SEX HORMONE INFLUENCE ON RATE AND EFFICIENCY OF GAINS, ENDOCRINES AND CARCASS CHARACTERISTICS OF RABBITS

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SEX HORMONE INFLUENCE ON RATE AND EFFICIENCY OF GAINS, ENDOCRINES, AND CARCASS CHARACTERISTICS OF RABBITS

INTRODUCTION

The accumulation of knowledge during the last thirty years has enabled scientists to become better informed about the role that sex hormones play in the various processes of growth, sexual development, and differentiation. This has been due partly to the development of better methods for the isolation and purification of naturally occurring hormones, and also to the synthesis of drugs and hormones of diverse structures and with active groupings that affect the potency of the preparations. The availability of such materials in quantity has made it possible for research workers to carry out numerous experiments, to study the physiology of these hormones, and to determine their possible therapeutic values. Nevertheless, our knowledge to date concerning the influence of the sex hormones on the various organs and processes of life is incomplete and not without certain limitations. No doubt there are many unexplored and vaguely understood interactions among the various hormones, glands, enzymes and other systems of the body. Information about the exact physiological quantities of the sex hormones necessary to promote and maintain normal growth and function of the different organs and systems in the various species under a multitude of environmental conditions is limited. Only fragmentary reports are available concerning the form in which the hormones circulate and act in the body following administration. There are some indications that they may combine with a protein molecule in the cells to facilitate transportation.

One of the primary reasons for the pronounced interest in sex hormones has been the many existing differences, both external and internal, between sexes of many species. Body form, size, activity (both sexual and physical), voice, color of coat or plumage, behavior, external features and genitalia are only a few of the characteristic differences. Other unseen sexual differences are the genetic constitution; the size, specific secretions and potency of the numerous endocrine glands especially the gonads; and the differences due to the interaction or overlapping of the chromosomal and hormonal influences (21, p.114).

Because of differences, which are of practical and economical interest to animal producers such as rate and efficiency of gain, quality of the carcasses, quantity of preferred meat cuts, tenderness and palatability, the administration of drugs and growth stimulating hormones to many farm animals is attracting the attention of many investigators. Already the practice of administering stilbestrol pellets for caponizing cockerels to tenderize the meat of chickens and accelerate fat deposition has been accepted by many progressive poultry men. There are, no doubt, possibilities for the use of growth stimulating hormones to improve efficiency in the livestock industry. There are favorable indications of such applications. Nevertheless, it should be clearly emphasized that this treatment would be of no value unless the meat from treated animals is proved free from such materials that might be retained in the tissues in quantities sufficient to constitute a hazard to consumers of the meat.

This study is presented as a contribution to our ever-increasing knowledge of the factors affecting sexual differentiation. Rabbits were used in this work for a variety of reasons. They require small space, are easy to manage, are inexpensive and make good laboratory animals.[1] Very little information is available on the hormone treatment and response of rabbits, especially toward the sex hormones. Rabbits are an excellent source of meat and any improvement along this line would be of economic importance to the rabbit industry. Studies covering the differences between males and females such as the rate of gain, efficiency of food utilization, dressing percentage, chemical composition of both lean and fat tissues, quality of the cooked meat and the palatability of fresh and frozen-stored meat samples will greatly augment our present knowledge of rabbits.

[1] Also, rabbits produce edible meat which may be tested organoleptically, which gives them a definite advantage over the rat and the guinea pig.

REVIEW OF LITERATURE

The findings of many investigators concerning the action of estrogens and androgens on the various systems and organs of many species are rather contradictory, diverse, and interesting. Therefore, a review of the literature dealing with the effect of the administration of estradiol, stilbestrol, and testosterone on laboratory and farm animals is presented for a better appreciation of their effects. No attempt is made to review all the literature available on hormones. Reference is made only to those studies pertaining to the present investigation.

Since the castration of males and females affords a more exact method for studying the effects of sex hormones, it has been considered advantageous to present some of the fundamental effects of gonadectomy in animals. Gonadectomized animals differ from intact animals in many respects; therefore, it is necessary to review some of these differences. Similarly, a description of the sex hormones should help to better understand how they act and are metabolized in the animal body. Also, some knowledge of the chemical composition of rabbits is useful so that changes which may be induced by hormones will be easily recognized and understood. The hormone response of laboratory animals such as rabbits in which the females grow faster and become larger than the males should be compared with the hormone response of other laboratory animals such as the rat and that of beef cattle which are opposite, with males growing faster and becoming larger than the females.

Effect of Castration.

In many species prepubertal castration will result in an arrest in the growth and development of the external and internal accessory genital organs, and in the failure of sexual differentiation in regard to deposition of fat, growth of hair and skeleton, and changes in voice and psychic characteristics (1, pp.886,896). Castration generally will result in an increased fat deposition, and will slow down gains in body weight (21, p.292). On the other hand, postpubertal castration in both males and females may cause the loss of mating instincts in some species and always results in sterilization of the individual. There is an atrophy of the accessory genital organs and a retrogression of the secondary sexual characters already developed. Nevertheless, there is still some controversy concerning the effects of castration especially in the case of removal of the testes from the adult (1, pp.336,393,886, 896).

The various glands of the body undergo many changes in size and weight, as well as histologically, following castration depending on the age of the animal and stage of maturity when gonadectomized. Fichera (1905), as reported by Allen (1, p.336), found an increase in the size of the pituitary of guinea pigs, rabbits, fowl, pigs, cattle and buffalo following castration. Allen (1, p.806) agreed with Fichera that castration in either males or females produced a larger size and caused histological changes in the anterior pituitary. Allen added that, although there are species differences and controversial opinions, he believed that castration resulted in an increase in eosinophiles in the rabbit, guinea pig, domestic fowl, cat, dog, pig,

ass, horse, ox and man. Allen (1, p.807) also stated that the increase in the size and weight of the pituitary must take place through changes in cell size (hyperaemia) since actual increase through cell division (mitosis) had rarely been reported and had never occurred in the matured gland (1, p.806).

Many observations have been made on rats following castration. Ovariectomy resulted in heavier rats than intacts (11, 17, 75). The latter workers (75) reported an increase in fat deposition, weight of the liver and weight of the adrenal glands and a slight decrease in weight of pituitaries of the castrates when compared with intact animals. The differences between males and females in response to gonadectomy have been the subject of many investigations. Korenchevsky et al (73, 75) found that castrated males had hypertrophied adrenals and pituitaries, increased fat deposition, and lowered body, kidney, and liver weights when compared to intacts. Spayed females when compared with intact females did not show any definite changes in the weights of adrenals, pituitaries, livers, kidneys and heart, or in fat deposition. The effect of gonadectomy on the adrenals of the rat was also found to differ in the two sexes; the gland became enlarged in the males but diminished in size in the female after the operation according to Hatai (1913, 1915) as reported by Burrows (21, p.543).

Prepubertal castration of young male rats resulted in changes that appeared gradually in the adrenals and were fully developed in about two months following castration. There was an increase in the size and weight of the adrenals following castration. This has been

attributed to the hypertrophy of the zona fasciculata and reticularis, especially in the latter, resulting in an increase in the size of the cells composing these layers (48). In addition to the hypertrophy of the adrenals in castrated immature rats, there was also hypertrophy of pituitaries and a decrease in the weight and size of the thyroids (78). On the other hand, Overholser (106) found no changes in the weights and sizes of thyroids from immature castrated albino rats.

There was a marked increase in the luteinizing hormone and the follicular stimulating hormone potency of the pituitary gland whether castration was carried out before or after puberty in the rat (41, 51, 52, 54).

It appears that prepubertal castration also resulted in an increase of urinary nitrogen excretion, disturbance of exogenous and endogenous sulfur metabolism with a rise in total sulfur as well as in neutral sulfur excretion, and a decrease in chlorine, sodium, and potassium retention (116).

Billing and copulation was found by Carpenter (1931), according to Allen (1, p.834), to be greatly reduced in birds. When male pigeons were castrated and mated to normal females, their nesting and brooding activities were completely abolished.

Another feature of interest is the effect of gonadectomy on the female monkey, Macacus rhesus, which showed the usual atrophy of the accessory genital organs and in addition there was a fading in the color and a reduction of the swelling of the sexual skin until the skin in these regions was pale and tight, reported Allen (1, p.446).

Several observations have been made on the mouse following gonadectomy. When castrated at the age of five weeks relatively large thymi were developed. The adrenals became larger than those of the controls and the mice accumulated large amounts of abdominal fat (68). Postpubertal castration resulted in the regression of the accessory sex organs to a basal state within one month following castration (30). Diminution of kidney weights also followed castration (69).

Knaur (1900) and Halban (1900), as reported by Allen (1, p.481), found that moving the ovaries to a different site did not result in the atrophy of the genitalia in either female rabbits or guinea pigs.

An increase in the chromophobes in the pituitaries of the castrated rabbits has been observed by Okinschitz (1914) as reported by Allen (1, p.807). Ferrari (1930), as reported by Crafts (28), found that male rabbits became more susceptible to anemia following castration. Allen (1, p.262) also reported that Truffi (1927) found no notable variations in either the hemoglobin or the red cells as a result of castration in the male or female rabbit. In some species, such as sheep and swine, castration resulted in the diminution of the erythrocytes (Sustchowa, 1910) and in dogs castration led to the diminution of hemoglobin and red cells (Antonelli, 1914) as reported by Allen (1, p.261).

Prepubertal castration of the fowl resulted in the failure of the comb and wattles to grow in the cock while postpubertal castration resulted in the involution of those parts. Capons are not attracted sexually toward females; they do not crow or fight other cocks but they grow slightly more rapidly and deposit more fat than cocks (1, p.299).

The Sex Hormones.

Four types of steroid hormones are recognized: estrogenic, androgenic, progestational, and adrenocortical (38). The role of steroid hormones as modifiers of the manifold morphological and functional manifestations of sexual phenomena have been investigated but little is actually known of the proximate functions of these biocatalysts as regulators in the metabolic processes associated with sexual functions (111, p.593). Each of the above-mentioned types of steroid hormones has subsidiary biological activities of its own which differentiate them from each other physiologically as well as revealing the source of each. For more enlightening and detailed information about the steroid hormones there are good reviews such as those of Allen and associates (2), Hartman and Brownell (50), Koch (66), Burrows (21), and Cameron (22).

The gonadal hormones are chemical substances which regulate the male and female characters of the body and control sexual impulses and behavior. They stimulate the development and activity of the accessory genital organs which, in the absence of the hormones, would not come into existence, or if already present, would not attain full development (21, p.115; and 38).

Androgens and estrogens are produced by both males and females (21, p.120; and 71). The difference between sexes in the elaboration of the gonadal hormones is one of degree alone (21, p.122). These hormones have been found in many tissues of the body besides being in the gonads (22, p.242). Selye (117) reported that weight for weight the androgens were considerably less active than the estrogens.

The sterol nucleus, a characteristic of naturally occurring gonadal hormones, does not appear to have any significant effect on the physiological activities of the hormones (21, p.117). However, the spacial relationships are important in their effect on the activity of the hormones, reported Kirk and Othmer (65, p.538) and there is great sensitivity to structural variations. These workers added that the trans- isomer, for example, in the case of diethylstilbestrol is the potent one while the cis- isomer has no biological effect. While the chemical structure of testosterone and estradiol (figure 1-a,b) has the same basis, a slight difference in the common pattern will result in diverse physiological action of the hormones. (Testosterone has an additional methyl group and a ketone group in place of one of the hydroxyl groups as compared with estradiol, reported Cameron (22, p.183) and Gortner and Gortner (47, p.973). But, a synthetic substance like stilbestrol, having estrogenic activities similar to those shown by estradiol, is completely different structurally from estradiol. It might be that an organic compound introduced into the body may undergo such changes that the biological effect produced is not necessarily due to the compound used but rather to a metabolite of the original compound.

Androgens are compounds which stimulate the secondary sex structures and characters of the male mammals and birds (38), maintain spermatogenesis (39), and affect the skeletal system, the skin and several other organs (46; 21, p.176; 65, p.529). Androgens also influence electrolyte metabolism (64, 111, 133) as well as nitrogen metabolism in mammals producing such systemic effects as muscle growth and nitrogen retention (64; 65, p.529; 67, 70, 107).

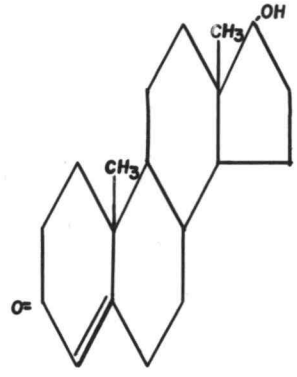
Testosterone, the most potent androgen known except for certain of its esters, has been isolated from the testes of man, the bull, the stallion, the boar and the rat (22, p.243; 38, 63). Testosterone ($C_{19}H_{28}O_2$) is written as:

Δ^4 - androstene - 17(α)-ol-3-one (65)

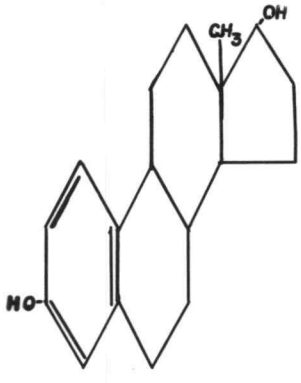
Estrogens are characterized as substances which can stimulate and maintain the female secondary characters and structures in mammals and birds. Estrogens also influence water and electrolyte metabolism (111), the skin, nipples, the skeletal system and other organs (21, p.124). Estrogenic stimulation has resulted in the deposition of glycogen, indicating a possible influence on carbohydrate metabolism, and it has also been found that estrogens cause alterations in fat metabolism (111). Inconclusive evidence is available concerning the influence of estrogens on protein metabolism (111). All these effects have been produced by using either naturally occurring estrogens, such as estrone, or those synthetically produced, such as stilbestrol and dienestrol, the last two being qualitatively similar in practically all respects of biological action to the naturally occurring estrogens (38, 99).

Alpha-estradiol, the most potent natural estrogen, has been isolated from such organs as the ovaries of the sow, testes of the stallion and the human placenta (22, p.243). Estradiol dipropionate (estradiol 3, 17 dipropionate: $C_{24}H_{32}O_4$) is prepared from estradiol (65, pp.514-515).

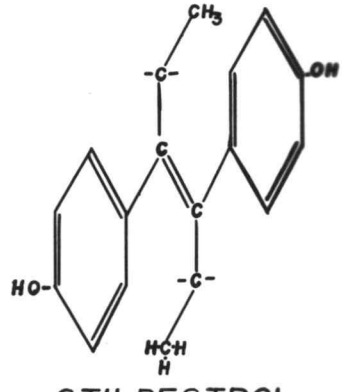
Diethylstilbestrol (4:4'-dihydroxy -αB -diethylstilbine: $C_{18}H_{20}O_2$) is one of the most potent synthetic, non-steroid estrogens



a. TESTOSTERONE



b. ESTRADIOL



c. STILBESTROL

Figure 1. BASIC STRUCTURAL FORMULAS FOR THE HORMONES USED IN THE STUDY

and has an activity almost comparable to that of estradiol, figure 3, (22, p.246). Gortner and Gortner (47, p.972) stated that the 4-hydroxyphenyl groups of the diethylstilbestrol are importantly concerned with the physiological activity of this substance.

Chemical Composition of the Rabbit Carcass:

The chemical constituents of the edible portions of many species of animals have been known to differ as a result of sex, age, breed, and nutritional condition at the time of slaughter. In the white Angora rabbit, several observations were made by Wilson and Morris (136). They reported that the dressing percentages for males and females were 58.0 and 61.0, respectively; and that in rabbits averaging eleven months of age, the females had about four per cent more fat than males, while in rabbits averaging twenty-four months of age, the females had about six per cent more fat than males. When they analyzed a sample of the well-minced and mixed edible parts (muscle, fat, liver, heart and kidneys) from each rabbit they found that young does had 20.3, 5.8, and 67.3 per cent protein, fat and moisture, respectively, while males had 21.1, 1.7, and 69.7 per cent of the same respective constituents. The increase in the dressing percentage as the rabbits grew older was due to an increase in the fat content and a decrease in the moisture content, in both sexes. When the fresh flesh was analyzed by itself, it was found by Rosedale (1931) as reported in USDA, Agricultural Handbook No. 34 (129, p.33) to be made up of 21.0, 8.0, and 70.0 per cent protein, fat and moisture, respectively. Winton and Winton (137, p.329) compared the composition of fresh and cooked rabbit meat. Average composition of the fresh meat was 20.4, 11.89, and 66.0 per cent, while that of cooked meat

was 28.1, 20.1, and 49.4 per cent protein, fat and moisture, respectively. Ziegler (141, p.258) had the following values for the protein, fat and moisture from fresh rabbit carcasses: 20.8, 10.2, and 67.7 per cent, respectively.

The quality of the fat from rabbits has also attracted much attention. Lea (83, pp.212-213) reported that the fat surrounding the kidneys and covering part of the abdominal wall in rabbits has an iodine value in the order of 110 to 180. He added that wild rabbits have an iodine number in the order of 117 to 179. On the other hand, Hilditch (57) showed that the iodine value of wild rabbit fat was in the order of 101.1, while that for tame rabbits was 64.4. He also concluded that about 70 per cent of the fatty acids were unsaturated and mostly made up of lenoleic acid. Lea (83) agrees that the perinephric fat of the rabbit contains about 68 per cent unsaturated fatty acids. He also added that the yellowing of the fat due to oxidation occurred after 120 to 150 days when stored at -10.5°C., or after 270 days when stored at -18°C.

The Response of Laboratory Animals to Sex Hormones:

1. Response to androgens. The growth of young animals, the development of their organs and the deposition of fat in both young and old animals have been affected in a variety of ways through androgen administration. Variations in response have been partly due to the dosages used, the periods of treatment, the sex and age of the animal and the method of administration.

There was no growth inhibition in immature female rats when they were injected three times per week with 0.5 mg. testosterone propionate

for a period of 102 days (89). Small amounts of androgens appeared to augment the rate of longitudinal growth of the skeleton, according to Gardner and Pfeiffer (46). However, Turner and associates (128) did not find any significant alterations in body growth or skeletal maturation of normal and castrated male rats subjected to prolonged injections of large amounts of testosterone propionate (0.25 to 2.0 mg. daily for 16 to 135 days) even when started at the age of one day. Rubinstein and Solomon (113, 114) found that small doses of testosterone propionate (0.05 mg.) daily during a 53-day period stimulated the growth of intact male rats. However, large doses (1.0 mg.) daily for 26 to 80 days resulted in a reduction of body weight and length of castrated males as compared to their controls. Papanicalaou and Falk (107) reported that the prolonged administration of testosterone propionate into immature castrated male rats as well as into intact and spayed adult female rats was conducive to the hypertrophy of various muscles in their bodies.

Comparing young normal and castrated male rats injected with 2.5 capon units, or multiplications of this dose, of a testicular hormone, Korenchevsky and associates (78) concluded that the treatment stimulated the appetite and resulted in larger gains in the castrates compared to the intacts. The latter showed no definite effect of the hormone on body gains. Korenchevsky and coworkers (76, 77) injected normal adult male and female rats with 0.5 to 1.5 mg. testosterone or testosterone propionate daily for 21 days. They reported that fat deposition and gains in body weight were reduced in the males when compared with the controls. There was less abdominal fat in the treated females but there

was no significant effect on the gains in body weight when compared to controls. However, castrated male rats injected with various dosages of male hormone preparations showed improvement in gains (72, 73). The latter workers also reported that the increase in weight gains due to the hormone treatment was not the result of fat deposition. However, when castrated males and females were injected with 167 to 1400 micrograms of either testosterone or testosterone propionate daily for an average period of 22 days, several facts were observed by Korenchevsky and associates (75). They found that small dosages of testosterone propionate (167 micrograms) resulted in an increase in body weight gains while larger dosages (500-1400 micrograms) resulted in a decrease in body weight gains of castrated males. They also found that in females the hormones caused a reduction in fat deposition and a decrease in gains. In another trial, the same workers (74) used 200 to 3000 micrograms of androstenediol or of androstenedione daily in castrated male and female rats. They found that androstenediol caused a reduction in fat deposition and a decrease in weight gains in both sexes. Androstenedione had no effect on females but it improved weight gains of males when compared to controls.

Body weight and length were increased in monkeys five months of age injected with testosterone propionate at the rate of 7.5 mg. per kilogram body weight per week, according to van Wagenen (130). He found that the weight and length of the body at the end of the first year of age was equal to that normally reached at the end of the second year of age. McCullagh and Rossmiller (90) using methyl testosterone were able to stimulate growth in a dwarf patient. They were also able to increase

gains in body weight of eunuchoid patients. Kenyon and associates (64) were also able to produce body weight gains in eunuchoid patients using testosterone propionate. They claimed that this increase in body weight was the result of increased nitrogen, sodium and chlorine retention and the subsequent water held in association with those elements. Nitrogen retention following testosterone propionate administration has also been observed in the dog by Kochakian (67).

The response of the gonads to the male sex hormones has been an interesting and important subject especially from the therapeutic point of view. The response of the ovaries differs somewhat from that of the testes but depends on the age of the animal as well as on many other factors.

Immature female rats subjected to treatment with testosterone propionate had smaller ovaries than the controls (81, 89). These investigators concluded that the male hormone inhibited the development of the ovaries. An arrest in the follicular development in rat ovaries following the administration of 1.0 mg. testosterone propionate three times per week was reported by Laqueur (80). He also found that the dosage used prevented luteinization of the follicles. However, from his experiments with immature female rats injected with a single dose of 1.0 or 5.0 mg. testosterone propionate, Salmon (115) concluded that androgens (testosterone propionate and androstenediol) stimulated the hypophysis to produce follicle stimulating hormone and luteinizing hormone resulting in the production of follicular growth as well as the production of corpora lutea in the ovaries of immature females. Papanicalaou and Falk (107) concluded that testosterone propionate

administration into females caused hyperplasia and hypertrophy of the interstitial tissues of the ovaries and that these stimulated tissues might be responsible for the stimulating effect on muscles.

In mature female rats, atrophy of the ovaries has been the general after effect of the administration of large doses of androgens (4.0 mg. every other day for 20 days, or 0.5 mg. three times per week for 62 to 68 days), according to Mazer and Mazer (89) and Laqueur and Fluhmann (81). However, Selye (117) concluded that the reduction in the size of ovaries in mice following the administration of 5.0 mg. of testosterone propionate daily for 20 days was not necessarily due to ovarian atrophy. Meanwhile, ovarian response to androgen therapy varies according to the phase of the estrual cycle. Wolfe and Hamilton (139) reported that testosterone propionate in doses of 0.5 to 2.0 mg. had the capacity to suppress the estrual cycle or induce luteinization. Korenchevsky and associates (76) agreed that testosterone propionate had the capacity to suppress the appearance of the estrual cycle. They added that testosterone propionate at the rate of 1.5 mg. daily for 21 days also resulted in the hypertrophy of the ovaries and the uterine body and horns as a result of an increase in the thickness of mymetrium and the mucosa. They also found that there were more corpora lutea in the ovaries and that the hypertrophy of the vagina took place with various degrees of epithelium mucification.

The ovaries of young female chicks treated with 0.5 mg. of testosterone propionate daily for 5 days were smaller than those of controls, and there was also a reduction in follicular development according to Herrick and Lockhart (56). These workers concluded that

the depression in the size of the ovaries was the result of pituitary suppression rather than the result of a direct effect of the injected material on the gonads. Monkeys receiving 7.5 mg. testosterone propionate per kilogram body weight per week at the age of five months developed sexual maturity by the end of the first year of age while this manifestation occurred at the end of the second year of age under normal condition, reported van Wagenen (130).

The response of the testes to androgen administration was found to vary. Immature male rats treated with various androgenic preparations showed reduction, depression or inhibition of testes development (86, 91, 96, 97). Inhibition of sperm maturation and damage to the interstitial tissues as a result of prepubertal administration of 3.0 mg. testosterone propionate per week was reported by Shay and coworkers (120). When they used 30.0 mg. testosterone propionate per week starting on the first day after birth, they found an increase in testes weight and a stimulation of spermatogenesis as compared to controls, when the treatment was carried out for 30 days. However, when treatment was conducted for 60 days inhibition of spermatogenesis occurred and the testes weighed less than controls. Rubinstein and Kurland (112) reported a significant increase in the weight of testes from young rats injected daily with only 5 micrograms of testosterone propionate with an accompanying stimulation in germinal epithelium proliferation. Meanwhile daily doses of 10 micrograms had no effect on the weight of the testes of young rats while with larger doses (50 to 2500 micrograms) there was a significant decrease in the weight of the testes as compared to controls. The same workers also found that 2.5 mg. testosterone

propionate daily resulted in the degeneration and sloughing of the germinal epithelium. Testosterone, testosterone propionate and dehydroandrosterone acetate have been found to maintain normal progress of spermatogenesis in the testes of immature male rats (29, 39). The latter workers added that atrophy of the interstitial tissues occurred nevertheless.

Several investigators (86, 96) agree that the gonadal hormones of the male do not have a direct effect on the gonads in either sex. Ludwig (86) suggested that the male hormone suppressed gonadotrophin secretion by the pituitary and thus indirectly injured the testes and inhibited sperm production. In comparing the gonad response of the male and female to doses of 0.5 to 10.0 mg. testosterone propionate daily, Freeman and Small (44) concluded that although the weights of the gonads in both sexes were increased, the ovaries were less responsive than testes to similar dosages. They added that the uterus was the most sensitive organ to testosterone followed by seminal vesicle and prostate combination and finally by the ovaries which were the least responsive. Korenchevsky and associates (78) found that a small dose (2.5 c.u.) of testicular hormone caused a slight decrease in the weight of the penis, prostate gland and seminal vesicle of young rats. Larger dosages (5.0 c.u. or more) caused an increase in the weights of these organs when compared to controls.

The administration of 0.5 to 1.5 mg. of either testosterone or testosterone propionate into mature male rats for 21 days resulted in a slight depression in the weight of the testes when compared to controls, according to Korenchevsky and associates (77). These workers added that

while testosterone had no effect on the secondary sexual organs, testosterone propionate resulted in the hypertrophy of these organs. A reduction in the weights of rat testes occurred when 0.05 to 1.0 mg. of testosterone propionate was administered daily for 30 days into mature rats according to Ludwig (86). Doses higher than 1.0 mg. (2.0 or 3.0 mg.) daily and for the same period maintained, at near normal level, testes weights. In adult mice, injected daily for 19 to 40 days with 5.0 mg. testosterone no change was obtained in testes weights reported Selye and Friedman (118). However, they found that doses of 2.0 or 10.0 mg. of testosterone per day resulted in the atrophy of the Leydig cells, and there was damage to the tubular tissue with the somewhat smaller doses. Moore and Price (96) reported that the daily injections of 3.5 r.u. of a testicular hormone caused significant stimulation to the secondary accessory organs in the mature rat although it had no effect on the testes. However, the same workers concluded from another trial (98) that although testosterone propionate caused grave retardation and injury to the testes in the young rat, the effect gradually declined with age.

Inhibition of testes growth in the ground squirrel occurred in most cases where daily doses of 0.05 to 20.0 mg. of testosterone or testosterone propionate were administered for from 18 to 20 days, according to Wells (132). He also found that the hormone treatment caused severe injury to the interstitial cells of the gonads but that there was no significant damage to the germinal epithelium. Wells also added that he did not find any reduction in the number of spermatozoa and that the formation of the latter was not prevented in the immature

animals. Cheng and Casida (23) found that a daily dose of 1.0 to 10.0 mg. of testosterone propionate for 20 to 32 days improved libido and sexual activity of the male rabbit. They added that there was also an improvement in the average motility of the sperms. In the chick, immediate cessation of testicular growth occurred following the daily administration of 3.0 to 30.0 capon units of testosterone for 5 days (15). In a later trial, Breneman (16) found that a daily dose of 0.05 mg. of testosterone propionate administered to chicks 40 days of age for a 10-day period inhibited testicular growth. He also found that the right testes was influenced more by testosterone propionate than the left one.

The role of the pituitary gland and more specifically that of either of its component lobes has been the subject of controversy especially in relation to its behavior toward administered androgenic preparations.

The immature female rat injected every other day with 1.0 mg. of testosterone propionate for ten days showed no changes in the weight of the pituitary when compared with controls, reported Clausen and Freudenberger (24). Wolfe and Hamilton (139) using a higher dose (2.0 to 8.0 mg. daily) for 10 to 20 days found that the immature female rat had slightly smaller pituitaries than the controls. The same workers using lower levels (0.1, 0.25, 0.5 and 1.0 mg. daily for 90 days) reported that the weights of the pituitaries from treated females were more comparable to those of their untreated brothers than to those of their sisters. They added that the pituitaries from treated females had a cellular pattern in the anterior pituitary that was also more similar

to that of the brothers than to that of the sisters. Mazer and Mazer (89) also found that immature female rats injected with 0.5 mg. testosterone propionate three times per week for 102 days had smaller pituitaries than their controls. When adult females were subjected to a similar dose but for 65 days, their pituitaries were smaller when compared to those of the controls but the difference was not significant. However, the pituitaries of young (36-day old) male and female rats injected daily with 0.2 to 2.0 mg. of testosterone did not show any difference in weights from those of the controls. Meanwhile, adult female mice receiving 5.0 mg. of testosterone propionate daily for 20 days had significantly smaller pituitaries than the controls according to Selye (117). Similar observations were made with rats by Mark and Biskind (87) when they implanted testosterone propionate pellets into intact females. These workers found that during a 36-day period the daily rate of hormone absorption was about 54 micrograms from the pellets and that this resulted in the reduction of pituitary size as compared to that of the controls.

In castrated male rats injected with 1.5 c.u. of testosterone daily for 7 or 21 days there was no difference between their pituitaries and those of control castrates, reported Korenchevsky and Dennison (72). Castrated male rats treated with various levels of androgens (8.0 to 1400 micrograms) showed no definite change in the hypertrophic condition of the pituitary due to castration when testosterone was used according to Korenchevsky and associates (73). However, when castrated females were treated with testosterone their pituitaries which had not been significantly changed as a result of castration, decreased in

weight as compared to controls. Heller and coworkers (54) reported that the administration three times per week of 1.0 to 2.0 mg. of testosterone propionate into castrated male rats caused no significant reduction in the weight of the anterior pituitary of the already hypertrophied gland. There was also no reduction in the hypophyseal gonadotrophic potency of the gland. However, when the same workers used 5.0 or 10.0 mg. doses of testosterone propionate the weights of the pituitaries were lowered in comparison to those of the controls. When a 0.1 mg. dose of testosterone propionate daily, which more closely approximated a physiological dose, was administered to castrated rats there was no effect on the pituitaries (84). Similarly, the administration of 200 to 3000 micrograms of androstenediol or androstenedione into castrated male and female rats did not have much effect on the hypertrophic condition of the pituitaries, which was more evident in the males according to Korenchevsky and associates (74). Testosterone propionate in daily doses of 0.05 mg. for 10 days caused a reduction in the weight of hypertrophied pituitaries of 40-day old chicks but had no effect on the gland of normal chicks, according to Breneman (16).

