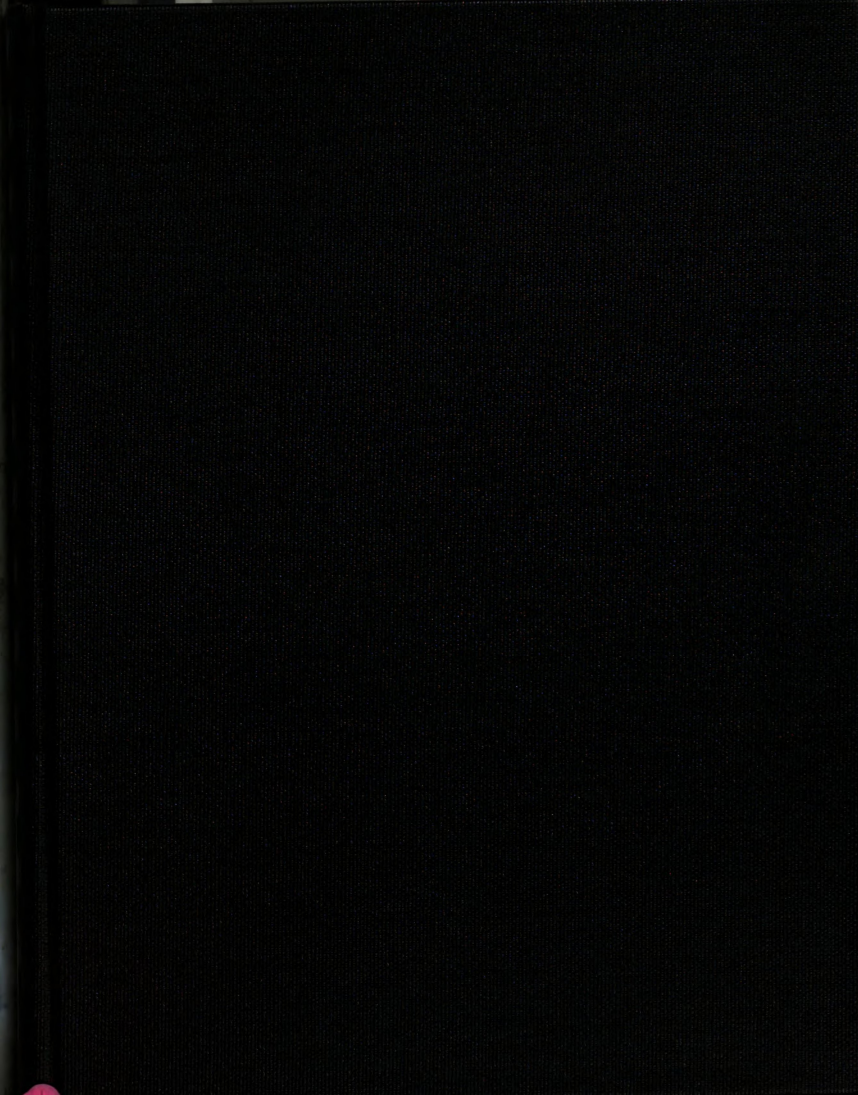






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THE EFFECTS OF OVARIECTOMY, GROWTH PROMOTANTS
AND PUBERTAL STATUS ON PERFORMANCE OF
GROWING AND FINISHING BEEF HEIFERS

presented by

David Glenn Main

has been accepted towards fulfillment
of the requirements for

MASTER OF SCIENCE degree in ANIMAL SCIENCE

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ABSTRACT

THE EFFECTS OF OVARIECTOMY, GROWTH PROMOTANTS
AND PUBERTAL STATUS ON PERFORMANCE OF
GROWING AND FINISHING BEEF HEIFERS

By

THE EFFECTS OF OVARIECTOMY, GROWTH PROMOTANTS AND
PUBERTAL STATUS ON PERFORMANCE OF GROWING AND
FINISHING BEEF HEIFERS

By

David Glenn Main

A THESIS

Submitted to

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in partial fulfillment of the requirements

