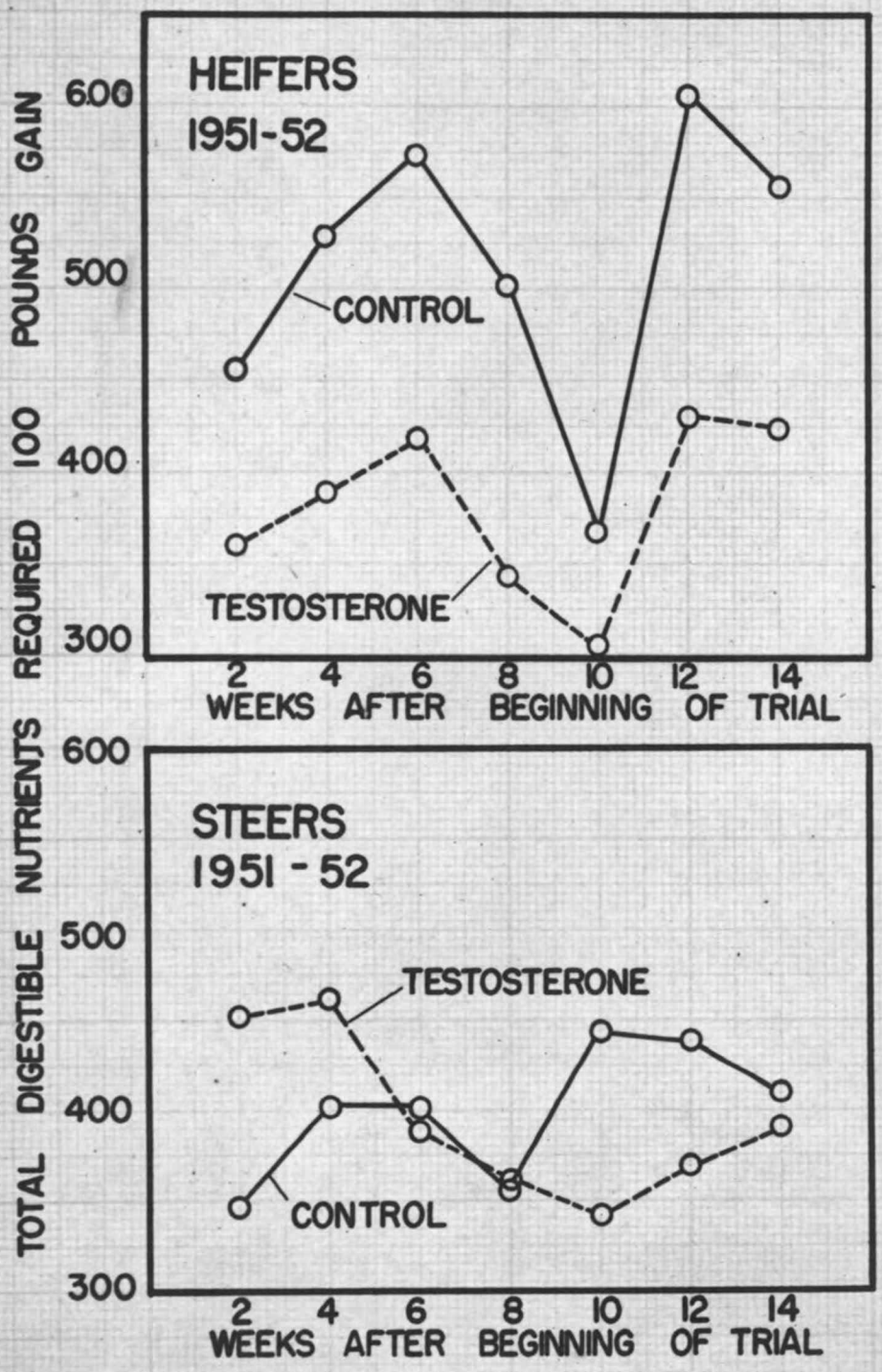


FIGURE 6. THE EFFECT OF TESTOSTERONE ON TOTAL DIGESTIBLE NUTRIENTS REQUIRED PER 100 POUNDS GAIN.

Effect of methyl testosterone

No significant differences in the total digestible nutrients required per 100 pounds gain existed between the four treatment groups in the methyl testosterone feeding trial (Table 40). The group of control calves required 444 pounds of total digestible nutrients for each 100 pounds gain in body weight (Table 39).

Table 39. The effect of various levels of methyl testosterone on the total digestible nutrients required per 100 pounds gain of steer calves

	Weekly intake of hormone (mg/kg body weight)			
Individual Average	0.00	0.25	0.50	1.00
	387	501	427	481
	466	474	438	466
	477	479	528	459
	447	523	470	446
	450	414	443	441
	439	367	- -	484
Treatment Average	444	460	461	463
Advantage of Control Group	-	16	17	19

Table 40. Analysis of variance of the effect of various levels methyl testosterone on the total digestible nutrients required per 100 pounds gain

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	19	429	.26
Error	3	1,648	

Each of the hormone-fed treatment groups were slightly less efficient than the control group, requiring more feed for each unit of gain.

The deviations were so slight as not to be a good indication of trend in efficiency with increasing levels of hormone treatment.

Effect of sires

Total digestible nutrients consumed for each unit gain for the three sire progeny groups in the 1950-51 trial (Table 24) and in the 1951-52 trial (Table 28) were not significantly different. The difference between the most efficient and least efficient progeny groups in the 1950-51 trial was 26 pounds of total digestible nutrients while in the 1951-52 trial the range was 20 pounds of total digestible nutrients (Table 41).

Table 41. The effect of sires on the total digestible nutrients (in pounds) per 100 pounds gain in body weight

Year of hormone trials	Sire groups			
	Sire 14	Sire 15	Sire 17	Sire 71
1950-51	453	- -	433	459
1951-52	402	405	425	- -

During the period from 675 to 800 pounds live weight no significant differences existed between the total digestible nutrients required per unit gain for the three sire groups in the 1950-51 trial (Table 26). However, in the 1951-52 trial a significant difference was found between the three sire groups (Table 30). The most efficient sire group in the 1950-51 trial required 36 pounds less total digestible nutrients than the least efficient, while in the 1951-52 trial the most efficient sire progeny group required

45 pounds less total digestible nutrients per hundred pounds gain than the least efficient (Table 42). The calves of Sire 14 were the least efficient group in converting feeds to body gain in the 1950-51 trial, but were the most efficient group in the 1951-52 trial.

Table 42. The effect of sires on the total digestible nutrients (in pounds) required per 100 pounds gain in body weight during period from 675 to 800 pounds live weight

	Sire groups			
	Sire 14	Sire 15	Sire 17	Sire 71
1950-51 trial	476	- -	440	474
1951-52 trial	407	413	452	- -

Effect of sex

A significant effect due to sex differences in feed requirements per unit gain in body weight in the overall test period occurred in the 1950-51 trial (Table 24) and in the 1951-52 trial (Table 28). The effects of sex differences in the response to injection of testosterone are shown in Tables 34 and 35 above. Steer calves required 57 and 55 pounds less total digestible nutrients in the 1950-51 and 1951-52 trials, respectively, for each 100 pounds increase in body weight than did the heifer calves in the corresponding trials (Table 43). These advantages of the steers over heifers in efficiency of feed utilization result in an advantage of 56 pounds of total digestible nutrients of the steers for both trials. A similar condition exists during the period from 675 to 800 pounds

Table 43. The effect of sex of calf upon the total digestible nutrients (in pounds) required per 100 pounds gain in body weight

Sex	1950-51 trial	1951-52 trial	Both trials
Heifers	477	438	458
Steers	420	383	402
Advantage of steers	57	55	56

live weight where a significant difference occurred between the efficiency of feed utilization for body gains of heifers and steers in both the 1950-51 and 1951-52 trials (Table 44). Steer calves

Table 44. The effect of sex of calf upon the total digestible nutrients (in pounds) required per 100 pounds gain in body weight of heifers and steers during the period from 675 to 800 pounds live weight

Sex	1950-51 trial	1951-52 trial	Both trials
Heifers	505	460	483
Steers	421	389	405
Advantage of steers	84	71	78

gained each 100 pounds on 84 pounds less total digestible nutrients than heifer calves during this period in the 1950-51 trial and on 71 pounds less total digestible nutrients in the 1951-52 trial during this period (Table 44). The heifers were much less efficient during this later period than during the overall test period, while the steers were about as efficient in this period as in the overall test period (Tables 43 and 44).

Average daily gain

The regression of total digestible nutrients required per 100 pounds of gain on the average daily gain in the 1950-51 trial was equal to -178 indicating that for each increase of one pound per day in average daily gain, there was a corresponding average decrease of 178 pounds of total digestible nutrients required for each 100 pounds of gain. In the 1951-52 trial, this regression was equal to -166 indicating that for each increase of one pound per day of average daily gain, there was a corresponding average decrease of 166 pounds of total digestible nutrients required per 100 pounds of gain. This source of variation accounted for 94% and 84% of the variance of total digestible nutrients required per 100 pounds gain in the 1950-51 and 1951-52 trials, respectively. The analysis of covariance of total digestible nutrients required for each hundred pounds gain adjusted for the effect of average daily gain for the 1950-51 hormone trial is given in Table 45 and for the 1951-52 trial in Table 46. The data in Table 45 indicate that after adjustment for the effect of average daily gain, a significant interaction exists between sires and treatments in the 1950-51 trial. The data in Table 46 indicate that after adjustment for the effect of average daily gain on total digestible nutrients per 100 pounds gain, a significant effect of hormone treatments on feed efficiency still exists. However, the effects of sex on total digestible nutrients required per 100 pounds gain adjusted for differences due to average daily gain were not

significant in either the 1950-51 or 1951-52 trials.

Table 45. Analysis of covariance of the effect of testosterone and methyl androstenediol treatments, sire, and sex upon total digestible nutrients required per 100 pounds gain adjusted for rate of gain of calves in the 1950-51 trial

Source of variance	Degrees of Freedom	Adjusted Mean Square	F
Treatments	2	706.13	1.79
Sires	2	305.51	.78
Sexes	1	261.89	3.33
Treatments x sires	4	394.34	4.99*
Treatments x sexes	2	55.22	.67
Sires x sexes	2	100.62	1.28
Treatments x sires x sexes	4	120.48	2.64
Error	5	45.68	
Pooled error (1)	9	78.93	
Pooled error (2)	13	78.62	

* Indicates statistical significance at .05

Table 46. Analysis of covariance of the effect of testosterone, sire, and sex upon total digestible nutrients required per 100 pounds gain adjusted for rate of gain of calves in the 1951-52 trial

Source of variance	Degrees of Freedom	Adjusted Mean Square	F
Treatments	1	6,286.68	2.70
Sires	2	282.46	.60
Sexes	1	1,174.02	.50
Treatments x sires	2	196.64	.42
Treatments x sexes	1	2,327.88	4.97*
Sires x sexes	2	186.17	.40
Treatments x sires x sexes	2	482.24	
Error	11	466.31	
Pooled error (1)	13	468.76	

Daily intake of total digestible nutrients

The average daily intake of total digestible nutrients during the entire test period is given in Table 47 for calves in the various treatment, sire and sex groups in the 1950-51 trial.

Corresponding information for calves in the 1951-52 trial is given in Table 51. The analysis of variance of factors contributing to the variations in average daily intake of total digestible nutrients for the entire feeding period is given in Table 48 for the 1950-51 trial and in Table 52 for the 1951-52 trial. The average daily intake of total digestible nutrients during the period from 675 to 800 pounds live weight for calves in the various treatment, sire and sex groups in the 1950-51 trial is given in Table 49, and for calves in the 1951-52 trial in Table 53. The analysis of variance of the effects of these sources of variation on average daily intake of total digestible nutrients is given in Table 50 for the 1950-51 trial and in table 54 for the 1951-52 trial.