The adrenal glands have been found to undergo weight and size changes as a result of androgen therapy. Smaller-than-normal adrenals were obtained by Mazer and Mazer (89) in immature intact female rats injected with 0.5 mg. of testosterone propionate three times per week for a period of 102 days. When only 0.1 mg. of testosterone propionate were injected every other day into immature female rats for ten days, no changes in the adrenals were found by Clausen and Freudenberger (24). Mitotic activity was stimulated when a single dose of 5.0 mg. of

testosterone propionate was given to immature female rats according to Nathanson and Brues (102). A slight but not significant reduction in the size and weight of the adrenals followed the administration of 2.0 mg. of testosterone daily into young male and female intact rats (25 days old) for 23 days, reported McEuen and associates (91). However, there was a decrease in the size and weight of the adrenals from normal adult female rats injected with 0.5 mg. of testosterone propionate daily for 21 days according to Korenchevsky and coworkers (76). Similar observations were made by Mazer and Mazer (89) with adult female rats injected with 0.5 mg. of testosterone propionate three times per week for 62 to 68 days. A daily dose of 1.5 mg. testosterone propionate daily did not have any effect on the gland (76).

In young castrated male rats injected with 2.5 c.u. of a testicular hormone (or a multiplication of that dose) during a three-week period showed a reduction in the size of hypertrophied adrenals according to Korenchevsky and associates (78). Castrated male rats injected daily with 1.5 c.u. of testosterone for 7 or 21 days returned to normal in adrenal size after the adrenals had become enlarged following castration (72). Similar observations were made by Korenchevsky and associates (73) when castrated male rats were injected with 167 micrograms of testosterone or more (up to 1410 micrograms) daily for 23 days. They added that in the female castrated rats testosterone, in daily doses of 167 to 700 micrograms, decreased the size and weight of the slightly hypertrophied adrenals. Hall and Korenchevsky (48) injected immature castrated male rats with 0.1 to 27.0 mg. of a male sex hormone daily for periods of 21 up to 59 days. They found that the

hormone produced a comparatively lasting recovery of the adrenals toward normal. They added that with the large doses there was a decrease below normal in the width of the zona fasciculata and the reticularis and of the size of the individual cells. There was also an abnormal decrease in vacuolation and in the number of lipoid cells. However, Leathem (84) reported that the daily administration of 0.1 mg. of testosterone propionate into castrated male rats did not cause any alterations in the weight or size of the adrenals when given for 20 to 25 days. He added that this dose more closely approximated a physiological dose. He also found that castration did not significantly cause any change in the adrenals.

Adult intact female mice injected daily with 5.0 mg. of testosterone propionate for 20 days showed a reduction in the size of the adrenals, according to Selye (117). He added that the atrophy was due mainly to the involution of the cortical cells with all three zones participating. Kochakian (68) reported that castration will result in gradual but definite increase in the size of the adrenals and he concluded that androgens prevented this hypertrophy.

Thyroid glands have been found to respond in a variety of ways to androgen administration. In the immature intact female rat there was a slight but not significant increase in the weight of the thyroids when a 1.0 mg. dose of testosterone propionate was injected every other day for ten days (24). Nathanson and associates (103) injected immature intact female rats with a single dose of 5.0 mg. testosterone propionate. The rats were injected with colchicine twelve hours before killing, and they were killed 24 hours or more after the androgen

injections. These workers concluded that the testosterone increased mitotic activity in the thyroids with an increase in the functional activity in the epithelium. There was also an increase in cell height of the glands. Young normal and castrated male rats injected daily with 2.5 c.u. of a male hormone preparation for a period of three weeks showed an increase in the weight of the thyroids toward normal in castrates, according to Korenchevsky and associates (78). Thyroids from castrated rats were smaller in size and less in weight than those from intact rats, added these workers. In castrated male rats injected daily with 1.5 c.u. of testosterone for 7 or 21 days there was a return toward normal from changes undergone by the thyroids as a result of castration (72). Normal male rats (150-155 days old) injected daily with 0.1 to 2.5 mg. of testosterone propionate for 20 to 25 days showed a slight decrease in the weight of the thyroids in some cases, according to Leathem (84). He added that castration caused a slight decrease in the weight and size of the thyroids. The castration of the female rat did not significantly affect the weight of the thyroid glands but a daily dose of 167 to 700 micrograms of testosterone resulted in an increase in thyroid weight, according to Korenchevsky and associates (73). In the adult female mouse a daily dose of 5.0 mg. testosterone propionate for 20 days resulted in an enlarged thyroid with an increase in the height of the follicular epithelium and some colloid absorption, reported Selye (117).

Androgenic substances influence the liver of treated animals depending on the sex, dose and sex status. Castrated female rats treated daily with 167 to 700 micrograms of testosterone resulted in a

definite decrease in liver weights, according to Korenchevsky and associates (73). They added that castration by itself did not affect liver weights significantly. However, when they injected castrated male rats with 33 to 1410 micrograms of testosterone daily for 23 days, liver weights were restored to normal. Similar observations were also made with male castrated rats using also 167 to 1400 micrograms but of testosterone propionate for 23 days (75). Korenchevsky and associates (75) found that although castration resulted in a decreased liver weight in males, there was an increase in the liver weights of castrated females when compared with their respective control intacts. The weights of livers from castrated male rats injected daily with 0.1 mg. of testosterone propionate for 20 to 25 days were found to increase above those of intacts and those of castrates, according to Leathem (84).

Castrated mice implanted with testosterone propionate pellets (10.0 to 24.0 mg.) and killed after certain intervals had heavier livers than their controls (68). However, the daily administration of 5.0 mg. of testosterone propionate to adult female mice caused no change in liver weights or histological structure (117).

2. Response to estrogens. In young immature female rats almost complete growth retardation was shown by Doisy and associates (37) as a result of the daily administration of three rat units of theelin for 35 days. Spencer and coworkers (125, 127) found that immature male and female rats injected daily with 10 to 20 rat units of estrin for 8 to 9 weeks had significantly slower growth rates and shorter bones when compared to controls. Similar observations concerning the growth

depressing action of 1.25 to 20 rat units of various estrogenic preparations in immature male rats were made by Wade and Doisy (131). However, when a large dose (120 rat units of theelin) was injected every other day into immature female rats for nine days' growth depression was not significant when compared to controls, according to Clausen and Freudenberger (24). Using stilbestrol in doses of 1.25 or 2.5 mg. three times per week for 28 to 150 days, Morrell and Hart (100) found that the growth rate of immature female rats was slowed down but was not inhibited. When one or two 15 mg. pellets of stilbestrol were implanted into immature male rats for seven or more days there were also significant reductions in gains, reported Nalbandov and Baum (101). Contrary to the above results, higher rates of gains were observed with castrated young and adult female rats injected daily with three Doisy rat units for 21 weeks or more (11). Korenchevsky and Dennison (71) using various levels of estrone on intact and castrated male rats found that up to 20 i.u. daily did not affect weight gains while all levels above 180 units daily resulted in depression in gains as compared to controls. Halpern and D'Amour (49) observed a difference between sexes in the response to estrin. They found that five rat units daily for three weeks followed by 20 rat units daily for from one to four weeks had no effect on body weights of intact female rats. Progressive weight losses occurred in both castrated females and intact males. In normal and ovariectomized female rats the daily administration of one rat unit estrone caused a depression in rate of growth, according to Bogart and associates (12). They also found that estrone caused more growth retardation in the spayed as compared to the intact females. They

concluded that large dosages (20 to 120 i.u.) every four days in spayed rats decreased growth rate and held it near that of normal females.

Estrogens have been found to regulate to some extent the morphogenesis of the skeleton and to control in part skeletal growth (46). Gardner and Pfeiffer (46) found that while large amounts of estrogens inhibit the growth of cartilage and hence longitudinal osseous growth, small amounts may augment the longitudinal rate of skeleton growth.

The response of the pituitary to estrogen therapy has been an important point of controversy. Modifications in the activity of the gland, changes in its size and weight, as well as histological alterations have been observed. Estrin has been found to suppress (95, 96) or decrease (94) the pituitary production of gonadotrophins in young castrated male and female rats. However, estrin has also been found to activate the anterior lobe of the pituitary (43, 82) of the young immature rat with the subsequent increase in luteinizing hormone production, or something associated with it.

The administration of two rat units of estrin daily for 20 or more days into immature female rats did not affect the weight of their pituitaries, according to Leonard and associates (85). No histological changes occurred in the pituitaries of immature male and female rats injected daily with 20 rat units of estrin for 54 days, reported Spencer and coworkers (125). However, a dose of 120 rat units of theelin every other day for nine days given to immature female rats resulted in pituitaries weighing 26 per cent more than controls (24). Stilbestrol, administered three times per week in doses of 1.25 or 2.5

mg. for 28 to 150 days caused an increase in the weight of pituitaries of immature female rats (100). However, Morrell and Hart (100) found that as the period of treatment increased, the differences between control and injected rats became less. Non-significant increases in the weights of pituitaries from young male rats over that of the controls were obtained when one or two 15 mg. pellets of stilbestrol were implanted subcutaneously, according to Nalbandov and Baum (101).

Enlargement of the pituitary in the normal adult female rat accompanied by chromophilic degranulation has been reported by Nelson (104), as a result of the daily injection of 40 rat units of estrone. No effect was observed with a daily dose of 20 rat units. However, Nelson (104) added that in the spayed female rat injected with 40 rat units changes in the pituitary following castration were prevented, and chromophilic degranulation as well as weight changes were less marked than in the case of intact rats. Considerable increase in the weight of pituitaries from normal and castrated male and female rats as a result of estradiol benzoate administration in doses of 2400 units, twice weekly for 250 to 300 days were reported by Del Castillo and Sammartino (32). They added that chromophobe cells predominated, basophile cells were decreased or absent, and there was a decrease in vacuolization of eosinophile cells. Similar results were obtained by Ellison and Burch (40) using such estrogenic preparations as trihydroxy-, dihydroxy-, and ketohydroxy- estrin, hydroxy estrin benzoate, and a placental extract, emmenin. Hypertrophy of the pituitaries from adult female rats were also obtained by Diaz and associates (33) using estradiol benzoate; and by Morrell and Hart (99) using stilbestrol.

Korenchevsky and Dennison (71) injected castrated and normal male rats with large doses of estrone (60 to 180 i.u. daily) and obtained pituitary hypertrophy. There was a difference in response to estrin by adult intact male and spayed female rats as compared with the response of intact females, according to Halpern and D'Amour (49). Rats treated with five rat units of estrin daily for three weeks followed by 20 rat units daily for one to four weeks had heavier pituitaries than controls. However, pituitaries from normal females were heavier than those from normal males and spayed females. According to Anderson (4), time required for the pituitaries of castrated female rats treated with five rat units of amniotin three times per day for two days to reach maximum weight was 24 hours.

In the adult rabbit the daily administration of 10,000 rat units of the estrogenic hormone for 7 to 21 days had no effect on the weight of the pituitaries, according to Mazer and associates (88). A larger dose (12,000 rat units) administered to infantile rabbits also had no effect on the weight of the pituitary. The same workers injected rats with 500 rat units daily of the estrogenic hormone for seven days, or 100 rat units daily for 30 days and found no effect on pituitary weight.

Immature dogs injected daily with from 25 to 800 rat units of a female sex hormone (prepared from human pregnancy urine) for from 6 to 17 weeks showed that the ones receiving the largest dose had smaller anterior lobes and much larger posterior lobes than controls, reported Kunde and coworkers (79).

The gonads of the laboratory animals respond in many ways to estrogen administration. In the immature female rat estrin (37, 93),

theelin (37) and stilbestrol (100) have prevented the ovaries from reaching full growth and development. Spencer and associates (125) reported that the ovaries from immature female rats treated with 20 rat units of estrin daily for 54 days showed very few normal Graafian follicles and no corpora lutea. Doisy and coworkers (37) also reported a decrease in the number of developing follicles as a result of the daily administration of three rat units of theelin for five weeks, and there was also an increase in the amount of atretic degeneration of follicles. Atrophy and reduction in the weight of the ovaries was the result of the administration of 1.25 or 2.5 mg. of stilbestrol three times per week for from 28 to 150 days into immature female rats according to Morrell and Hart (100). In the mature female rat, ovarian growth was inhibited by the presence of circulating estrogens used at or above physiological levels, according to Heller and Jungck (53). Atrophy of the adult female ovaries occurred using 2400 units of estradiol benzoate (32) as well as with five rat units daily of estrin for three weeks followed by 20 rat units daily for one to four weeks (49). In the latter case the ovaries were 66 per cent of the size of those from non-treated rats. However, the formation of enlarged corpora lutea was obtained with 40 rat units of estrone daily (104), and with larger doses of other estrogenic substances (40). Enlargement of the ovaries was present in the latter case. Yet, continuation of the treatment in the first case resulted in the degeneration of corpora lutea and estrus became continuous (104).

In the immature male rat, testes development was slowed down as a result of estrin (95), theelol, theelin or extracts of the liquor

folliculi (131), and stilbestrol (101) administration. Estrin administration also resulted in the testes having small tubules with no evidence of advanced spermatogenesis (126). The same workers, in another trial (125) using 20 rat units daily of estrin found that the testes from treated animals weighed about 16 per cent of those from controls. These workers believed that the testes actually decreased in weight as a result of the treatment. They reported that the treated rats showed no sperms but that mitosis in spermatogonia was active while further development was inhibited. In the adult male, atrophy of the testes and loss of weight has been reported by Halpern and D'Amour (49), using estrin, and by Del Castillo and Sammartino (32) using estradiol benzoate. Testes weights were 65 per cent that of controls when five rat units of estrin daily were injected for three weeks followed by 20 rat units daily for one to four weeks, according to Halpern and D'Amour (49). They added that by extending the daily dose of 20 rat units for four weeks, testes weights were only 23 per cent of the controls. Similar observations had been made by Moore and Price (96) using 10 to 15 rat units of estrin on the adult male rat and they had found that the testes weighed from one-third to one-half as much as normal testes; there was a reduction in the weight of the seminal vesicles and prostate glands; and little or no spermatozoa were found in the epididymis. The seminiferous tubules were smaller than normal. However, Meyer and associates (93) found that females were more susceptible to estrogens than males.

In the immature rabbit, the subcutaneous administration of extracts of hog liquor folliculi retarded the development of the testes

according to Gould and Doisy (1924) and reported by Wade and Doisy (131). Several observations were made by Mazer and coworkers (88) using various doses of estrogenic compounds on rats and rabbits. Daily injections of 12,000 rat units for seven days into infantile rabbits had no effect on the weight of the ovaries although there was definite follicular stimulation. However, when 10,000 rat units were administered daily for 21 days into infantile rabbits the ovaries became heavier than those of controls, there were fewer follicles and there was dense growth of interstitial tissue. In the adult rabbit, a daily dose of 10,000 rat units of an estrogen for 21 days resulted in smaller ovaries, fewer follicles, follicular atresia and dense growth of interstitial tissue as compared to controls. A similar dose administered only for seven days caused a marked increase in the size of the ovaries of the adult rabbit. Mazer and associates (88) using rats in their experiment found that 500 rat units of an estrogen in single doses or daily for seven days caused advanced follicular growth in the immature animals. Using 100 rat units daily for 30 days in the infantile rats caused atrophy of the ovaries while the same dose used in the adult rat resulted in heavier ovaries, a decrease in the number of growing follicles, no corpora lutea, and adema of the interstitial tissue probably responsible for the increase in the weight of the ovaries.

In the young dog (8 weeks old) diminution of the size of the ovaries followed the subcutaneous administration of estrin for 6 to 17 weeks, and in doses ranging from 25 up to 400 rat units, according to Kunde and associates (79). They added that an arrest in follicular

development occurred with a relative increase in the amount of ovarian stroma.

The adrenal glands also undergo changes following estrogen administration, under specific conditions. Immature female rats treated with two rat units of estrin daily for varying periods of time (85), or with 1.25 or 2.5 mg. stilbestrol three times per week for 28 to 150 days (100) showed no effect on the adrenals. However, spayed immature female rats treated with three Doisy rat units for 21 weeks had slightly heavier adrenals than spayed controls, according to Billeter (11). He added that in older rats treated for 25 weeks, the adrenals were significantly smaller than controls. Theelin injections in doses of 120 rat units every other day for nine days into immature intact female rats caused a reduction of 12.3 per cent in adrenal weight (24). Diaz and associates (33) reported that in the mature intact female rat there was no significant change in the weight of the adrenals as a result of the daily administration of 200 rat units of estradiol benzoate for 70 days. Nevertheless, when the dose was increased on the sixtieth day to 1000 rat units daily for ten more days, hypertrophy of the adrenals became evident. Similar observations were also made by Ellison and Burch (40) using normal, castrated and hypophysectomized adult female rats injected with various dosages (200 to 1000 rat units daily) of several estrogenic preparations. They concluded that the moderate doses did not significantly increase the weight of the adrenals but significant increase was obtained with the higher dosages. In the spayed adult female rat, Anderson (4) found that five rat units of amniotin given three times a day for a period of two days restored

to normal weight found at estrous of atrophied adrenals. He added that the time required for the glands to show maximal response was about 48 hours.

Large doses of estrone (60 to 180 i.u.) daily caused hypertrophy of the adrenals of adult intact male rats while no effect was obtained in the castrates according to Korenchevsky and Dennison (71). They added that smaller doses (10 to 20 i.u.) did not have any effect on the intact rats. Hypertrophy of the adrenals occurred with large doses (2400 units) of estradiol benzoate when administered twice weekly for 250 to 300 days into normal and castrated male and female rats (32). However, in the immature male rat implanted with one or two 15 mg. pellets of stilbestrol no significant changes were found in the adrenals within a period of 7 to 28 days (101).

Immature dogs of both sexes treated with 25 to 800 rat units of estrin daily for periods up to 17 weeks were not significantly affected as far as weights of the adrenals are concerned (79).

Inconsistent results have been obtained on the response of the thyroid gland and the liver of animals treated with estrogenic compounds. In the immature female rat, heavy thyroids were obtained when 120 rat units of theelin were injected every other day for nine days (24), and when 2.5 mg. stilbestrol was given three times per week for periods from 28 to 150 days (100). A dose of two rat units daily for 20 to 66 days had no effect on the thyroid gland (85) while a daily dose of 20 rat units caused a slight but not significant increase in the colloid of the gland in both immature male and female rats (125). No change in the weight of the thyroids was obtained with various doses of

injected estrogenic compounds (40), or with implanted pellets of stilbestrol (101) in adult female and immature male rats, respectively. Meanwhile, in the mature spayed female rats injected three times per day with five rat units of amniotin for a period of two days atrophied thyroid glands were restored to normal weights found at estrus and the maximal response of the glands took place after 72 hours following treatment, according to Anderson (4). On the other hand, the biweekly injections of 2400 units of estradiol benzoate into normal and castrated male and female rats for 8 to 10 months caused the loss in weight of the thyroids, with homogenous colloid which stained lightly and with cells that were cubic and vacuolized (32).

The daily administration of 10,000 rat units of an estrogenic hormone for seven days had no effect on rabbit thyroids while treatment for 21 days caused histological changes indicative of gland inactivation (88). Mazer and associates (88) also found that this inactivation was due to the inhibition of the thyrotrophic function of the pituitary. Kunde and associates (79) reported that in the immature male and female dog marked hyperplazia of the thyroids occurred when large doses of estrin (800 rat units) were used daily.

The effect of estrogens on the liver does not seem to be constant or pronounced. Korenchevsky and Dennison (71) reported a slight decrease in the weight of livers from castrated and intact male rats injected with estrone, the effect being less pronounced in the intact rats. No pathological effects were observed in the liver of the immature dog receiving estrin (79) and no changes occurred in the liver of immature female rats injected with 1.25 or 2.5 mg. stilbestrol (100).

The Response of Farm Animals to Sex Hormones:

1. Swine. The subcutaneous implantation of a 15 mg. pellet of testosterone propionate at the start and then a second 12 weeks later into feeder pigs weighing on the average 43 pounds did not significantly affect rate of gain, feed efficiency or dressing percentage, reported Woehling and associates (138). Sleeth and coworkers (122) also found no increase in daily gains as a result of the intramuscular injection of 1.0 mg. testosterone propionate per kilo body weight per week into weanling pigs for six weeks followed by biweekly injections at the same level for the rest of the 115 days feeding period. There was also no difference between treated and untreated animals in tenderness, palatability, food consumption, carcass scores or average thickness of back fat. When 46-pound pigs were injected with 0.5 mg. testosterone propionate biweekly, there was also no difference between treated and untreated animals in average daily gains, added the same workers. Similar results were obtained by Bratzler and associates (14) when they implanted castrated male pigs weighing 40 pounds with 193 mg. pellets of testosterone propionate. They concluded that the hormone treatment did not affect rate of gain or efficiency of feed utilization of treated animals as compared with control castrated or normal burrows.

The subcutaneous implantation of either one or two 12.0 mg. pellets of stilbestrol in the ear, in the dorsal region of the neck, or in the scrotal sac did not consistently stimulate gains of 90-100 pounds in pigs, reported Dinusson and coworkers (35). The treated pigs were more efficient in their feed utilization than controls, but the difference was not significant. Pearson and coworkers (108) reported that

pigs weighing 35 pounds and implanted with a 25.0 mg. pellet at the start and after one month followed by two 25 mg. pellets after two months did not differ significantly from the controls in average daily gains, efficiency of feed utilization, thickness of back fat, or carcass grades. In a second trial pigs weighing 84 pounds were implanted with either one 50 mg. pellet of stilbestrol or one at the start and one every three weeks. The single treatment did not affect the average daily rate of gain but the higher dose did increase daily gains over control animals. Pearson and associates (108) added that there was no effect on dressing percentage, or on tenderness in these experiments just mentioned, but that there was a growth-depressing effect on the younger boars and little effect on the weight of the testicles. Similar observations were reported by Woehling and associates (138) when they implanted one 12 mg. pellet of stilbestrol at the start and another 12 weeks later into pigs weighing 43 pounds. There was no effect on rate of gain, efficiency of feed utilization, daily food consumption or dressing percentage. However, stilbestrol-treated gilts had smaller ovaries and follicles than controls while treated burrows had larger seminal vesicles, prostate and Cowper's glands than controls. The administration of 1.0 mg. estradiol benzoate per kilogram body weight biweekly into pigs weighing 46 pounds had no effect on average daily gains in a 39-day period, reported Sleeth and coworkers (122). There was also no effect on efficiency of feed utilization, carcass grades or tenderness.

2. Sheep. The subcutaneous implantation of a 10 mg. pellet of testosterone in wether lambs resulted in an increase in average daily gain and efficiency of feed utilization during a 68-day period, reported Andrews and coworkers (6). When another group of wethers received an additional 10 mg. pellet 43 days after the first one, there was no improvement over the controls in average daily gains. There was no effect due to the testosterone treatment on the daily food consumption of the treated wethers as compared with the controls. Treated wethers had carcasses that graded slightly higher than those of controls. However, the subcutaneous implantation of a 15 mg. pellet of testosterone propionate in lambs weighing on the average 76 pounds did not increase rate of gain or efficiency of feed utilization over that of the controls reported Pope and associates (110). O'Mary and coworkers (105) also found that the implantation of a 12 mg. pellet of testosterone in ewe and wether lambs did not cause any significant change in the rate of gain or efficiency of feed utilization. When 20 mg. testosterone dosages were injected weekly, there was a significant increase in the average daily gains and food consumption of ewes and wethers. It appeared that there existed a significant interaction between the sex of the animal and the hormone treatment. Treated wethers had slightly more external fat (20.2 gms.) than control wethers (19.2 gms.), while treated ewes had much less fat (21.6 gms.) than control ewes (27.2 gms.) in representative samples. Means, Andrews and Beeson (92) concluded that the subcutaneous implantation of 30 mg. testosterone propionate into lambs weighing 74 or 81 pounds resulted in faster and more efficient gains. The quality of the testosterone-treated carcasses did not differ

significantly from those of the controls. The increase in body weight of the treated animals was due to an increase in moisture and protein retention with less fat deposition.

The use of estrogens appears to have attracted more workers than the use of testosterone in lamb hormone research. Andrews and associates (6) found that the subcutaneous implantation of one or two 12 mg. pellets of stilbestrol in wether lambs resulted in a significant increase in rate of gain and efficiency of feed utilization when compared with the controls. Although the stilbestrol treatment tended to lower the dressing percentage as compared to that of controls, the difference was not significant. Jordan and Dinusson (61) reported that the subcutaneous implantation of a 12 mg. pellet of stilbestrol into suckling lambs one or two months of age weighing an average of 25 pounds did not influence the rate of gain or the development of testes in the males. Jordan (58) treated lambs four months of age as well as those seven to eight months of age with 12 mg. pellets of stilbestrol implanted subcutaneously. He found that treated animals made more rapid gains and were more efficient in their feed utilization than the controls. The heavier animals were more efficient than the lighter ones. The carcasses of all treated animals were watery and soft; the older animals showing a poorer grade when compared with the controls while carcasses from the younger animals that were treated were comparable to those of the controls. The subcutaneous implantation of a 15 mg. pellet of diethylstilbestrol into lambs weighing 76 pounds resulted in more rapid and efficient gains for the treated group as compared with the controls, reported Pope and coworkers (110). The

carcasses from the treated animals had less fat and were of a lower grade as compared with those from the control animals. Perry, Andrews and Beeson (109) found that the subcutaneous implantation of either one or two 12 mg. pellets of stilbestrol to ewes and wether lambs which were 21 to 42 days old resulted in a significantly higher rate of gain over that of the untreated animals. When ewe and wether lambs, weighing 76 pounds, were implanted subcutaneously with either one 12 mg. pellet of stilbestrol at the start, or with one at the start and a second 28 days later, there was an increase in the rate of gain, food consumption and efficiency of feed utilization as compared with untreated animals, according to O'Mary and coworkers (105). However, the treated animals when compared with the controls had lower live grades, lower dressing percentages and less external fat which had a higher moisture content. Jordan (59) implanted one 12 mg. pellet of stilbestrol into suckling lambs ranging from two to four months of age as well as into feeder lambs. The treatment did not improve the rate of gain or efficiency of feed utilization in the suckling lambs. There was a temporary arrest of testes growth from the stilbestrol treatment. However, there was an increase in the rate of gain and efficiency of feed utilization in the treated feeder lambs when compared to their controls. These treated lambs had carcasses of a lower grade, lower dressing percentages, and more shrinkage of the carcass during storage than controls. The carcasses from treated animals were soft and watery, were longer, and had less internal and external fat than those from the controls. During cooking there was no significant difference between the samples from treated and non-treated animals in the amount of

shrinkage although there was less vapor and drip losses in the samples from the treated lambs. There was a difference in the type of drip, however; there was more fat in the drip from control animals but more water in the drip from treated animals. Jordan (60) implanted either one 6 mg. or one 12 mg. pellet of stilbestrol subcutaneously into lambs weighing from 70 to 73 pounds and found no difference in response of the lambs to the two levels. However, all treated animals were more efficient in their feed utilization and gained faster than the controls. Carcass yields and grades were lower for the treated animals than for the controls. Means and associates (92) also found that the subcutaneous implantation of one or two, 12 mg. pellets of stilbestrol into fattening lambs weighing between 74 and 81 pounds resulted in faster gains with an increase in efficiency of feed utilization. There was a reduction in the carcass grades, an increase in the moisture and protein, and a reduction in body fat in the treated lambs as compared to the controls. Andrews and Beeson (5) stated that the site of stilbestrol injection or implantation did not influence the results. They also found that wether lambs weighing between 60 and 90 pounds implanted with one 12 mg. pellet of stilbestrol or injected with the hormone resulted in an increase in the rate of gain and efficiency of feed utilization. The subcutaneous implantation of two 12 mg. pellets of stilbestrol into feeder wether lambs weighing about 69 pounds resulted also in faster gains accompanied with an increase in nitrogen, calcium, and phosphorus retention, concluded Whitehair and associates (134). More recently, Clegg and Cole (26) showed that the implantation of one or two 12 mg. pellets of stilbestrol resulted in an increase in the rate

of gain and efficiency of feed utilization of ewes and wethers. They added that the response to the treatment was greater on the low dose rather than on the high one. Treated lambs had larger pituitaries and adrenals than controls. The number of treated animals with high carcass grades was lower than for the controls. The thyroids of the treated animals appeared to be larger than those from the controls but not significantly so. Bell and coworkers (10) using feeder lambs weighing on the average 67 pounds implanted one 15 mg. pellet of stilbestrol at the start or implanted one at the start and a second 70 days later. They concluded that the hormone treatment caused an increase in rate of gain, but that the treated lambs dressed one to five per cent less than the controls. The treated animals had slimy and watery carcasses and the pelts were hard to remove. In a second trial where 7.5 or 15 mg. single pellets were used, similar results were obtained and the authors reported that there was no significant difference due to the various levels used except in the apparent development of the secondary sex organs. Wilkinson and associates (135) reported that the subcutaneous implantation of one 15 mg. pellet of diethylstilbestrol into wether lambs weighing 75 pounds on the average resulted in blood and liver composition of the treated lambs which differed from the composition of blood and livers from untreated lambs. Treated lambs had lower hematocrit and higher plasma-free cholestrol and fibrinogen levels than the controls. Blood samples collected in the morning showed that there was no significant difference between treated and control animals in non-protein nitrogen, globulin, total protein, and phospholipid. Blood collected in the afternoon showed

that treated animals had a significantly lower quantity of non-protein nitrogen and phospholipid and a significantly higher quantity of globulin and total protein than the controls. There was no effect due to treatment on plasma glucose, albumin, ester cholesterol, total cholesterol or neutral fat. A significantly greater amount of total liver tissue on a dry matter basis and a significantly smaller amount of ester cholesterol of the liver was found in the treated lambs. Estrogen treatment did not affect percentage dry matter, glycogen, protein, phospholipid, free cholesterol, total cholesterol, neutral fat or total lipid content of the liver.