MASTER OF SCIENCE

1990

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efficiency ($p < .05$) of all ABSTRACT. Ovariectomized heifers had low THE EFFECTS OF OVARIECTOMY, GROWTH PROMOTANTS AND PUBERTAL STATUS ON PERFORMANCE OF carcass fat ($p < .01$) GROWING AND FINISHING BEEF HEIFERS ($p < .005$) than intact heifers. Prepubertal By heifers gained more weight ($p < .01$) than pubertal David Glenn Main grazing. Pubertal status, ovariectomy and implant treatment were involved in many Ovariectomy of beef heifers has become a management tool of many producers and has reduced problems associated with handling and care of heifers in commercial feedyards. Benefits of ovariectomy can only be realized if performance and carcass quality of ovariectomized heifers are equal to intact heifers. Growth promoting implants and pubertal status of heifers may influence performance of ovariectomized heifers. Four hundred ten yearling crossbred heifers (256 kg) were utilized to evaluate the effects of ovariectomy, growth promotants and pubertal status on rate, efficiency and composition of gain and carcass characteristics. Heifers grazed northern Michigan pastures for approximately 120 d prior to being placed in the feedyard. Carcass characteristics measured at slaughter and carcass protein and fat analyses were performed.

An ovariectomy x implant interaction ($p < .05$) occurred for daily gains on pasture and in the feedlot; carcass weights; and ribeye areas. These results may be due to differences in dry matter intake of the heifers in the various treatment groups. Ovariectomized non-implanted heifers had the lowest weight gain and feed conversion

efficiency ($p < .05$) of all heifers. Ovariectomized heifers had lower dressing percentages ($p < .001$), gained less carcass fat ($p < .01$) and less carcass protein plus fat ($p < .005$) than intact heifers. Prepubertal heifers gained more weight ($p < .01$) than pubertal heifers while grazing. Pubertal status, ovariectomy and implant treatment were involved in many interactions with respect to feedlot performance, carcass characteristics and compositional gain. Dr. Harlan Ritchie, Dr. Ken Refsal and Dr. David Hawkins as their input proved valuable.

Second, I would like to thank those who provided physical and mental support throughout my master's program. Thank you Tom Forton and crew and Elaine Vink for helping process and analyze meat samples. I appreciated the help of the following graduate students: Frank Werdynski, David Lust, Steve Zinn and Aubrey Schneider. A special thank you goes out to Paul Nease, Doug Nielsen, Ron Graher, Ken Metz and their crews for help processing and weighing heifers.

Third, I would like to thank my family. Thank you Mom and Dad for constant support and faith in my abilities. It meant a lot to me. Most importantly, I thank my wife, best friend and typist, Lynn. I most assuredly would not have finished this program without her support and patience.

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First, I would like to thank Dr. Steven Rust for his guidance throughout my master's program. He truly had great patience with me and my completion of this degree. I would also like to thank the members of my committee; Dr. Harlan Ritchie, Dr. Ken Refsal and Dr. David Hawkins as their input proved valuable.

Second, I would like to thank those who provided physical and mental support throughout my master's program. Thank you Tom Forton and crew and Elaine Fink for helping process and analyze meat samples. I appreciated the help of the following graduate students: Frank Wardynski, David Lust, Steve Zinn and Aubrey Schroeder. A special thank you goes out to Paul Naasz, Doug Nielsen, Ron Graber, Ken Metz and their crews for help processing and weighing heifers.