Effect of methyl androstenediol

The injection of methyl androstenediol had no significant effect on the average daily intake of total digestible nutrients in the overall feeding period (Table 48). The average daily feed consumption for calves receiving methyl androstenediol was, however, slightly less than that of the other treatment groups (Table 55). The average daily intake of total digestible nutrients by the methyl androstenediol-treated calves during the period from 675 to 800 pounds live weight was significantly lower than the intake of control calves (Table 50) during the same period. The control calves (Table 56) had an average daily intake of 11.56 pounds of total digestible nutrients during this period while the methyl

Table 47. The effect of methyl androstenediol and testosterone treatments, sire, and sex upon the daily intake of total digestible nutrients of calves in the 1950-51 trial

Sire and sex groups	Treatment groups			Sire and Sex Averages
	Control	Testosterone	Methyl Androstenediol	
	Average daily intake of total digestible nutrients (pounds)			
Sire 14				
Heifers	9.90	9.88	9.59	9.82
Steers	10.02	9.60	9.53	9.79
Average	9.96	9.74	9.56	9.81
Sire 17				
Heifers	10.35	10.24	9.77	10.18
Steers	10.41	10.40	9.87	10.27
Average	10.38	10.32	9.82	10.22
Sire 71				
Heifers	10.21	9.67	9.81	9.98
Steers	10.00	9.32	10.50	9.95
Average	10.10	9.50	10.15	9.96
Treatment Averages				
Heifers	10.14	9.77	9.97	10.01
Steers	10.15	9.93	9.72	10.00
Average	10.15	9.85	9.84	10.00

Table 48. Analysis of variance of the effect of methyl androstenediol and testosterone treatments, sire and sex upon the daily intake of total digestible nutrients of calves in the 1950-51 trial

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	2	.2656	2.91
Sires	2	.3564	3.91
Sexes	1	.0014	.02
Treatments x sires	4	.1796	2.30
Treatments x sexes	2	.0617	.79
Sires x sexes	2	.0092	.12
Treatments x sexes x sires	4	.0689	.82
Error	6	.0842	
Pooled error (1)	10	.0781	
Pooled error (2)	18	.0912	

Table 49. The effect of methyl androstenediol and testosterone treatments, sire, and sex upon the daily intake of total digestible nutrients during period from 675 to 800 pounds live weight of calves in the 1950-51 trial

Sire and sex groups	Treatment groups			Sire and sex Averages
	Control	Testosterone	Methyl Androstenediol	
	Average daily intake of total digestible nutrients (pounds)			
Sire 14				
Heifers	11.74	11.56	10.34	11.35
Steers	10.94	10.70	10.58	10.79
Average	11.34	11.13	10.46	11.07
Sire 17				
Heifers	11.73	10.77	11.08	11.33
Steers	12.33	11.74	10.60	11.75
Average	12.03	11.26	10.84	11.54
Sire 71				
Heifers	11.74	10.81	11.15	11.36
Steers	10.90	10.61	11.30	10.93
Average	11.32	10.71	11.23	11.14
Treatment averages				
Heifers	11.74	11.05	10.86	11.34
Steers	11.39	11.02	10.83	11.16
Average	11.56	11.03	10.84	11.25

Table 50. Analysis of variance of average daily intake of total digestible nutrients during period from 675 to 800 pounds of calves in the 1950-51 trial

Source of Variance	Degrees of Freedom	Mean Square	F.
Treatments	2	1.2323	4.52*
Testosterone vs. others	1	.3813	1.40
Methostan vs control	1	2.0832	7.64*
Sires	2	.5119	1.88
Sexes	1	.2128	.78
Treatments x sires	4	.2987	1.23
Treatments x sexes	2	.0755	.31
Sires x sexes	2	.5672	2.34
Treatments x sexes x sires	4	.3058	1.52
Error	6	.2006	
Pooled error (1)	10	.2427	
Pooled error (2)	18	.2726	

* Indicates statistical significance at .05

Table 51. The effect of testosterone treatment, sire and sex upon the daily intake of total digestible nutrients of calves in the 1951-52 trial

Sire and Sex groups	Treatment groups		Sire and sex Averages
	Control	Testosterone	
	Average daily intake of total digestible nutrients (lbs)		
Sire 14			
Heifers	10.61	9.40	10.00
Steers	10.06	10.36	10.21
Average	10.34	9.88	10.11
Sire 15			
Heifers	10.28	10.41	10.34
Steers	10.76	9.88	10.32
Average	10.52	10.14	10.33
Sire 17			
Heifers	10.27	9.81	10.04
Steers	10.61	9.92	10.27
Average	10.44	9.87	10.15
Treatment averages			
Heifers	10.39	9.89	10.13
Steers	10.48	10.05	10.26
Average	10.43	9.96	10.20

Table 52. Analysis of variance of the effect of testosterone treatment, sire and sex upon the daily intake of total digestible nutrients of calves in the 1951-52 trial

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	1	1.3179	4.11
Sires	2	.1141	.36
Sexes	1	.1091	.34
Treatments x sires	2	.0191	.05
Treatments x sexes	1	.0117	.03
Sires x sexes	2	.0038	.01
Treatments x sires x sexes	2	.8787	2.50
Error	12	.3510	
Pooled error (1)	14	.4264	
Pooled error (1)	19	.3208	

Table 53. The effect of testosterone treatment, sire and sex upon the daily intake of total digestible nutrients during the period from 675 to 800 pounds live weight of calves in the 1951-52 trial

Sex and sire groups	Treatment groups		Sire and sex Averages
	Control	Testosterone	
	Average daily intake of total digestible nutrients (lbs)		
Sire 14			
Heifers	11.91	10.85	11.38
Steers	11.52	11.36	11.44
Average	11.71	11.10	11.41
Sire 15			
Heifers	11.63	11.89	11.76
Steers	11.82	11.23	11.52
Average	11.72	11.56	11.64
Sire 17			
Heifers	11.36	10.77	11.06
Steers	12.08	11.19	11.63
Average	11.72	10.98	11.35
Treatment averages			
Heifers	11.63	11.17	11.40
Steers	11.81	11.26	11.53
Average	11.72	11.21	11.46

Table 54. Analysis of variance on daily intake of total digestible nutrients during period from 675-800 pounds of calves in the 1951-52 trial

Source of Variation	Degrees of Freedom	Mean Square	F.
Treatments	1	1.525	5.37*
Sires	2	.192	.68
Sexes	1	.100	.35
Treatments x sires	2	.181	.58
Treatments x sexes	1	.012	.04
Sires x sexes	2	.330	1.06
Treatments x sires x sexes	2	.405	1.37
Error	12	.296	
Pooled error (1)	14	.312	
Pooled error (2)	19	.284	

* indicates statistical significance at .05

androstenediol-treated calves had an average daily intake of 10.84 pounds. The average daily intake of total digestible nutrients

Table 55. The effect of male hormones on the average daily intake of total digestible nutrients (in pounds)

Treatment	1950-51 trial	1951-52 trial
Methyl androstenediol	9.84	- - -
Testosterone	9.85	9.96
Control	10.15	10.43

Table 56. The effect of male hormones on the average daily intake of total digestible nutrients (in pounds) during the period from 675 to 800 pounds live weight

Treatment	1950-51 trial	1951-52 trial
Methyl androstenediol	10.84	- - -
Testosterone	11.03	11.21
Control	11.56	11.72

during consecutive two-week periods after beginning of the feed test is given in Table 57 for heifers and steers in the control and methyl androstenediol treatment groups. The trend of average daily feed intake for these periods is presented graphically in Figure 7. The average daily feed intake of the methyl androstenediol-treated steers was quite consistently lower than that of control steers after the fourth week of the trial. The methyl androstenediol-treated heifers were lower in daily intake of total digestible nutrients than control heifers for the first eight weeks of the trial. For the next eight weeks the daily feed consumption of control heifers was lower than that of methyl androstenediol-treated heifers.

Table 57. The effect of methyl androstenediol and testosterone treatments on the average daily intake of total digestible nutrients (pounds) of heifer and steer calves in the 1950-51 male trial

Weeks after beginning of test	Treatment groups					
	Control		Testosterone		Methyl androstenediol	
	Heifers	Steers	Heifers	Steers	Heifers	Steers
2	8.47	8.12	8.48	8.32	8.10	8.48
4	8.93	8.78	8.67	8.77	8.31	9.00
6	9.15	9.61	9.27	9.18	8.38	8.85
8	9.15	10.00	9.78	9.46	8.64	9.47
10	8.97	10.05	10.15	9.59	9.46	9.97
12	9.56	10.79	10.26	10.69	9.91	9.96
14	10.42	10.53	10.26	10.91	10.53	10.52
16	10.97	10.93	11.03	10.84	11.03	11.03

Effect of testosterone

The effects of testosterone on the average daily intake of total digestible nutrients were not significant either in the 1950-51 trial (Table 48) or in the 1951-52 trial (Table 52). The average daily intake of total digestible nutrients was lower, however, for the testosterone-treated calves than for the control calves in both trials conducted (Table 55). During the period from 675 to 800 pounds live weight, the average daily intake of total digestible nutrients of testosterone-treated calves was not significantly different from that of control calves in the 1950-51 trial (Table 50). In the 1951-52 trial, a significant difference existed between the average daily intake of total digestible nutrients of these treatment groups during this period (Table 54). The testosterone-treated calves consumed 0.53 and 0.51 pounds less total digestible nutrients daily in the 1950-51 trial and the 1951-52

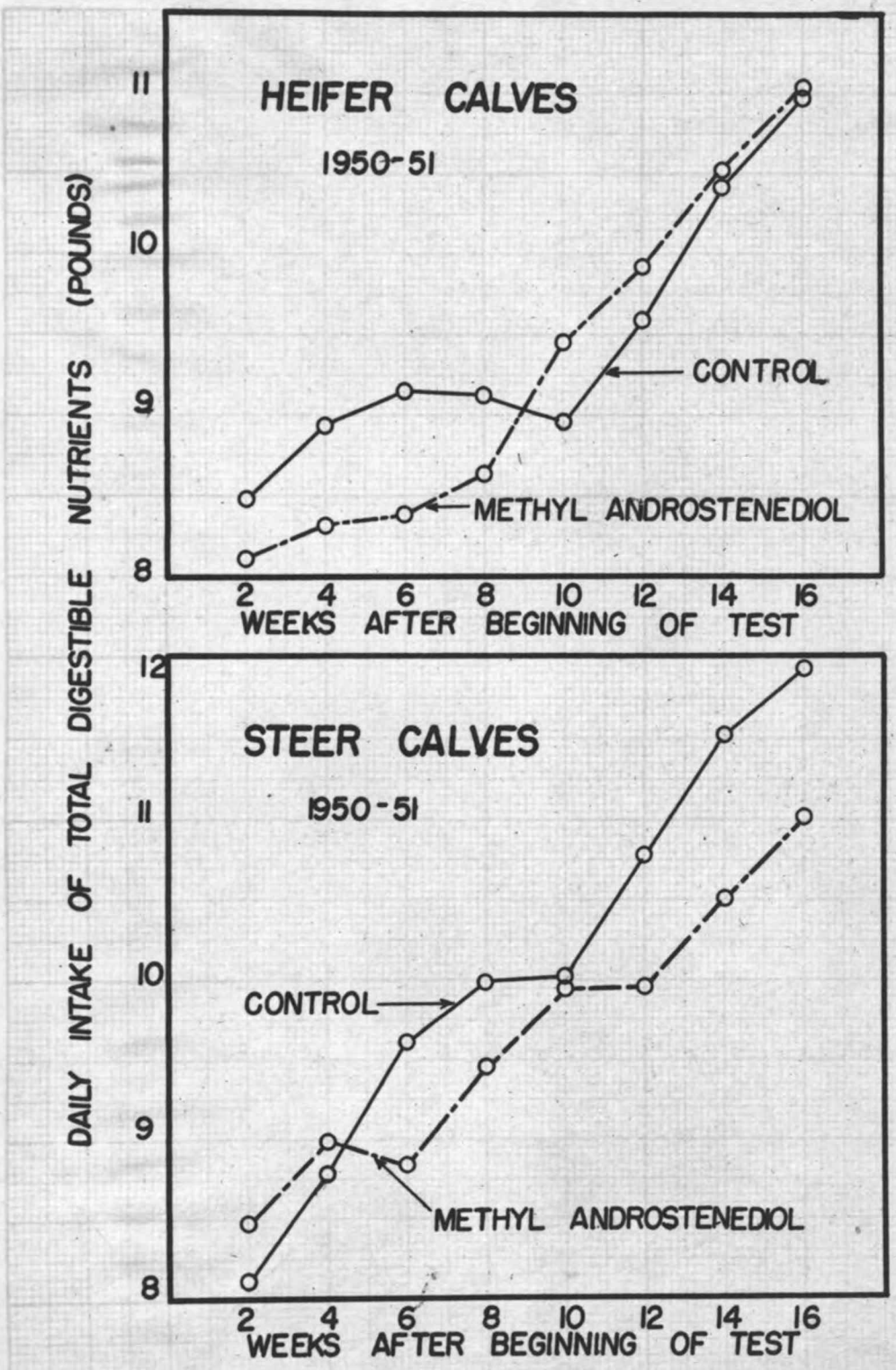


FIGURE 7. THE EFFECT OF METHYL ANDROSTENEDIOL ON DAILY INTAKE OF TOTAL DIGESTIBLE NUTRIENTS

trial, respectively, than the corresponding control calves (Table 56), during the period from 675 to 800 pounds live weight. The average daily intake of total digestible nutrients during consecutive two week periods after beginning of the feed test is given in Table 57 for heifers and steers in the control and testosterone-treated groups in the 1950-51 trial and in Table 58 for heifers and steers in the 1951-52 trial. The trend of average daily feed intake of these groups is presented graphically in Figures 8 and 9 for the 1950-51 and 1951-52 trials, respectively