3. Cattle. Numerous investigators have reported on the action of male and female sex hormones in cattle. However, because of the dosage levels used or the conditions under which the experiments have been conducted, results have been inconsistent. Burris, Bogart and Oliver (19) reported that an increase in rate of gain and in the efficiency of feed utilization was obtained when beef steers and heifers, weighing 500 pounds, were injected intramuscularly with 1.0 mg. testosterone per kilogram body weight per week. Weekly injections of methyl androstenediol at the above level did not affect rate of gain, economy of feed utilization or carcass characteristics of steers or heifers. Burris and associates (20) showed that heifer calves responded more than steer calves when injected weekly with 1.0 mg. testosterone per kilogram body weight and that this treatment tended to diminish differences between steers and heifers in the rate and economy of gains. Nevertheless, non-treated animals had a higher dressing percentage and higher carcass grades than the treated ones. There was very

little difference between the treated and the non-treated animals in intensity and desirability of meat characteristics. The hormone treatment tended to cause a decrease in drip losses, an increase in evaporation losses during cooking as well as an increase in the resistance to shear. Weight of the thyroid glands from treated animals was increased but the increase in the weight of the pituitaries, adrenals, hearts and livers of the treated animals was not statistically significant. Burris, Bogart and Krueger (18) reported an increase in the weight of the thyroid and in its secretory activity as well as a decrease in the stores of thyroxine in the gland as a result of the weekly administration of 1.0 mg. testosterone per kilogram body weight. Bogart and coworkers (13) found that the intramuscular injection of 1.0 mg. testosterone per kilogram body weight per week into beef steers and heifers weighing 500 pounds resulted in an increase in daily gains of 0.4 pound per day more per animal which also required 100 pounds less total digestible nutrients for each 100 pounds gain than controls. They concluded that the "non-masculinizing" hormone, methyl androstenediol, did not influence rate of gain or feed efficiency of steers or heifers. Dinusson and coworkers (34) reported that the intramuscular injection of 50 mg. testosterone propionate followed by another injection (32.5 mg.) 56 days later into beef heifers resulted in a temporary growth stimulation and an increased daily food intake. However, there was no significant increase in daily gains or efficiency of feed utilization over the entire feeding period. When 50 mg. pellets of testosterone propionate were implanted subcutaneously into beef heifers, no differences were obtained in rate of gain,

efficiency of feed utilization or daily food consumption between treated and control animals. There were also no differences in carcass quality or dressing percentage. Similarly, the subcutaneous implantation of a 180 mg. pellet of testosterone did not significantly affect rate of gain, economy of feed utilization or carcass grade of yearling steers, reported Andrews, Beeson and Johnson (7). In another trial the same workers (8) implanted 255 mg. testosterone pellets subcutaneously into beef steers and found no significant changes in rate of gain or dressing percentage. It is to be noted that the total amount of testosterone given by Burris and associates (19, 20) approximated 4800 mg. whereas the total amount given by other investigators never reached 300 mg. per animal.

Andrews and coworkers (8) found that the subcutaneous implantation of 60, 108, or 120 mg. pellets of stilbestrol; 60 mg. stilbestrol plus 200 mg. progesterone; or 80 mg. dienestrol resulted in an increase in rate of gain of beef steers. Efficiency of feed utilization was also improved with all treatments except at the level of 60 mg. stilbestrol. There was no effect on dressing percentage due to treatment but there was a reduction in carcass grade of all stilbestrol-treated steers. Andrews and coworkers (7) had also found that the subcutaneous implantation of 60 or 120 mg. of stilbestrol increased the rate of gain and efficiency of feed utilization of yearling steers. There was no difference in carcass grade between treated and control steers. Similarly, Dinusson, Andrews and Beeson (34) found that beef heifers treated with subcutaneous implants of 42 or 48 mg. pellets of stilbestrol showed a significant increase in rate of growth, feed efficiency and food

consumption. There was no difference in carcass grade or dressing percentage between treated and control animals. Clegg, Cole, and Guilbert (27) reported that when five 12.0 mg. pellets of stilbestrol were implanted into beef steers and heifers the rate of gain was increased in animals in the feedlot while no effect was obtained from those on grass. Treated animals had lower carcass grades than control animals. The treatment caused an increase in the weight of the adrenal glands and the pituitary but there was no effect on the weight of the thyroid or ovaries. Clegg (25) found that the subcutaneous implantation of 60 mg. diethylstilbestrol resulted in a larger eye muscle and less fat deposition in treated animal; an increase in protein anabolism; and that the total nitrogen retained daily by the treated steers was twice in excess of that of the controls. Clegg and Cole (26) using yearling heifers and two-year-old steers concluded that the subcutaneous implantation of 60 or 120 mg. pellets at the start or 60 at the start and 60 mg. pellets after 66 days caused an increase in daily food consumption and efficiency of feed utilization. Treated steers in feedlots or on grass supplemented with concentrates made better gains than controls or treated steers on grass alone. Treated steers in feedlots made better gains than corresponding treated heifers. On grass, treated heifers did not differ from controls in rate of gain. Treated animals had larger pituitaries and adrenals than controls. The hypophysis of treated heifers had twice as much growth hormone as the control heifers. In the treated steers, the thyroids were slightly larger than those of controls but treated heifers had thyroids that were significantly depressed by the treatment. The treatment did not affect the weight of

the ovaries. Nitrogen retention was doubled in the treated steers over the controls. There were less high grade carcasses from the treated animals than from controls.

EXPERIMENTAL MATERIAL AND METHODS

Sixty-four rabbits, primarily New Zealand White, between eight and nine weeks of age were used in this experiment. The group consisted of 32 males and 32 females. Sixteen males and 16 females were castrated and spayed respectively after being selected at random. Following a recovery period of four to five weeks, the rabbits were weighed and placed in individual metal cages provided with individual feeding and drinking pans. The average weight of the males was 3321.5 grams and that of the females was 3274.7 grams. The rabbits were weighed once each week on a uniform day and at a uniform time. They were fed all they could consume of a complete ration[1] in pellet form, and daily records were kept of food consumption. Drinking water contained two tablespoonfuls of Merameth[2] per gallon of water to prevent respiratory infections. Aureomycin[3], in powder form, was mixed with the pellets whenever a rabbit had a soft and shiny excreta. Only one rabbit died of pneumonia near the end of the experiment. The rabbits were under hormonal treatment for a period of twelve weeks.

Two estrogenic preparations and one male hormone were used for this work: (1) 25.0 mg./ml. preparation of diethylstilbestrol in oil, (2) 50.0 mg./ml. preparation of estradiol dipropionate in aqueous suspension, and (3) 50.0 mg./ml. preparation of testosterone in aqueous suspension (Oreton-F). To facilitate the administration of the desired

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[1] "Nutri-Dine," manufactured by Willis H. Small Company, Eugene, Oregon.

[2] Merameth (Sharp & Dohme) to control infections due to bacteria in animals. Its composition is 5% sodium sulfamerazine and 5% sodium sulfamethazine.

[3] Approximately 5 to 10 grams per 350 grams of food.

dosages, the following dilutions were made: (1) 1.0 ml. of the diethylstilbestrol preparation was diluted up to 62.5 ml. using Wesson oil, (2) 1.0 ml. of the estradiol dipropionate preparation was diluted up to 294 ml. using sterile isotonic saline solution, and (3) 1.0 ml. of the testosterone preparation was diluted up to 5.0 ml. using sterile isotonic saline solution. These dilutions were prepared so that a 0.1 ml. dose injected intramuscularly would contain 0.04, 0.017, and 1.0 mg. of diethylstilbestrol, estradiol dipropionate, and testosterone respectively.

The rabbits were divided into four groups. Group I served as the control group; Group II as the testosterone group; Group III as the estradiol dipropionate group; and Group IV as the diethylstilbestrol group. Each of these groups was made up of four intact males, four castrated males, four intact females and four spayed females. Each rabbit under hormonal treatment was injected intramuscularly in the thigh with 0.1 ml. of the respective hormone. The rabbits were subjected to the dose of 0.1 ml. per injection for a period of six weeks, following which the dose was doubled. A dose of 0.2 ml. was used per injection for the remaining six weeks of the experimental period, using the same respective dilutions. The experiment began on October 13, 1953 and terminated on January 4, 1954.

All rabbits were killed within a period of four weeks. Hormone injections were continued at the high level until all hormone-treated rabbits were slaughtered. It was not possible to have all rabbits killed on the same day due to the lack of facilities and equipment for slaughtering, handling of the carcasses, chemical analyses, and cooking

tests. A minimum number of four rabbits were killed daily. This group of rabbits represented one sex, intact or castrate, but included a rabbit from the control, testosterone, estradiol and stilbestrol groups. Live weights were taken before killing.

At slaughter, blood samples were collected for chemical analysis and the following measurements made: Weight of the dressed carcass; weight of the head, legs and skin; weight of the liver; weight of the individual adrenal glands; weight of the pituitary gland; weight of the thyroid gland; weight of each testicle; and weight of each ovary. The pituitaries, adrenals, thyroids, ovaries, and parts from the testicles were fixed in Bouin's solution for histological studies. Sections were also cut and fixed from each epididymis, ampullae, vas deferens and penis from each male, and the uterus, cervix and fallopian tubes from each female.

The carcasses were placed in a cooler (at 32°F.) for three to four hours before photographs were taken of the front and back sides of each carcass. The carcasses were split in half, longitudinally. One-half was double wrapped in an inner wrap of waxed paper and an outer wrap of aluminum foil. These halves were frozen solid at -20°F. for twenty-four hours and then placed in storage at 0°F. for four months. The remaining half from each carcass was split crosswise; the fore-quarter was used for the chemical determinations while the hind quarters were used for cooking tests. Following the four months' storage period, cooking tests were again conducted using the hind quarters.

Chemical determinations included the following: Per cent dry matter in lean muscle and kidney fat tissues; per cent ether extractable materials in both dry lean muscle and kidney fat tissues; and per cent crude protein in the dry lean muscle tissues. Iodine number and peroxide values were determined for the kidney fat. Methods of analysis followed were those outlined in the A.O.A.C.'s Methods of Analysis (9).

Each rabbit hindquarter was cooked individually, on a rack in an uncovered pan. An oven temperature of 257°F. (125°C. ± 1°C.) was maintained throughout the roasting period. A thermometer was inserted in the meat, with the bulb centered in the thigh. The roasts were removed from the oven when the interior temperature reached 194°F. (90°C.), at which temperature the meat was well done.

Drip and evaporation losses were calculated as a per cent of the weight of the raw meat.

The cooked meat, while still warm, was scored by a panel of seven judges for the following factors: Texture, tenderness, juiciness, and the intensity and desirability of aroma, flavor of the fat, and flavor of the lean. A score of "1" indicated "least intense" or "least desirable" while a score of "7" indicated "most intense" or "most desirable".

The frozen rabbits, wrapped individually, were thawed at room temperature for 20 hours before cooking. During this period of time, the interior temperature rose from 0°F. to 77°F. (-18°C. to 25°C.).

EXPERIMENTAL RESULTS

Statistical Analysis:

The analysis of variance was used to determine the significance of treatment means as well as other group means. When F values exceeded those given for the F distribution at the 0.05 or at the 0.01 level, the differences were considered significant. The method of "the least significant difference" was also used whenever necessary to show how much difference was necessary between the means for significance (124, p.406).

When results were compared on a percentage basis (dressing percentage, for example), conversion tables (9, pp.449-450) were used and the values comparable to those obtained in the experiment were used for statistical analysis.

Pre-treatment Rabbit Weights:

The rabbits were weighed at the start of the experiment, prior to the administration of testosterone, estradiol dipropionate and diethylstilbestrol but following their random distribution into the various subgroups using the tables of random numbers (36, pp.290-294). A comparison of the average weight of the rabbits from the subgroups is presented in tables 1 and 2. There was no significant difference in the average weight of males and females, likewise between the intact rabbits and the castrates. Similarly, there was no difference in the average weight of the rabbits comprising the would-be treatment groups (table 2). However, there was a significant difference in the average weight of the rabbits comprising the would-be sex-treatment subgroups and those

comprising the would-be sex status-treatment subgroups also (table 2). The wide variations in the weights of the individual rabbits within the subgroups may have contributed to the lack of significance between the average weight of the male and the female rabbits, and also between those of the intact and castrate rabbits (table 1).

Table 1. A comparison of the average initial weight of the rabbits.

Treatment	Sex Status				Treatment Average
	Males		Females		
	Intacts	Castrates	Intacts	Spayed	
	grams	grams	grams	grams	grams
Control	3170	3545	3025	2592	
	3160	3520	2780	2782	
	3217	3685	3685	2620	
	3617	3872	3480	3240	
Ave.	3291	3656	3243	2809	3249
Testosterone	3010	3375	3665	2700	
	2680	3407	3575	3705	
	3543	3963	3257	3310	
	3845	3580	3765	2950	
Ave.	3270	3581	3566	3166	3396
Estradiol	3380	3310	3272	3495	
	2936	3560	4057	3095	
	3100	3043	3500	3638	
	3043	3470	3200	2822	
Ave.	3115	3346	3507	3263	3308
Stilbestrol	3430	3450	2942	3415	
	2863	3592	3542	3438	
	2990	3000	3513	3290	
	2838	3095	3757	2684	
Ave.	3030	3284	3439	3207	3240
Sex-status Ave.	3176	3467	3438	3111	
Sex average	3322		3275		

Table 2. Analysis of variance of the average initial weight of the rabbits.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	192389	1.77
Sex	1	35016	0.32
Sex status	1	5532	0.05
Treatment	3	81914	0.75
Sex x treatment	3	328750	3.03*
Sex status x treatment	3	2548	0.02
Sex x sex status	1	1526769	14.10**
Sex x sex status x treatment	3	26294	0.24
Error	47	108536	

* Indicates significance at 0.05
** Indicates significance at 0.01

Measures of Feeding Performance:

1. Growth rate. The effects on growth rate of the weekly intramuscular administration of 1.0 mg. of testosterone, 0.017 mg. of estradiol dipropionate and 0.04 mg. of diethylstilbestrol per kilogram body weight, injected semiweekly in two equal doses, into intact and castrated male and female rabbits for a 42-day period are shown in tables 3 and 4, and in figures 2, 3, 4, 5, and 6.

Results show that there was no difference in average total gains between the treated and the non-treated rabbits. However, testosterone-injected rabbits made significantly better gains than those treated with estrogens (table 4; figure 2). The former group appeared to have made better gains than the control animals while those treated with estrogens appeared to have made less gains than the controls although these differences were not statistically significant. A significant difference was found as a result of sex-sex status interaction (table 4;

Table 3. The effect of injected hormones (testosterone, estradiol, dipropionate, and diethylstilbestrol), sex and sex status upon the average gains in body weight during the first 42-day period.

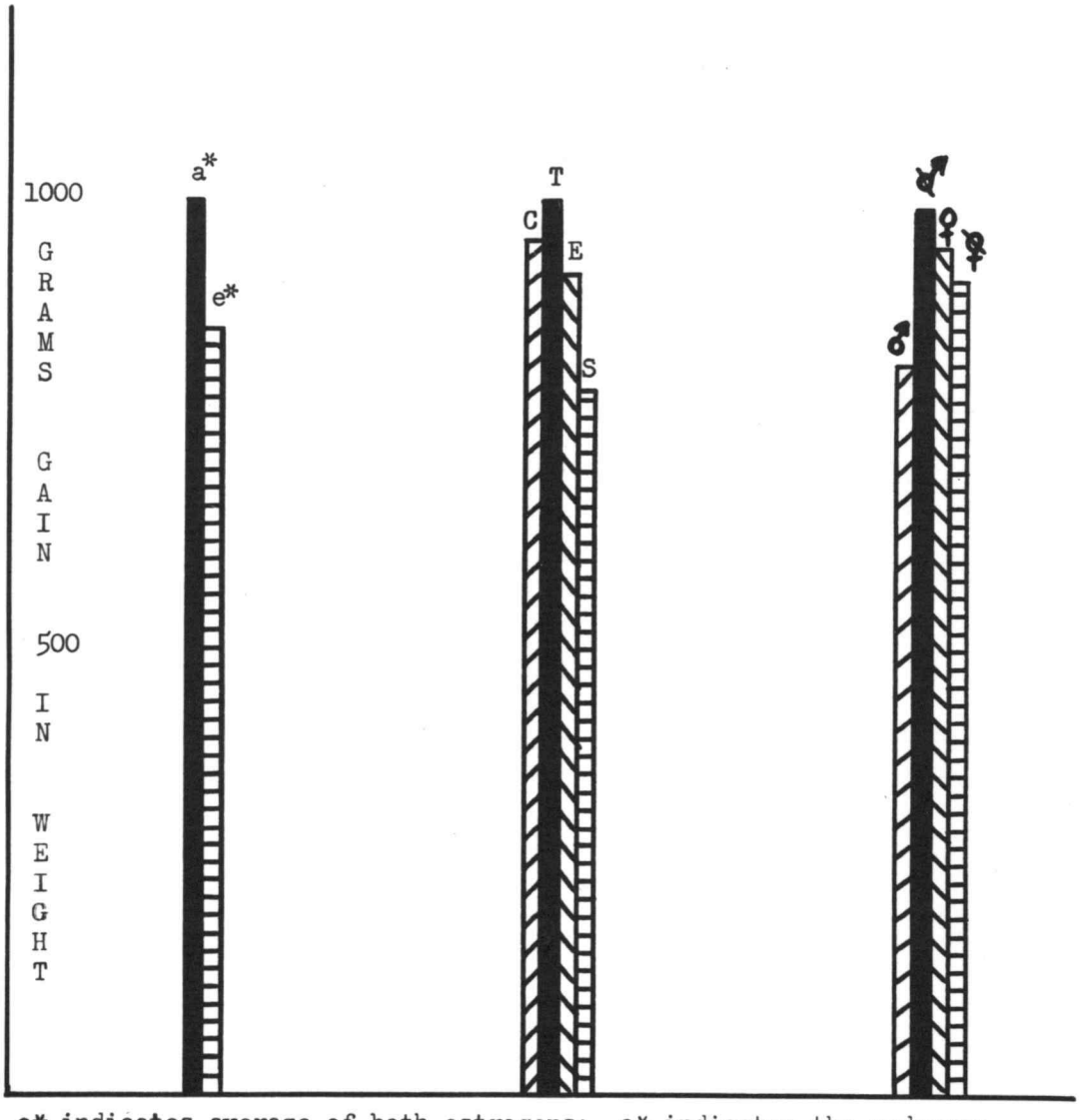
Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	grams	grams	grams	grams	grams
Control	856	862	839	1126	
	806	1235	848	908	
	992	1014	916	589	
	953	1315	1091	966	
Ave.	904	1107	924	897	958
Testosterone	1123	592	1083	1166	
	746	886	1066	1320	
	788	1090	927	963	
	771	1068	1355	1113	
Ave.	857	909	1108	1141	1004
Estradiol	964	1183	1112	816	
	605	782	813	1054	
	884	899	1160	1070	
	1073	1092	548	727	
Ave.	882	989	908	917	924
Stilbestrol	250	992	1014	742	
	668	870	967	763	
	766	589	584	525	
	866	1432	879	781	
Ave.	638	971	861	703	793
Sex-Sex Status Ave.	820	994	950	914	
Sex average	907		932		

Table 4. Analysis of variance of gains in body weight during the first 42-day period.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	70127	1.61
Sex	1	10251	0.23
Sex status	1	76176	1.74
Treatment	3	130964	3.00*
Control vs. treatment	1	31212	0.71
Testosterone vs. estrogens	1	224653	5.14*
Estradiol vs. stilbestrol	1	137026	3.14
Sex x treatment	3	87456	2.00
Sex status x treatment	3	2051	0.05
Sex x sex status	1	175771	4.02*
Sex x sex status x treatment	3	42767	0.98
Error	47	43684	

* Indicates significance at 0.05
** Indicates significance at 0.01

Figure: 2 VARIATIONS IN GAINS MADE DURING A 42-DAY PERIOD ASSOCIATED WITH HORMONE TREATMENT AND SEX STATUS (FIRST TRIAL)



e* indicates average of both estrogens; a* indicates the androgen C, control ; T, testosterone; E, estradiol ; and S, stilbestrol.