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APPENDIX A - COLLATERAL STUDY I - TWO MANAGEMENT

SCHEMES FOR GROWING BEEF HEIFERS	95
SUMMARY	95
EXPERIMENTAL PROCEDURE	96
RESULTS AND DISCUSSION	98

APPENDIX B - COLLATERAL STUDY II - EFFECT OF PUBERTAL STATUS AND GROWTH PROMOTANTS ON PERFORMANCE OF OVARIECTOMIZED GROWING BEEF HEIFERS	105
SUMMARY	105
EXPERIMENTAL PROCEDURE	106
RESULTS AND DISCUSSION	107
	<u>Page</u>
LIST OF TABLES	vii
LIST OF FIGURES	x
CHAPTER I - INTRODUCTION	1
CHAPTER II - REVIEW OF LITERATURE	4
STEROID HORMONES	4
GONADAL STEROIDS	4
ADRENAL STEROIDS	11
PEPTIDE HORMONES	12
THYROID HORMONES	15
EFFECTS OF ANABOLIC STEROIDS	16
PUBERTAL STATUS OF HEIFERS	21
METHODS OF OVARIECTOMY	23
EFFECTS OF OVARIECTOMY	29
EFFECTS OF OVARIECTOMY ON THE ENDOCRINE SYSTEM	36
EFFECTS OF AUTOGRAFT	43
CHAPTER III - EFFECT OF OVARIECTOMY AND GROWTH PROMOTANTS ON GROWING AND FINISHING BEEF HEIFERS	50
SUMMARY	50
INTRODUCTION	51
EXPERIMENTAL PROCEDURE	52
RESULTS AND DISCUSSION	60
IMPLICATIONS	71
CHAPTER IV - EFFECT OF OVARIECTOMY AND PUBERTAL STATUS ON GROWING AND FINISHING BEEF HEIFERS ...	72
SUMMARY	72
INTRODUCTION	73
EXPERIMENTAL PROCEDURE	75
RESULTS AND DISCUSSION	83
CONCLUSIONS	91
CHAPTER V - RECOMMENDATIONS	93
APPENDIX A - COLLATERAL STUDY I - TWO MANAGEMENT SCHEMES FOR GROWING BEEF HEIFERS	95
SUMMARY	95
EXPERIMENTAL PROCEDURE	96
RESULTS AND DISCUSSION	98

APPENDIX B - COLLATERAL STUDY II - EFFECT OF PUBERTAL STATUS AND GROWTH PROMOTANTS ON PERFORMANCE OF OVARIECTOMIZED GROWING BEEF HEIFERS	105
SUMMARY	105
EXPERIMENTAL PROCEDURE	106
RESULTS AND DISCUSSION	107
TABLE 1. RELATIVE ACTIVITY OF SYNTHETIC LIST OF REFERENCES	115
TABLE 2. EFFECTS OF OVARIECTOMY ON WEIGHT GAINS OF GRAZING HEIFERS	30
TABLE 3. EFFECTS OF OVARIECTOMY ON WEIGHT GAINS OF HEIFERS WITHOUT AN EXOGENOUS SOURCE OF HORMONE AND FED IN CONFINEMENT	32
TABLE 4. EFFECTS OF OVARIECTOMY ON WEIGHT GAINS OF HEIFERS GIVEN AN EXOGENOUS SOURCE OF HORMONES AND FED IN CONFINEMENT	33
TABLE 5. EFFECTS OF OVARIECTOMY ON DAILY FEED INTAKE AND FEED CONVERSIONS OF HEIFERS FED IN CONFINEMENT	35
TABLE 6. EFFECTS OF OVARIECTOMY ON CARCASS CHARACTERISTICS OF GROWING-FINISHING HEIFERS	37
TABLE 7. PITUITARY AND BLOOD PLASMA LEVELS OF SHAM OPERATED AND OVARIECTOMIZED HOLSTEIN HEIFERS	41
TABLE 8. SUMMARY OF BLOOD CONSTITUENTS OF INTACT AND OVARIECTOMIZED BEEF HEIFERS	42
TABLE 9. COMPARISON OF DAILY WEIGHT GAINS OF AUTOGRAFTED AND OVARIECTOMIZED HEIFERS ON PASTURE	44
TABLE 10. SUMMARY OF FEEDLOT PERFORMANCE IN AUTOGRAFTED AND OVARIECTOMIZED HEIFERS	45
TABLE 11. COMPARISON OF CARCASS CHARACTERISTICS OF AUTOGRAFTED AND OVARIECTOMIZED HEIFERS	47
TABLE 12. LEVEL OF ESTRADIOL AND TESTOSTERONE IN SERUM OF OVARIECTOMIZED AND AUTOGRAFTED HEIFERS	49