Table 58. The effect of testosterone on the average daily intake of total digestible nutrients (pounds) of steer and heifer calves in the 1951-52 trial

Weeks after beginning of test	Treatment groups			
	Control		Testosterone	
	Heifers	Steers	Heifers	Steers
2	8.81	8.96	8.60	8.94
4	9.45	9.16	8.90	8.78
6	9.97	9.51	8.78	9.53
8	9.86	10.37	9.32	9.88
10	10.33	11.11	9.94	10.46
12	10.76	11.41	10.39	10.88
14	10.52	11.67	11.28	11.48

Effect of sires

A significant difference existed between the average daily intake of total digestible nutrients of the three sire groups in the 1950-51 trial (Table 48). During the overall feeding period there was a .41 pound difference between the high and low sire groups in daily intake (Table 58). Calves of sire 17 had the highest

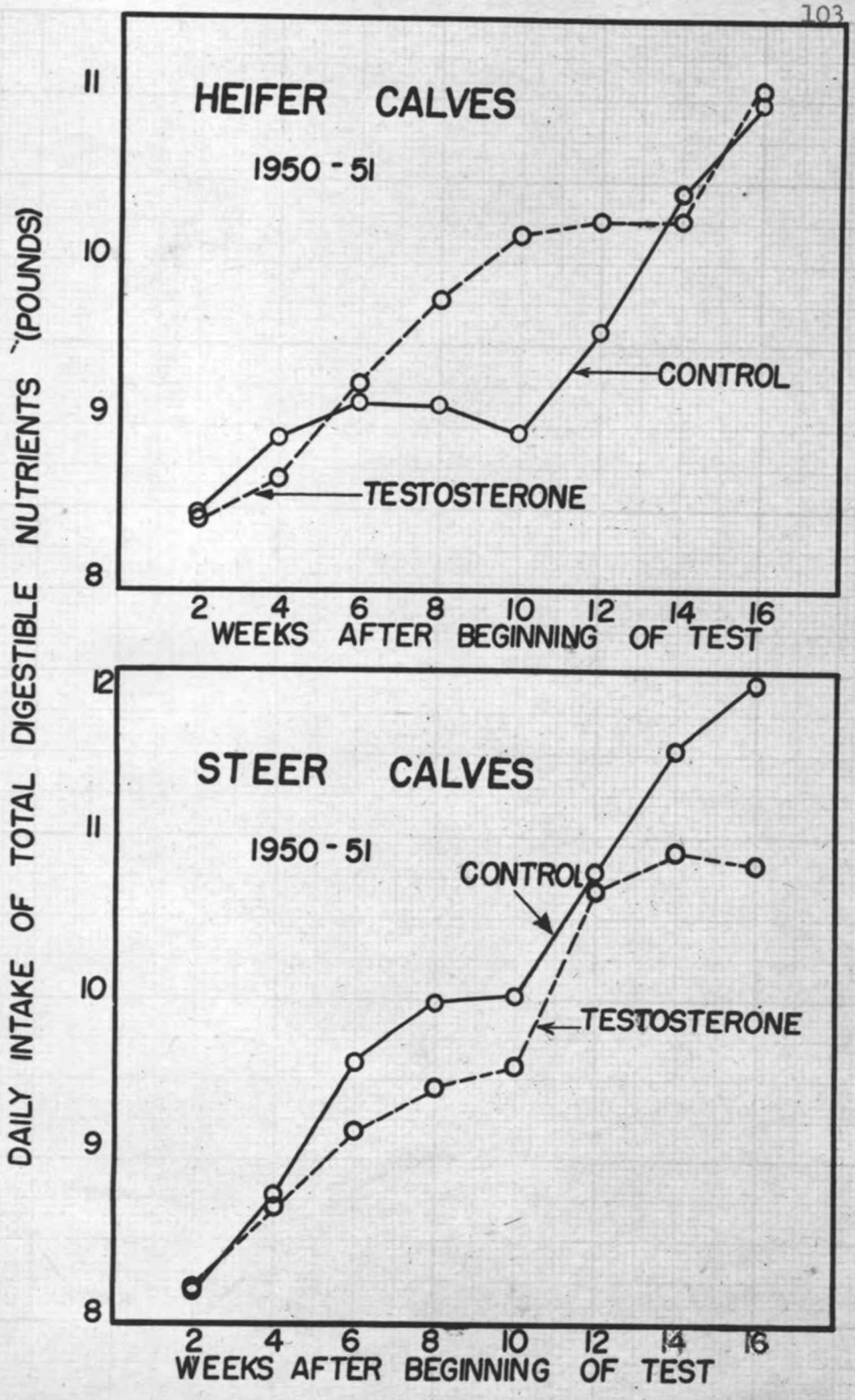


FIGURE 8. THE EFFECT OF TESTOSTERONE ON DAILY INTAKE OF TOTAL DIGESTIBLE NUTRIENTS.

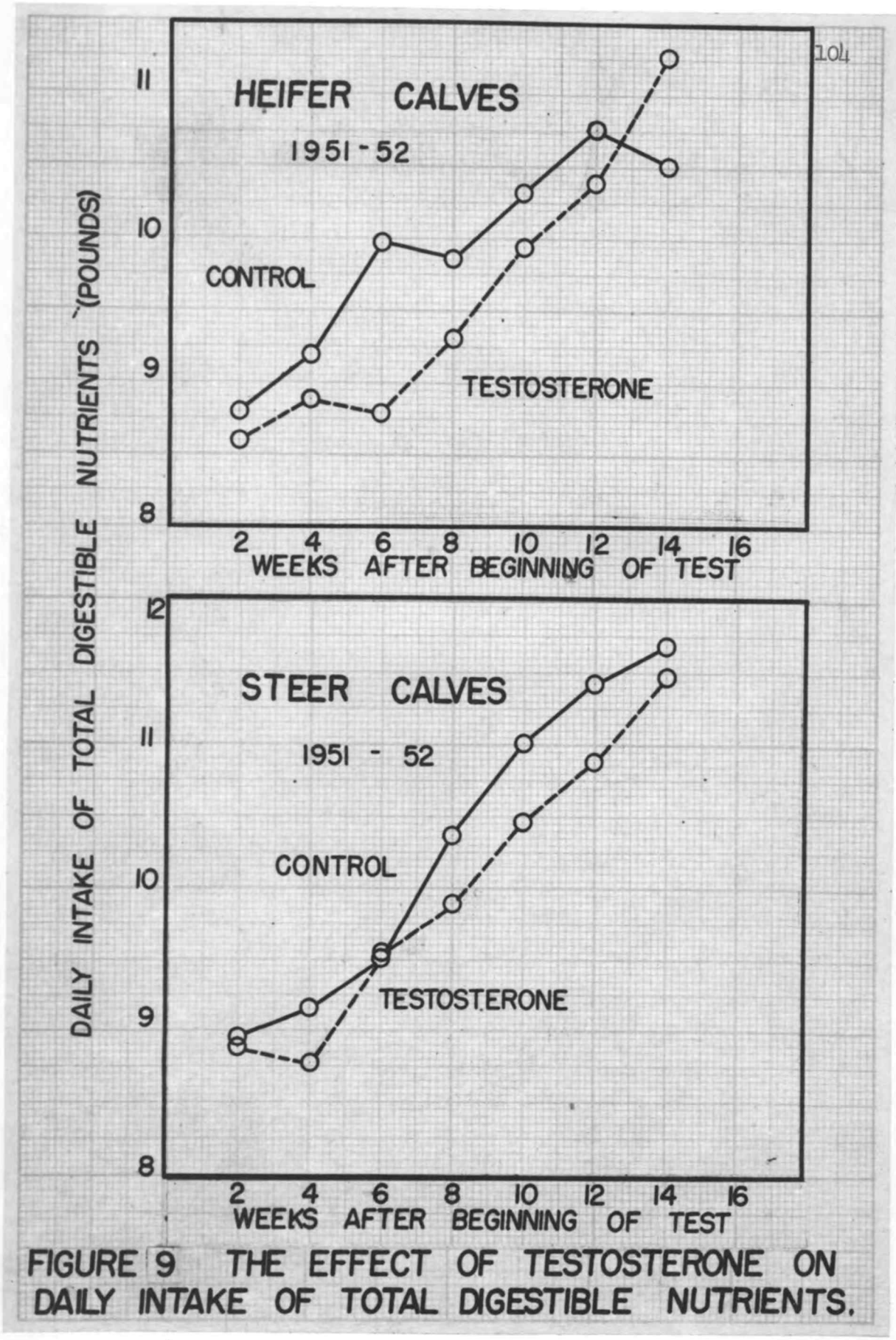


FIGURE 9 THE EFFECT OF TESTOSTERONE ON DAILY INTAKE OF TOTAL DIGESTIBLE NUTRIENTS.

average daily intake of total digestible nutrients, 10.22 pounds (Table 59), the greatest average daily gain, 2.42 pounds (Table 19), and the least requirements of total digestible nutrients per pound of gain, 433 pounds (Table 41) of the three sire groups in the 1950-51 trial. A significant difference of sire groups in average daily intake of total digestible nutrients was also found in the 1950-51 trial during the period from 675 to 800 pounds live weight (Table 50). Progeny of sire 17 had the greatest average daily intake in this period (Table 60) as well as during the entire test period. In the 1951-52 trial, the average daily intake of total digestible nutrients for the sire groups was not significantly different in either the period from 675 to 800 pounds live weight (Table 54), or in the overall feeding period (Table 52). The Average daily intake of the sire groups for these period are given in Tables 59 and 60.

Table 59. The effect of sire upon the average daily intake of total digestible nutrients (in pounds)

Year of trial	Sire 14	Sire 15	Sire 17	Sire 71
1950-51 trial	9.81	- - -	10.22	9.96
1951-52 trial	10.11	10.33	10.15	- - -

Table 60. The effect of sire upon the average daily intake of total digestible nutrients (in pounds) during the period from 675 to 800 pounds live weight

Year of trial	Sire 14	Sire 15	Sire 17	Sire 71
1950-51 trial	11.07	- - -	11.54	11.14
1951-52 trial	11.41	11.64	11.35	- - -

Effect of sex

The average daily intake of heifers and steers did not differ significantly in either the 1950-51 trial (Table 48) or in the 1951-52 trial (Table 52). The average daily intake of heifer and steer groups during the period from 675 to 800 pound live weight was not significantly different in either the 1950-51 trial (Table 50) or in the 1951-52 trial (Table 54). Data in Tables 61 and 62 indicate that there is little difference between the heifer and steer groups in average daily intake of total digestible nutrients in these trials.

Table 61. The effect of sex upon the average daily intake of total digestible nutrients (in pounds)

Sex of calves	1950-51 trial	1951-52 trial
Heifers	9.90	10.13
Steers	10.01	10.26

Table 62. The effect of sex upon the average daily intake of total digestible nutrients (in pounds) during period from 675 to 800 pounds live weight

Sex of calves	1950-51 trial	1951-52 trial
Heifers	11.34	11.40
Steers	11.16	11.53

Hormonal alteration of carcass characteristics

The traits which determine the value of the live animal for human consumption are best measured by carcass observations after slaughter. Perhaps the first consideration is dressing percent

since this represents the percent yield of marketable meat. The slaughter grade based on conformation and condition in a given market class determines under present conditions the value per pound of carcass. The percent of round, hindquarter and chuck represent the weight distribution and, therefore, percent of the certain marketable cuts. The percent of fat in the carcass determines finish and therefore price, but high finish also means more waste fat products. The percent of flesh to bone-plus-flesh gives a measure of the relative amounts of meat and bone and is of importance in determining the food value of meat. A study of these carcass characteristics also gives valuable information on the ability of treatment conditions to change the normal distribution of meat, fat, and bone in the animal body. Thus, for example, if differences exist between the two sexes in percent of round, the use of sex hormones might be expected to affect the percent of round. The effect of hormones and sex on dressing percent and percent of hindquarter, round and chuck are given in Tables 63 and 64 for the 1950-51 and 1951-52 trials, respectively. Carcass grades of the calves in these trials are given in Table 65.