Figure: 3 CUMULATIVE WEEKLY GAINS ACCORDING TO HORMONE TREATMENT

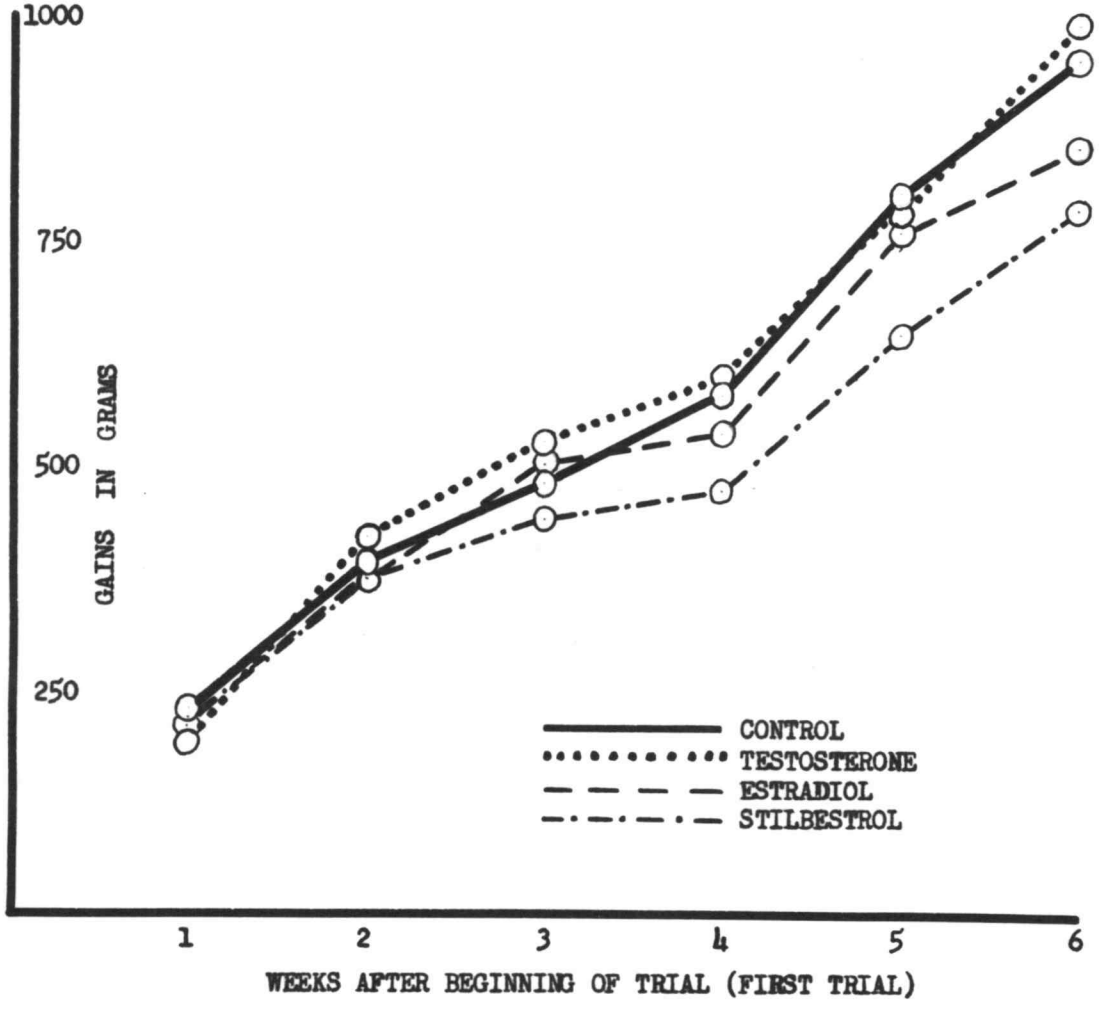


Figure: 4 CUMULATIVE WEEKLY GAINS ACCORDING TO SEX STATUS

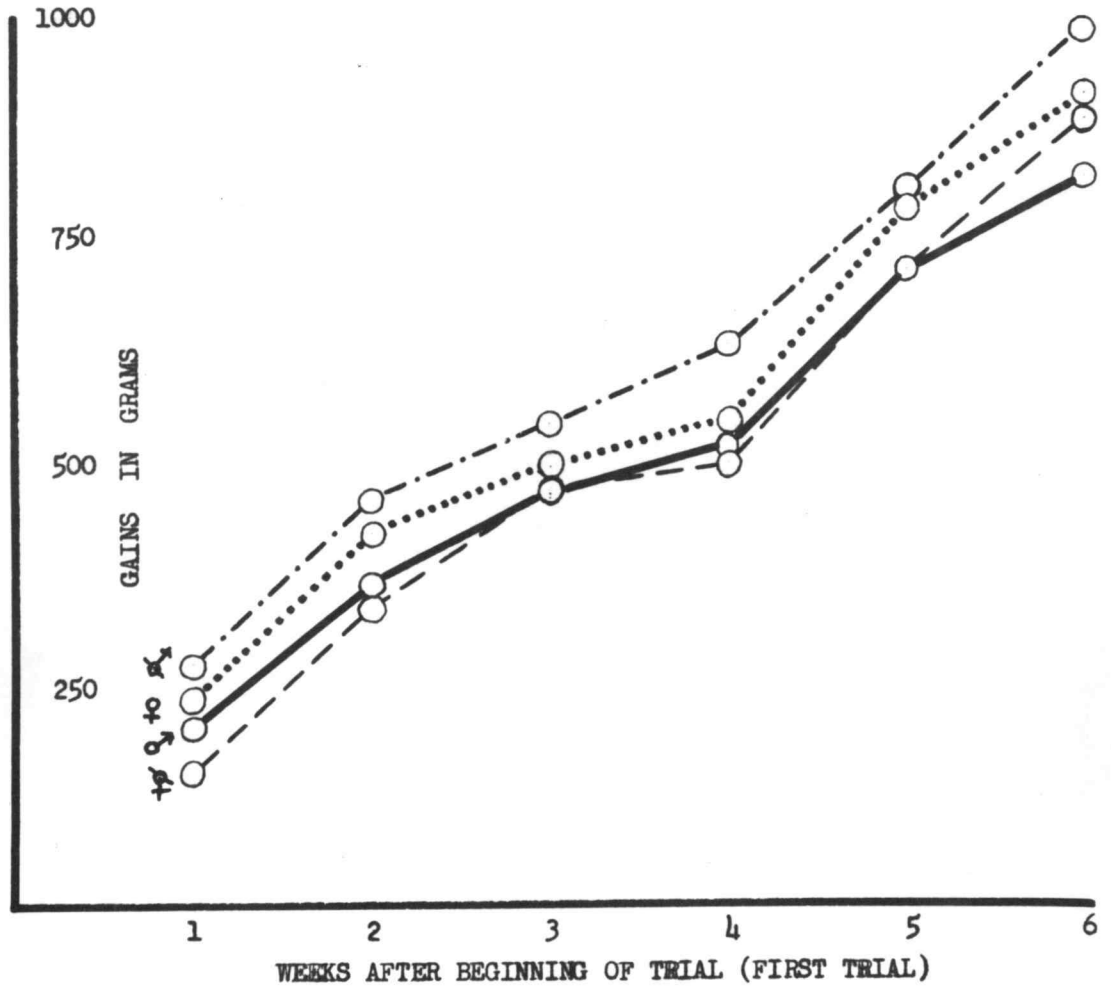


Figure: 5-A AVERAGE WEEKLY GAINS IN WEIGHT ACCORDING TO HORMONE TREATMENT

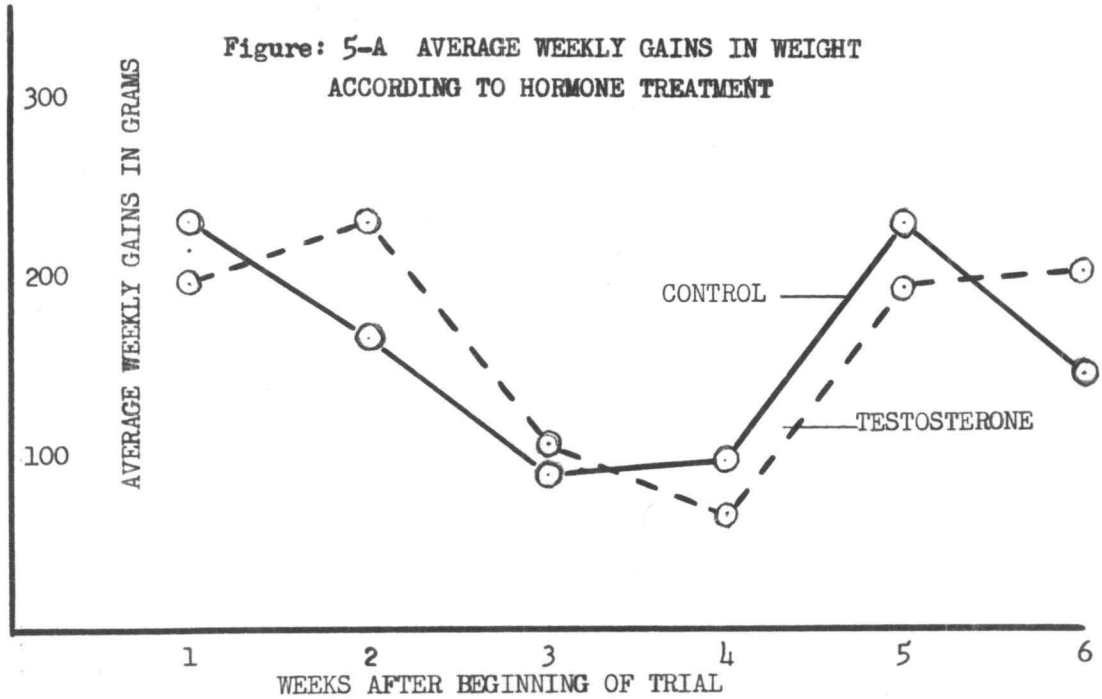


Figure: 5-B AVERAGE WEEKLY GAINS IN WEIGHT ACCORDING TO HORMONE TREATMENT

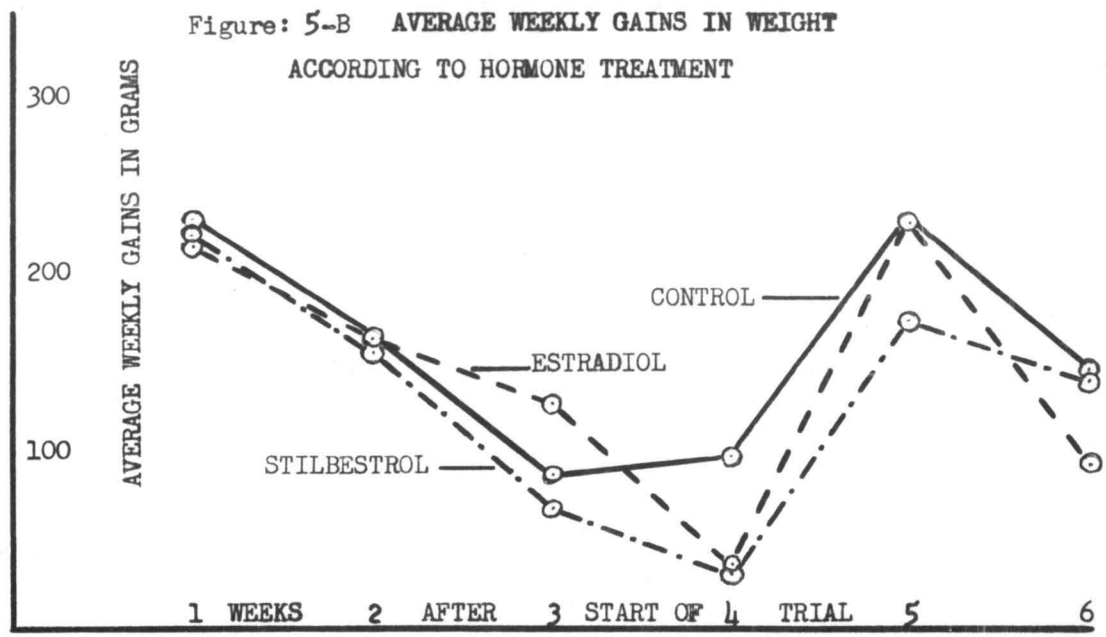


Figure: 6 AVERAGE WEEKLY GAINS IN WEIGHT DURING THE FIRST 42-DAY PERIOD ACCORDING TO SEX STATUS

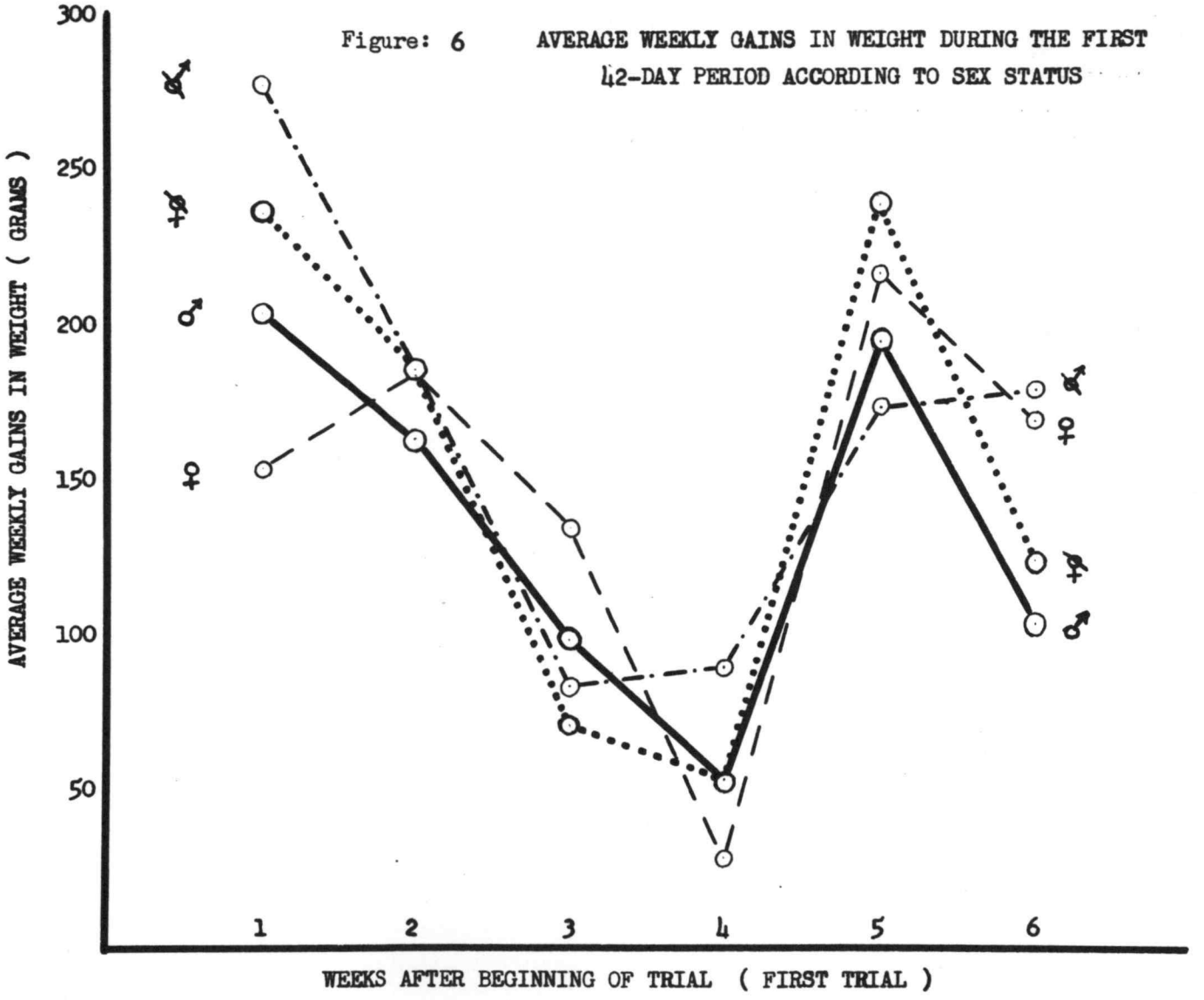


figure 2), and the average gains in grams for the intact males, the castrated males, the intact females and the spayed females were: 820, 994, 950 and 914, respectively. This would indicate that castrated males made significantly better gains than intacts while spayed females made significantly less gains than intact females (table 4; figure 2). It also showed that intact females made better gains than intact males (table 3). However, in the over-all results, there was no difference between the male rabbits and the females and likewise between the intact rabbits and the castrates (table 4).

During the second 42-day period, when the injected rabbits received weekly doses of 2.0 mg. of testosterone, 0.034 mg. of estradiol dipropionate and 0.08 mg. of diethylstilbestrol per kilogram body weight, administered semiweekly in two equal doses, many rabbits from the various subgroups lost weight (table 5). Although testosterone and stilbestrol administration appeared to have stimulated gains above those of the control rabbits, the difference was not significant (table 6). The tremendous variation in gains within subgroups and the losses in the weight of some rabbits may have led to the lack of significance among the treatment groups; between the male and female rabbits and between the intact and the castrated rabbits. Yet, there was a significant difference in gains due to sex status-treatment interaction (table 6; figure 7). Average gains in grams were: 18.75, 146.9, 204.3 and 83.8 respectively for the intact rabbits; and 115.5, 183.3, -179 and 196.5 respectively for the castrates and representing control, testosterone-injected, estradiol-injected and stilbestrol-injected rabbits.

Table 5. The effect of injected hormones (testosterone, estradiol dipropionate, and diethylstilbestrol), sex, and sex status upon the average gains in body weight during the second 42-day period.

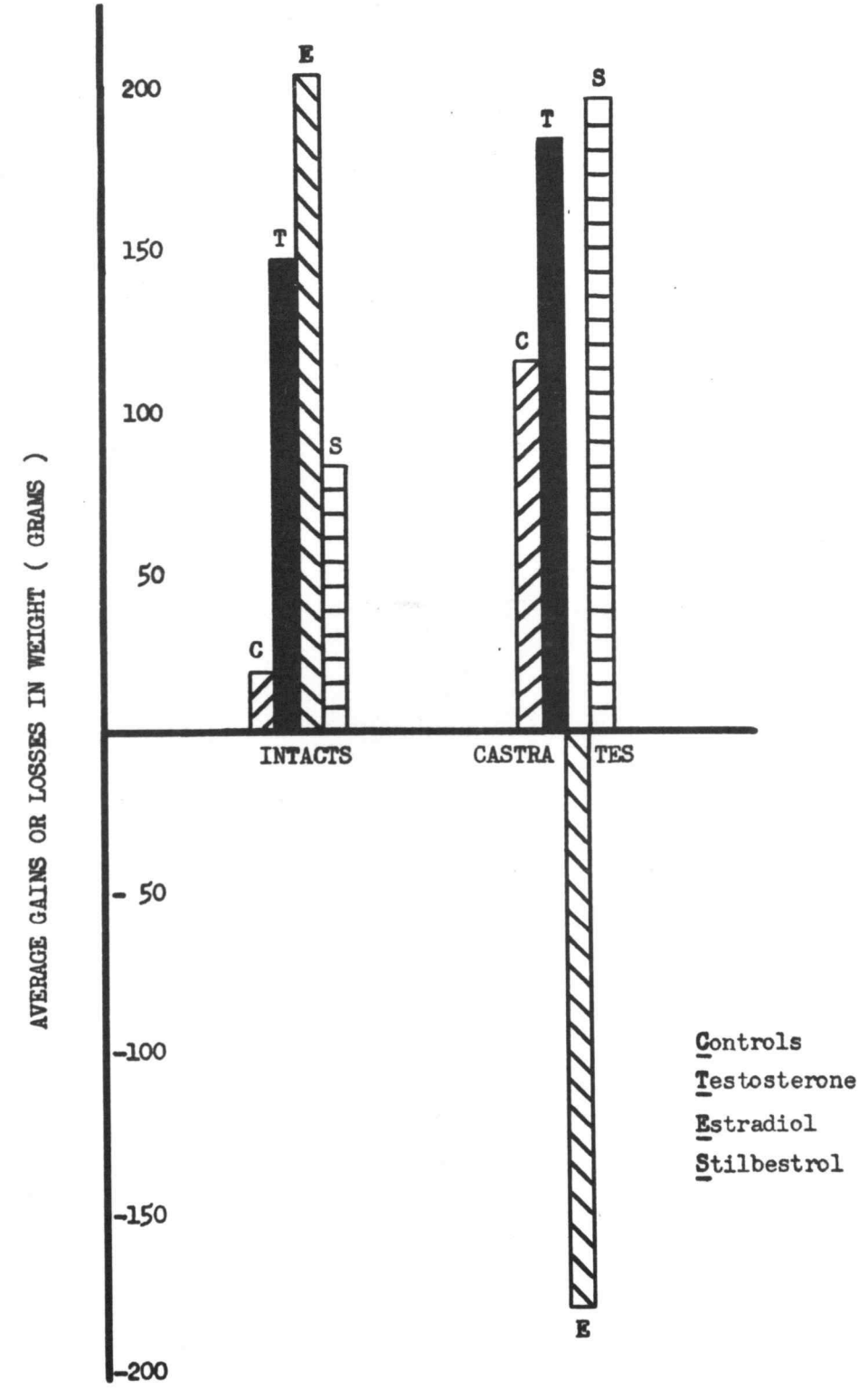
Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	grams	grams	grams	grams	grams
Control	- 37	- 81	-113	201	
	117	24	208	283	
	92	-216	210	191	
	-839	368	512	154	
Ave.	-167	24	204	207	67
Testosterone	267	526	237	348	
	367	423	233	163	
	283	274	-533	-225	
	299	-342	22	299	
Ave.	304	220	- 10	146	165
Estradiol	- 26	59	170	-728	
	44	-165	322	305	
	248	-291	192	- 40	
	353	-810	331	238	
Ave.	155	-302	254	- 56	13
Stilbestrol	167	154	216	375	
	420	88	44	103	
	-304	230	231	192	
Ave.	76	138	92	255	140
Sex-Sex Status Ave.	92	20	135	138	
Sex average		56		137	

Table 6. Analysis of variance of gains in body weight during the second 42-day period.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	108806	1.39
Sex	1	103628	1.32
Sex status	1	18882	0.24
Treatment	3	77348	0.99
Sex x treatment	3	163678	2.09
Sex status x treatment	3	220732	2.82*
Sex x sex status	1	22399	0.29
Sex x sex status x treatment	3	33971	0.43
Error		78216	

* Indicates significance at 0.05

Figure: 7 VARIATIONS IN GAINS MADE DURING THE SECOND 42-DAY PERIOD ASSOCIATED WITH TREATMENT X SEX STATUS INTERACTION



2. Food consumption. The effects of the administration of a weekly dose of 1.0 mg. of testosterone, 0.017 mg. of estradiol dipropionate and 0.04 mg. of diethylstilbestrol per kilogram body weight, semiweekly in two equal doses into intact and castrate, male and female rabbits, are shown in tables 7 and 8 and in figure 8.

The differences among the treatment groups in regard to average total food consumption was not significant (table 8). However, testosterone appeared to have stimulated food intake above that of controls, while stilbestrol appeared to have depressed food consumption below that of the control rabbits (table 7). Variations in total food intake within subgroups may have led to the lack of significance between the treated and the non-treated rabbits. A significant difference was obtained due to sex-sex status interaction (table 8; figure 8). Average individual total food intake in grams during this first 42-day period was: 8360, 9211, 9347 and 8859, respectively, for the intact males, the castrated males, the intact females and the spayed females. This would indicate that castrated males consumed significantly more than the intacts, while spayed females consumed less than the intact females, on the average (table 7; figure 8). It also showed that the intact females consumed on the average more food than the intact males during this period, while castrated male rabbits consumed on the average significantly more than did the spayed females (table 7).

Food consumption during the second 42-day period during which the treated rabbits were injected with 2.0 mg. of testosterone, 0.034 mg. of estradiol dipropionate and 0.08 mg. of diethylstilbestrol per kilogram

Table 7. The effect of injected hormones (testosterone, estradiol dipropionate, and diethylstilbestrol), sex, and sex status upon the average food intake during the first 42-day period.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	grams	grams	grams	grams	grams
Control	8246	8910	8374	8969	
	7028	10135	8285	8767	
	9332	10097	10595	7329	
	9912	11197	9338	8982	
Ave.	8630	10085	9148	8512	9094
Testosterone	9761	7160	9593	8479	
	7049	8320	9283	10653	
	9943	10591	8893	8989	
	9514	10043	10920	9609	
Ave.	9067	9029	9672	9433	9300
Estradiol	9226	9142	8709	9575	
	7743	9590	10087	9668	
	8319	8076	10425	9554	
	8745	9880	8613	7360	
Ave.	8508	9172	9459	9039	9045
Stilbestrol	5644	8196	9667	8019	
	8152	8535	9796	10119	
	7220	7926	7740	7822	
	7919	9570	9233	7850	
Ave.	7234	8557	9109	8453	8338
Sex-Sex Status Ave.	8360	9211	9347	8859	
Sex average		8785		9103	

Table 8. Analysis of variance of average food intake during first 42-day period.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	1674460	1.51
Sex	1	1617348	1.46
Sex status	1	527076	0.48
Treatment	3	2807587	2.54
Sex x treatment	3	1439487	1.30
Sex status x treatment	3	241657	0.22
Sex x sex status	1	7170345	6.48*
Sex x sex status x treatment	3	778646	0.70
Error	47	1106579	

* Indicates significance at 0.05

Figure: 8 VARIATIONS IN TOTAL FEED INTAKE DURING A 42-DAY PERIOD ASSOCIATED WITH SEX STATUS. (FIRST TRIAL)

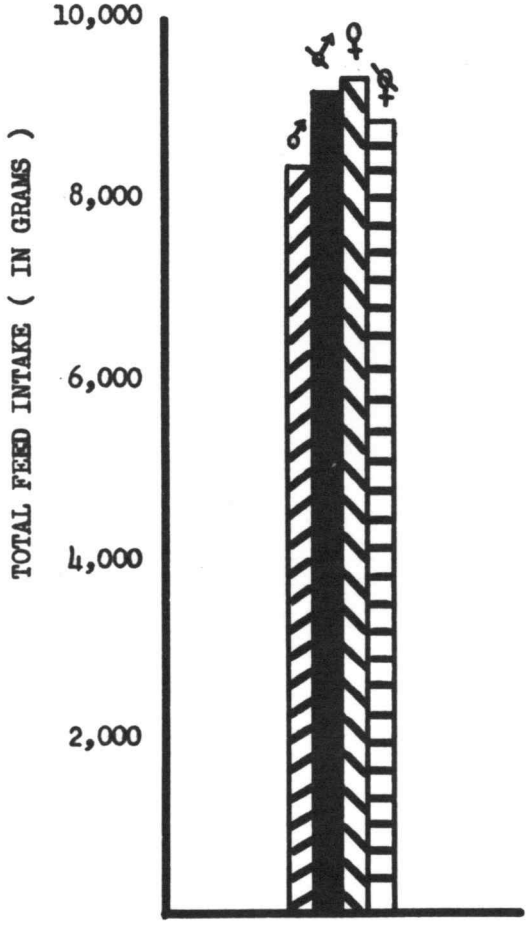


Table 9. The effect of injected hormones (testosterone, estradiol dipropionate, and diethylstilbestrol), sex, and sex status upon the average food intake during the second 42-day period.

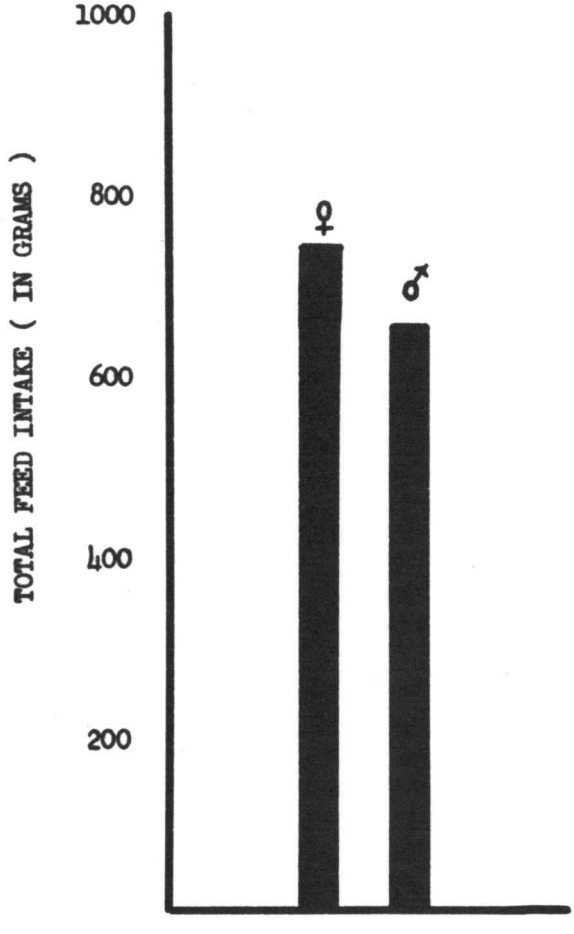
Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	grams	grams	grams	grams	grams
Control	5592	8559	6285	7401	
	6237	3791	7221	7714	
	6623	6910	9407	6949	
	3853	11051	9529	8320	
Ave.	5576	7578	8111	7596	7215
Testosterone	7322	8345	8267	7537	
	7261	7409	7514	9579	
	7521	8495	4811	5090	
	8549	5315	9091	8644	
Ave.	7663	7391	7421	7713	7547
Estradiol	5782	6579	7172	3734	
	5829	4199	8830	8464	
	7217	3976	8531	7239	
	7463	5776	6493	6137	
Ave.	6573	5133	7757	6394	6464
Stilbestrol	6461	6429	8076	7941	
	7579	5828	7915	8254	
	4943	6056	6851	6606	
	5348	5668	5726	7804	
Ave.	6083	5995	7142	7651	6718
Sex-Condition Ave.	6474	6524	7607	7338	
Sex average		6499		7473	

Table 10. Analysis of variance of average food intake during second 42-day period.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	3234392	1.48
Sex	1	15176868	6.94*
Sex status	1	191406	0.09
Treatment	3	3795644	1.73
Sex x treatment	3	1564671	0.72
Sex status x treatment	3	3352075	1.53
Sex x sex status	1	408320	0.19
Sex x sex status x treatment	3	2200703	1.01
Error	47	2187983	

* Indicates significance at 0.05

Figure: 9 VARIATIONS IN TOTAL FEED INTAKE DURING A 42-DAY PERIOD ASSOCIATED WITH SEX (2nd TRIAL)



body weight, administered semiweekly in two equal doses, is shown in tables 9 and 10; figure 9). Females consumed significantly more feed than males (tables 9 and 10; figure 9). Testosterone appeared to have stimulated food intake while both estrogens appeared to have caused a reduction in the average food intake (table 9) but the differences were again not significant (table 10). This was probably due to the wide variation within subgroups in the total food intake during this period.

3. Efficiency of feed utilization. The effects of the weekly administration of 1.0 mg. of testosterone, 0.017 mg. of estradiol dipropionate and 0.04 mg. of diethylstilbestrol per kilogram body weight, injected semiweekly in two equal doses for a 42-day period on gains per unit of feed consumed are shown in table 11. Results show that there was no difference due to the injected materials on efficiency of feed utilization, probably as a result of within-group variation. There was no difference between males and females or between the intact rabbits and the castrates in this respect.

During the second 42-day period when the treated rabbits were injected with weekly doses of 2.0 mg. of testosterone, 0.034 mg. of estradiol dipropionate and 0.08 mg. of diethylstilbestrol per kilogram body weight, administered semiweekly in two equal doses, rabbits from various treated and non-treated groups lost weight as shown in table 5. There was no significant difference between the treated and the non-treated rabbits in efficiency of feed utilization (table 13) probably due to the wide variation within subgroups and the fact that some of the rabbits lost weight. Similarly, there was no difference between males

and females or between the intact and the castrated rabbits in the efficiency of feed utilization (table 13). Yet, a significant difference was found as a result of sex status-treatment interaction (table 13).

Table 11. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon change in weight (in grams) per unit food intake (in grams) during the first 42-day period.

Treatment	Sex Status				Treatment Average
	Males		Females		
	Intacts	Castrates	Intacts	Spayed	
	gr./gr.	gr./gr.	gr./gr.	gr./gr.	gr./gr.
Control	0.11	0.10	0.10	0.13	
	0.11	0.12	0.10	0.10	
	0.11	0.10	0.09	0.08	
	0.10	0.12	0.12	0.11	
Ave.	0.11	0.11	0.10	0.10	0.11
Testosterone	0.12	0.08	0.11	0.14	
	0.11	0.11	0.11	0.12	
	0.08	0.10	0.10	0.11	
	0.08	0.11	0.12	0.12	
Ave.	0.10	0.10	0.11	0.12	0.11
Estradiol	0.10	0.13	0.13	0.09	
	0.08	0.08	0.08	0.11	
	0.11	0.11	0.11	0.11	
	0.12	0.11	0.06	0.10	
Ave.	0.10	0.11	0.10	0.10	0.10
Stilbestrol	0.04	0.12	0.10	0.09	
	0.08	0.10	0.10	0.08	
	0.11	0.07	0.08	0.07	
	0.11	0.15	0.10	0.10	
Ave.	0.09	0.11	0.09	0.08	0.09
Sex-Sex Status Ave.	0.10	0.11	0.10	0.10	
Sex average	0.10		0.10		

Table 12. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon change in weight (in grams) per unit food intake (in grams) during the second 42-day period.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	gr./gr.	gr./gr.	gr./gr.	gr./gr.	gr./gr.
Control	-0.01	-0.01	-0.02	0.03	
	0.02	0.01	0.03	0.04	
	0.01	-0.03	0.02	0.03	
	-0.22	0.03	0.05	0.02	
Ave.	-0.05	-0.0003	0.02	0.03	0.0002
Testosterone	0.04	0.06	0.03	0.05	
	0.05	0.06	0.03	0.02	
	0.04	0.03	-0.11	-0.04	
	0.04	-0.06	0.002	0.03	
Ave.	0.04	0.02	-0.01	0.01	0.02
Estradiol	-0.01	0.01	0.02	-0.20	
	0.01	-0.04	0.04	0.04	
	0.03	-0.07	0.02	-0.01	
	0.05	-0.14	0.05	0.04	
Ave.	0.02	-0.06	0.03	-0.03	-0.09
Stilbestrol	0.03	0.02	0.03	0.05	
	0.06	0.02	0.01	0.01	
	-0.06	0.04	0.03	0.03	
	0.004	0.01	-0.02	0.04	
Ave.	0.01	0.02	0.01	0.03	0.02
Sex-Sex Status Ave.	0.01	-0.004	0.01	0.01	
Sex average	0.0003		0.01		

Table 13. Analysis of variance of the change in unit weight per unit food intake during the second 42-day period.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	356478	1.25
Sex	1	221959	0.78
Sex status	1	54347	0.19
Treatment	3	276382	0.97
Sex x treatment	3	431409	1.51
Sex status x treatment	3	850320	2.98*
Sex x sex status	1	14550	0.05
Sex x sex status x treatment	3	136687	0.48
Error	47	285403	

* Indicates significance at 0.05

Hormonal Alterations of Carcass Characteristics.

Dressing percentage and the percentage of skin, head and legs are two economically important characteristics in the commercial production of rabbit meat and pelts. Therefore, the effects of the intramuscular injection of testosterone, estradiol dipropionate and diethylstilbestrol during two 6-week periods and at two dosage levels on the dressing percentage and the percentage skin, head and legs have been studied in the intact and the castrated, male and female young rabbits.

1. Dressing percentage. The effects of castration and of the injected materials on this characteristic are presented in tables 14 and 15 and figure 10. Females dressed significantly higher than males under all treatment conditions (table 15 and figure 10). Castrates showed slightly higher but insignificant values as compared to intact rabbits. Small differences were obtained in the average dressing percentage as a result of the injected materials but these were not statistically significant (tables 14 and 15). This was probably due to the variation

within subgroups in the dressing percentage (table 14).

Table 14. The effect of injected hormones (testosterone, estradiol dipropionate, and diethylstilbestrol), sex, and sex status upon the average dressing percentage of rabbits.

Treatment	Sex Status: Males		Sex Status: Females		Treatment Average
	Intacts	Castrates	Intacts	Spayed	
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	60.7	53.8	59.7	55.6	
	54.8	(58.2)*	57.8	59.8	
	60.1	61.7	60.9	62.8	
	52.2	61.7	63.5	64.9	
Ave.	56.9	58.2	60.5	60.8	59.1
Testosterone	57.8	59.9	57.9	62.3	
	58.3	54.9	58.7	60.2	
	54.0	59.2	60.8	57.7	
	59.1	59.7	62.8	61.3	
Ave.	57.3	58.4	60.1	60.4	59.1
Estradiol	56.4	56.5	57.5	56.4	
	53.3	56.6	61.3	63.0	
	57.5	51.0	60.3	62.0	
	57.3	54.8	56.9	60.9	
Ave.	56.1	54.7	59.0	60.6	57.6
Stilbestrol	57.5	57.1	57.4	62.0	
	58.0	58.8	62.9	60.9	
	57.6	64.3	57.9	61.3	
	56.6	54.5	56.3	59.0	
Ave.	57.4	58.7	58.6	60.8	58.9
Sex-Sex Status Ave.	56.9	57.5	59.6	60.6	
Sex average	57.2		60.1		

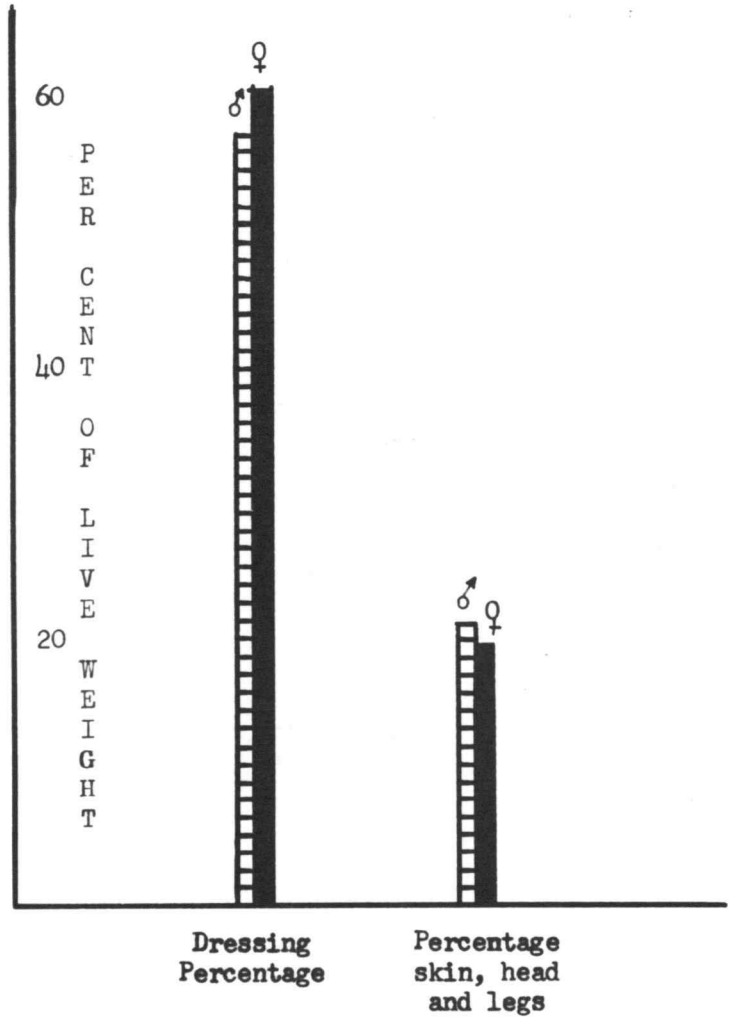
*Numbers in parentheses indicate dummy values

Table 15. Analysis of variance of the effect of injected hormonal materials (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the average dressing percentage of rabbits.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	4.47	1.71
Sex	1	44.27	16.93**
Sex status	1	3.75	1.43
Treatment	3	2.70	1.03
Sex x treatment	3	1.79	0.68
Sex status x treatment	3	0.61	0.23
Sex x sex status	1	0.39	0.15
Sex status x sex x treatment	3	1.13	0.43
Error	47	2.62	

* Indicates significance at 0.05
** Indicates significance at 0.01

Figure:: 10. VARIATIONS IN DRESSING PERCENTAGE AND IN PERCENTAGE SKIN, HEAD AND LEGS ACCORDING TO SEX.