TABLE 13. EXPERIMENTAL FINISHING DIET	56
TABLE 14. THE EFFECTS OF OVARIECTOMY AND GROWTH PROMOTANTS ON GRAZING PERFORMANCE OF CROSSBRED LIST OF TABLES	61
	<u>Page</u>
TABLE 15. THE EFFECTS OF OVARIECTOMY ON CARCASS TABLE 1. RELATIVE ACTIVITY OF SYNTHETIC ESTROGENS	73
TABLE 2. EFFECTS OF OVARIECTOMY ON WEIGHT GAINS OF GRAZING HEIFERS	30
TABLE 3. EFFECTS OF OVARIECTOMY ON WEIGHT GAINS OF HEIFERS WITHOUT AN EXOGENOUS TABLE 17. SOURCE OF HORMONE AND FED IN GROWTH CONFINEMENT	32
TABLE 4. EFFECTS OF OVARIECTOMY ON WEIGHT GAINS OF HEIFERS GIVEN AN EXOGENOUS TABLE 18. SOURCE OF HORMONES AND FED IN CONFINEMENT	33
TABLE 5. EFFECTS OF OVARIECTOMY ON DAILY FEED INTAKE AND FEED CONVERSIONS OF HEIFERS FED IN CONFINEMENT	35
TABLE 6. EFFECTS OF OVARIECTOMY ON CARCASS CHARACTERISTICS OF GROWING-FINISHING TABLE 21. HEIFERS	37
TABLE 7. PITUITARY AND BLOOD PLASMA LEVELS OF SHAM OPERATED AND OVARIECTOMIZED HOLSTEIN HEIFERS	41
TABLE 8. SUMMARY OF BLOOD CONSTITUENTS OF INTACT AND OVARIECTOMIZED BEEF HEIFERS	42
TABLE 9. COMPARISON OF DAILY WEIGHT GAINS OF AUTOGRAFTED AND OVARIECTOMIZED TABLE 23. HEIFERS ON PASTURE	44
TABLE 10. SUMMARY OF FEEDLOT PERFORMANCE IN AUTOGRAFTED AND OVARIECTOMIZED HEIFERS	45
TABLE 11. COMPARISON OF CARCASS CHARACTERISTICS OF AUTOGRAFTED AND OVARIECTOMIZED HEIFERS	47
TABLE 12. LEVEL OF ESTRADIOL AND TESTOSTERONE IN SERUM OF OVARIECTOMIZED AND AUTOGRAFTED HEIFERS	49

TABLE 13. EXPERIMENTAL FINISHING DIET	56
TABLE 14. THE EFFECTS OF OVARIECTOMY AND GROWTH PROMOTANTS ON GRAZING PERFORMANCE OF CROSSBRED HEIFERS	61
TABLE 15. THE EFFECTS OF OVARIECTOMY ON CARCASS COMPOSITION OF GAIN IN CROSSBRED HEIFERS ON PASTURE	63
TABLE 16. THE EFFECTS OF OVARIECTOMY AND GROWTH PROMOTANTS ON FEEDLOT PERFORMANCE OF CROSSBRED HEIFERS: INTERMEDIATE WEIGH PERIODS	64
TABLE 17. THE EFFECTS OF OVARIECTOMY AND GROWTH PROMOTANTS ON FEEDLOT PERFORMANCE OF CROSSBRED HEIFERS: OVERALL	65
TABLE 18. THE EFFECTS OF OVARIECTOMY AND GROWTH PROMOTANTS ON CARCASS CHARACTERISTICS OF CROSSBRED HEIFERS	68
TABLE 19. THE EFFECTS OF OVARIECTOMY ON GROWTH PROMOTANTS ON CARCASS COMPOSITION OF GAIN IN CROSSBRED HEIFERS	70
TABLE 20. EXPERIMENTAL FINISHING DIET	80
TABLE 21. THE EFFECTS OF PUBERTAL STATUS, OVARIECTOMY AND GROWTH PROMOTANTS ON GRAZING PERFORMANCE OF CROSSBRED HEIFERS	84
TABLE 22. THE EFFECTS OF PUBERTAL STATUS, OVARIECTOMY AND GROWTH PROMOTANTS ON FEEDLOT PERFORMANCE OF CROSSBRED HEIFERS: TOTAL WEIGH PERIOD	86
TABLE 23. THE EFFECTS OF PUBERTAL STATUS, OVARIECTOMY AND GROWTH PROMOTANTS ON FEEDLOT PERFORMANCE OF CROSSBRED HEIFERS: INTERMEDIATE WEIGH PERIODS	87
TABLE 24. THE EFFECTS OF PUBERTAL STATUS, OVARIECTOMY AND GROWTH PROMOTANTS ON CARCASS CHARACTERISTICS OF CROSSBRED HEIFERS	89