Effect of methyl androstenediol

The methyl androstenediol-treated calves were not significantly different from control calves in any of these traits. The difference between the control and methyl androstenediol-treated

Table 63. The effect of methyl androstenediol and testosterone treatments and sex on various carcass characteristics

	Control group			Testosterone			Methyl androstenediol		
	Heifers	Steers	Average	Heifers	Steers	Average	Heifers	Steers	Average
Dressing percent	61.1	58.8	60.0	59.7	58.2	58.9	58.3	58.6	58.5
Percent of hindquarter	50.9	49.4	50.1	50.0	49.2	49.6	50.4	48.8	49.6
Percent of round	20.1	22.1	21.1	22.9	24.7	23.8	20.9	21.4	21.2
Percent of chuck	25.5	27.5	26.5	27.8	27.0	27.4	25.1	26.9	26.0

Table 64. The effect of testosterone treatment on various carcass characteristics

	Control group			Testosterone		
	Heifers	Steers	Average	Heifers	Steers	Average
Dressing percent	60.7	59.7	60.2	59.7	60.1	59.9
Percent of hindquarter	51.0	49.8	50.4	50.4	48.9	49.6
Percent of round	19.8	21.6	20.7	21.8	21.0	21.4
Percent of chuck	26.0	27.1	26.6	27.1	28.0	27.6
Percent of flesh to flesh-and-bone	85.3	83.1	84.2	83.6	83.2	83.4

groups is, however, indicative of a possible effect of this hormone in lowering dressing percent.

Effect of testosterone

A significant interaction existed between the sexes and the testosterone treatment in the effect on dressing percent in the 1951-52 trial. The testosterone-treated heifers were 1.0 percent lower in this trial than control heifers, while control and testosterone-treated steers were very similar in dressing percent. The apparent reduction of dressing percent by testosterone treatment in the 1950-51 trial was not significant.

The testosterone-treated calves were significantly lower in percent of hindquarter than control calves in the 1951-52 trial. The testosterone-treated calves were 0.5 and 0.8 percent lower in hindquarter than control calves in the 1950-51 and 1951-52 trials, respectively. No significant differences between treatment groups in percent of hind quarter occurred in the 1950-51 hormone trial.

The percent of round of testosterone-treated calves was significantly greater than that of control calves in the 1950-51 trial. The rounds of testosterone-treated calves were 2.7 percent greater than those of control calves in the 1950-51 trial. A significant interaction between the effect of testosterone treatments and sex on the percent of round existed in the 1951-52 hormone trial. The percent of round of testosterone-treated

heifers was greater than that of control heifers, while the percent of round of testosterone-treated steers was less than that of control steers.

A significant difference occurred between the percent of chuck of testosterone-treated and control calves in the 1951-52 trial. The chuck of control calves was 1.0 percent less than that of testosterone-treated calves in that trial. In the 1950-51 trial there was a significant interaction between the hormone treatments and sex in their effects on percent of chuck. The percent of chuck of testosterone-treated heifers was greater than that of control heifers, while the percent of chuck of testosterone-treated steers was less than that of control steers. Testosterone produced no significant effect on the percent of flesh to flesh- and bone in the 9-10-11-12 rib roast in the 1951-52 trial.

Effect of sex

Heifers had a significantly higher dressing percent than steers in the 1950-51 trial. In the 1951-52 trial, the difference between sexes in dressing percent was not significant but a significant interaction existed between sex and testosterone treatment. The dressing percent of heifers was 1.4 percent higher than that of steers in the 1950-51 trial and 1.3 percent higher in the 1951-52 trial.

The percent of hindquarter of heifers was significantly higher than that of steers in both the 1950-51 and 1951-52 trials. The

hindquarter of heifers was 1.3 and 1.4 percent greater than that of steers in the 1950-51 and 1951-52 trials respectively.

The percent of round of steers was significantly greater than that of heifers in the 1950-51 trial, but not in the 1951-52 trial. In each case the percent of round of steers was greater than that of heifers (1.6 and 0.5 percent in the 1950-51 and 1951-52 trials). There was, however, no effect of sex on the percent of chuck.

A significant difference between the two sexes in the percent of flesh to flesh-plus-bone occurred in the 1951-52 trial. The percent of flesh to flesh-plus-bone of rib roasts from heifer calves was 84.4%, while that from steer calves was 83.2%.

Carcass grade

Calves receiving methyl androstenediol were quite similar to control calves in carcass grade (Table 65) and there was apparently no effect of this hormone treatment on finish or conformation. The carcass grades of calves receiving testosterone treatment were slightly lower than those of control calves.

Table 65. The effect of methyl androstenediol and testosterone treatments on carcass grades of calves

Treatment groups	1950-51 trial	1951-52 trial
Control	1 prime, 11 choice	8 choice, 4 good
Methyl androstenediol	6 choice	- - - - - -
Testosterone	5 choice, 1 good	4 choice, 8 good

Alteration of meat characteristics

The value and desirability of a sample of meat for human food depends upon the physical and chemical properties of that sample. An entirely objective evaluation of the sample may be a very poor measure of such abstract characteristics as palatability, flavor, texture, and tenderness. However, the mechanical measure of certain traits is desirable when it is known that these traits affect the food value, or have an effect on any of the above characteristics. Protein and caloric content can be determined by chemical analysis. The tenderness is a function of the shearing force required to sever a core sample of constant diameter. A portion of the cooking losses can be measured by determination of the amount of evaporation and the amount of drip accumulated during cooking.

Evaporation loss

The loss due to evaporation is given in Table 66 for meat samples from calves in the treatment and sex groups in the 1951-52 trial. No significant differences in evaporation loss occurred between the sex groups or the treatment groups.

Drip loss

The loss due to drip is given in Table 66 for meat samples from calves in the treatment and sex groups in the 1951-52 trial. A significant interaction occurred between sex and the testosterone

treatment in the effect on drip loss. The drip loss of meat samples from heifer calves was reduced from 4.6 to 2.8% by testosterone treatment, while the drip loss of steer calves was only reduced from 2.8 to 2.5% by the testosterone treatment.

Press fluid

The percent of press fluid of meat samples of calves in the treatment and sex groups in the 1951-52 trial is given in Table 66. Sex and treatment had no significant effect on the press fluid of the meat samples.

Shearing strength

The average force in pounds required to shear a one-inch diameter core sample of cooked meat from calves in the sex and treatment groups in the 1951-52 hormone trial is given in Table 66. A significant interaction occurred between treatment and sex in the effect on shearing strength. The shearing strength of meat samples from heifers was reduced from 13.4 to 12.3 pounds by the administration of testosterone, while the shearing strength of meat samples from steer calves was increased from 9.9 to 15.5 pounds by the testosterone treatment.

Chemical composition of the meat

The chemical composition of meat samples is given in Table 67

Table 66. The effect of testosterone and sex on evaporation and drip losses during cooking, press fluid, and shearing strength of meat samples

	Source of meat samples (treatment groups)					
	Control			Testosterone		
	Heifers	Steers	Average	Heifers	Steers	Average
Evaporation loss (percent) during cooking	8.1	8.9	8.5	9.7	9.7	9.7
Drip loss (percent) during cooking	4.6	2.8	3.7	2.8	2.5	2.6
Press fluid of cooked meat (percent)	59.2	60.5	59.8	58.4	58.6	58.5
Shearing strength (pounds) required to shear 1" diameter core samples	13.4	9.9	11.6	12.3	15.5	13.9

Table 67. The effect of testosterone treatment and sex upon the chemical composition of meat sample of experimental calves

Treatment groups	Percent of Moisture	Dry weight basis		
		Percent of Fat	Percent of Protein	Percent of Ash
Control heifers	46.0	72.2	24.9	1.2
Testosterone-treated heifers	56.8	57.0	41.0	1.9
Control steers*	55.8	51.0	46.9	2.2
Testosterone-treated steers	50.5	47.4	49.6	3.0

* averages based on four samples

for the treatment and sex groups in the 1951-52 trial. The control heifers were much higher in fat content than the other groups and therefore lower in protein and water content. Treatment of heifers with testosterone resulted in a much lower content of fat and increased protein and water content of the meat samples. Although the meat samples from control steers were much lower in fat and higher in protein than meat samples from control heifers, treatment with

testosterone appears to have also decreased the percent of fat in steers; however, the reduction was not as great as with the heifers.

The chemical composition of meat samples from steers receiving methyl testosterone orally is given in Table 68. The meat samples from control steers were higher in fat and lower in protein than the meat samples from calves in various methyl testosterone treatment groups. The moisture and ash content of the control group was

Table 68. The effect of various levels of methyl testosterone on the chemical composition of meat samples from experimental steers

(Weekly intake of hormone mg/ kg body weight)	Percent of Moisture	Dry basis Percent of fat	Dry basis Percent of Protein	Dry basis Percent of Ash
0.00	51.0	65.7	33.2	1.0
0.25	54.6	56.8	41.4	1.8
0.50*	53.4	57.5	40.8	1.7
1.00	56.4	55.4	43.1	1.9

* Average based on five samples

also lower than those of the treated groups.

Estimation of induced hormonal activity

Determinations of gonadotropin and thyrotropin content of the anterior pituitary gland and thyroid hormone content of the thyroid gland were made by biological methods. Histological examination of the thyroid glands were made to check for evidence of inhibition and stimulation. Observations were made on follicular and luteal

development in the ovaries of female calves. Alterations in the activity of either the thyrotropic, gonadotropic, or associated hormones might indicate the route of action of the male hormones or explain the responses in various "target" sites. Thus, each of these observations might be expected to contribute to the understanding of androgenic activity by supplying information on induced hormonal changes.

Thyrotropic hormone content of the anterior pituitary gland

The thyrotropic hormone content of the anterior pituitary of the calves in the three male hormone trials was estimated by the ability of a given percent of the entire gland to stimulate the weight of the thyroid gland of the baby chick. The average thyroid weight of baby chicks receiving injections of anterior pituitary tissue of calves in the various treatment, sex, and sire groups and subgroups is given in Table 69 for the 1950-51 trial. The analysis of variance of the effects of certain of these sources of variation is given in Table 70. The average thyroid weight of chicks receiving injections of anterior pituitary tissue of calves in the various treatment, sex and sire groups and subgroups in the 1951-52 trial is given in Table 71. The analysis of variance of the effects of certain of these sources of variation are given in Table 72.

Table 69. The effect of testosterone and methyl androstenediol treatments, sire and sex upon the ability of the anterior pituitary gland of calves in the 1950-51 trial to stimulate the weight of baby chick thyroid glands

Sire and sex groups	Treatment groups			Sire and sex Averages
	Control	Testosterone	Methyl Androstenediol	
	Average weight of chick thyroid glands (mg.)			
Sire 14				
Heifers	4.56	5.08	3.98	4.54
Steers	3.61	4.39	3.40	3.75
Average	4.09	4.74	3.69	4.14
Sire 17				
Heifers	3.06	4.69	3.44	3.56
Steers	4.70	5.62	4.22	4.81
Average	3.88	5.16	3.83	4.19
Sire 71				
Heifers	2.93	2.95	2.93	2.93
Steers	4.88	4.95	4.97	4.92
Average	3.91	3.95	3.95	3.93
Treatment averages				
Heifers	3.52	4.24	3.45	3.68
Steers	4.40	4.99	4.20	4.49
Average	3.96	4.61	3.82	4.09

Table 70. Analysis of variance of the ability of the anterior pituitary gland of calves in the 1950-51 trial to stimulate the weight of baby chick thyroid glands

Source of Variation	Degrees of Freedom	Mean Square	F.
Replications	5	46.131	24.49*
Treatments	2	20.577	10.92*
Testosterone vs. other treatments	1	39.900	21.18*
Methyl androstenediol vs. controls	1	1.253	.67
Levels	2	16.568	8.79*
Treatment x level	4	1.143	.61
Error	415	1.891	
Pooled error	419	1.884	

* indicates statistical significance at .05

Table 71. The effect of testosterone treatment, sire, and sex upon the ability of the anterior pituitary of calves in the 1951-52 trial to stimulate the weight of baby chick thyroid glands

Sire and sex groups	Treatment groups		Sire and sex Averages
	Control	Testosterone	
	Average weight of chick thyroid glands (mg.)		
Sire 14			
Heifers	3.26	4.02	3.64
Steers	4.34	4.70	4.52
Average	3.80	4.36	4.08
Sire 15			
Heifers	4.24	4.59	4.42
Steers	3.76	5.01	4.38
Average	4.00	4.80	4.40
Sire 17			
Heifers	3.94	4.78	4.36
Steers	4.19	4.89	4.54
Average	4.07	4.83	4.45
Treatment averages			
Heifers	3.81	4.46	4.14
Steers	4.10	4.87	4.48
Average	3.96	4.44	4.31

Table 72. Analysis of variance of the effect of testosterone treatment, sex of calf, and level of anterior pituitary injection on the ability of the anterior pituitary gland of calves in the 1951-52 trial to stimulate the weight of baby chick thyroid glands

Source of Variation	Degrees of Freedom	Mean Square	F.
Replications	5	28.485	13.93*
Sex	1	12.813	7.52*
Treatment	1	53.905	31.63*
Levels	2	20.541	12.05*
Sex x treatment	1	.403	.24
Sex x levels	2	.310	.18
Treatment x levels	2	4.145	2.43
Sex x treatment x levels	2	5.006	2.97
Error	412		
Pooled error (1)	414		
Pooled error (2)	419		

* indicates statistical significance at .05

Effect of methyl androstenediol

The anterior pituitary glands of calves treated with methyl androstenediol were not significantly different from those glands of control calves in total thyrotropic hormone content according to the baby chick bioassay method (Table 70). The average weight of the thyroid glands from chicks receiving anterior pituitary tissue from methyl androstenediol-treated calves was slightly less than that of chicks receiving anterior pituitary tissue from control calves (Table 73). The increasing weight of the thyroid gland of the chicks receiving increasing dosages of anterior pituitary from these two sources is demonstrated in Table 73.