2. Percentage skin, head and legs. The effects of the injected testosterone, estradiol dipropionate and diethylstilbestrol as well as the effects of castration on the percentage of skin, head and legs in relation to the live weight of the animal are shown in tables 16 and 17 and figure 10. Males showed a higher percentage of skin, head and legs, under all treatment conditions than females (table 17; figure 10). However, there was no difference between intact animals and castrates and likewise among the treatment groups. There was a certain amount of variation within subgroups which may explain the lack of significance among treatment groups (tables 16 and 17).

Table 16. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the average percentage of skin, head and legs in rabbits.

Treatment	Sex Status				Treatment Average
	Males		Females		
	Intacts	Castrates	Intacts	Spayed	
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	20.5	21.7	19.4	21.0	
	23.4	(20.2)*	20.0	21.1	
	18.6	20.5	18.7	19.2	
	23.6	18.5	18.8	18.5	
Ave.	21.5	20.2	19.3	20.0	20.2
Testosterone	21.1	18.0	20.0	18.7	
	20.8	20.7	21.1	20.0	
	21.6	22.0	20.9	21.0	
	20.5	21.9	18.9	20.1	
Ave.	21.0	20.6	20.2	20.0	20.5
Estradiol	21.9	21.3	18.6	23.8	
	21.2	20.7	18.8	19.3	
	23.1	24.8	20.2	19.1	
	23.7	24.0	17.5	19.3	
Ave.	22.5	22.7	18.8	20.4	21.1
Stilbestrol	21.0	21.7	20.5	18.6	
	19.4	19.1	19.1	19.4	
	20.6	18.2	20.9	19.3	
	23.1	21.6	20.1	18.4	
Ave.	21.0	20.2	20.1	19.0	20.1
Sex-Sex Status Ave.	21.5	20.9	19.6	19.8	
Sex average	21.2		19.7		

* Numbers in parentheses indicate dummy values

Table 17. Analysis of variance of the effect of injected hormonal materials (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the average percentage of skin, head and legs of rabbits.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	2.43	2.28*
Sex	1	18.3	17.17**
Sex status	1	0.28	0.26
Treatment	3	1.55	1.45
Sex x treatment	3	2.01	1.89
Sex status x treatment	3	1.35	1.27
Sex x sex status	1	1.26	1.18
Sex status x sex x treatment	3	0.62	0.58
Error	47	1.07	

* Indicates significance at 0.05
** Indicates significance at 0.01

Hormonal Alterations of Endocrine Gland Weights:

During the entire experimental period of 84 days when two dose levels of testosterone, estradiol dipropionate and diethylstilbestrol were injected during two 6-week periods into intact and castrated male and female rabbits, some of the endocrine glands underwent weight and size changes. These changes were either due to castration or to the injected materials. Some of the glands were not affected at all.

1. The gonads. The effects of the injected materials on the weight of the testes and the ovaries are shown in tables 18 and 19 and in figures 11 and 12. Testosterone, estradiol dipropionate and diethylstilbestrol caused a significant reduction in the size and the weight of the testes (tables 18 and 19; figure 11) but non-significant reductions in the size and weight of the ovaries (tables 18 and 19; figure 12). The fact that one of the control females had exceptionally

large ovaries may explain this lack of significance.

Table 18. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the average weight of testes and ovaries of rabbits.

Treatment	Sex Status	
	Males Testes	Females Ovaries
	Grams	Milligrams
Controls	5.2	304
	6.5	281
	6.4	354
	8.4	727
Ave.	6.6	417
Testosterone	2.8	403
	4.1	272
	4.2	231
	3.9	339
Ave.	3.8	311
Estradiol	3.4	160
	1.0	312
	0.9	189
	2.9	269
Ave.	2.0	233
Stilbestrol	6.3	254
	4.5	342
	0.4	425
	4.3	322
Ave.	3.9	336

2. The pituitary gland. The effects of castration and of the injected materials on the size of the pituitary gland are shown in tables 20 and 21; figure 13. Castrated rabbits had significantly larger pituitaries than intact rabbits, under the various treatments (table 21;

figure 13). Testosterone and stilbestrol injections caused insignificant increases in the weight of the pituitary gland. There was a significant difference due to sex-sex status interaction (table 21 and figure 13) and the average weights in milligrams of the pituitaries from intact males, castrated males, intact females and spayed females were: 25.8, 38.8, 32.9 and 36.7, respectively (table 20). This would indicate that castration in males resulted in significantly more hypertrophy of the pituitary than did spaying in the female. Meanwhile there was tremendous variation in the weight of the pituitary within some of the subgroups which may have led to the lack of significance among the treatment groups.

Table 19. Analysis of variance of testes and ovaries weight in rabbits.

Source of variance	Degrees of freedom	Mean square	F.
Testes:			
Treatment	3	14.37	5.67*
Control vs. treatment	1	34.62	13.66*
Testosterone vs. estrogens	1	1.71	0.67
Estradiol vs. stilbestrol	1	6.80	2.68
Error	12	2.54	
Ovaries:			
Treatment	3	22954	1.55
Error	12	14839	

* Indicates significance at 0.05

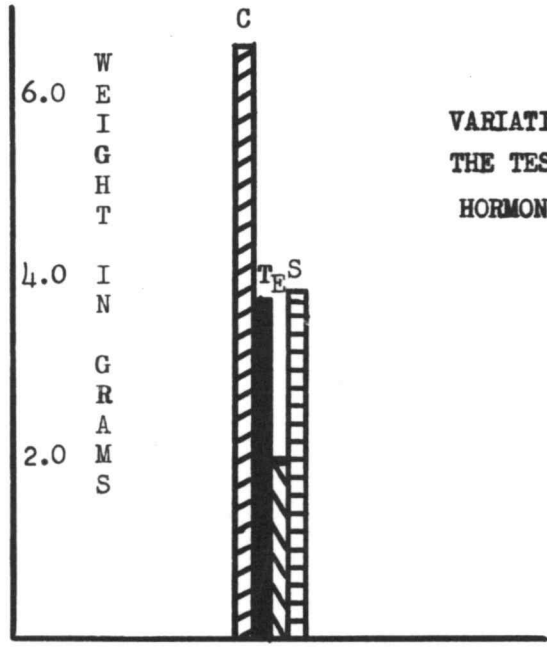


Figure: 11

VARIATIONS IN THE WEIGHTS OF THE TESTES ASSOCIATED WITH HORMONE TREATMENT .

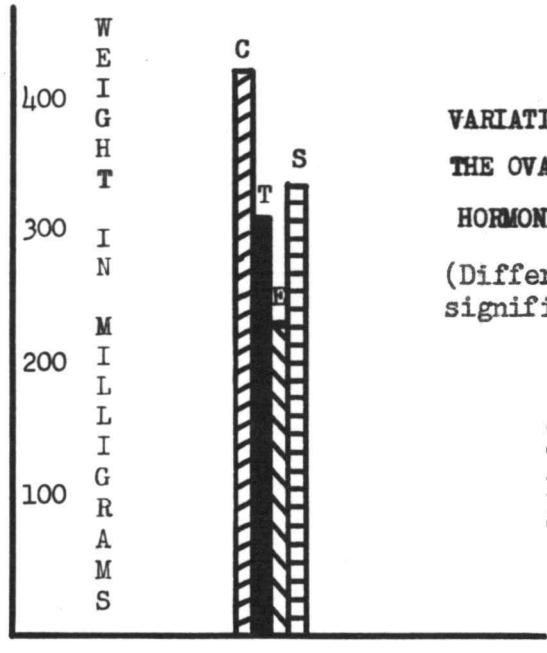


Figure: 12

VARIATIONS IN THE WEIGHTS OF THE OVARIES ASSOCIATED WITH HORMONE TREATMENT .

(Differences were non-significant.)

C control
T testosterone
E estradiol
S stilbestrol

Table 20. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the average weight of the pituitary gland in male and female rabbits.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	mg.	mg.	mg.	mg.	mg.
Control	24.0	44.4	28.1	35.0	
	24.9	(34.7)*	29.8	30.3	
	27.8	35.5	33.9	30.3	
	24.6	24.2	34.5	37.1	
Ave.	25.3	34.7	31.6	33.2	31.2
Testosterone	26.2	37.0	39.3	51.9	
	17.5	50.1	33.0	23.4	
	25.0	42.6	35.8	43.2	
	25.6	40.4	39.4	41.5	
Ave.	23.6	42.5	36.9	40.0	35.8
Estradiol	28.3	47.9	27.7	31.3	
	24.4	32.7	30.8	27.0	
	21.3	32.3	28.6	39.8	
	32.7	36.7	32.9	28.2	
Ave.	26.7	37.4	30.0	31.6	31.4
Stilbestrol	28.0	34.4	26.6	38.8	
	28.1	46.2	23.2	47.2	
	22.3	30.6	47.9	39.4	
	31.0	50.2	35.0	42.9	
Ave.	27.4	40.4	33.2	42.1	35.7
Sex-sex status Ave.	25.8	38.8	32.9	36.7	
Sex average	32.3		34.8		

* Numbers in parentheses indicate dummy values

Table 21. Analysis of variance of pituitary weight in rabbits.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	144.5	3.51*
Sex	1	105.6	2.56
Sex status	1	1130.6	27.45**
Treatment	3	105.2	2.55
Sex x treatment	3	32.0	0.78
Sex status x treatment	3	36.0	0.87
Sex x sex status	1	339.5	8.24**
Sex status x sex x treatment	3	24.0	0.58
Error	47	41.2	

* Indicates significance at 0.05
** Indicates significance at 0.01

Figure:13 VARIATIONS IN THE WEIGHTS OF THE PITUITARY GLANDS ASSOCIATED WITH SEX STATUS AS WELL AS SEX X SEX STATUS INTERACTION

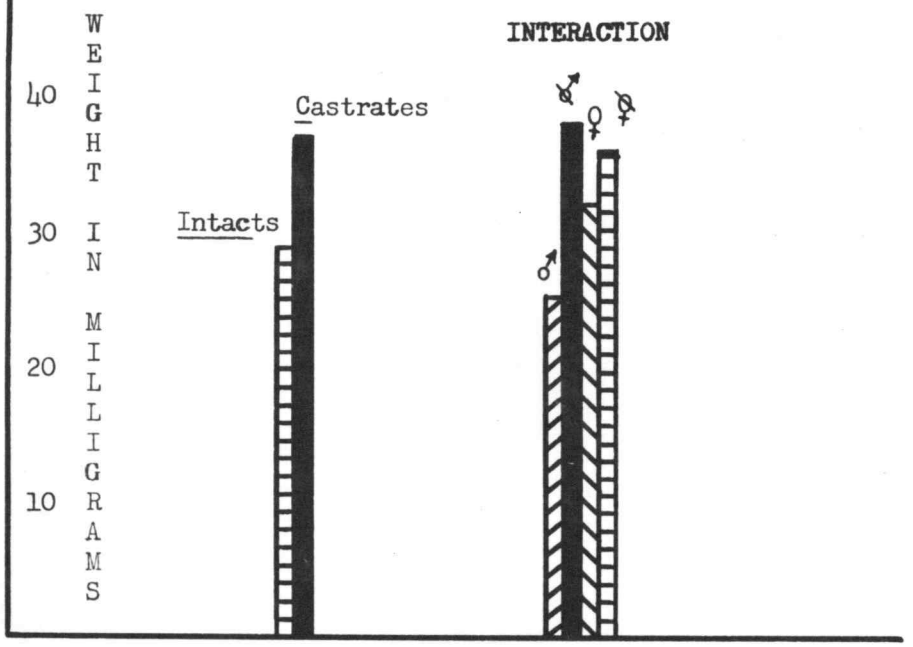
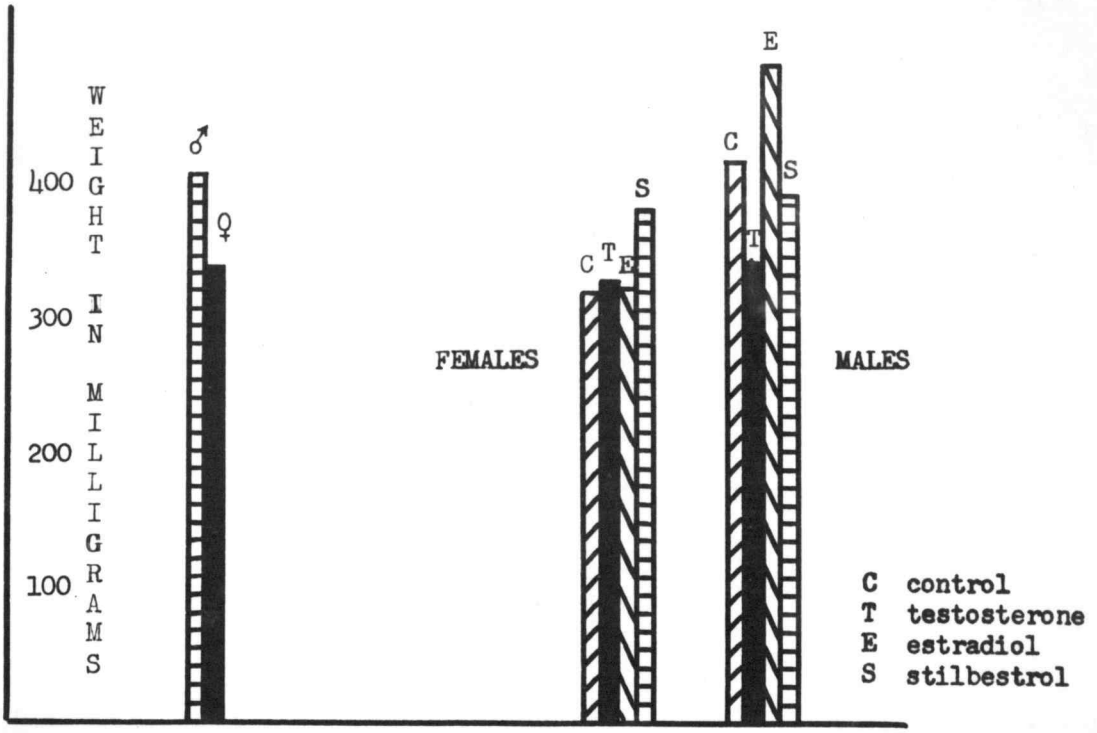


Figure:14 VARIATIONS IN THE WEIGHTS OF THE ADRENAL GLANDS ASSOCIATED WITH SEX AS WELL AS WITH SEX X TREATMENT INTERACTION



3. The adrenal glands. The effects of castration and of injected materials on the combined weight of the adrenal glands in the individual rabbits are shown in tables 22 and 23 and figure 14. The combined weight of the adrenals in the females was significantly lower than in the males (table 23; figure 14). Meanwhile, because of large within-group variation, no difference in the average combined weight of the adrenals was found as a result of testosterone, estradiol dipropionate or diethylstilbestrol administration. Similarly, there was no difference between intact rabbits and castrates in the average combined weight of the adrenal glands (table 23). Yet, there was a significant difference due to treatment-sex interaction (table 23; figure 14). In the males, estradiol stimulated significantly the growth of the adrenal glands above that of controls while both testosterone and stilbestrol resulted in the reduction of the average combined weight of the glands. In the females, however, all three injected materials caused a non-significant hypertrophy of the adrenals above that of the controls (table 23; figure 14).

4. The thyroid gland. The effects of the injected materials and of castration on the size of the thyroid gland of both males and females are shown in tables 24 and 25 and in figure 15. Although there was no difference in the average weight of the thyroid gland from treated and non-treated rabbits, there was a significant difference between the two estrogenic materials in their effect on the average size of the thyroid gland (table 25; figure 15). Stilbestrol caused a significant reduction in the weight of the thyroid gland as compared to that from

estradiol-treated rabbits, irrespective of sex or sex status. (See table 24 and figure 15) There was also a significant difference due to sex-sex status interaction (table 25; figure 15), and the average weight of the thyroid gland in milligrams from the intact males, the castrated males, the intact females and the spayed females was: 383, 443, 426 and 395, respectively. This would indicate that castration of the male rabbit resulted in the hypertrophy of the thyroid gland while spaying of the female resulted in a reduction of the thyroid size (table 24; figure 15). There was no difference between males and females in the average weight of the thyroid gland, in the overall. Meanwhile, there was a lot of variation in the weight of the thyroid gland within some of the subgroups; a condition which probably explains the lack of significance among the treatment groups.

Hormonal Alterations of Liver Size:

The effects of administered testosterone, estradiol-dipropionate and diethylstilbestrol for two 6-week periods during which two dosage levels were used, as well as the effects of castration on the size of the liver from male and female rabbits, are presented in tables 26 and 27 and in figure 16. Livers from treated rabbits did not differ significantly from those of control animals. Yet, testosterone administration resulted in significantly larger livers than those from estrogen-treated rabbits under practically all sex and sex-status conditions (tables 26 and 27; figure 16). Wide variations in the weight of livers within subgroups may have led to the lack of significance among the treatment groups.

Table 22. The effect of injected hormones (testosterone, estradiol dipropionate, and diethylstilbestrol), sex, and sex status upon the adrenal glands in male and female rabbits.

Treatment	Sex Status: Males		Females		Treatment Average
	Intacts	Castrates	Intacts	Spayed	
	Mg.	Mg.	Mg.	Mg.	Mg.
Controls	357	429	271	450	
	380	(431)*	390	232	
	334	367	381	174	
	582	495	369	294	
Ave.	413	431	353	287	371
Testosterone	357	304	336	443	
	289	390	364	300	
	313	253	360	322	
	366	497	286	246	
Ave.	331	361	337	328	339
Estradiol	322	438	312	252	
	471	454	257	395	
	740	479	391	313	
	573	466	308	359	
Ave.	526	459	317	330	408
Stilbestrol	417	410	563	352	
	299	340	326	305	
	559	297	372	288	
	373	466	488	365	
Ave.	412	378	437	327	389
Sex-Sex Status Ave.	421	407	361	318	
Sex average		414		339	

* Numbers in parentheses indicate dummy values

Table 23. Analysis of variance of adrenal weight in rabbits.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	16374	2.1*
Sex	1	88916	11.36**
Sex status	1	12558	1.61
Treatment	3	13701	1.75
Sex x treatment	3	22967	2.94*
Sex status x treatment	3	4539	0.58
Sex x sex status	1	3397	0.43
Sex status x sex x treatment	3	5704	0.73
Error	47	7826	

* Indicates significance at 0.05
** Indicates significance at 0.01

Table 24. The effect of injected hormones (testosterone, estradiol dipropionate, and diethylstilbestrol), sex, and sex status upon the average weight of the thyroid gland in male and female rabbits.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	Mg.	Mg.	Mg.	Mg.	Mg.
Control	343	355	451	322	
	411	(466)*	330	361	
	508	460	493	367	
	544	583	368	508	
Ave.	451	466	411	390	429
Testosterone	431	565	361	387	
	369	433	422	426	
	399	428	241	490	
	338	371	430	424	
Ave.	384	449	363	432	407
Estradiol	353	491	366	409	
	368	413	899	462	
	277	401	525	405	
	406	518	508	402	
Ave.	351	456	575	420	450
Stilbestrol	281	344	319	362	
	447	364	379	320	
	302	439	324	382	
	351	454	406	286	
Ave.	345	400	357	337	360
Sex-Sex Status Ave.	383	443	426	395	
Sex average	413		411		

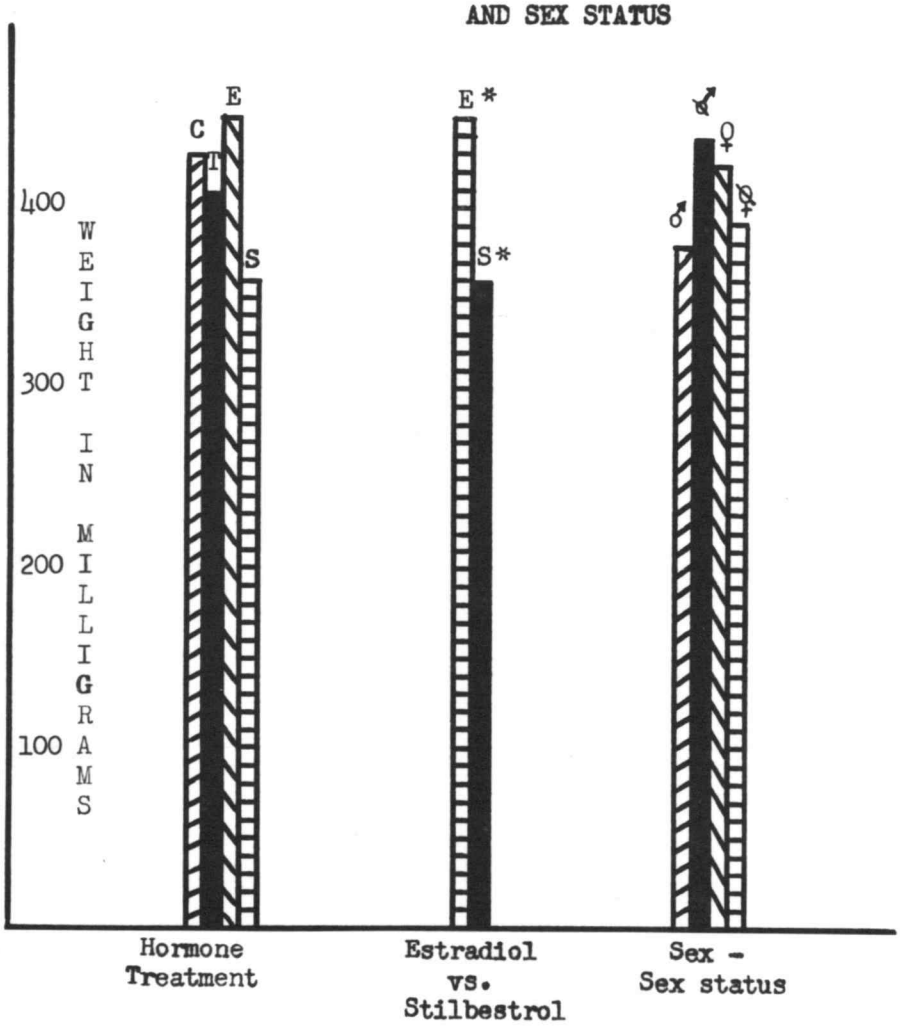
* Numbers in parentheses indicate dummy values

Table 25. Analysis of variance of thyroid weight in rabbits.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	14701	1.95*
Sex	1	82	0.01
Sex status	1	3133	0.42
Treatment	3	24007	3.19*
Control vs. treatment	1	6688	0.89
Testosterone vs. estrogens	1	46	0.01
Estradiol vs. stilbestrol	1	65287	8.67**
Sex x treatment	3	17623	2.34
Sex status x treatment	3	6167	0.82
Sex x sex status	1	33416	4.44*
Sex x sex status x treatment	3	13495	1.79
Error	47	7527	

*Indicates significance at 0.05
**Indicates significance at 0.01

Figure: 15. VARIATIONS IN THE WEIGHTS OF THE THYROID GLANDS ASSOCIATED WITH TREATMENT AND SEX STATUS



The difference between the effect of estradiol (E*) and of stilbestrol (S*) on the average size of the thyroid gland was significant.

Table 26. The effect of injected hormones (testosterone, estradiol dipropionate, and diethylstilbestrol), sex, and sex status upon the average weight of the livers from male and female rabbits.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	gr.	gr.	gr.	gr.	gr.
Control	68	96	78	64	
	104	(105)*	87	94	
	88	72	117	67	
	72	147	82	67	
Ave.	83	105	91	73	88
Testosterone	102	89	96	85	
	120	114	92	111	
	94	100	71	88	
	120	68	84	73	
Ave.	109	93	86	89	94
Estradiol	66	72	74	67	
	77	87	84	92	
	58	64	120	65	
	91	64	94	63	
Ave.	73	72	93	72	77
Stilbestrol	75	64	108	61	
	116	92	72	72	
	69	52	84	79	
	87	97	95	85	
Ave.	87	76	90	74	82
Sex-Sex Status Ave.	88	86	90	77	
Sex average	87		83		

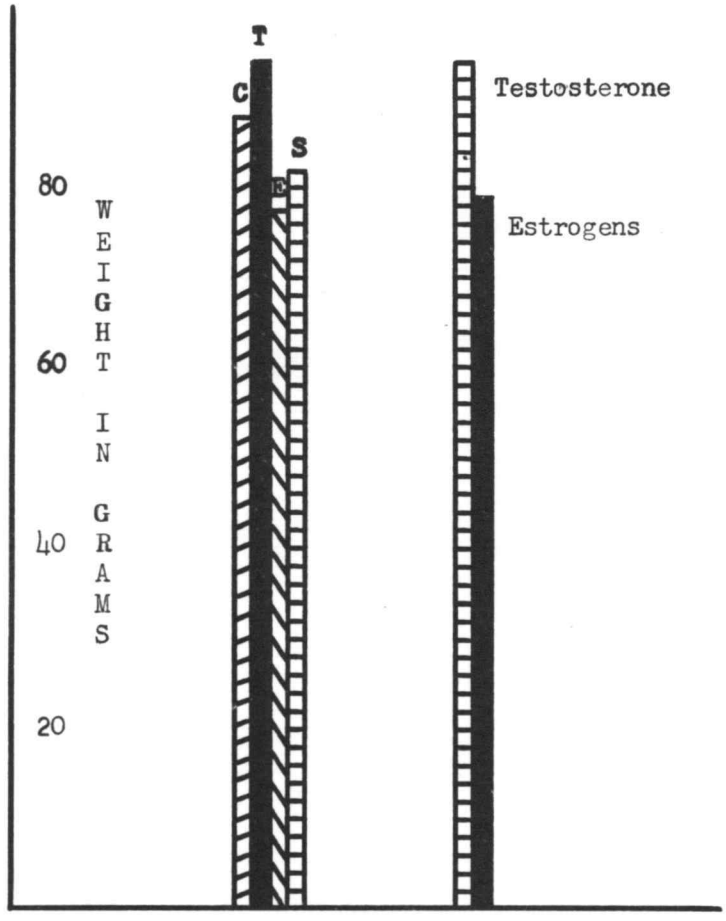
* Numbers in parentheses indicate dummy values

Table 27. Analysis of variance of liver weight in rabbits.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	537.0	1.74
Sex	1	221.3	0.72
Sex status	1	819.4	2.66
Treatment	3	862.3	2.80*
Control vs. treatment	1	152.30	0.49
Testosterone vs. estrogens	1	2281.50	7.40**
Estradiol vs. stilbestrol	1	153.13	0.50
Sex x treatment	3	490.4	1.59
Sex status x treatment	3	180.5	0.59
Sex x sex status	1	511.9	1.66
Sex x sex status x treatment	3	634.4	2.10
Error	47	308.5	

* Indicates significance at 0.05
** Indicates significance at 0.01

Figure:16. VARIATIONS IN LIVER WEIGHTS ASSOCIATED WITH HORMONE TREATMENT



C control
T testosterone
E estradiol
S stilbestrol

Hormonal Alterations of the Chemical Composition of Lean Muscle and Fatty Tissue:

1. Analysis of lean muscle. The effects of castration and the administration of testosterone, estradiol dipropionate and diethylstilbestrol in two dosage levels (the first six weeks at 1.0, 0.017 and 0.04 milligrams; and the second six weeks at 2.0, 0.034 and 0.08 milligrams, respectively) on the composition of the lean loin muscle from male and female rabbits, are presented as follows:

a. Per cent dry matter. The effects of castration and injected hormone materials on the total dry matter content of lean muscle samples after drying for 24 hours at 110°C., are shown in tables 28 and 29; and figure 17. Females had a significantly higher percentage of dry matter in the lean muscle than did males irrespective of treatment or sex status (table 29 and figure 17). The injected materials did not have any effect on the dry matter content of lean muscle. Castration likewise did not alter the dry matter content of lean muscle of male or female rabbits (table 29).

b. Per cent crude protein. The effects of castration and administration of hormone materials on the crude protein content of lean muscle on a dry weight basis are presented in table 30. The crude protein content of the dry lean muscle was about the same in male and female rabbits. Castration in either sex did not seem to alter the crude protein content (table 30). Results also indicate that the injected materials had no effect on the crude protein content of dry lean muscle, however, lack of significance may have been due to the large within-subgroup variation.