Table 73. The effect of methyl androstenediol treatment upon the ability of beef pituitary glands to stimulate the weight of baby chick thyroid glands (Weight of thyroid in mg.)

Source of pituitary material	Percent of whole anterior pituitary received			
	0.00	0.64	1.28	2.56
Control calves	3.04	3.66	3.82	4.39
Methyl androstenediol-treated calves	- -	3.48	3.81	4.19

Effect of testosterone

The thyrotropic hormone content of the anterior pituitary gland of calves receiving testosterone was significantly greater than that of the anterior pituitary gland of control calves in both the 1950-51 trial (Table 70) and the 1951-52 trial (Table 72). The

thyroid glands from chicks receiving anterior pituitary tissue from testosterone-treated heifers averaged 0.72 mg. and 0.65 mg. heavier in the 1950-51 trial and the 1951-52 trial, respectively, than the thyroid glands from chicks receiving anterior pituitary tissue from control heifers (Table 74). Similarly, the thyroid glands from chicks receiving anterior pituitary tissue from testosterone-treated steers were 0.59 mg. and 0.77 mg. heavier than those from chicks receiving anterior pituitary tissue from control steers in the 1950-51 and 1951-52 hormone trials, respectively. The calves receiving testosterone had anterior pituitary glands which contained thyrotropic hormone in amounts that approached those of anterior pituitary glands from bull calves.

Table 74. The effect of testosterone treatment upon the ability of beef anterior pituitary glands to stimulate the weight of baby chick thyroid glands (weight of thyroid gland in mg.)

Source of anterior pituitary material	1950-51 trial	1951-52 trial
None	3.04	2.83
Control heifer calves	3.52	3.81
Testosterone-treated heifer calves	4.24	4.46
Control steer calves	4.40	4.10
Testosterone-treated steer calves	4.99	4.87
Bull calves	5.38	4.37

Effect of methyl testosterone

The average thyroid weight of chicks receiving anterior pituitary tissue from steers in the methyl testosterone trial is given in Table 75. The average thyroid gland weight of chicks receiving

anterior pituitary tissue is given for each calf in the trial. The animals were allotted to these replications on the basis of beginning weight on test. The bull anterior pituitaries served as a positive control with each replication. As is evident from Table 75, there was a tendency for increasing thyrotropic content of the anterior pituitary with the increasing intake of methyl testosterone. The thyrotropic hormone content of the anterior pituitary of bull calves appears to be intermediate between that of calves on the 0.25 mg. and 0.50 mg. level of methyl testosterone. The analysis of variance of weights of chick thyroids (Table 76) indicates significant differences between treated and control steers and between the 0.25 mg. level and the other treatment levels.

Table 75. The effect of various levels of methyl testosterone on the ability of the anterior pituitary to stimulate the weight of the thyroid gland of baby chicks (average weight of thyroid glands in mg.)

	Source of anterior pituitary material				
	Bulls	Steers-weekly intake of hormone (mg/kg body weight)			
		0.0	0.25	0.50	1.00
Replications					
1	6.48	5.95	5.34	6.32	5.91
2	5.70	3.97	5.08	4.75	4.36
3	5.19	5.18	6.83	6.33	7.28
4	6.04	4.99	5.80	6.02	7.32
5	4.22	4.30	4.67	5.97	6.18
6	5.49	5.08	5.11	5.07	5.64
Average	5.52	4.91	5.47	5.74	6.12

Table 76. The analysis of variance of the effect of various levels of methyl testosterone on the ability of the anterior pituitary gland to stimulate the weight of the thyroid glands of baby chicks

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	5	30.999	8.96*
Treatment	4	20.714	5.98*
Steers vs. bulls	1	.131	.04
Control vs. treated	1	60.321	17.42*
0.25 mg. vs. other treated	1	15.033	4.34*
0.50 mg. vs. 1.00 mg.	1	7.370	2.13
Level of injection	2	111.504	32.21*
Treatment x level	8	5.216	1.52
Error	504	3.434	
Pooled error	512	3.462	

* indicates statistical significance at .05

Effect of sire

No accurate measure of the difference in thyrotropic activity of the anterior pituitary gland between sire groups is possible since sire groups were confounded with replications in both the 1950-51 and 1951-52 trials. The sire averages given in Tables 69 and 70 are therefore not reliable indications of the actual difference between sire groups in this trial.

Effect of sex

Statistical analysis of the effect of sex on the thyrotropic activity of the anterior pituitary was not attempted in the 1950-51 trial since the design of the experiment resulted in a confounding of sex with replications. However, a significant difference in thyrotropic activity of the anterior pituitary gland of the two sexes occurred in the 1951-52 trial (Table 72). The thyroid

glands of chicks receiving the anterior pituitary material of control steer calves were on the average 0.29 mg. heavier than the thyroid glands of chicks receiving the anterior pituitary material from control heifer calves. Similar differences are found between the estimated thyrotropin content of testosterone-treated heifers and steers in both trials and of control heifers and steers in the 1950-51 trial. The steer pituitaries are consistently higher in the ability to stimulate the weight of chick thyroids than are heifer pituitaries. The thyroid glands of chicks receiving the anterior pituitary material of bull calves were heavier than the thyroid glands of chicks receiving the anterior pituitary tissue from either control heifers or steers in both the 1950-51 and 1951-52 trials (Table 74).

The gonadotropic hormone content of the anterior pituitary

The gonadotropic hormone content of the anterior pituitary gland of the experimental calves was measured by the weight increase of the testes of baby chicks. The average weight of both testes of baby chicks receiving injections of anterior pituitary tissue from calves in the various treatment, sex and sire groups and subgroups in the 1950-51 trial is given in Table 77. The analysis of variance of the effect of certain of these sources of variation is given in Table 78. The average weight of testes of baby chicks receiving injections of pituitary tissue of calves in the various treatment, sex and sire groups and subgroups is given in Table 79. The analysis of variance of the effect of certain of these sources of

Table 77. The effect of testosterone and methyl androstenediol treatments, sire and sex of calf upon the ability of the anterior pituitary of calves in the 1950-51 trial to stimulate the weight of baby chick testes

Sex and sire groups	Treatment groups			Sire and sex Averages
	Control	Testosterone	Methyl Androstenediol	
	Average weight of chick testes (mg.)			
Sire 14				
Heifers	17.0	18.4	16.5	17.2
Steers	19.6	25.0	20.2	21.1
Average	18.3	21.7	18.4	19.2
Sire 17				
Heifers	20.7	22.3	22.7	21.6
Steers	21.8	24.6	23.5	22.9
Average	21.3	23.5	23.1	22.3
Sire 71				
Heifers	15.7	13.9	17.4	15.7
Steers	23.3	23.4	26.0	24.0
Average	19.5	18.7	21.7	19.9
Treatment averages				
Heifers	17.8	18.2	18.9	18.2
Steers	21.6	24.3	23.2	22.7
Average	19.7	21.3	21.0	20.4

Table 78. Analysis of variance of the effect of testosterone and methyl androstenediol treatments, and level of injection of anterior pituitary gland of calves in the 1950-51 trial to stimulate the weight of baby chick testes

Source of Variation	Degrees of Freedom		Mean Square	F
Replications	5		774.19	25.87*
Treatments	2		120.61	4.03*
Treated vs. controls		1	238.52	7.97*
Testosterone vs. methyl androstenediol		1	2.71	.09
Levels	2		307.96	10.29*
Treatment x levels	4		16.15	.54
Error	415		30.06	
Pooled error	419		29.93	

*indicates statistical significance at .05

Table 79. The effect of testosterone treatment, sire and sex of calf upon the ability of the anterior pituitary of calves in the 1951-52 trial to stimulate the weight of baby chick testes

Sire and sex groups	Treatment groups		Sire and sex Averages
	Control	Testosterone	
	Average weight of chick testes (mg.)		
Sire 14			
Heifers	16.9	15.3	16.1
Steers	19.3	18.1	18.7
Average	18.1	16.7	17.4
Sire 15			
Heifers	18.9	16.1	17.5
Steers	14.5	14.6	14.6
Average	16.7	15.3	16.0
Sire 17			
Heifers	14.9	14.4	14.7
Steers	14.2	14.6	14.4
Average	14.5	14.5	14.5
Treatment averages			
Heifers	16.9	15.3	16.1
Steers	16.0	15.8	15.9
Average	16.4	15.5	16.0

Table 80. Analysis of variance of the effect of testosterone treatment, sex of calf, and level of anterior pituitary injection on the ability of the anterior pituitary gland of calves in the 1951-52 trial to stimulate the weight of baby chick testes

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	5	234.55	13.14*
Treatment	1	93.15	5.22*
Sex	1	3.70	.21
Levels	2	234.02	13.11*
Treatment x sex	1	55.04	2.53
Treatment x levels	2	56.12	2.58
Sex x levels	2	38.03	1.75
Treatment x sex x levels	2	18.02	.83
Error	413	21.79	
Pooled error (1)	415	21.77	
Pooled error (2)	420	17.85	

* indicates statistical significance at .05

variation is given in Table 80. The increase in testis weight of baby chicks with increasing amounts of anterior pituitary tissue administered is indicated by the data in Table 81. Significant differences in weight of the testes between the levels of anterior pituitary injected occurred in both the 1950-51 trial (Table 78) and the 1951-52 trial (Table 80).

Table 81. The effect of dosage level of anterior pituitary material on the weight (mg.) of the testes of baby chicks

Year of hormone trial	Percent of whole anterior pituitary received		
	0.64	1.28	2.56
1950-51	19.4	19.7	22.1
1951-52	14.9	15.7	17.4

Effect of methyl androstenediol

The anterior pituitary glands from calves receiving injections of methyl androstenediol had a significantly greater gonadotropic hormone content than did anterior pituitary glands from control calves. The testes of chicks receiving anterior pituitary material from methyl androstenediol-treated calves were, on the average, 1.4 mg. heavier than those from chicks receiving anterior pituitary tissue from control calves (Table 82).

Table 82. The effect of methyl androstenediol and testosterone treatments on the ability of the anterior pituitary of calves to stimulate the weight (mg.) of the testes of baby chicks

Source of pituitary material	1950-51 trial	1951-52 trial
Control calves	19.7	16.4
Methyl androstenediol calves	21.0	15.5
Testosterone calves	21.3	- -

Effect of testosterone

The anterior pituitary glands from calves receiving testosterone produced a significantly greater stimulus to the weight of testes of baby chicks than did the anterior pituitary tissue of control calves in the 1950-51 trial (Table 78). The chicks receiving anterior pituitary tissue from the testosterone-treated calves had testes that were 1.6 mg. heavier than testes from chicks treated with anterior pituitary tissue of control calves (Table 82). The testes of chicks stimulated with anterior pituitary tissue from testosterone-treated calves were not as heavy as the testes of chicks treated with the anterior pituitary tissue of control calves in the 1951-52 trial (Table 82). This difference between the testosterone-treated and control groups was significant (Table 80).

Effect of methyl testosterone

The various levels of methyl testosterone had no significant effect on the ability of the anterior pituitary gland to stimulate the weight of the testes of baby chicks (Table 84). The anterior

pituitary glands of the group of bulls which were used had a significantly greater gonadotropic hormone content than did any of the groups of steers as evidence by their ability to stimulate the weight of the testes of baby chicks (Table 84). The average weight of testes of chicks receiving anterior pituitary tissue from each of the steers in the methyl testosterone trial is given in Table 83.

Table 83. The effect of various levels of methyl testosterone on the ability of the anterior pituitary of steers to stimulate weight of testes of baby chick (average weight of testes in mg.)

		Steers-weekly intake of hormone (mg/kg body weight)			
Replications	Bulls	0.00	0.25	0.50	1.00
1	19.6	14.6	15.7	17.6	15.3
2	17.8	13.7	14.3	16.0	15.2
3	15.6	16.1	13.7	15.3	14.0
4	17.6	18.0	13.9	15.6	15.3
5	12.7	12.5	12.1	13.6	12.7
6	18.1	14.4	14.7	13.3	13.3
Average	16.9	14.9	14.1	15.2	14.3

Table 84. Analysis of variance of the effect of various levels of methyl testosterone on the ability of the anterior pituitary of steers to stimulate weight of baby chick testis

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	5	162.19	8.74*
Treatments	4	133.46	7.19*
Bulls vs. steers	1	441.19	23.76*
Treated vs. non-treated	1	10.06	.54
0.25 mg. vs. other treatments	1	34.63	1.87
0.50 mg. vs. 1.0 mg.	1	47.98	2.58
Levels of pituitary	2	320.81	17.28*
Level x treatment	8	18.57	1.00
Error	512	18.57	
Pooled error	520	18.57	

* indicates statistical significance at .05

Effect of sires

No accurate measure can be made of the differences between sire groups in the gonadotropic activity of the anterior pituitary gland because of the confounding of sire groups with replications in both trials.

Follicular and luteal development of the ovaries

Effect of methyl androstenediol

From gross examination of the ovaries of heifer calves receiving methyl androstenediol, no consistent effects on weight, follicular or luteal development were noted. Recent corpora lutea were present in ovaries of the three heifers receiving methyl androstenediol and the size of follicles and ovaries did not differ greatly from those of control heifers (Table 85).

Table 85. The effect of methyl androstenediol and testosterone treatments on the ovaries of heifer calves in the male 1950-51 trial

	Control	Testosterone	Methyl Androstenediol
Percent of heifers with ovaries showing recent corpora lutea	100	0	100
Average ovarian weight-grams	10.6	7.0	11.7
Average diameter of largest follicle (mm)	9.0	13.3	10.6

Effect of testosterone

There was a rather striking absence of corpora lutea in the ovaries of the three heifers receiving testosterone in the 1950-51

trial (Table 85) and in the ovaries of four of the six heifers receiving testosterone in the 1951-52 trial (Table 86). In both trials the average diameter of the largest follicle of each pair of ovaries was slightly greater for the calves receiving testosterone than for the control calves. The number of follicles exceeding 4 mm. in diameter for each pair of ovaries was much greater for control calves, than for testosterone calves (Table 86).

Table 86. The effect of testosterone on the ovaries of heifer calves in the 1951-52 trial

	Control	Testosterone
Percent of heifers with ovaries showing recent corpora lutea	100	33
Average ovarian weight (gm.)	10.9	10.2
Average diameter of largest follicle (mm)	12	14
Average number of follicles over 4 mm diameter (per calf)	7	3

Thyroid hormone content of the thyroid gland

The effect of thestosterone treatment and sex of calf upon the ability of a given amount of thyroid tissue from experimental calves to decrease the time required for asphyxiation of thiouracil-treated male and female mice is shown in Table 87. The analysis of variance of the effects of these sources of variation is given in Table 88. The female mice were able to live considerably longer in the jars than male mice (Table 87). The sex of calf from which the thyroid gland was obtained had no apparent effect on the thyroid hormone content of the thyroid gland as measured

by its ability to alter asphyxiation time (Table 88). The calves receiving testosterone had thyroid glands which altered the asphyxiation time of mice significantly less than did thyroid gland tissue from control calves. Mice receiving thyroid tissue from testosterone-treated calves were asphyxiated after 48.2 minutes in the sealed half-pint jar, while mice receiving thyroid tissue from control calves lived for only 44.4 minutes in this sealed container (Table 87.

Table 87. The effect of testosterone treatment and sex upon the ability of injected thyroid gland tissue of calves to decrease the time (minutes) required for asphyxiation of thiouracil-treated mice

	Sex of mice used		
Source of thyroid gland tissue	Male	Female	Average
	Time (minutes) required for asphyxiation		
Heifers			
Control	33.6	50.4	43.2
Testosterone	36.0	57.1	48.1
Steers			
Control	35.3	53.3	45.6
Testosterone	37.0	56.9	48.4
Both heifers and steers			
Control	34.5	51.9	44.4
Testosterone	36.5	57.0	48.2
Non-injected control mice	46.1	58.0	54.0

Table 88. Analysis of variance of the effect of testosterone treatment and sex of calf upon the ability of thyroid gland tissue to decrease the time required for asphyxiation of male and female

Source of Variation	Degrees of Freedom	Mean Square	F
Treatment	1	206.75	5.32*
Sex of calves	1	25.52	.66
Sex of mice	1	4911.31	126.42*
Treatment x sex of calves	1	15.65	.39
Treatment x sex of mice	1	33.44	.83
Sex of calves x sex of mice	1	.01	.00
Treatment x sex of mice x sex of calves	1	5.52	.14
Error	48	40.89	
Pooled error (1)	49	40.24	
Pooled error (2)	52	38.85	

* indicates statistical significance at .05

Histological changes in the thyroid gland

Microscopical examination of the thyroid tissue revealed a rather striking demonstration of the effect of testosterone treatment. The area of the colloid follicles of the animals which received testosterone were very small (Table 89) and the epithelial cells surrounding the colloid areas appeared tall. The thyroid glands of control calves, on the other hand, had large colloid areas and the epithelium appeared to be of a flat or cuboidal form. The total area of the field was taken up largely by colloid in the case of the control calves while in the case of testosterone-treated calves a small part of the total area was made up of colloid areas, the remainder being epithelial tissue and interstitual and connective tissue.

Table 89. The effect of testosterone on the average area of colloid follicles in the thyroid (in square millimeters)

Treatment group	Sex of calf		
	Heifer	Steer	Both sexes
Control	.0638	.0474	.0556
Testosterone	.0218	.0196	.0207
Both Treatments	.0428	.0335	

Induced changes in the size of certain organs and glands

The thyroid, pituitary, and adrenal glands, and the liver and heart were weighed at the time the calves were slaughtered. The length of the small intestine was also determined. The sizes of these organs and glands of calves in the different treatment groups were compared to determine the extent of sex differences and differences induced by hormone treatment.

Effect of methyl androstenediol

The size of the various organs and glands of methyl-androstenediol-treated and control calves is given in Table 90. Methyl androstenediol treatment produced no significant changes in the size of any of the organs and glands listed. The average weight of these parts was very similar for both treatment groups.

Effect of testosterone

The size of organs and glands of testosterone-treated and control calves are given in Tables 90 and 91 for the 1950-51 and 1951-52 trials, respectively. Although the pituitary glands of calves

Table 90. The effect of methyl androstenediol and testosterone treatments and sex on the size of certain glands and organs

	Control group			Testosterone			Methyl androstenediol		
	Heifers	Steers	Average	Heifers	Steers	Average	Heifers	Steers	Average
Pituitary gland (grams)	1.53	1.55	1.54	1.77	1.92	1.84	1.59	1.56	1.58
Thyroid glands (grams)	17.9	23.6	20.8	19.8	19.4	19.6	19.7	21.9	20.8
Adrenal glands (grams)	12.3	12.4	12.4	12.5	12.5	12.5	12.3	11.6	12.0
Heart (grams)	1229	1242	1236	1182	1293	1238	1447	1229	1338
Liver (grams)	4360	3999	4179	4334	4062	4199	4147	4085	4116
Small intestine (feet)	106	107	106	119	109	114	107	101	104

Table 91. The effect of testosterone treatment and sex on the size of certain organs and glands

	Control			Testosterone		
	Heifers	Steers	Average	Heifers	Steers	Average
Pituitary gland (grams)	1.42	1.57	1.49	1.59	1.67	1.63
Thyroid glands (grams)	16.3	17.2	16.7	19.4	19.6	19.5
Adrenal glands (grams)	12.2	13.3	12.7	13.9	14.1	14.0
Heart (grams)	1343	1389	1365	1400	1358	1379
Liver (grams)	4007	4264	4135	4213	4388	4301
Small intestine (feet)	101	101	101	100	104	102
Seminal vesicles (grams)		5.5			30.1	

Table 92. The effect of various levels of methyl testosterone on the size of certain organs and glands

	Weekly intake of methyl testosterone (mg/kg body weight)			
	0.00	0.25	0.50	1.00
Pituitary gland (grams)	1.77	1.87	1.90	1.70
Thyroid glands (grams)	23.2	40.3	42.8	53.6
Adrenal glands (grams)	14.8	13.7	13.1	12.1
Heart (grams	1612	1498	1604	1431
Liver (grams)	4766	4821	5333	4979
Small intestines (feet)	98	92	92	94
Seminal vesicles (grams)	6.6	11.1	17.5	25.0

receiving testosterone were heavier than those of control calves in both trials, this difference was significant in only the 1950-51 trial. Testosterone produced a significant increase in the weight of the thyroid glands in the 1951-52 trial, but in the 1950-51 trial the thyroid glands of testosterone-treated calves were smaller than those from control calves. The adrenal glands of testosterone-treated calves were significantly heavier than those of the control calves in the 1951-52 trial, while the adrenal glands of calves in the testosterone-treated and control groups were quite similar in the 1950-51 trial. The weights of the heart, and liver, and the length of the small intestine were not significantly altered by the testosterone treatment.

Effect of methyl testosterone

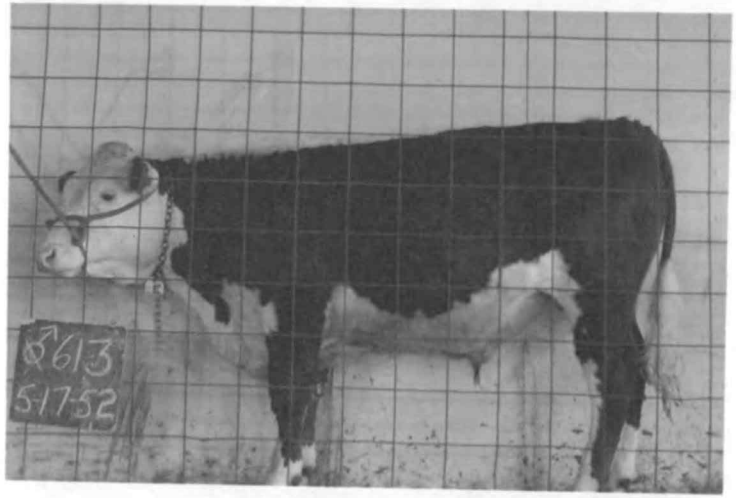
The size of organs and glands of calves in the various treatment groups in the methyl testosterone trial is given in Table 92. Methyl testosterone had no significant effect on the weight of the pituitary gland. The thyroid glands of calves receiving methyl testosterone were significantly heavier than those of control calves. Although there was a trend of increasing thyroid weight with increasing dosage of methyl testosterone, the differences between groups receiving this hormone were not significant. No significant effects of methyl testosterone on the weights of the liver and heart, or the length of the small intestine occurred. A consistent increase of the weight of the seminal vesicles was

evident with the increasing dosages of methyl testosterone. A significant difference existed between the weight of the seminal vesicles of each of the treatment groups.

Development of masculinity

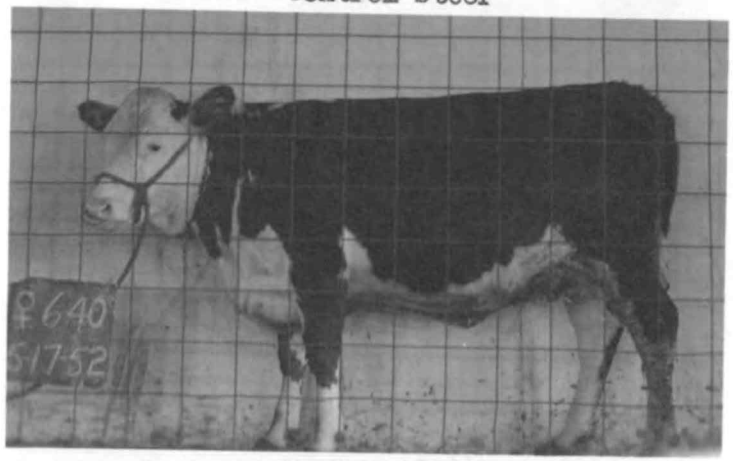
Calves receiving methyl androstenediol showed no prominent signs of masculinity throughout the entire test. It was impossible to distinguish animals receiving methyl androstenediol from control animals by an examination of either the live animal or the carcass. No outstanding patterns of behavior served to distinguish them from control animals.