Table 28. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the percentage dry matter in the lean.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	27.1	26.8	27.4	26.7	
	26.4	(26.8)*	26.8	27.7	
	27.2	27.1	28.9	27.6	
	26.7	26.4	28.5	27.8	
Ave.	26.8	26.8	27.9	27.4	27.2
Testosterone	27.5	26.7	27.0	26.0	
	27.5	26.5	27.6	27.7	
	26.5	28.2	26.5	26.6	
	26.6	26.5	27.6	27.6	
Ave.	27.0	27.0	27.2	27.0	27.0
Estradiol	27.1	27.2	27.9	31.0	
	26.1	27.1	28.0	27.8	
	27.4	26.7	26.7	26.2	
	26.9	26.9	25.9	27.9	
Ave.	26.9	27.0	27.1	28.2	27.3
Stilbestrol	26.7	26.7	27.2	27.7	
	27.3	25.9	29.1	27.5	
	26.9	27.9	26.9	27.2	
	25.9	27.6	26.5	27.3	
Ave.	26.7	27.0	27.4	27.4	27.2
Sex-Sex Status Ave.	26.9	26.9	27.4	27.5	
Sex average	26.9		27.5		

* Numbers in parentheses indicate dummy values

Table 29. Analysis of variance for percentage of dry matter in lean loin muscle.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	0.279	0.95
Sex	1	2.056	6.97*
Sex status	1	0.062	0.21
Treatment	3	0.081	0.28
Sex x treatment	3	0.204	0.69
Sex status x treatment	3	0.234	0.79
Sex x sex status	1	0.002	0.01
Sex x sex status x treatment	3	0.169	0.57
Error	47	0.295	

* Indicates significance at 0.05

Figure: 17. VARIATIONS IN PERCENTAGE DRY MATTER IN THE LEAN ASSOCIATED WITH SEX

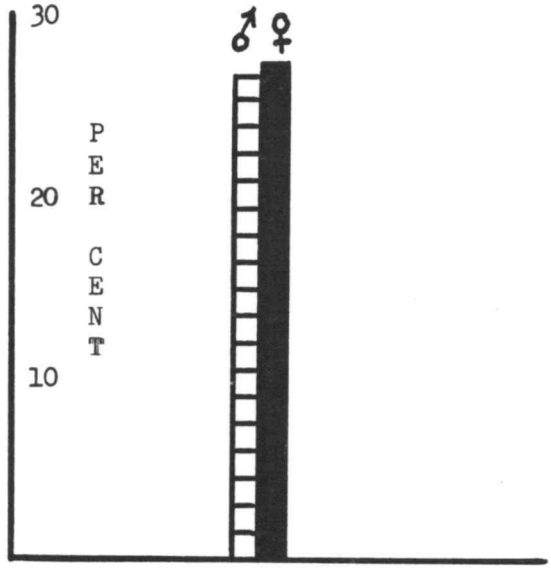
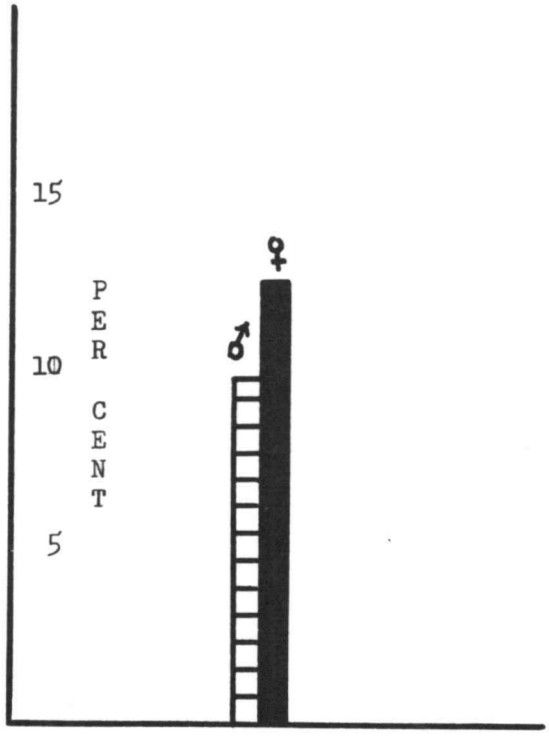


Figure: 18. VARIATIONS IN PERCENTAGE ETHER EXTRACT FROM THE LEAN ASSOCIATED WITH SEX



c. Per cent ether extract. The effects of castration and injected hormone materials on the ether extractable materials from the dry lean muscle tissue are presented in tables 31 and 32 and in figure 18. The dry lean tissue from females showed a significantly higher content of ether extractable materials than dry lean tissue from males. This sex difference existed regardless of hormone treatment or sex status of the rabbits (table 32; figure 18). The injected materials had no significant effect on the ether extractable materials of the dry lean muscle tissue, but the lack of significance may be explained on the basis of the wide variations among and within the subgroups (table 31). The removal of the gonads had no effect on the ether extractable materials from the dry lean muscle tissue (table 32).

2. Analysis of kidney fat. The effects of gonadectomy and of the administration of testosterone, estradiol dipropionate and diethylstilbestrol on the composition of the fatty tissue surrounding the kidneys are shown in the following:

a. Per cent dry matter. The effects of castration and injected hormone materials on the dry matter content of fatty tissue after drying for 24 hours at 110°C. are shown in table 33. There was no difference due to sex, sex status or treatment on the dry matter content of fatty tissue but the lack of significance may have been due to the variation within some of the subgroups (table 33).

b. Per cent ether extract. The effects of gonadectomy and injected testosterone, estradiol dipropionate and diethylstilbestrol on the ether extractable materials in the dry fatty tissue are shown in tables 34 and 35. Results indicate that there was no difference between

Table 30. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the percentage crude protein in the lean.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	86.3	70.4	85.5	84.5	
	92.8	(78.8)*	86.1	78.2	
	78.3	83.6	84.0	82.5	
	85.0	82.4	78.6	81.0	
Ave.	85.6	78.8	83.6	81.5	82.4
Testosterone	82.5	86.2	86.6	87.9	
	86.6	88.1	87.3	87.5	
	82.8	82.3	84.9	82.1	
	83.8	87.9	86.1	83.9	
Ave.	83.9	86.1	86.2	85.4	85.4
Estradiol	86.4	83.4	81.2	68.3	
	89.9	86.0	83.9	89.8	
	85.9	84.7	85.4	83.7	
	86.5	85.9	85.0	86.0	
Ave.	87.2	85.0	83.9	81.9	84.5
Stilbestrol	88.5	84.2	82.6	74.8	
	81.8	84.6	78.7	79.1	
	84.1	82.1	83.8	82.0	
	90.5	84.0	82.2	88.8	
Ave.	86.2	83.7	81.8	81.2	83.2
Sex-Sex Status Ave.	85.7	83.4	83.9	82.5	
Sex average	84.6		83.2		

* Numbers in parentheses indicate dummy values

Table 31. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the percentage ether extract of the lean.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	9.3	14.8	8.8	6.1	
	5.0	(10.7)*	16.5	27.6	
	10.9	6.8	14.7	11.2	
	8.8	10.6	15.7	7.0	
Ave.	8.5	10.7	13.9	13.0	11.5
Testosterone	11.4	8.1	11.8	8.7	
	6.3	5.1	28.8	14.4	
	7.9	24.9	7.9	7.6	
	13.1	7.7	9.0	15.3	
Ave.	9.6	11.5	14.4	11.5	11.7
Estradiol	10.3	14.1	12.4	25.1	
	9.0	1.0	16.8	8.7	
	11.8	10.3	15.2	10.9	
	10.3	10.4	5.5	9.0	
Ave.	10.4	8.9	12.5	13.4	11.3
Stilbestrol	4.9	3.5	7.1	14.1	
	10.2	5.5	16.0	11.9	
	11.3	14.6	8.5	10.7	
	6.4	12.0	7.2	6.3	
Ave.	8.2	8.9	9.7	10.7	9.4
Sex-Sex Status Ave.	9.2	10.0	12.6	12.2	
Sex average	9.6		12.4		

* Numbers in parentheses indicate dummy values

Table 32. Analysis of variance for percentage ether extractable materials from dry lean muscle.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	12.72	0.49
Sex	1	104.65	4.07*
Sex status	1	0.15	0.01
Treatment	3	14.11	0.55
Sex x treatment	3	1.73	0.07
Sex status x treatment	3	2.10	0.08
Sex x sex status	1	1.95	0.08
Sex x sex status x treatment	3	10.06	0.39
Error	47	25.72	

* Indicates significance at 0.05

intact animals and castrates or between male animals and females in the percentage of ether extract from the dry fatty tissue (table 35). Similarly, there was no difference due to the injected materials on these constituents (table 35); however, lack of significance was probably due to the within-subgroup variation (table 35). Significant differences, however, were shown due to sex status-treatment interaction and due to sex-sex status-treatment interaction.

3. Per cent lean and bone in the forequarter. The effects of gonadectomy and the injected hormone materials on the amount of lean and bone remaining in the forequarter following the removal of all possible separable fat are presented in tables 36 and 37 and in figure 19. Results indicate that there was significantly more separable fat from female rabbits than from males with correspondingly less lean and bone in the former than in the latter (table 37; figure 19). Although castration appeared to have caused a slight increase in the amount of separable fat, in both males and females, the difference was not

Table 33. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the percentage dry matter in the fat.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	96.0	94.7	97.4	90.8	
	96.9	(95.0)*	95.8	95.8	
	96.7	94.5	95.6	97.9	
	95.0	95.9	95.9	94.5	
Ave.	96.1	95.0	96.2	94.8	95.5
Testosterone	97.9	96.9	95.6	94.9	
	95.8	97.8	95.4	96.4	
	95.9	95.9	95.7	95.9	
	94.6	96.2	95.9	95.9	
Ave.	96.0	96.7	95.7	95.7	96.0
Estradiol	95.7	96.1	97.3	92.3	
	97.2	94.4	96.9	94.5	
	94.4	93.6	94.9	95.8	
	96.9	93.3	96.4	96.3	
Ave.	96.1	94.3	96.4	94.7	95.4
Stilbestrol	96.1	95.9	97.3	90.2	
	96.2	96.8	97.7	95.1	
	94.0	95.9	96.4	97.0	
	95.4	96.2	94.9	96.8	
Ave.	95.4	96.2	96.6	94.8	95.7
Sex-Sex Status Ave.	95.9	95.6	96.2	95.0	
Sex average	95.7		95.6		

* Numbers in parentheses indicate dummy values

Table 34. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the percentage ether extract from dry fat.

Treatment	Sex Status: Males		Sex Status: Females		Treatment Average
	Intacts	Castrates	Intacts	Spayed	
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	98.6	99.7	100.0	97.2	
	99.3	(99.3)*	99.0	97.2	
	97.6	98.4	99.7	98.5	
	98.0	99.9	100.0	98.8	
Ave.	98.4	99.3	99.7	97.9	98.8
Testosterone	99.7	99.4	98.7	99.9	
	98.9	99.3	93.6	99.5	
	99.3	99.3	97.5	98.8	
	100.0	100.0	99.9	98.9	
Ave.	99.5	99.5	97.4	99.3	98.9
Estradiol	99.8	99.8	98.8	98.2	
	99.6	97.0	98.8	98.8	
	99.8	97.5	99.7	98.3	
	100.0	98.5	99.1	99.8	
Ave.	99.8	98.2	99.1	98.8	99.0
Stilbestrol	99.1	99.7	99.5	99.8	
	98.0	99.8	100.0	97.5	
	99.0	99.5	98.7	99.5	
	90.5	99.5	99.4	99.0	
Ave.	96.6	99.6	99.4	99.0	98.7
Sex-Sex Status Ave.	98.6	99.2	98.9	98.7	
Sex average	98.9		98.8		

* Numbers in parentheses indicate dummy values

Table 35. Analysis of variance for percentage ether extractable materials from fatty tissue of rabbits.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	17.28	2.17*
Sex	1	2.31	0.29
Sex status	1	0.02	0.003
Treatment	3	1.12	0.14
Sex x treatment	3	13.34	1.68
Sex status x treatment	3	22.03	2.77*
Sex x sex status	1	16.76	2.11
Sex x sex status x treatment	3	43.56	5.48*
Error	47	7.95	

* Indicates significance at 0.05

significant. Likewise, there was no influence on the amount of separable fat due to the injected materials although slight differences were obtained (table 37 and 38). Within-group variation may have led to the lack of significance among the treatment groups.

4. Iodine number of kidney fat. The effects of castration as well as of the injected testosterone, estradiol dipropionate and diethylstilbestrol on the degree of unsaturation of kidney fat are presented in table 38. Results indicate that there was no difference between males and females or between intact rabbits and castrates in the degree of unsaturation of their kidney fat. The injected materials, likewise, showed no effect on this fat characteristic. Yet, there was considerable variation within and among the subgroups, a factor that was probably responsible for the lack of significance among the treated rabbits.

Table 36. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the average per cent of lean and bone in the forequarter of rabbits.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	70.5	81.5	78.1	83.5	
	77.8	(79.1)*	73.5	75.8	
	91.2	85.0	72.4	74.4	
	86.8	70.6	83.9	75.4	
Ave.	81.6	79.1	77.0	77.3	78.7
Testosterone	86.0	77.5	79.3	79.7	
	80.0	73.6	82.8	74.2	
	77.0	85.0	83.0	82.1	
	78.6	82.4	81.2	67.6	
Ave.	80.2	79.6	81.6	75.9	79.3
Estradiol	78.6	89.5	74.1	77.5	
	88.0	81.5	84.3	78.9	
	82.9	79.4	75.3	83.4	
	85.8	89.7	76.1	73.0	
Ave.	83.8	85.0	77.4	78.2	81.1
Stilbestrol	86.7	74.7	83.7	79.7	
	90.9	82.4	74.3	79.4	
	82.5	82.0	79.4	73.8	
	72.7	80.3	67.0	73.4	
Ave.	83.2	80.0	76.1	76.6	78.9
Sex-Sex Status Ave.	82.2	80.9	78.0	77.0	
Sex average	81.5		77.5		

* Numbers in parentheses indicate dummy values

Table 37. Analysis of variance for percentage lean and bone in the forequarter of frozen-stored half carcasses.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	18.51	1.18
Sex	1	151.38	9.62**
Sex status	1	15.14	0.96
Treatment	3	10.46	0.66
Sex x treatment	3	12.48	0.79
Sex status x treatment	3	5.87	0.37
Sex x sex status	1	0.76	0.05
Sex x sex status x treatment	3	8.00	0.51
Error	47	15.74	

** Indicates significance at 0.01

Figure: 19. VARIATIONS IN PERCENTAGE LEAN & BONE IN THE FRONT QUARTER

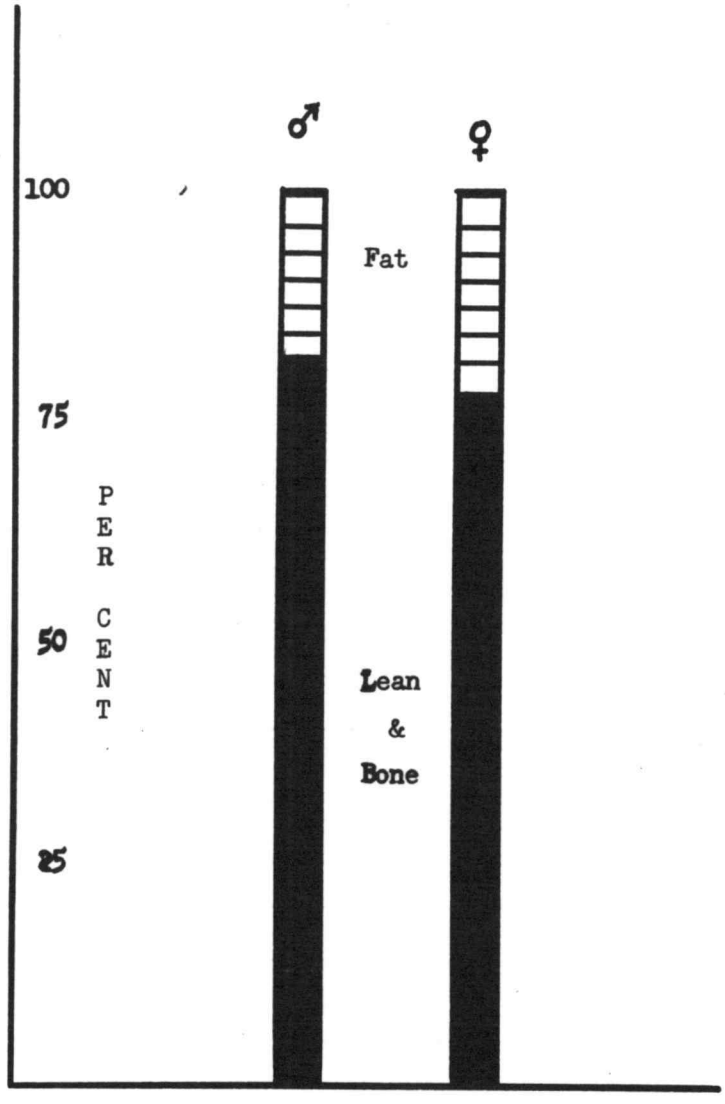


Table 38. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon the iodine number of kidney fat from rabbits.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	73.8	76.0	74.3	76.7	
	72.1	(73.1)*	72.5	72.3	
	73.2	74.1	74.4	75.2	
	71.7	69.3	71.5	73.0	
Ave.	72.7	73.1	73.2	74.3	73.3
Testosterone	72.4	71.7	76.4	66.6	
	71.8	70.2	74.9	68.5	
	76.1	76.8	70.3	73.2	
	72.1	76.0	73.0	70.9	
Ave.	73.1	73.7	73.7	69.8	72.6
Estradiol	73.9	75.0	75.7	69.0	
	74.0	69.1	69.5	73.7	
	66.7	67.6	(72.3)*	71.6	
	74.2	70.2	71.8	74.0	
Ave.	72.2	70.5	72.3	72.1	71.8
Stilbestrol	74.0	75.4	72.5	71.0	
	76.3	70.9	73.9	71.4	
	68.1	72.6	71.3	69.9	
	72.8	69.2	69.4	73.9	
Ave.	72.8	72.0	71.8	71.6	72.1
Sex-Sex Status Ave.	72.7	72.3	72.7	71.9	
Sex average	72.5		72.3		

* Numbers in parentheses indicate dummy values

Hormonal Alterations of the Cooking Characteristics of Rabbit Meat:

1. Cooking losses. The effects of castration or of injected hormone materials on evaporation and drip losses during the process of cooking the hindquarters, either fresh or following a four-month storage period at 0°F., are presented as follows:

a. Evaporation losses. The effects of gonadectomy and of injected testosterone, estradiol dipropionate and diethylstilbestrol on evaporation losses from fresh and from frozen-stored meat samples are shown in tables 39, 40, 41 and 42 as well as in figure 20. Results, calculated as a per cent of the weight of the raw meat, indicate that meat from males showed a significantly higher loss through evaporation than meat from females (tables 40 and 42; figure 20). Gonadectomy apparently had no effect on evaporation loss. Likewise, the injected hormone materials had no effect on evaporation losses from fresh or frozen meat samples. However, this lack of significance among treatment means (tables 40 and 42) may have been due to the wide variation within subgroups (tables 39 and 41). There was an apparent increase in evaporation losses from stored meat samples as compared to fresh samples, however, significance has not been proven statistically.

b. Drip losses. The influence of castration and of the injected hormone materials on drip losses from fresh and frozen-stored meat samples is shown in tables 43 and 44, respectively. Results, calculated as a per cent of the weight of the raw meat, indicate that hormone treatment had no effect on drip losses in either the fresh or the stored meat samples. This was probably due to the tremendous variation observed within subgroups in both the fresh and the stored meat

(tables 43 and 44). There was no difference between sexes in drip losses during cooking of meat. Also, meat from intact and castrated rabbits showed the same amount of drip losses from both fresh and stored samples.

Table 39. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon evaporation losses* from rabbit meat cooked when fresh to an internal temperature of 194°F. at an oven temperature of 257°F.

Treatment	Sex Status				Treatment Average
	Males		Females		
	Intacts	Castrates	Intacts	Spayed	
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	19.9	17.4	10.2	18.3	
	18.5	(18.7)**	12.6	11.7	
	13.9	17.8	10.4	19.6	
	16.4	20.8	13.5	18.9	
Ave.	17.2	18.7	11.6	17.2	16.2
Testosterone	20.3	17.6	12.4	16.1	
	21.9	20.8	19.1	11.7	
	15.2	14.6	16.2	18.9	
	16.6	21.9	12.15	19.3	
Ave.	18.5	18.7	15.0	16.5	17.2
Estradiol	9.5	18.2	15.7	13.6	
	18.3	6.8	13.4	9.9	
	10.4	15.7	15.9	16.0	
	14.5	20.3	13.2	19.2	
Ave.	13.2	15.3	14.5	14.7	14.4
Stilbestrol	14.4	20.3	15.3	18.6	
	22.1	10.7	14.0	11.1	
	17.2	11.7	11.1	9.0	
	22.7	17.9	13.8	19.7	
Ave.	19.1	15.1	13.6	14.6	15.6
Sex-Sex Status Ave.	17.0	17.0	13.7	15.7	
Sex average	17.0		14.7		

* Percentage based on weight of raw meat.
** Numbers in parentheses indicate dummy values

Table 40. Analysis of variance for per cent evaporation loss* during cooking of rabbit meat cooked when fresh to an internal temperature of 194°F. at an oven temperature of 257°F.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	12.53	1.43
Sex	1	48.42	5.53**
Sex status	1	8.84	1.01
Treatment	3	14.16	1.62
Sex x treatment	3	9.41	1.08
Sex status x treatment	3	10.69	1.22
Sex x sex status	1	10.64	1.22
Sex x sex status x treatment	3	5.76	0.66
Error	47	8.75	

*Percentage based on the weight of raw meat.
**Indicates significance at 0.05

Figure: 20. VARIATIONS IN EVAPORATION LOSSES FROM FRESH AND FROZEN MEAT SAMPLES ASSOCIATED WITH SEX

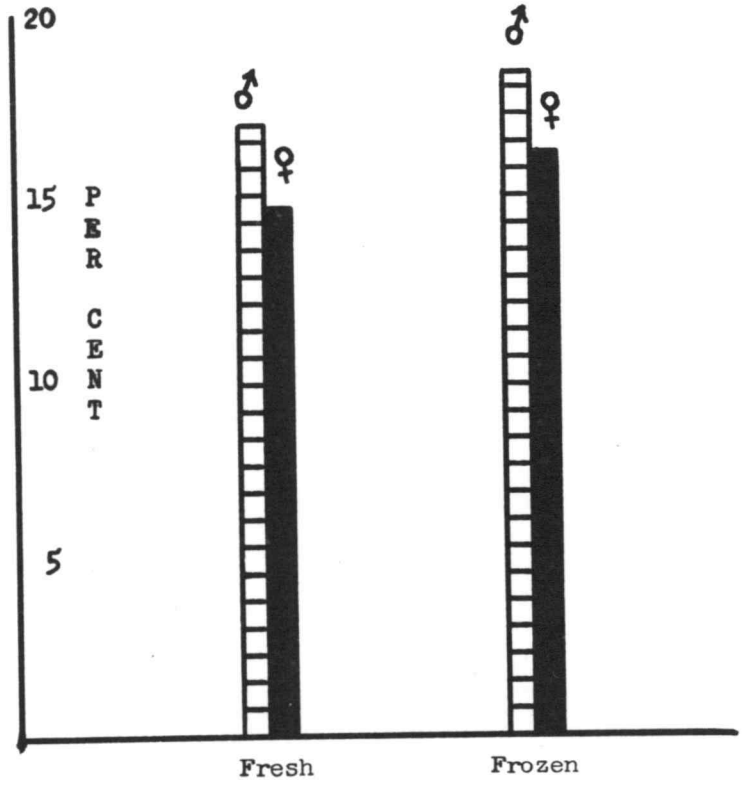


Table 41. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon evaporation losses* from rabbit meat following four months' storage at 0°F. and cooked to an internal temperature of 194°F. at an oven temperature of 257°F.

Treatment	Sex Status: Males, Intacts	Males, Castrates	Females, Intacts	Females, Spayed	Treatment Average
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	17.7	23.5	16.0	15.0	
	18.9	(22.3)**	18.7	14.3	
	21.2	14.7	12.7	18.5	
	24.1	28.6	12.3	15.7	
Ave.	20.5	22.3	14.9	15.9	18.4
Testosterone	13.4	21.4	15.1	20.8	
	16.5	12.7	19.8	14.9	
	25.0	10.6	20.4	19.6	
	20.4	20.9	11.7	17.0	
Ave.	18.8	16.4	16.8	18.1	17.5
Estradiol	16.6	15.1	18.0	17.0	
	14.7	16.5	13.6	14.0	
	25.2	23.1	16.4	16.6	
	15.6	18.6	17.5	17.6	
Ave.	18.0	18.3	16.4	16.3	17.3
Stilbestrol	17.7	20.0	16.0	17.3	
	16.1	10.1	14.3	17.7	
	19.2	14.8	15.1	13.1	
	22.0	14.0	14.9	16.3	
Ave.	18.7	14.7	15.1	16.1	16.2
Sex-Sex Status Ave.	19.0	17.9	15.8	16.6	
Sex average	18.5		16.2		

*Percentage based on weight of raw meat.
**Numbers in parentheses indicate dummy values

Table 42. Analysis of variance for per cent evaporation loss* during cooking of rabbit meat frozen-stored for four months, and cooked to an internal temperature of 194°F. at an oven temperature of 257°F.

Source of variance	Degrees of freedom	Mean square	F.
Between subgroups	15	9.55	1.30
Sex	1	42.76	5.82**
Sex status	1	0.29	0.04
Treatment	3	7.08	0.96
Sex x treatment	3	14.57	1.98
Sex status x treatment	3	3.38	0.46
Sex x sex status	1	9.92	1.35
Sex x sex status x treatment	3	5.04	0.69
Error	47	7.34	

* Percentage based on the weight of raw meat.
** Indicates significance at 0.05

Table 43. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon drip losses* from rabbit meat cooked when fresh to an internal temperature of 194°F. at an oven temperature of 257°F.

Treatment	Sex Status: Males, Intacts	Sex Status: Males, Castrates	Sex Status: Females, Intacts	Sex Status: Females, Spayed	Treatment Average
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	2.7	2.8	1.8	2.1	
	1.2	(2.6)**	1.4	2.0	
	3.3	1.3	3.3	6.0	
	1.4	3.6	2.9	4.3	
Ave.	2.1	2.6	2.4	3.6	2.7
Testosterone	2.8	2.4	1.8	2.0	
	4.2	1.7	2.4	1.5	
	1.8	3.8	2.3	2.8	
	2.3	2.6	1.2	5.4	
Ave.	2.8	2.6	1.9	2.9	2.6
Estradiol	0.9	2.3	2.7	2.2	
	1.9	0.3	2.7	1.5	
	1.6	1.1	2.8	3.0	
	1.7	1.6	2.2	3.1	
Ave.	1.5	1.3	2.6	2.4	2.0
Stilbestrol	0.4	2.6	2.4	3.4	
	5.1	2.0	4.5	2.0	
	2.1	2.3	1.7	1.6	
	1.9	3.2	3.0	2.5	
Ave.	2.4	2.6	2.9	2.4	2.6
Sex-Sex Status Ave.	2.2	2.3	2.4	2.8	
Sex average	2.2		2.6		

* Percentage based on weight of raw meat.
** Numbers in parentheses indicate dummy values

Table 44. The effect of injected hormones (testosterone, estradiol dipropionate and diethylstilbestrol), sex, and sex status upon drip losses* from rabbit meat following four months' storage at 0°F. and cooked to an internal temperature of 194°F. at an oven temperature of 257°F.

Treatment	Sex Status: Males Intacts	Males Castrates	Females Intacts	Females Spayed	Treatment Average
	Per cent	Per cent	Per cent	Per cent	Per cent
Control	1.9	3.7	3.9	1.8	
	3.1	(3.1)**	2.5	2.8	
	6.9	2.0	5.5	4.2	
	2.1	3.5	2.3	3.9	
Ave.	3.5	3.1	3.6	3.2	3.3
Testosterone	3.7	2.7	2.2	2.3	
	3.5	1.4	3.7	2.4	
	4.1	4.3	2.4	2.5	
	2.5	2.8	1.6	3.9	
Ave.	3.4	2.8	2.5	2.8	2.9
Estradiol	1.8	1.6	2.4	2.0	
	1.2	1.9	3.7	3.1	
	3.9	2.0	4.1	3.6	
	3.2	1.5	2.4	2.8	
Ave.	2.5	1.8	3.2	2.9	2.6
Stilbestrol	0.4	2.3	2.4	2.9	
	3.9	3.6	3.9	3.9	
	1.8	3.5	2.3	2.2	
	1.5	2.0	3.7	0.8	
Ave.	1.9	2.9	3.1	2.5	2.6
Sex-Sex Status Ave.	2.8	2.6	3.1	2.8	
Sex average	2.7		2.9		

* Percentage based on weight of raw meat.
** Numbers in parentheses indicate dummy values

2. Palatability scores. The effects of castration and of injected testosterone, estradiol dipropionate and diethylstilbestrol on palatability scores of the fresh and the frozen cooked meat samples are presented in tables 45, 46, 47 and 48. Results show that in the fresh cooked meat the aroma was significantly more intense from the meat of male rabbits than that from the meat of females. Likewise, the aroma of meat from intact animals was more intense than that from the meat of castrates (table 46). The flavor of lean from stilbestrol-treated rabbits was less desirable than that of lean from control rabbits (table 46). The flavor of lean was not affected by either testosterone or estradiol administration. There was no effect of treatment on any of the other characteristics studied. There was also no difference due to sex or sex status on texture, tenderness, desirability and intensity of juiciness, flavor of fat and flavor of lean. This lack of significance may be due to the tremendous variation within subgroups in regard to texture, intensity of aroma, and intensity and desirability of juiciness, flavor of fat, and flavor of lean (table 46). The meat of frozen cooked rabbits showed no effect of treatment, castration or sex on any of the characteristics studied (table 48). This was probably due to the significant variation within subgroups in regard to texture, desirability of juiciness and aroma. A significant difference in the intensity of the flavor of lean was found due to sex-sex status interaction.

Table 45. AVERAGE PALATABILITY SCORES*--FRESH RABBIT

Characteristic	Estradiol				Stilbestrol				Testosterone				Control			
	Male		Female		Male		Female		Male		Female		Male		Female	
	C**	I**	S**	I	C	I	S	I	C	I	S	I	C	I	S	I
Juiciness-Desirability	4.7	4.6	5.0	4.8	4.9	4.3	5.1	4.8	4.7	4.8	4.6	4.8	5.0	4.9	4.6	4.9
Juiciness-Intensity	4.4	4.2	4.6	4.4	4.5	4.2	4.8	4.3	4.3	4.4	4.4	4.3	4.7	4.7	4.3	4.6
Tenderness-Intensity	5.1	4.9	5.1	5.3	5.5	4.5	5.6	5.3	5.6	5.3	5.1	5.1	5.1	5.2	5.1	5.5
Flavor of Lean - Desirability	4.8	4.9	5.1	5.3	4.8	4.5	5.4	5.0	5.3	5.3	4.7	5.4	5.3	5.4	5.2	5.6
Flavor of Lean - Intensity	4.5	4.9	4.9	4.7	4.6	4.8	4.6	4.8	4.9	4.7	4.6	4.8	4.8	5.0	4.7	4.9
Flavor of Fat - Desirability	5.1	4.6	4.6	5.0	5.5	4.7	5.2	4.9	5.3	5.1	4.8	5.1	5.3	5.1	5.3	5.0
Flavor of Fat - Intensity	4.9	4.7	4.9	4.9	5.0	5.2	5.0	4.9	4.8	5.0	4.9	4.7	4.7	4.7	5.0	4.7
Texture-Intensity	5.4	5.0	5.3	5.2	5.4	5.0	5.4	5.3	5.4	5.4	5.3	5.4	5.7	5.5	5.1	5.4
Aroma-Desirability	5.3	5.6	5.3	5.5	5.5	5.6	5.5	5.5	5.3	5.6	5.6	5.4	5.2	5.6	5.4	5.7
Aroma-Intensity	5.0	5.2	4.9	5.1	5.2	5.3	4.8	5.1	5.1	5.4	5.1	5.1	5.0	5.6	5.0	5.0

* Each figure is the average of 28 scores

** C - Castrates, I - Intacts, S - Spayed

Table 46. ANALYSIS OF VARIANCE OF PALATABILITY SCORES FOR ROASTS FROM HORMONE-INJECTED AND CONTROL RABBITS. COOKED WHEN FRESH.