Calves receiving testosterone injections produced many masculine characteristics, both in form and behavior, which were often evident as early as the tenth week of test and continued until the conclusion of the test period. The traits appeared to be more acute during the 1951-52 trial than in the 1950-51 trial, but comparison of photographs of calves in these trials indicate that the physical traits, at least, were highly developed in the 1950-51 trial. Both heifers and steers receiving testosterone developed pronounced crests in the neck region, caused apparently by intense development of muscles in this area. This condition closely resembles that of normal bulls of comparable size and age (Figure 10). The musculature throughout the carcass, particularly in the round and loin, showed the characteristic bulging of bull or "stag" carcasses as compared with a rather flat or smoothly filled round



Control Steer

Testosterone-treated Steer



Control Heifer

Testosterone-treated Heifer

Figure 10. Representative animals in treatment and sex groups (note testosterone-induced masculinity)

and loin of control heifers and steers. Alterations in the hair coat of the testosterone-treated animals were particularly striking since the white areas were greatly discolored and yellowish. The hair coat was curly and unruly as compared with the straight hair coat of control calves. The treated animals were often wet and steaming from sweat on cool mornings, a condition frequently observed in young bulls when they were stabled in pens adjoining those where one or more females might be in estrus. This sweating may also be the cause for some of the discoloration and curliness of the hair coat. The voice of the testosterone-treated calves changed to the deep bellow and snort characteristic of bulls.

Both heifers and steers receiving testosterone demonstrated masculine behavior traits. The presence of strange cattle in the alley was sufficient to evoke interest, activity and considerable bellowing from these treated animals. Observations were made on the behavior of one heifer and one steer in the testosterone-treated and control groups in the 1951-52 trial. The testosterone-treated heifer when allowed in the pen with a normal bull attempted to mount the bull and readily accepted service by him. The control heifer, however, avoided the bull and would not accept service. Neither heifer was in estrus (heat) at the time. The testosterone-treated steer when allowed in the pen with a non-estrus heifer attempted to mount the heifer unsuccessfully. When the heifer was

secured in a breeding stanchion, the steer successfully mounted the heifer a number of times, developed a partial erection and emission of the penis, and demonstrated a series of pelvic thrusts with each mounting. Successful intromission was not accomplished. The control steer, however, showed only a casual interest in the heifer and demonstrated no sexual activity. Although all animals were not subjected to this trial, the general activities of the treated and control animals would indicate this behavior to be typical of these groups.

The steers receiving methyl testosterone also showed a considerable development of masculine characteristics including a pronounced crest development in the neck region. No observations were made on the sexual behavior of these steers receiving methyl testosterone.

DISCUSSION

Feed-lot performance

The work by Kochakian and Murlin (52, p.751) initiated the study of the action of androgens on renotropic activity and nitrogen retention. Kenyon (50, p.133) demonstrated marked increases in weight of humans with testosterone propionate administration. These two studies set the stage for further demonstration of the ability of many of the androgenic compounds to stimulate weight gains. The extensive data with the use of certain male hormones in experimental animals have indicated an increase in rate of gain in many cases, but not in every case. The level and method of administration of these hormones appear to be very important factors in determining growth responses to them. Thus, though work with swine, sheep and beef cattle have usually resulted in only slight increase and often decrease in rate of gain by the administration of male hormones, successful demonstration of induced growth responses with other levels and methods of androgen treatment is quite feasible.

The weekly injection of testosterone at the level of 1 mg/kg of body weight resulted in a considerable increase in average daily gain as compared with the growth rate of control calves. The graphical representation of growth rate of testosterone-treated and control calves indicates that differences in average daily gain between these groups occurred soon after beginning of the hormone-treatment and persisted or increased up to 16 weeks thereafter. The analysis

of variance of average daily gain during the period from 675 to 800 pounds live weight reveals that the testosterone-treated calves have a greater advantage over control calves at this time than when the entire feeding period is considered. These observations serve to show that during the period following the beginning of testosterone injection under the conditions of this experiment, there is a constant or increasing advantage of the testosterone animals over control animals in average daily gain. In many growing laboratory animals the stimulation to growth produced by male hormones was of a temporary nature and after a few weeks the control animals reached and surpassed the male-hormone-treated animals in growth rate and, frequently, body size. Absence of this phenomena in the beef cattle in these experiments may be a indication of a permanent stimulation of the hormone, a closer approximation to a physiological level of hormone in the animal body, a reflection of the lower metabolic rate of cattle as compared to mice and rats or other possible factors. A temporary stimulation in beef cattle might expire at a time much later than the termination of this trial while a temporary stimulus of the same nature in mice and rats might expire in a few days. The results of the weekly injection of methyl androstenediol at the level of 1 mg/kg of body weight in the 1950-51 trial indicated no stimulation to growth rate of calves under these conditions. The feeding of methyl testosterone to steers at the levels of 0.00, 0.25, 0.50 and 1.00 mg/kg of body weight had no significant effect on average daily gain. Since other characteristics such as masculinization indicated that oral administered

hormone was not completely destroyed in the rumen, one must assume a different action of methyl testosterone on growth rate than the effect produced by testosterone.

The measure of total digestible nutrients per 100 pounds of feed indicates that animals receiving testosterone were able to convert a given amount of feed to a greater increase in body weight than could control calves. The steer calves were likewise able to make greater gains on a given amount of feed than heifer calves. The heifer calves had a much greater reduction in total digestible nutrients required per 100 pounds gain than did steer calves due to the administration of testosterone. These comparisons indicate differences in efficiency of feed utilization if total-weight-gain compared to total-digestible-nutrients-taken-in is to be the measure of efficiency. If the measure of efficiency is the total-calories-stored-as-body-weight as compared to total-calories-taken-in however, the weight gain is a valid estimate of efficiency only as long as the caloric content of stored materials is constant for both groups. Samples of meat from these calves had the following chemical composition: control heifers, 72% fat, 25% protein; control steers, 51% fat, 47% protein; testosterone-treated heifers, 57% fat, 41% protein; and testosterone-treated steers, 47% fat, 50% protein. Although these values cannot be taken as representative for the carcass in its entirety, they are indicative of differences in the proportions of different body stores laid down by the animals in each treatment group. Thus, on a calorie-stored to calorie-consumed basis, the four groups may not vary greatly in

efficiency. However, the value of animal protein is much greater than that of animal fat under the present economical conditions. Thus protein-produced is actually a more practical measure of gain than is calories-stored. On an economical basis, protein-produced to calories-consumed might be the best measure of feed efficiency. On this basis the testosterone-treated animals would greatly exceed the control animals in efficiency. Part of the reduction in feed required per one hundred pounds gain in the heifers by testosterone-treatment can readily be explained on the differences in storage of fat by animals in the control and treated groups. Since the fat contains 2.25 times as many calories per gram, lean animals, storing low amounts of fat and high amounts of protein, would be expected to gain weight on less feed than animals storing high amounts of fat and low amounts of protein, other conditions being equal.

The more rapid gaining animals required less feed per 100 pounds of gain than slow gaining animals. In these trials an average decrease of 178 and 166 pounds of total digestible nutrients per 100 pounds of gain resulted for each increase in daily gain of one pound during the test period. After adjusting for differences in daily gain only a small portion of the original variation in total digestible nutrients required per 100 pounds gain remains. Analysis of this residual variation indicates a significant interaction between hormone treatments and sires in the 1950-51 hormone trial and a significant effect of testosterone treatment in the 1951-52 trial. An effect of testosterone treatment in

decreasing the total digestible nutrients required per 100 pounds gain, independent of the effect of testosterone in increasing average daily gain, is indicated. The rate of gain may be explainable on the differences in relative amounts of fat and protein tissue deposited. More rapid growth with protein deposition than with fat deposition might well be expected on a given caloric intake since fewer calories are required per gram of protein than per gram of fat. If a constant percent of all nutrients above maintenance will be converted to body gains, a larger amount of protein will be deposited than of fat if the same quantity of nutrients were available for fat deposition. On a given caloric intake a growing animal would thus be expected to gain faster than a fattening animal if maintenance requirements were equal.

Average daily feed consumption becomes important as it affects the efficiency of gain and average daily gain. The more feed which a growing animal eats above maintenance requirements the faster and more efficient will be its gains is a general rule which has practical applications, but is not necessarily true under many situations. The treatment of calves with testosterone in these trials tended to result in a lower daily intake of total digestible nutrients as compared with control calves, particularly in the later weeks of the trials. However the rate of gain and feed efficiency of the calves was higher than those of control calves during the same periods. The increased rate of gain and feed efficiency produced by testosterone therapy is not, therefore, due to stimulation in feed consumption but rather is dependent upon the animal's ability to use

a limited feed supply more effectively. The calves receiving methyl androstenediol had a significantly lower daily intake of total digestible nutrients than did control calves during the period from 675 to 800 pounds live weight. The slightly lower average daily gain of methyl androstenediol-treated calves as compared with control calves may be a result of this decrease in nutrient intake per day during the last of the feeding test.

Carcass characteristics

A consistent difference in dressing percent of heifers and steers occurred in the control groups in both the 1950-51 and 1951-52 trials. This indicates that without hormone treatment the heifers at the same weight as steers have a larger percent of their live weight made up of the flesh and bone of the carcass than do steer calves. However, the treatment of heifers with testosterone tended to decrease dressing percent in both trials. In the steers, on the other hand, there was no consistent effect of testosterone on dressing percent in the two trials. This difference between sexes in dressing percent may be at least partially explained on the basis of fat content of the carcass. As was indicated in the section on chemical composition of the fat content of the meat samples from control heifers was very high, while the samples from steers were relatively low in fat content. The heifers would be expected to have a greater dressing percent since the stores of fat in the carcass are often not accompanied by proportional weight increases in other organs and tissues such as the skin, viscera, and head. The heifers

receiving testosterone in the 1951-52 trial had a much lower percent of fat in the sample taken and on this basis would be expected to have a lowered dressing percent which was observed.

The relative weights of the round, hindquarter, and chuck may also be a reflection of differences of fat deposition in these cuts depending on the presence of preferential sites and gradients for fat deposition. For instance, the fat deposition in the area of the kidneys was much more marked in the animals with higher condition than in animals of lower condition, thus causing an increase in the weights of wholesale cuts from this area and resulting in a decrease in percent of other cuts. Thus, although steers had a higher percent of round than heifers, the percent of the hindquarter, which included the loin and kidney area, was greater for the heifer calves. This would be expected if the kidney area of heifers was very heavy in fat deposits in comparison with other parts of the carcass. The higher percent of fat in heifer carcasses as compared to steer carcasses may well explain the corresponding higher percent of flesh to flesh-plus-bone since an additional layer of fat was deposited over the muscle and bones. The testosterone treatment tended to increase the percent of chuck and round of heifer calves, a condition which would be expected if the deposits of fat were decreased, particularly in the kidney and loin area.

The carcass grades of heifer calves were higher than those of steer calves in both the 1950-51 and 1951-52 trials, indicating a greater degree of finish in the heifers. The carcass grades of

the testosterone-treated calves were slightly lower than those of control calves, a possible indication of decreased fat deposition and a lower degree of finish. The effects of sires on the dressing percent and percent of carcass cuts may also be largely a reflection of finish since body scores and measurements and photographs did not show striking differences.

The decrease in fat deposition is accompanied by a greater percent of protein and water in carcass. These are verified by the chemical analyses of the meat samples which indicate increased protein and water content of steers as compared to heifers and of testosterone-treated calves as compared with control calves. The increased nitrogen retention and fat metabolism which was found in several species of laboratory animals with the administration of male hormones supports the observations of decreased fat deposits and increased percent of protein found in the testosterone-treated calves.

These findings are in agreement with the concept of greater output of thyroxine by the thyroid gland in calves receiving testosterone. Certainly the increase in thyroxine secretion would be conducive to greater water and protein retention and reduced fat storage.

Meat characteristics

The observations made on the cooked meat samples offer interesting information which ties in rather closely with the other

observations. The drip loss of meat samples during cooking was greatest for the group of control heifers which was also the group with the highest percent of fat in the meat samples. Since, in cooking the water which leaves the roast is evaporated away, the drip will be largely of a fatty nature. The samples therefore, which lost the greatest amount due to drip in cooking, were from the calves highest in fat. Conversely, the calves which had samples higher in protein and water content would be expected to have roasts which lost larger amounts of water by evaporation. This trend, however, was not consistent for all groups although the control heifers were somewhat lower in percent of evaporation loss and percent of protein than the other groups.

The effect of testosterone on the shearing strength of samples from heifer and steers is difficult to explain on the basis of existing knowledge of male hormone activity. The increase in shearing strength of steers receiving testosterone might well be expected from the protein anabolic activity of male hormones and from the results by Herrick (45, p.147) indicating increased strength of the skin and the gastrocnemius muscle of the fowl following the administration of testosterone propionate. However, the lack of effect or decrease in shearing strength in the heifer calves was not consistent with the observations in the fowl.

Induced hormonal activity

Considerable evidence exists to indicate that the thyrotropic

hormone content of the anterior pituitary gland is a rather reliable indication of the activity of that gland in secreting the thyrotropic hormone. The work by Reece and Turner with beef cattle (91, p.96) indicates an increase in thyrotropic hormone content of the anterior pituitary during the period of most rapid growth (from 4-10 months). The period of most active growth was presumably the time of greatest secretion of the thyrotropic hormone. Likewise the more rapid gaining bulls had a much higher thyrotropic hormone content than the slower growing heifers in the trials conducted by Reece and Turner. In the rabbit, there was increasing thyrotropic hormone content of the hypophysis as the animals reached their most rapid period of growth and as the growth rate declined upon nearing maturity, the thyrotropic hormone content decreased (110, p.652). The castration of young male rats which results in a decrease in growth rate was also found to decrease the thyrotropic hormone content of the anterior pituitary (109, p.1043).

In the beef cattle trials reported here the thyrotropic hormone content of the anterior pituitary gland of steer calves was greater than that of heifer calves, and the growth rate of steer calves was also greater than that of heifer calves. The thyrotropic hormone content of the anterior pituitary was markedly increased by the testosterone injections and also to some extent by the oral administration of methyl testosterone. The growth rate of calves was also markedly increased by the use of testosterone. The tendency

for these two traits to occur together indicates that there may be a definite association between them. The testosterone treatment also quite definitely decreased the total percent of fat in the carcass. These changes in rate and kind of growth tend to resemble those of bull calves under similar feed conditions. The thyrotropic hormone acts first and principally on the thyroid gland to cause secretion of the thyroid hormone, thyroxin, but it may have other functions and could possibly act synergistically with the growth hormone.

In the gonadotropic assay of the anterior pituitary it is necessary to remember that two or more factors in the pituitary may be effective in stimulating the weight of the testes of the assay animal. Follicle-stimulating hormone and luteinizing hormone, are known to be important and often act synergistrically in stimulating weight of the testes. The absence or reduction of number of corpora lutea in the ovaries of testosterone-treated calves indicates an interference with the activity of the luteinizing hormone either due to suppression of its formation or secretion or an antagonistic effect by other hormones to prevent its normal action. In nearly all cases Hellbaum and Greep (42, pp.34-35) produced only follicular development in the ovaries of 21-day old female rats by injecting the anterior pituitary gland tissue of castrated male rats receiving 0.5 mg. of testosterone propionate daily for periods of 30 days or longer. However the pituitary gland tissue from non-treated castrated male rats produced both follicular stimulation and corpora lutea formation in the ovaries of 21-day old female rats. This would

indicate that the deficiency or antagonistic material existed as such in the anterior pituitary, thus demonstrating an action of male hormone on this gland. The great increase in gonadotropic hormone content of the anterior pituitary with castration and the decline following male hormone therapy reported by many workers may be due to a corresponding fluctuation in the luteinizing hormone content of this gland. The great variations in activity might be due to relatively slight deviations in the luteinizing hormone content which could act on an all-or-none basis and dependent upon the synergistic activity of this hormone with follicle-stimulating hormone to produce the changes in the assay material. The assay of total gonadotropic hormone content of the anterior pituitary gland of calves in the 1951-52 trial clearly indicates a decrease in gonadotropic hormone content of calves receiving testosterone treatment as compared with normal controls. This would coincide with the lowering of luteinizing hormone activity by testosterone treatment as was indicated by examination of the ovaries. When the pituitaries of calves in the 1950-51 trial were assayed, however, the gonadotropic hormone content of those in the testosterone treatment group was greater than those in the control group. The 1950-51 material may not be reliable, however, since the pituitaries were stored for over twelve months before they were assayed and one of the gonadotropic hormones may have become inactivated to some degree. When a response is dependent on two causative agents as is the weight of the testes of these assay

chicks the entire destruction of one agent may completely change the rank of response to the materials being tested.

The gonadotropic hormone content of the anterior pituitary of methyl androstenediol-treated calves was greater than that of control calves in the 1950-51 trial. The validity of these estimations may be open to criticism because of the long period of time which the glands from calves in the 1950-51 trial were stored prior to assay. The condition of increased gonadotropic hormone following male hormone treatment is not in agreement with most of the experimental results reported.

The decrease in thyroid hormone content per gram of thyroid gland of calves receiving the testosterone treatment is the condition expected in a highly active gland where a large amount of thyroxin is being produced, but a greater amount is being secreted. The colloid areas containing stores of thyroxin are being depleted and, although the production of thyroxin is quite high, the actual amount in the gland is relatively low. A further indication of the increased activity of the thyroid of testosterone-treated calves is shown by the histology of the gland. The testosterone-treated calves have thyroids with very small colloid areas surrounded by tall columnar secretory epithelium, while the thyroids of control calves have large colloid deposits and low cuboidal or flat cells surrounding the colloid. The large size of the thyroid glands may be a result of thyroid stimulation, either directly by the testosterone or indirectly through the anterior pituitary gland. Although

the thyroxin content of the thyroid of testosterone-treated calves is lower per unit weight than that of control calves, the large size of the thyroid glands of testosterone-treated calves might mean that the total thyroxin content of the thyroid glands of testosterone-treated calves may be equal to or even greater than that of control calves. However, in the control calves the secretory activity is low while in the calves receiving testosterone it is probably quite high. The thyroid gland is an excellent example of a condition in which the hormone content of a gland is not directly proportional to the activity of the gland in secreting that hormone.

Gross changes in organs and glands

Apparent inconsistencies reported by various workers concerning the effects of male hormones on the organs and glands of experimental animals are reconcilable on the basis of differences in hormone used, dosage levels, methods of administration and type of experimental animal used. Perhaps the most valuable information of this sort is that which is accompanied by a concise description of the overall changes accompanying the alteration of organ and gland size. For instance, the knowledge that testosterone treatment increases the weight of the thyroid gland of rats is aided greatly by a description of the accompanying change in histology of the gland. The data on size of organs and glands are presented therefore as an aid in describing the overall effect of male hormone treatment.

Although the size of the pituitary gland was increased by

testosterone treatment in the 1951-52 trial, there were no other consistent effects of hormone treatments on pituitary gland size. The pituitary glands of calves receiving methyl androstenediol, methyl testosterone, or testosterone in the 1951-52 trial were equal in weight to pituitary glands of control calves. Thus, although there were significant changes in the thyrotropic hormone content and, in some cases, the gonadotropic hormone content, there were no corresponding changes in the size of the pituitary gland. The data indicate that both methyl testosterone and testosterone treatments produce increases in the size of the thyroid glands. This increase in size is apparently accompanied by an increased hormone production and cellular activity of the thyroid gland as is indicated by biological assay and histological examination. The role that the thyroid gland plays in controlling the metabolic rate makes changes of size and activity of this gland of considerable importance. The lack of consistent effects of hormone treatment on the size of the adrenal glands makes a general statement on their response of little value. The increase of adrenal weight produced in the 1951-52 trial by testosterone treatment was not found in the methyl testosterone trial or in any studies in the 1950-51 trial. Of the three types of male hormone used, none produced significant effects on heart weight, liver weight or small intestine length under the conditions of these trials. However in these organs, as well as the glands listed above, considerable change in function may occur before change in size is evident.

Masculinity

The development of masculine sexual behavior is apparently dependent on the high concentration of male hormone in the animal body. This has been clearly demonstrated by the loss of sexual drive and activity in the adult male after castration. As is indicated by the work of Grunt and Young (38, p.244) the sexual drive lost by male guinea pigs following castration is regained quickly from male hormone therapy. In the trials with beef cattle, the development of masculine sexual behavior of both heifers and steers following testosterone treatment further indicates the prominent role played by male hormones in this trait. Other manifestations of masculinity which were very prominent in the testosterone-treated animals included partial penis erection of steer calves, the deep, coarse voice characteristic of intact males, development of prominent musculature, and discoloration of the hair coat. Increased weight of the seminal vesicles is also an indication of the androgenic activity of the hormone.

The intense development of these various masculine characteristics in the testosterone-treated calves and the absence of such development in the methyl androstenediol-treated calves is indicative of the difference in androgenic activity of these two substances. This correlation between lack of androgenic activity and lack of effect on growth rate and feed efficiency demonstrated by the methyl androstenediol may have definite physiological significance. The

ability of the various androgens to stimulate growth may be a function of their ability to stimulate masculinization. However, there is little indication that the level of methyl androstenediol treatment used in this trial was sufficient to bring about a physiological response of any sort.

In the methyl testosterone trial, the weights of the seminal vesicles increased with increasing levels of dosage showing a quite remarkable sensitivity of response of these glands to the level of hormone consumed. Despite this demonstration of a physiological action on the seminal vesicles the various levels of methyl testosterone used had no significant effect on the rate or economy of gain. The development of masculine sex characters was also much less obvious in the methyl testosterone-treated calves than in the testosterone-treated calves. A further consideration is that the seminal vesicles of 950 pound steers in the group receiving the highest level of methyl testosterone were not as large as the seminal vesicles of 800 pound steers receiving testosterone injection. This would indicate that the androgenic activity of methyl testosterone at 1 mg/kg of body weight per week is lower than that of 1 mg/kg of body weight per week of testosterone injected intramuscularly.

Genetic effects

Differences between sire groups in feed-lot performance are indications of genetic differences between sires. The sires of the experimental calves were selected from a group of half-sibs on the basis

of conformation. Genetic differences between these sires were probably less than the average for half-sib animals chosen at random. A significant difference between sire groups in both rate and efficiency of gain occurred in the 1951-52 trial during the period from 675 to 800 pounds live weight; no other significant differences in feed-lot performance between sire groups occurred. This may indicate that performance during the period from 675 to 800 pounds live weight is more highly heritable than performance during the period from 500 to 800 pound live weight. The lack of significant differences between sire groups is a reflection of the degree of relationship between sires and, consequently, the genetic similarities between them. These small differences between sire groups may also indicate that average daily gain and feed efficiency may not be as highly heritable as some previous estimates that have been made.

Commercial implications

The trials suggest a method for decreasing the cost of producing beef, particularly in a market which is demanding a high protein meat product with a relatively low amount of waste fat. The method of application which gave best responses, intramuscular injections weekly during the feeding period, is, however, rather impractical with commercial beef producing methods. The cost of these hormones is also prohibitive at the present time but a less pure substance which could possibly be used in commercial beef production would be available if satisfactory methods for administration are developed.

SUMMARY AND CONCLUSIONS

1. Steer calves gain more rapidly and require less feed per unit gain than heifers of similar genotype and under similar environmental conditions during the period from 500 to 800 pounds live weight. Under the conditions of these trials, heifer calves had a higher dressing percent, a higher carcass grade, a greater fat content of carcass, a greater percent of hindquarter, a lower percent of round, and a higher percent of flesh to-bone-plus-flesh, than steer calves. Meat samples cooked under similar conditions indicate that meat from heifers has a greater drip loss during cooking and a greater shearing strength than meat from steers. The thyrotropic hormone content of the anterior pituitary of steer calves is greater than that of heifer calves.

2. The weekly intramuscular injection of testosterone at the rate of 1 mg/kg of body weight resulted in an increase in rate of gain and a decrease in feed required per unit gain. Testosterone-treated heifers had a slightly lower dressing percent, a lower percent of fat, a higher percent of protein, a higher percent of round and a higher percent of chuck than control heifers, while testosterone-treated steers were very similar to control steers in these traits. The thyrotropic hormone content of testosterone-treated calves was much greater than that of control calves, and the testosterone-treated calves had larger thyroid glands than control calves. Testosterone produced effects on the weights of the adrenals and pituitary gland but these were not consistent. The calves receiving

testosterone developed masculine appearance and patterns of masculine behavior which were entirely lacking in the control calves.

3. The weekly intramuscular injection of 1 mg/kg of methyl androstenediol during the period from 500 to 800 pounds live weight had no effect on average daily gain, feed required per unit gain, carcass characteristics, thyrotropic hormone content of the anterior pituitary, size of certain organs and glands, or on the sexual behavior of beef calves.

4. The oral administration of methyl testosterone at the levels of 0.25, 0.50, and 1.0 mg/kg body weight per week to steer calves had no effect on the average daily gain or feed required per unit gain, but decreased the percent of fat and increased the percent of lean in the carcass, increased the thyrotropic hormone activity of the anterior pituitary gland, and produced a graded response in the increase of weight of seminal vesicles.

5. The action of testosterone in increasing average daily gain may be through the stimulation of the anterior pituitary gland to secret thyrotropic hormone which stimulates the thyroid gland to secret thyroxine. A high level of thyroxin in turn speeds the metabolic rate which decreases fat storage and increases nitrogen retention. The difference in caloric requirements for these two types of growth would account for the reduction in feed required per unit gain and the consequent increase in average daily gain on the same daily food intake.

6. The lack of genetic-treatment interactions in the measures of feed-lot performance indicates that the use of male hormones may be expected to give comparable results to those reported in this work, in widely diverging genetic groups of cattle.

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