Source of Variance	Degrees of Freedom	Mean Squares									
		Intensity						Desirability			
		Aroma	Texture	Tender-ness	Flavor of Fat	Flavor of Lean	Juici-ness	Aroma	Flavor of Fat	Flavor of Lean	Juici-ness
Total	62	--	--	--	--	--	--	--	--	--	--
Sex	1	.939**	.093	.124	.001	.003	.028	.001	.041	.398	.140
Sex Status	1	.835**	.166	.480	.074	.110	.222	.446	.411	.151	.115
Treatments	3	.049	.142	.077	.155	.084	.193	.033	.353	.775*	.057
S x SS	1	.015	.308	.714	.052	.004	.026	.144	.502	.224	.239
S x T	3	.050	.188	.495	.065	.048	.175	.041	.007	.504	.274
SS x T	3	.028	.127	.552	.059	.032	.200	.040	.347	.352	.261
S x SS x T	3	.113	.019	.026	.059	.165	.054	.068	.214	.110	.045
Rabbits	3	.585**	.834**	.475	.285*	.721**	.805**	.442	.511*	.940**	.649*
Error	44	.107	.144	.249	.082	.063	.155	.161	.165	.210	.218

S - Sex, SS - Sex Status, T - Treatment

* Significant at the 5% level
** Significant at the 1% level

Table 47. AVERAGE PALATABILITY SCORES*--FROZEN RABBIT

Characteristic	Estradiol				Stilbestrol				Testosterone				Control			
	Male		Female		Male		Female		Male		Female		Male		Female	
	C**	I**	S**	I	C	I	S	I	C	I	S	I	C	I	S	I
Juiciness-Desirability	4.9	5.1	5.1	5.0	5.0	5.1	5.0	4.9	4.9	5.2	4.8	5.4	5.3	4.9	5.2	5.0
Juiciness-Intensity	4.4	4.6	4.8	4.5	4.7	4.6	4.6	4.6	4.3	4.8	4.3	4.8	4.9	4.7	4.6	4.7
Tenderness-Intensity	5.6	5.7	5.6	5.6	5.7	5.6	5.7	5.7	5.9	5.4	5.7	5.4	5.7	5.8	6.0	5.8
Flavor of Lean - Desirability	5.6	5.6	5.6	5.4	5.3	4.9	5.5	5.0	5.1	5.4	5.5	5.6	5.5	5.6	5.5	5.6
Flavor of Lean - Intensity	4.9	4.8	4.8	4.6	4.9	4.9	5.0	4.6	4.8	5.0	4.6	4.7	4.6	5.0	4.8	4.8
Flavor of Fat - Desirability	5.1	5.1	5.3	5.4	5.3	5.1	5.4	4.9	5.3	5.1	4.5	5.5	5.3	5.3	5.4	5.2
Flavor of Fat - Intensity	4.7	4.7	4.9	5.0	5.1	5.0	4.9	4.9	5.0	5.0	4.9	4.9	4.9	4.7	4.9	5.0
Texture-Intensity	5.9	5.7	5.6	5.8	5.6	5.6	5.7	5.8	5.6	5.8	5.6	5.6	6.0	5.7	5.7	5.9
Aroma-Desirability	5.8	5.3	5.7	5.9	5.6	5.3	5.4	5.0	5.6	5.1	5.2	5.6	5.4	5.5	5.4	5.2
Aroma-Intensity	5.0	4.9	5.0	5.1	5.0	5.2	5.1	5.0	4.8	5.0	5.9	4.9	5.2	5.1	4.7	4.9

* Each figure is the average of 28 scores

** C - Castrates, I - Intacts, S - Spayed

Table 48. ANALYSIS OF VARIANCE OF PALATABILITY SCORES FOR ROASTS FROM HORMONE-INJECTED AND CONTROL RABBITS. COOKED AFTER FOUR MONTHS OF FROZEN STORAGE.

Source of Variance	Degrees of Freedom	Mean Squares									
		Intensity						Desirability			
		Aroma	Texture	Tender-ness	Flavor of Fat	Flavor of Lean	Juici-ness	Aroma	Flavor of Fat	Flavor of Lean	Juici-ness
Total	62	--	--	--	--	--	--	--	--	--	--
Sex	1	.014	.037	.007	.008	.160	.001	.010	.0001	.096	.001
Sex Status	1	.0004	.011	.111	.001	.053	.126	.462	.078	.098	.136
Treatments	3	.073	.065	.111	.057	.130	.105	.316	.056	.605	.063
S x SS	1	.092	.130	.008	.011	.429*	.012	.189	.044	.014	.007
S x T	3	.072	.031	.042	.165	.045	.054	.191	.049	.086	.039
SS x T	3	.031	.017	.095	.006	.095	.250	.047	.227	.373	.209
S x SS x T	3	.065	.077	.044	.010	.030	.101	.279	.339	.014	.063
Rabbits	3	.146	.413**	.247	.060	.097	.245	.975**	.234	.296	.574*
Error	44	.098	.073	.149	.061	.061	.168	.132	.163	.216	.152

S - Sex, SS - Sex Status, T - Treatment

* Significant at 5% level

** Significant at 1% level

DISCUSSION

Feeding Performance:

It appears that testosterone, estradiol and stilbestrol at the levels used during the first 42 days (1.0, 0.017, and 0.04 mg. of the respective hormonal materials, per kilogram body weight per week) did not significantly alter rate of gain. However, the tendency was toward a slightly higher rate of gain in the testosterone-injected rabbits, especially in the females. In contrast to the action of testosterone, both estrogens appeared to have produced slight depressions in the gains made with stilbestrol showing a stronger depressing effect than estradiol. Although significance was lacking in the difference between treated and non-treated rabbits, testosterone-injected rabbits made significantly better gains than rabbits treated with estrogens. These results strongly demonstrate the direction of action that both types of hormonal materials impose upon rate of gain in young growing rabbits. Had the variation within and among the various subgroups not been so wide, the differences in gains between treated and non-treated rabbits would have been clear-cut. However, there is the possibility that the dosages used of each of the hormonal materials may not have been optimum for bringing forth the differences in gains. There are some indications that the intact males vary from the intact females in their response to the injected materials. Also the castrated males differ from the spayed females in their response to the hormonal materials.

During this first period of 42 days' food consumption, although not significantly altered by the injected hormonal materials, did show

certain trends which may have resulted from the treatments. Testosterone appeared to have stimulated food consumption while both estrogens seemed to cause a reduction in the food intake, stilbestrol being more effective than estradiol in that respect. There is no available information in the literature to show whether the reduction in food intake caused by estrogens or the stimulatory effect of testosterone are directly responsible for the corresponding variations in gains. No statistical correlations could be found between food intake and gains during this period. Variations observed among the individuals of each subgroup were so large that they may have led to the lack of significance among the treatment groups. There was no alteration due to the injected testosterone or estrogens in the efficiency of food utilization during this period.

A significant difference due to sex-sex status interaction was obtained in regard to gains and food consumption during the first 42-day period. While castrated males made better gains and consumed more food than intacts, the spayed females made less gains and consumed less food than did the intacts. These observations could be partly explained on the basis of the activity of the thyroid gland in those animals; the alterations in the size of the thyroid gland followed the same pattern as that of the gains in weight and the food intake. Castrated males had larger thyroids than the intacts while spayed females had smaller thyroids than the intacts. There was no significant difference between males and females in regard to average gains or food intake although females tended to make slightly better gains and consume more food. There was no difference in efficiency of food utilization between the

two sexes. Likewise, gonadectomy had no effect on this characteristic.

A general conclusion on the behavior and the response of the castrated and intact rabbits of the two sexes injected with testosterone, estradiol and stilbestrol would indicate that castration was more influential on gains and on food intake than the hormonal materials. This was probably due to an insufficient quantity of the injected materials since castration, in general, is primarily the removal from circulation of the naturally occurring sex hormones. However, whether the administration of testosterone, estradiol and stilbestrol in sufficient quantities could cause a return to normal of all the changes resulting from castration is rather doubtful.

In evaluating the results obtained by various investigators, the controversies regarding responses of animals to various hormones point to differences in the dosage levels used. Burris and associates (20) obtained significant increases in the rate of gain and in the efficiency of food utilization of beef heifers and steers injected with 1.0 mg. of testosterone per kilogram body weight per week. Dinusson and coworkers (34), however, got no results when they injected beef heifers with a small dose of only 50.0 mg. testosterone propionate followed by another dose of 32.5 mg. after 56 days. Somewhat larger doses of testosterone were used by other investigators (7, 8) ranging from 180 to 255 mg. pellets, implanted subcutaneously into beef heifers and yearling steers with no effect on rate of gain or economy of food utilization.

Yet, contrary to the observations made with rabbits, stilbestrol has been used successfully in inducing beef heifers and steers of various ages (25, 26, 27, 7, and 8) to make better and more efficient

gains, especially under feedlot conditions (27). Pigs appeared to have behaved in a similar way to rabbits when injected with 1.0 mg. of testosterone per kilogram body weight per week; they showed no improvement in gains during a 6-week period (122). Smaller doses also did not cause any alterations in gains of 46-pound pigs (14).

The use of stilbestrol (35, 108, 138) or estradiol benzoate (122) as pelleted implants or injections into pigs did not cause any alterations in gains or in the efficiency of food utilization. In sheep, the work of several investigators indicated the lack of effect on gains and on food efficiency of administered testosterone in pellet form or when injected intramuscularly (6, 105, 110). Nevertheless, the subcutaneous implantation of 30.0 mg. of testosterone propionate into 74-pound lambs resulted in faster and more efficient gains according to Means and associates (92).

Results obtained during the second feeding trial of the present study when the rabbits were injected with 2.0, 0.034, and 0.08 mg. respectively of testosterone, estradiol and stilbestrol per kilogram body weight per week are of very little value in regard to gains. Some rabbits from various subgroups lost weight with no apparent reason. There was no effect of treatment but a treatment-sex status interaction was found to be significant. There was a tremendous difference between sexes in the average gains but that too was not significant. During this period, however, it appeared that females consumed significantly more food than males. No differences in total amount of food consumed were found among the treatment groups, during this period. The assumption that the increase in the dosage levels might have been

responsible for weight losses may not be likely since some control rabbits also lost weight. No useful evaluation of the efficiency of food utilization is possible since some rabbits lost weight. However, a significant difference due to sex status-treatment interaction was obtained in regard to efficiency of food utilization.

There is, meanwhile, one fact worth consideration at this time which might have a lot of bearing on some of the confusing results obtained during the second 42-day period. It is believed that during this period males as well as females had reached maturity and were well within the stage where metabolic processes slow down and fat deposition increases. The interaction between the injected materials with the endocrine glands, organs and other processes may have led to such unexpected changes in gains, food consumption and efficiency of food utilization.

Carcass Characteristics:

Dressing percentage and the percentage of skin, head and legs in relation to the live weight of the animal at slaughter appeared to be primarily sex characteristics. Females dressed consistently and significantly higher than males under all hormone treatments and in the presence or absence of the gonads. The average dressing percentage values for males and females were 57.2 and 60.1, respectively, and these are in close agreement with the values obtained by Wilson and Morris (136) who were using Angoras in their work. On the other hand, the percentage of skin, head and legs was consistently and significantly higher in the males than in the females irrespective of treatment or sex status. Testosterone, estradiol and stilbestrol administration did

not have any effect on either characteristic. Similar observations were made by various investigators in swine (108, 122, 138), sheep (6) and cattle (8, 34) injected with androgens and estrogens. However, some workers did find that estrogen administration in sheep (10, 59, 60, 105) and in cattle (20) lowered the dressing percentage. In view of the fact that estrogenic materials did not increase dressing percentage or reduce percentage skin, head and legs in the males and likewise testosterone did not reduce dressing percentage or increase percentage skin, head and legs in the females, it would appear that these characteristics are influenced by the genetics of the sex rather than by hormonal influences. Gonadectomy, meanwhile, did not alter the dressing percentage or the percentage of skin, head and legs in either sex.

General conclusions drawn from the statistical analysis of the results obtained by the chemical separation of the components of muscle and fat tissues would indicate that the administered hormonal materials were without effect. However, certain patterns of effects of these hormonal materials could be detected, comparing treatment means, that would indicate that had variation within and among subgroups not been so great, these differences might have expressed themselves significantly. All three injected materials caused slight but non-significant increases in the per cent of crude protein, probably due to a stimulatory effect on protein anabolism. Similarly, the amount of fat separated from the forequarter of each rabbit was slightly less in the treated rabbits than in the controls, a fact which also indicates an increase in the rate of metabolic processes accompanied by increased protein anabolism and

decrease in fat deposition. Similar observations have been reported in sheep (58, 59, 92, 105, 110) as well as in cattle (25, 26).

Differences were obtained between the male rabbits and the females many of which were significant and persisted throughout the experimental period irrespective of treatment or sex status. Females showed more dry matter in lean muscle, more ether-extractable materials in dry lean tissue and more separable fat from the forequarters than did males. Males showed slightly more protein content in lean muscle tissue; lack of significance being most probably due to the tremendous variation within subgroups.

Non-significant reductions in the crude protein content of the dry lean muscle tissue from castrates were observed. This difference would have expressed itself significantly had not the differences within and among the subgroups been so great.

The degree of unsaturation of fat was not affected by treatment, sex or sex status. No information is available in the literature to agree with or disprove this observation. However, all the rabbits were fed an identical ration and so far as is known, hormonal alterations have been shown to cause quantitative rather than qualitative alterations in the chemical composition of body tissues by causing changes in the metabolic rate or levels.

The difference between the two sexes is of interest especially when the content of certain tissue components remained constant, such as the dry matter content and the ether extractable materials from the dry muscle tissue. This could presumably indicate a genetic control with genes associated with sex. The constant higher content of separable fat

and the fat within the muscle tissue is in agreement with the fact that females reach maturity at an earlier age than males do and thus begin depositing fat, as the result of a slower metabolic rate, at a time when males are still growing muscle tissue with little fat deposition. The increase in fat deposition in the female would also explain the higher dressing per cent in this sex since the increase in fat deposition in the body is usually at the expense of moisture content (136), resulting in an increased dry matter content of lean muscle, too.

Gross Changes in Glands and Organs:

It was quite evident from the data obtained in this study that the endocrine glands had responded in a variety of ways, in regard to size and weight, to castration and to the intramuscular administration of testosterone, estradiol dipropionate and diethylstilbestrol. The same glands in the two sexes were also found to respond differently to the same treatment. Any alterations in the size of the endocrine glands as a result of the treatment would be due to the cumulative action of the two dosage levels of the hormonal materials used (1.0, 0.017, or 0.04 mg. of testosterone, estradiol and stilbestrol per kilogram body weight per week during the first 6-week period followed by 2.0, 0.034, or 0.08 mg. of the respective materials per kilogram body weight per week during the second 6-week period).

The testes of intact male rabbits injected with testosterone, estradiol or stilbestrol were significantly smaller in size and weighed less than those of control rabbits. These findings are in agreement with those of other investigators who reported the depression of testes size in rats (32, 49, 77, 86, 91, 95, 96, 97, 101, 125, 131); in rabbits

(131); in the ground squirrel (132); in dogs (79); in chicks (15); in pigs (138) and in sheep (59) using androgens and estrogens. However, no effect was found of either estrogens or testosterone on the size of the ovaries in the treated intact female rabbits. Many investigators have reported growth inhibition and depression of the development of the ovaries in rats (32, 37, 49, 53, 80, 81, 89, 93, 100), mice (117), chicks (56), dogs (79) and rabbits (88) when treated with androgens and estrogens. However, Mazer and associates (88) reported that daily injections of 12,000 rat units of estrogenic compounds for seven days into infantile rabbits had no effect on the weight of the ovaries, while 10,000 rat units daily for 21 days into infantile rabbits resulted in heavier ovaries than in the controls. Yet, a similar dose (10,000 rat units daily for 21 days) in the adult female rabbits resulted in smaller ovaries than in the controls. A possible explanation lies in the differences in the dosage level per animal, and in length of the treatment.

The growth depression of rabbit testes is possibly mediated through the pituitary gland (45, pp.1172-1199). The injected materials probably depress the pituitary's output of gonadotrophic hormones necessary for the development of the testes. A mutual regulation of androgen and gonadotrophin production (45, p.1199) as well as of estrogen and gonadotrophin production (45, p.1172) has been suggested.

Some investigators agree that injected sex-hormonal materials do not have a direct effect on the gonads in either sex (86, 96). Furthermore, Freeman and Small (44) concluded from their work that the male and female gonads in rats do not respond equally to similar doses of testosterone propionate, the ovaries being less responsive than the

testes. A similar situation existed for the gonads of our rabbits injected with similar doses of testosterone, estradiol and stilbestrol.

The most striking observation made on the pituitary gland was its increase in size following gonadectomy, a condition that persisted irrespective of further treatment. The increase in the size of the gland was marked and statistically significant in the castrated male as compared to the intact males. The increase in the size of the pituitary in the female following gonadectomy was not as marked or statistically significant when compared to intact females as in the males. Allen (1, p.336) reported that in 1905 Fichera observed an increase in the size of the pituitary gland of rabbits following gonadectomy. Similar observations have been reported in the rat by various investigators (73, 75, 78). Korenchevsky and associates (73, 74, 75) reported that in the male rat castration resulted in a significant increase in the size of the pituitary. In the spayed female rat, however, no definite changes were obtained in regard to the size of the pituitary. In our experiment, testosterone, estradiol and stilbestrol caused no significant alterations in the size of the pituitary gland. However, it would be reasonable to assume that sex hormones do affect the size of the pituitary since the removal from circulation of naturally occurring estrogens and androgens through gonadectomy resulted in significant increase in the size of the gland. Observations made by various investigators in regard to alterations in the size of the pituitary gland following androgen or estrogen administration have been varied. The increase in the size of the gland has been observed in rats (24, 32, 40, 100, 104), sheep (26) and cattle (27) following androgen and estrogen

administration. Other studies showed no change in the size of the gland of normal and castrated rats (72, 73, 74, 84, 85, 101), of chicks (16), of rabbits (88), or of cattle (20).

The combined weight of the adrenals was found to vary significantly between male and female rabbits, being larger in the former. Unfortunately, no information could be obtained in the literature concerning this fact, however, it would be in order to state that under the specific conditions of this experiment in regard to age, breed and treatment, males had significantly larger adrenals than females although body size is just the opposite. Castration apparently had no effect on the adrenals, however, the tremendous variation within and among subgroups may have led to lack of significant difference between castrates and intacts. The response of the adrenals to testosterone, estradiol dipropionate and diethylstilbestrol administration differed somewhat in the two sexes. In the females all three treatments tended to cause non-significant increases in the size of the glands. In the males, however, estradiol caused a significant increase in the size of the glands as compared to controls while both testosterone and stilbestrol caused non-significant reductions in the size of the glands. Heavier-than-normal adrenals have been reported in intact and castrated rats (11, 33, 40, 4, 71, 32) and in cattle (26, 27), treated with estrogens. However, non-significant changes have also been obtained as a result of estrogen administration in rats (85, 101) and in the dog (79). Androgens have caused reductions in adrenal sizes in rats (72, 73, 76, 78, 89) and in mice (117). Further, other investigators have also reported that androgens did not cause any alterations in adrenal

size in rats (24, 76, 84, 91).

The dosage levels appear to play an important part in the effect of estrogens and androgens on the size of the adrenals. Several investigators (32, 40, 71) agree that large doses of estrogenic materials resulted in an increase in the size of the glands while moderate (40) and small (71) doses had no effect. A difference in response was obtained between intact male rats and castrates (71); there was an increase in the size of the adrenals in the former and no change in the adrenals of the latter, when large daily doses (60 to 180 i.u.) of estrone were used.

When there is a change in the size of the adrenals, one does not know whether this change is in the cortex, medulla or both. Alterations in the size of the adrenal glands have been known to occur depending on various factors. Removal of ACTH causes atrophy of the adrenal cortex (50, pp.292-304), while pituitary extracts will cause hypertrophy of the normal adrenal (50, p.297). Hypertrophy in the latter case being due to the increase in the size of the adrenal cortex under the influence of ACTH present in the pituitary extract. Hypertrophy of the adrenal cortex has been found to follow increased thyroid activity (50, p.320), the enlargement being due probably to a greater hormone demand. Estrogens have also been found to affect the adrenals, directly or indirectly. Adrenal atrophy has been produced by estradiol (50, p.304). Yet, stilbestrol was found to stimulate ACTH release by the pituitary (50, p.301). Furthermore, gonadectomy has been found to modify the structure and probably the activity of the adrenal cortex (50, p.324) which, likewise, has been found to be modified by the

administration of androgens and estrogens (50, p.324). In our work, variations in the response of the adrenals from both sexes toward injected sex hormonal materials could conceivably be due to the difference in the initial size of the glands unless some other factors besides the dosages were effective in determining the concentration of the injected sex hormonal materials in the adrenals. Yet, there is probably a specific sex variation in response to administered hormones since an increase in the rat adrenal had been observed during estrus (45, p.326), and it is also believed that in the spayed female rat injected with estrone, the increase in the size of the adrenals was independent of the pituitary (45, p.326).

The thyroid gland of the male and the female rabbit was altered in opposite directions following gonadectomy; the size of the gland was increased in the castrated male but decreased in the spayed female when compared with control animals. The thyroid gland of the intact female appeared to be larger than that in the intact male. In our experiment testosterone, estradiol and stilbestrol administration caused no significant alterations in the size of the thyroid gland when compared to those of control rabbits. This lack of effect was probably due to, among other things, the dosage levels used and the length of the treatment periods. However, comparing the effect of the two estrogenic materials, it was found that stilbestrol caused a significant reduction in the size of the gland as compared to those from estradiol-treated rabbits. This was probably due to the higher concentration of stilbestrol (0.04 and 0.08 mg. per kilogram body weight per week, during the first and second 6-week periods, respectively) than that of

estradiol (0.017 and 0.034 mg. per kilogram body weight per week during the same respective periods). However, results obtained in our work are in agreement with observations made on rabbits treated with estrogens (88). Several investigators using androgens (24) and estrogens in rats (40, 101), and estrogens in sheep (26) and in cattle (27) also obtained no alterations in the size of the thyroid gland as a result of treatment.

Meanwhile, enlargement of the gland was observed in rats (24, 73, 78, 100, 103), mice (117) and cattle (18, 20, 26) treated with androgens or estrogens, while reduction in the size of the thyroid was reported by several investigators (32, 26, 84). Such varied information is probably due to the wide variations in the dosage levels used, the length of treatment periods, age and sex of the animals used and the type of preparations applied.

The size of the thyroid gland in the castrated and intact male and female rabbits may be one of the factors concerned with gains in weight especially those obtained during the first 6-week period. During that period, castrated males made better gains than intact males while spayed females made less gains than the intact females. The increase in the size of the gland in the castrated males may have been responsible for the increase in gains over those made by the intacts. Spayed females, on the other hand, gained less and had smaller thyroids as compared to intacts indicating a probable reduced activity of the gland. That there is a difference in response to castration between the pituitaries of males and females besides size changes is very possible. Physiological as well as specific types and magnitude of changes

possibly occur that differ in the male and in the female of the various species. It should be kept in mind, however, that alterations in the size of the pituitary could possibly be in either lobe or in both of them, as a result of castration and hormonal therapy. Yet, changes in the anterior and posterior lobes of the pituitary as a result of hormonal treatment may occur in opposite directions and at such rates that the final weight of the gland would still be similar to those of non-treated animals. Future study of the histology of the endocrine glands will help tremendously in explaining any changes in the size and activity of the glands as well as the mechanism involved.

In general, several conclusions have been drawn from this study with rabbits concerning the differences between sexes in the size of some of the glands, the effects that castration may have on their weight and activity as well as the effect of injected hormonal materials and the degree and direction of alterations they produce. Apparently, the intramuscular injection of 1.0 mg. of testosterone, 0.017 mg. of estradiol dipropionate and 0.04 mg. of stilbestrol per kilogram body weight for a period of 42 days followed by another 42-day period during which the dose per kilogram body weight of the respective hormonal materials was doubled, affected the male endocrine glands in a more pronounced way than those of the females. The testes of all treated rabbits were significantly reduced in size while the ovaries of treated females showed a slight but not significant reduction, when compared to controls. In the treated females, the tendency was toward heavier adrenals under the various hormonal treatments. In the males, however, estradiol resulted in significant hypertrophy of the adrenals

while testosterone and stilbestrol tended to reduce the size of the glands when compared to those of controls.

Meanwhile, castration effects also varied in both sexes and the changes produced in some endocrine glands were maintained throughout the treatment period. Castration in the males resulted in hypertrophy of the pituitary and the thyroid glands; in the spayed female, slight increases in the size of the pituitary but definite decreases in the size of the thyroids were obtained. Although there was a tendency toward adrenal hypertrophy in the castrated male and female rabbits as compared to intacts, the differences were not significant.

Rabbits are a species in which the females are larger than males throughout their growing period and at maturity. Apparently the females reach maturity at an earlier age than do the males and thus the females were closer to maturity than the males when this experiment started. At the age of 9 to 10 weeks, females were getting closer to maturity than males, and it is reasonable to assume that some of the results obtained in the females and their lack of response may have been due to the fact that they had reached maturity during the experimental period while the males had not. However, valuable information has been gathered in the process of experimentation with those animals, in regard to some of the endocrine glands. On the average, intact females have heavier pituitaries, thyroids and smaller adrenals than the male rabbits. The larger thyroids and pituitaries are good reasons for the larger body size especially in the young growing animals.

Hormonal Alterations of Liver Weight:

Changes in the size and activity of the liver as a result of androgen or estrogen administration are not clear or well understood. Under the conditions of this experiment, livers from treated rabbits did not differ significantly in size when compared with those from non-treated rabbits. Similar observations were made with cattle (20)and with mice (117). However, testosterone-treated rabbits had significantly larger livers than estrogen-treated rabbits. Larger livers were also obtained in rats (75, 84) and in mice (68) treated with androgens. Reductions in liver weights were reported in rats (71) treated with estrogens. There is no proof yet as to a direct effect of injected hormonal materials on the liver cells. Selye (117) found no histological and structural changes in the livers of female mice treated with 5.0 mg. of testosterone propionate daily for 20 days. Kunde and associates (79) reported no pathological effects in the liver of an immature dog treated daily with 800 rat units of estrin. However, the response of liver size to androgen and estrogen administration in rabbits corresponded in an identical way to the response of these rabbits in regard to gains, especially during the first 6-week period. In this respect, the change in liver size was identical to the change in body size, thus behaving as an integral part of the whole body. Yet, it would be reasonable to assume that the size of the liver was modified to meet such body needs for glycogen storage and metabolizing hormones, that arise from the administration of hormonal materials in excess of those already and naturally produced. Stilbestrol was found to raise liver glycogen by stimulating ACTH release by the pituitary (50, p.301).

The tremendous variation within and among the subgroups may have been responsible for the lack of difference between sexes as well as between intact and castrated rabbits.

Meat Characteristics:

Evaporation and drip losses as a per cent of the raw meat as well as palatability scores present interesting information that ties in rather closely with some of the other observations made. Evaporation losses were consistently higher in the meat from male rabbits than in the meat from females, indicative of a higher free-water content in the tissues of the former. These observations are in agreement with the chemical analysis where there was less dry matter in the lean muscle of males than there was in the same tissues of females. Likewise, there was less separable fat from the forequarters and less ether extractable materials from the dry lean muscle in the males. The lower evaporation losses during cooking from female carcasses are also in agreement with the chemical analysis which showed less moisture in the lean muscle. There was more separable fat from the forequarters of the females. This as well as the lower percentage of moisture indicated less water in the carcass of the female in an overall way as compared to male carcasses. Neither castration nor the intramuscular administration of testosterone, estradiol and stilbestrol had any effect on evaporation losses. Variations within and among the subgroups may have been responsible for the lack of significance. Drip losses during cooking, however, were about the same in carcasses from male and female rabbits. Neither castration nor the injected materials altered the amount of loss as drip. Variation within subgroups may explain this lack of effect. A chemical

analysis of the composition of drip would have been of much value in view of Jordan's report (59) that differences in the composition of drip constituents were found due to hormone treatment. More fat occurred in the drip of non-treated lambs but more water in the drip of stilbestrol-treated ones. Jordan (59) also found that there was no significant difference between stilbestrol-treated and control lambs in the amount of drip. However, a decrease in the amount of drip was reported by Burris and coworkers (20) as a result of the intramuscular administration of 1.0 mg. of testosterone per kilogram body weight per week into beef steers and heifers. They also added that there was an increase in evaporation losses in the treated animals. This is undoubtedly due to the increase in the quantity of muscle tissue and the decrease in fat deposition. No information is available in the literature in regard to the composition of materials lost through evaporation. It has been taken for granted that the major component in such cases is water. The possibility should not be overlooked that volatile aromatic compounds, too, would be lost through evaporation when cooking is carried out at an oven temperature of 257°F. for two to three hours.

The cooked rabbit meat was scored while still warm by a panel of seven judges for texture, tenderness, juiciness and the intensity and desirability of aroma, flavor of fat and flavor of lean. Treatment had no apparent effect on any of the above-mentioned characteristics except that in fresh rabbit meat stilbestrol treatment reduced desirability of lean meat flavor. The aroma of meat from the male rabbits was more intense than that of meat from the females. Likewise, the aroma of

fresh meat from intact animals was more intense than the aroma of meat from castrates. The differences in the intensity of aroma between sexes and between intact animals and castrates could have possibly been due to the degree of fatness--the increase in fat content masking somehow the water soluble components contributing to the aroma of meat. Females showed more fat within the muscle tissue and covering the body, as shown by the greater quantity of separable fat, than did the males. Although the difference between intact rabbits and castrates in regard to fat within the muscle tissue or that separated from the forequarters was not significant, the tendency was toward a higher fat content in the castrates than in the intacts. Thus it appears that the increase in fat content tends to lower the intensity of aroma. The lack of significance among the treatment groups and between sexes in regard to some of the other characteristics may have been due to the wide significant differences within subgroups. Such differences were shown in regard to texture, intensity of aroma, intensity and desirability of juiciness, flavor of fat and flavor of lean.

Palatability scores from meat of frozen rabbit carcasses showed no significant differences due to treatment, sex or sex status. However, a significant difference due to sex-sex status was shown in regard to the intensity of the flavor of lean. Intact male carcasses showed a more intense flavor of lean while intact female carcasses showed a less intense flavor of lean as compared to their respective castrates. The lack of significance in the difference found when the meat was cooked fresh may have been due to the introduction of an extra factor, that of storage under frozen conditions for four months.

The doses used of the injected hormonal materials were based on the weight of the animals. They were calculated from the physiological level of natural hormones circulating in the human system. The lack of significance of effect obtained in some of the characteristics studied leads to the belief that the dosages were probably not quantitatively optimum. However, the difference between sexes in the response of the gonads to similar doses would indicate that in this particular species, certain characteristics are probably genetically controlled and influenced strongly by the genetics of the sex rather than by sex hormones either naturally occurring in the system or introduced to the body.

There was probably a difference between sexes in their qualitative response to the introduced hormones. The purpose of this work was primarily to study the role that sex hormones might play in the behavior of rabbits during growth from the standpoint of rate of gain, quantity of food necessary to meet those gains and any alterations in efficiency in the utilization of food--an important aspect of the economic production of various meat animals. The administration of these pure preparations in the castrated animals has shown several things--that the dose used was probably not optimum to produce such effects that the presence of testes or ovaries usually produce, that there are other hormones or chemically-related compounds that are produced by the gonads besides what are normally considered the sex hormones that do affect some of the characteristics studied and without which normal function of glands and organs cannot be reproduced.

For all purposes, it might have been more effective if both estrogenic and androgenic compounds had been administered to either

castrated or intact animals since both types of hormones have been found in the testes of many species.

Yet, no definite conclusions can really be made before the histological study of the glands and organs of the treated rabbits had been studied to find out the truth about the alterations in size that did take place or the changes that might have taken place without their showing any physical changes.

It is reasonable to assume that at certain dosage levels glands and organs respond differently; some may be more susceptible than others, while some may not be affected entirely by those types of compounds. Due to limited facilities, only a few facts could be studied and determined at one time. To completely understand the multiple correlations between the introduced materials with those naturally occurring or their replacement value as in the castrated animals would require time and work of no limitation.

Time of treatment in the age of the animal is of importance. If the treatment had been conducted at a time when maturity was not approaching, potential changes would have been obtained.

SUMMARY AND CONCLUSIONS

The weekly intramuscular administration of 1.0 mg. of testosterone, 0.017 mg. of estradiol dipropionate or 0.04 mg. of diethylstilbestrol per kilogram body weight injected in two equal doses semi-weekly into castrated and intact male and female rabbits during a 42-day period showed the following:

1. Testosterone-treated rabbits made significantly higher gains than those injected with estrogens. No significant difference could be demonstrated between treated and non-treated rabbits in regard to gains. There was no effect of the injected hormonal materials on food intake during this period. Likewise, there was no effect of treatment on efficiency of food utilization.

2. During the first 42-day experimental period, a significant difference due to sex-sex status interaction was obtained in regard to gains and food intake. The average gains in grams of 820, 994, 950 and 914 were made by intact males, castrated males, intact females and spayed females, respectively. The following average values in grams represent total food consumption per rabbit for intact males, castrated males, intact females and spayed females: 8360, 9211, 9347 and 8859, respectively.

Continuation of the hormonal treatment for another 42-day period during which the rabbits were injected intramuscularly with weekly doses of 2.0 mg. of testosterone, 0.034 mg. of estradiol dipropionate or 0.08 mg. of diethylstilbestrol per kilogram body weight, administered semi-weekly in two equal doses, showed the following:

1. None of the injected materials had any effect on gains, food intake or efficiency of food utilization. This was probably due to the tremendous variation, especially in regard to gains within subgroups caused by losses in the weight of some of the rabbits during the period. There was, however, a significant difference due to treatment-sex status interaction in regard to gains and efficiency of food utilization. Yet, the validity of those results is questionable under the circumstances because of the losses in the weight of some of the rabbits in the various subgroups.

From the carcass and the organ studies at slaughter, it has been concluded that testosterone, estradiol dipropionate and diethylstilbestrol at the two levels used and during the two 6-week periods showed the following:

1. All three injected hormonal materials had no effect on either the dressing percentage or the percentage of skin, head and legs of the rabbits.

2. Testosterone, estradiol and stilbestrol administration caused a significant reduction in the weight of the testes but had no effect on the ovaries. The three injected materials had no effect on the size of the pituitary. Although injected rabbits did not differ from the controls in regard to the size of the thyroid gland, a significant difference was obtained between both estrogen-treated rabbits. Those injected with stilbestrol had significantly smaller thyroids than those injected with estradiol. The adrenal glands responded in a different way in both sexes in regard to administered hormonal materials. In the males, testosterone and stilbestrol caused a non-significant reduction

in the weight of the adrenal glands while estradiol caused a significant increase in adrenal weight as compared to controls. All three hormonal materials caused a non-significant increase in the weight of the adrenal glands of females as compared to controls.

3. Livers from estrogen-treated rabbits (79.5 grams) were significantly lighter in weight than those from testosterone-treated rabbits (94.2 grams). There was no difference, however, between control and injected rabbits in the average weight of the livers.

4. Apparently, the injected hormonal materials had no effect on the chemical composition of lean muscle or kidney fat of rabbits. Treated rabbits did not differ from controls in the amount of fat separated from the forequarters.

5. Palatability studies showed no effect of treatment on any of the characteristics studied except in one case in which stilbestrol-treated rabbits had a less desirable flavor of lean from freshly cooked meat.

In addition to the various effects of testosterone, estradiol or stilbestrol administration, many valuable observations were obtained which undoubtedly will add to our knowledge of rabbits.

1. During the first 42-day period, castrated males gained more than intact males while spayed females gained less than intact females. Furthermore, during this same period castrated males consumed more food than did the intact males while spayed females consumed less food than did the intact females. During the second 42-day period, however, females consumed significantly more food than did the males.

2. Carcass and endocrine studies at slaughter showed that females dressed significantly higher than males while males had a significantly higher percentage of skin, head and legs. Castration resulted in a marked and significant increase in the size of the male pituitaries but a slight and non-significant increase in the female pituitaries. Furthermore, castration resulted in an increase in the size of the male thyroids but a decrease in the size of the female thyroids. Males had significantly heavier adrenals than females.

3. The chemical analysis of lean muscle and kidney fat showed that females had significantly more dry matter and more ether extractable materials in fresh and dry lean muscle, respectively, than males. Females also had more separable fat from the forequarters than did males.

4. Evaporation losses from fresh and frozen carcasses were higher for males than for females.

5. Palatability studies showed that intensity of aroma in fresh meat of males and intact animals was greater than aroma of fresh meat from females or castrated animals. In the frozen cooked meat samples the flavor of lean was more intense in carcasses from intact males and spayed females as compared to those from castrated males and intact females.

BIBLIOGRAPHY

1. Allen, Edgar. Sex and internal secretions. Baltimore, The Williams and Wilkins Co., 1932. 951p.

2. Allen, Edgar, Charles H. Danforth and Edward A. Doisy. Sex and internal secretions. 2d ed. Baltimore, The Williams and Wilkins Co., 1939. 1346p.

3. Almquist, John O. and F. Andrews. Effect of testosterone propionate on thermo-regulatory function of rat scrotum. Anatomical record 89:125-133. 1944.

4. Anderson, D. H. The effect of ovarian hormone on the pituitary, thyroid and adrenal glands of spayed female rats. Journal of physiology 83:15-25. 1934.

5. Andrews, F. N. and W. M. Beeson. The effects of various methods of estrogen administration on the growth and fattening of wether lambs. Journal of animal science 12:182-187. 1953.

6. Andrews, F. N., W. M. Beeson and Claude Harper. The effect of stilbestrol and testosterone on the growth and fattening of lambs. Journal of animal science 8:578-582. 1949.

7. Andrews, F. N., W. M. Beeson and F. D. Johnson. The effect of hormones on the growth and fattening of yearling steers. Journal of animal science 9:677. 1950.

8. Andrews, F. N., W. M. Beeson and F. D. Johnson. The effect of stilbestrol, dienestrol, testosterone and progesterone on the growth and fattening of beef steers. Journal of animal science 13:99-107. 1954.

9. Association of official agricultural chemists. Official and tentative methods of analysis. 6th ed. Washington, A.O.A.C. 1945. 932p.

10. Bell, T. Donald, Walter H. Smith and A. B. Erhart. The effect of stilbestrol upon lamb performance in the feedlot. Journal of animal science 13:425-432. 1954.

11. Billeter, O. A. The effect of spaying and theelin injections on body growth and organ weights of the albino rat. American journal of anatomy 60:367-395. 1937.

12. Bogart, Ralph, J. F. Lasley and D. T. Mayer. Influence of reproductive hormones upon growth in ovariectomized and normal female rats. Endocrinology 35:173-181. 1944.

13. Bogart, Ralph, A. C. Warnick, J. J. Dahman and Martin J. Burris. The effect of the male sex hormone on rate of gain and feed efficiency of beef cattle. Journal of animal science 10: 1073. 1951.

14. Bratzler, L. S., R. P. Soule,Jr., E. P. Reineke and Pauline Paul. The effect of testosterone and castration on the growth and carcass characteristics of swine. Journal of animal science 13:171-176. 1954.

15. Breneman, W. R. Male hormone and the testis-comb relationship in the chick. Endocrinology 21:503-510. 1937.

16. Breneman, W. R. A factorial analysis of pituitary-gonad-comb relationships in the chick. 2. Action of pregnant-mare-serum and testosterone-propionate on the growth of the pituitary and gonad. Poultry science 30:399-408. 1951.

17. Bugbee, E. P. and A. E. Simond. The effects of injections of ovarian follicular hormone on body growth and sexual development of male and female rats. Endocrinology 10:360-369. 1926.

18. Burris, Martin J., Ralph Bogart and Hugo Krueger. Alterations of activity of thyroid gland of beef cattle with testosterone. Proceedings of the society for experimental biology and medicine 84:181-183. 1953.

19. Burris, Martin J., Ralph Bogart and A. W. Oliver. Alterations of daily gain, feed efficiency and carcass characteristics in beef cattle with male hormones. Journal of animal science 12:740-746. 1953.

20. Burris, Martin J., Ralph Bogart, A. W. Oliver and A. O. Mackey. The effect of testosterone propionate on rate of gain, feed efficiency and carcass quality of beef heifers and steers. Journal of animal science 11:789. 1952.

21. Burrows, Harold. Biological actions of sex hormones. Cambridge, University press, 1949. 615p.

22. Cameron, A. T. Recent advances in endocrinology. 6th ed. W. I., J. and A. Churchill, Ltd., 1947. 443p.

23. Cheng, Peilieu and L. E. Casida. Effects of testosterone propionate upon sexual libido and the production of semen and sperm in the rabbit. Endocrinology 44:38-48. 1949.

24. Clausen, Fred W. and C. B. Freudenberger. A comparison of the effects of male and female sex hormones on immature female rats. Endocrinology 25:585-592. 1939.

25. Clegg, M. T. The use of diethylstilbestrol to increase nitrogen retention. Journal of animal science 11:758. 1952.

26. Clegg, M. T. and H. H. Cole. The action of stilbestrol on the growth response in ruminants. Journal of animal science 13:108-130. 1954.

27. Clegg, M. T., H. H. Cole and H. R. Guilbert. Effects of stilbestrol on beef heifers and steers. Journal of animal science 10: 1074. 1951.

28. Crafts, Roger C. Effects of hypophysectomy, castration and testosterone propionate on hemopoiesis in the adult male rat. Endocrinology 39:401-413. 1946.

29. Cutuly, Eugene and Elizabeth C. Cutuly. Observations on spermatogenesis in rats. Endocrinology 26:503-507. 1940.

30. Deanesly, R. and A. S. Parkes. Size changes in the seminal vesicles of the mouse during development and after castration. Journal of physiology 78:442-450. 1933.

31. Deanesly, R. and A. S. Parkes. Comparative activities of compounds of the androsterone-testosterone series. Biochemical journal 30:291-303. 1936.

32. Del Castillo, B. E. and R. Sammartino. Effect of prolonged treatment with large doses of oestrone on the endocrine and sexual organs of the rat. (Accion de las grandes dosis prolongadas de estrona sobre los organos endocrinos y sexuales e en la rata). Rev. Soc. argent. de biol. 13:455. 1937. (Abstracted in Endocrinology 23:113-114. 1938.)

33. Diaz, J. T., D. Phelps, E. T. Ellison and J. C. Burch. The effects of various gonadotrophic substances upon the ovaries, pituitaries and adrenals of animals receiving long-term injections of estrin. American Journal of physiology 121: 794-799. 1938.

34. Dinusson, Williams, F. N. Andrews and W. M. Beeson. The effects of stilbestrol, testosterone, thyroid alteration and spaying on the growth and fattening of beef heifers. Journal of animal science 9:321-330. 1950.

35. Dinusson, Williams E., Earle W. Klosterman and M. L. Buchanan. Stilbestrol, effect of subcutaneous implantation on growing-fattening swine. Journal of animal science 10:885-888. 1951.

36. Dixon, Wilfrid J. and Frank J. Massey,Jr. Introduction to statistical analysis. New York, McGraw-Hill, 1951. 370p.

37. Doisy, E. A., J. Curtis and W. D. Collier. Effect of theelin upon the developing ovary of the rat. Proceedings of the society for experimental biology and medicine 28:885-887. 1931.

38. Dorfman, Ralph I. Bioassey of steroid hormones. Physiological review 34:138-166. 1954.

39. Dvoskin, Samuel. Local maintenance of spermatogenesis in hypophysectomized rats with low dosages of testosterone from intratesticular pellets. Proceedings of the society for experimental biology and medicine 54:111-113. 1943.

40. Ellison, E. and J. C. Burch. The effect of estrogenic substances upon the pituitary, adrenals and ovaries. Endocrinology 20: 746-752. 1936.

41. Evans, H. M. and M. S. Simpson. A comparison of anterior hypophyseal implants from normal and gonadectomized animals with reference to their capacity to stimulate the immature ovary. American journal of physiology 89:371-374. 1929.

42. Evans, H. M. and M. E. Simpson. A sex difference in the hormone content of the anterior hypophysis of the rat. American journal of physiology 89:375-378. 1929.

43. Fevold, H. L., F. L. Hisaw and R. Greep. Effect of oestrin on the activity of the anterior lobe of the pituitary. American journal of physiology 114:508-513. 1936.

44. Freeman, W. and R. Small. Effect of testosterone propionate on various responsive organs of immature rats. Endocrinology 29:758-761. 1941.

45. Fulton, John F. Textbook of physiology. 16th ed. Philadelphia, W. B. Saunders Co., 1950.

46. Gardner, W. U. and C. A. Pfeiffer. Influence of estrogens and androgens on the skeletal system. Physiological review 23: 139-165. 1943.

47. Gortner, Ross A. and Willis A. Gortner. Outlines of biochemistry. 3d ed. New York, John Wiley and Sons, Inc., 1950. 1078p.

48. Hall, Kathleen and V. Korenchevsky. Effects of castration and of sexual hormones on the adrenals of male rats. Journal of physiology 91:265-373. 1938.

49. Halpern, S. R. and F. E. D'Amour. Effects of estrin upon gonads, mammary glands and hypophysis of the rat. Proceedings of the society for experimental biology and medicine 32: 108-110. 1934.

50. Hartman, F. A. and Katharine A. Brownell. The adrenal gland. Philadelphia, Lea and Febiger, 1949. 581p.

51. Hellbaum, Arthur A. and R. O. Greep. Qualitative changes in the gonadotropic complex of the rat pituitary following removal of the testis. American journal of anatomy 67:287-304. 1940.

52. Hellbaum, Arthur A. and R. O. Greep. Qualitative changes induced in gonadotropic complex of pituitary by testosterone propionate. Endocrinology 32:33-40. 1943.

53. Heller, Carl G. and E. C. Jungck. Regulation of ovarian growth: Inhibition by estrogen or stimulation by gonadotrophins? Proceedings of the society for experimental biology and medicine 65:152-154. 1947.

54. Heller, Carl G., A. Segaloff and W. O. Nelson. Effect of testosterone propionate on the pituitary gonadotrophic potency of the castrated male rat. Endocrinology 33:186-188. 1943.

55. Herrick, Earl H. Tensile strength of tissues as influenced by male sex hormone. Anatomical record 93:145-149. 1945.

56. Herrick, Earl H. and Charles H. Lockhart. The effect of male sex hormone on the developing ovaries of young fowl. Endocrinology 26:509-515. 1940.

57. Hilditch, T. P. The chemical constitution of natural fats. New York, John Wiley and Sons, Inc., 1940. 438p.

58. Jordan, R. M. The effect of stilbestrol on fattening lambs. Journal of animal science 9:383-386. 1950.

59. Jordan, R. M. Effect of stilbestrol on suckling and fattening lambs. Journal of animal science 12:670-678. 1953.

60. Jordan, R. M. Effect of level of stilbestrol on growth and fattening of lambs. Journal of animal science 12:680-683. 1953.

61. Jordan, R. M. and W. E. Dinusson. Effect of stilbestrol on the growth rate of suckling lambs. Journal of animal science 9:380-382. 1950.

62. Jungck, Edwin C., C. G. Heller and W. O. Nelson. Regulation of pituitary gonadotrophic secretion: Inhibition by estrogen or inactivation by the ovaries? Proceedings of the society for experimental biology and medicine 65:148-152. 1947.

63. Kenyon, Allan T. The effect of testosterone propionate on the genitalia, prostate, secondary sex characters and body weight in eunuchoidism. Endocrinology 23:121-134. 1938.

64. Kenyon, Allan T. et al. The effect of testosterone propionate on nitrogen, electrolyte, water and energy metabolism in eunuchoidism. Endocrinology 23:135-153. 1938.

65. Kirk, Raymond E. and Donald F. Othmer (ed.s). Encyclopedia of chemical technology, vol. 7. New York, The interscience encyclopedia, inc., 1951. 982p.

66. Koch, Fred C. The male sex hormones. Physiological review 17: 153-238. 1937.

67. Kochakian, Charles D. Testosterone and testosterone acetate and the protein and energy metabolism of castrated dogs. Endocrinology 21:750-755. 1937.

68. Kochakian, Charles D. The rate of absorption and effects of testosterone propionate pellets on mice. Endocrinology 28:478-484. 1941.

69. Kochakian, Charles D. and R. P. Fox. The effect of castration and testosterone propionate on the "alkaline" and "acid" phosphatases of the kidney, liver and intestine of the mouse. Journal of biological chemistry 153:669-674. 1944.

70. Kochakian, Charles D. and J. R. Martin. The relationship of the synthetic male hormone, androstenedion, to the protein and energy metabolism of castrated dogs and the protein metabolism of a normal dog. American journal of physiology 117:642-657. 1936.

71. Korenchevsky, V. and M. Dennison. The effect of oestrone on normal and castrated male rats. Biochemical journal 28:1474-1485. 1934.

72. Korenchevsky, V. and M. Dennison. The effect on male rats of the simultaneous administration of male and female sexual hormones and the relation to the assey of the hormones. Biochemical journal 28:1486-1499. 1934.

73. Korenchevsky, V., M. Dennison and I. Brovsin. The assey and the effect of testosterone on rats compared with those of other sexual hormones. Biochemical journal 30:558-575. 1936.

74. Korenchevsky, V., M. Dennisgn and M. Eldridge. The effects of 4-androstenedione and 5-androstenediol in castrated and ovariectomized rats. Biochemical journal 31:467-474. 1937.

75. Korenchevsky, V., M. Dennison and M. Eldridge. The prolonged treatment of castrated and ovariectomized rats with testosterone propionate. Biochemical journal 31:475-485. 1937.

76. Korenchevsky, V., M. Dennison and K. Hall. The action of testosterone propionate on normal adult female rats. Biochemical journal 31:780-785. 1937.

77. Korenchevsky, V., M. Dennison and K. Hall. The effects of testosterone and testosterone propionate on adult male rats (compared with those on female rats). Biochemical journal 31:1434-1437. 1937.

78. Korenchevsky, V. et al. Changes produced by testicular hormone in normal and in castrated rats. Biochemical journal 27:557-579. 1933.

79. Kunde, M. M. et al. The effect of estrin administration on the reproductive and blood vascular system: The thyroid, thymus, hypophysis, adrenals, kidneys, liver and spleen. American journal of physiology 96:677-682. 1931.

80. Laqueur, G. L. Effects of testosterone propionate on genital organs of female rats treated from date of birth. Proceedings of the society for experimental biology and medicine 55:268-270. 1944.

81. Laqueur, G. L. and C. F. Fluhmann. Effects of testosterone propionate in immature and adult female rats. Endocrinology 30:93-101. 1942.

82. Lane, C. E. Some influences of oestrin on the hypophyseal-gonad complex of the immature female rat. American journal of physiology 110:681-685. 1935.

83. Lea, C. H. Rancidity in edible fats. New York, chemical publishing co., inc., 1939. 230p.

84. Leathem, James H. Plasma protein concentrations and organ weights of castrated and testosterone propionate treated rats. American journal of physiology 154:459-464. 1948.

85. Leonard, S. L., R. K. Meyer and F. L. Hisaw. The effect of oestrin on development of the ovary in immature female rats. Endocrinology 15:17-24. 1931.

86. Ludwig, Dorothy J. The effect of androgen on spermatogenesis. Endocrinology 46:453-481. 1950.

87. Mark, J. and G. R. Biskind. The effect of long-term stimulation of male and female rats with estrone, estradiol benzoate and testosterone propionate administered in pellet form. Endocrinology 28:465-477. 1941.

88. Mazer, C., S. Leon Israel and B. J. Alpers. The time element in the pituitary-ovarian response to large doses of the estrogenic hormone. Endocrinology 20:753-761. 1936.

89. Mazer, M. and C. Mazer. The effect of prolonged testosterone propionate administration on the immature and adult female rat. Endocrinology 24:175-181. 1939.

90. McCullagh, E. Perry and H. R. Rossmiller. Methyl testosterone. III. Effect upon body weight and growth. Journal of clinical endocrinology 1:507-510. 1941.

91. McEuen, C. S., H. Selye and J. B. Collip. Effect of testosterone on somatic growth. Proceedings of the society for experimental biology and medicine 36:390-394. 1937.

92. Means, T. M., F. N. Andrews and W. M. Beeson. The effects of hormones on the growth and fattening of lambs. Journal of animal science 12:176-181. 1953.

93. Meyer, R. K. et al. Effect of oestrin on gonad stimulating power of the hypophysis. Proceedings of the society for experimental biology and medicine 27:702-704. 1930.

94. Meyer, R. K. et al. The influence of oestrin on the gonad-stimulating complex of the anterior pituitary of castrated male and female rats. Endocrinology 16:655-665. 1932.

95. Moore, Carl R. and Dorothy Price. The question of sex hormone antagonism. Proceedings of the society for experimental biology and medicine 28:38-40. 1930.

96. Moore, Carl R. and Dorothy Price. Gonad hormone functions and the reciprocal influence between gonads and hypophysis with its bearing on the problem of sex hormone antagonism. American journal of anatomy 50:13-72. 1932.

97. Moore, Carl R. and Dorothy Price. Some effects of synthetically prepared male hormone (androsterone) in the rat. Endocrinology 21:313-329. 1937.

98. Moore, Carl R. and Dorothy Price. Some effects of testosterone and testosterone propionate in the rat. Anatomical record 71:59-78. 1938.

99. Morrell, J. A. and G. W. Hart. Studies on stilbestrol. 1. Some effects of continuous injections of stilbestrol in the adult female rat. Endocrinology 29:796-808. 1941.

100. Morrell, J. A. and G. W. Hart. Studies on stilbestrol. II. The effect of massive doses on normal immature female rats. Endocrinology 29:809-816. 1941.

101. Nalbandov, A. V. and G. J. Baum. The use of stilbestrol inhibited males as test animals for gonadotrophic hormones. Endocrinology 43:371-379. 1948.

102. Nathanson, I. T. and A. M. Brues. Effect of testosterone propionate upon the mitotic activity of the adrenals in the intact immature female rat. Endocrinology 29:397-401. 1941.

103. Nathanson, Ira T., A. M. Brues and R. W. Rawson. Effect of testosterone propionate upon thyroid and parathyroid glands of intact immature female rats. Proceedings of the society for experimental biology and medicine 43:737-740. 1940.

104. Nelson, Warren O. Gonad hormone effects in normal, spayed and hypophysectomized rats. Anatomical record 64:52. 1936.

105. O'Mary, C. et al. The effects of diethyl-stilbestrol, testosterone, and progesterone on growth and fattening and certain carcass characteristics of western lambs. Journal of animal science 11:656-673. 1952.

106. Overholser, Milton D. The effect of castration upon the size of the parathyroid glands and upon the susceptibility to tetania parathyropriva in the albino rat. Anatomical record 41:303-321. 1929.

107. Papanicalaou, George N. and Emil A. Falk. General muscular hypertrophy induced by androgenic hormone. Science 87:238-239. 1938.

108. Pearson, A. M. et al. The effects of stilbestrol implants on swine of different sexes. Journal of animal science 11: 251-260. 1952.

109. Perry, T. W., F. N. Andrews and W. M. Beeson. The effects of stilbestrol on suckling lambs. Journal of animal science 10:602-606. 1951.

110. Pope, A. L. et al. The effect of certain steroid hormones on the growth, fattening and carcass quality of heavy lambs. Journal of animal science 9:680. 1950.

111. Roberts, S. and Clara Szego. Steroid interaction in the metabolism of reproductive target organs. Physiological reviews 33(4):593-629. 1953.

112. Rubinstein, H. S. and A. A. Kurland. The effect of testosterone propionate on the rat testis. Endocrinology 28:495-505. 1941.

113. Rubinstein, H. S. and M. L. Solomon. Growth-stimulating effect of testosterone propionate. Proceedings of the society for experimental biology and medicine 44:442-443. 1940.

114. Rubinstein, H. S. and M. L. Solomon. The growth depressing effect of large doses of testosterone propionate in the castrate albino rat. Endocrinology 28:112-114. 1941.

115. Salmon, U. J. Gonadotropic effect of androgens upon the immature rat ovary. Proceedings of the society for experimental biology and medicine 38:352-353. 1938.

116. Sandberg, Marta, David Perla and Olive M. Holly. The effect of castration in albino rats on nitrogen, sulfur, chloride, sodium and potassium metabolism, and on changes in weight and food intake. Endocrinology 24:503-509. 1939.

117. Selye, Hans. Morphological changes in female mice receiving large doses of testosterone. Journal of endocrinology 1: 208-215. 1939.

118. Selye, Hans, and Sydney Friedman. The action of various steroid hormones on the testis. Endocrinology 28:129-140. 1941.

119. Selye, Hans, E. M. Rowley and C. E. Hall. Changes in the adrenals following prolonged treatment with methyl testosterone. Proceedings of the society for experimental biology and medicine 54:141-143. 1943.

120. Shay, Harry et al. Inhibition and stimulation of testes in rats treated with testosterone propionate. Endocrinology 28: 485-494. 1941.

121. Simonson, E., W. M. Kearns and N. Enzer. Effect of oral administration of methyl testosterone on fatigue in eunuchoids and castrates. Endocrinology 28:506-512. 1941.

122. Sleeth, R. B. et al. Effects of injection of testosterone, estradiol and a combination of the two upon growing-fattening swine. Journal of animal science 12:322-330. 1953.

123. Smith, Philip E. and Earl T. Engle. Experimental evidence regarding the role of the anterior pituitary in the development and regulation of the genital system. American journal of anatomy 40:159-217. 1927.

124. Snedecor, George W. Statistical methods. 4th ed. Ames, Iowa state college press, 1946. 485p.

125. Spencer, J., F. E. D'Amour and R. G. Gustavson. Effects of continued estrin injections on young rats. American journal of anatomy 50:129-137. 1932.

126. Spencer, J., F. E. D'Amour and R. G. Gustavson. Further studies on estrin-hypophyseal antagonism in the white rat. Endocrinology 16:647-654. 1932.

127. Spencer, J., R. G. Gustavson and F. E. D'Amour. Effect of estrin injections on the growth curve of young rats. Proceedings of the society for experimental biology and medicine 28: 500-501. 1931.

128. Turner, Henry H., Ernest Lachmann and Arthur A. Hellbaum. Effect of testosterone propionate on bone growth and skeletal maturation of normal and castrate male rats. Endocrinology 29:425-429. 1941.

129. U.S. dept. of agriculture. Composition of foods used in far eastern countries. Washington, U.S. gov't. P.O., March 1952. Agricultural handbook no. 34, bureau of human nutrition and home economics.

130. van Wagenen, G. Accelerated growth with sexual precocity in female monkeys receiving testosterone propionate. Endocrinology 45:544-546. 1949.

131. Wade, N. J. and E. A. Doisy. Effects of crystalline theelol and theelin and extracts of liquor folliculi on male rats. Proceedings of the society for experimental biology and medicine 28:714-715. 1931.

132. Wells, L. J. Effects of large doses of androgen on the testis in the ground squirrel, Citellus tridecemlineatus. Endocrinology 32:455-462. 1943.

133. West, Charles D., F. H. Tyler and H. Brown. The effect of intravenous testosterone on nitrogen and electrolyte metabolism. Journal of clinical endocrinology 11:833-842. 1951.

134. Whitehair, C. K., Willis D. Gallup and M. C. Bell. Effect of stilbestrol on ration digestibility and on calcium, phosphorus and nitrogen retention in lambs. Journal of animal science 12:331-337. 1953.

135. Wilkinson, W. S. et al. The influence of diethylstilbestrol on certain blood and liver constituents of lambs. Journal of animal science 13:684-693. 1954.

136. Wilson, W. King and S. Morris. Studies in the composition of rabbit carcasses. 1. White angoras. Journal of agricultural science 22:453-459. 1932.

137. Winton, Andrew L. and Kate B. Winton. The structure and composition of foods. Vol. III, New York, John Wiley and Sons, Inc., 1937. 524p.

138. Woehling, H. L. et al. Effects of stilbestrol and testosterone pellets implanted into growing-fattening pigs. Journal of animal science 10:889-892. 1951.

139. Wolfe, J. M. and J. B. Hamilton. Action of male sex hormones with and without estrin in the female rat. Proceedings of the society for experimental biology and medicine 37:189-193. 1937.

140. Wolfe, J. M. and J. B. Hamilton. Action of testosterone propionate on the structure of the anterior pituitary of the female rat with particular reference to the effects of the prolonged administration on the levels of cells. Endocrinology 25:572-584. 1939.

141. Ziegler, P. Thomas. The meat we eat. Danville, Illinois. The interstate printers and publishers, 1948. 497p.