TABLE 25. THE EFFECTS OF PUBERTAL STATUS, OVARIECTOMY AND GROWTH PROMOTANTS ON CARCASS COMPOSITION AND COMPOSITION OF GAIN IN CROSSBRED HEIFERS	90
TABLE 26. EXPERIMENTAL FINISHING DIET	97
TABLE 27. EXPERIMENTAL GROWING DIETS FED TO INITIAL FEEDLOT HEIFERS	99
TABLE 28. THE EFFECT OF MANAGEMENT SYSTEM ON FEEDLOT PERFORMANCE OF CROSSBRED HEIFERS	100
TABLE 29. THE EFFECT OF MANAGEMENT SYSTEM ON CARCASS MEASUREMENTS OF CROSSBRED HEIFERS	102
TABLE 30. THE EFFECT OF MANAGEMENT SYSTEM ON CARCASS COMPOSITION AND COMPOSITIONAL GAIN IN CROSSBRED HEIFERS	103
TABLE 31. THE EFFECT OF PUBERTAL STATUS ON GRAZING PERFORMANCE OF OVARIECTOMIZED CROSSBRED HEIFERS	108
TABLE 32. THE EFFECTS OF PUBERTAL STATUS AND GROWTH PROMOTANTS ON FEEDLOT PERFORMANCE OF OVARIECTOMIZED CROSSBRED HEIFERS	109
TABLE 33. THE EFFECTS OF PUBERTAL STATUS AND GROWTH PROMOTANTS ON CARCASS CHARACTERISTICS IN OVARIECTOMIZED CROSSBRED HEIFERS	111
TABLE 34. THE EFFECTS OF PUBERTAL STATUS AND GROWTH PROMOTANTS ON CARCASS COMPOSITION AND COMPOSITION OF GAIN IN OVARIECTOMIZED CROSSBRED HEIFERS ..	112

CHAPTER I

LIST OF FIGURES

Traditionally, beef producers have been concerned	Page
FIGURE 1. FORMULA USED TO CALCULATE SOFT and sold every year TISSUE ACCRETION RATES	59
FIGURE 2. SERUM PROGESTERONE LEVELS IN CROSSBRED HEIFERS INDICATING PUBERTAL ACTIVITY	77
FIGURE 3. SERUM PROGESTERONE LEVELS IN CROSSBRED HEIFERS INDICATING LACK OF PUBERTAL ACTIVITY	78
FIGURE 4. SERUM PROGESTERONE LEVELS IN CROSSBRED HEIFERS WITH QUESTIONABLE PUBERTAL ACTIVITY	79

priced \$4-7 per hundred weight less than steers, which has stimulated the feeding of heifers to the choice quality grade. However, approximately 10-20% of heifers entering a feedlot are pregnant which causes severe financial and management problems.

Heifers which are guaranteed non-pregnant are worth more to feedlot operators. In addition, cattle slaughter plants typically pay less for heifers on a live weight basis because of the high incidence of pregnancy. Ovariectomized heifers can be grazed with the breeding herd and guaranteed non-pregnant upon entry into feedlots. Benefit of ovariectomy can only be realized if performance and carcass quality of ovariectomized heifers are equal to intact heifers.

Ovariectomized (OVX) beef heifers do not gain as well as intact heifers while grazing (Kercher et al., 1969).

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Differences in performance are recovered when OVX heifers are implanted with growth hormone. (Grotelueschen et al., 1988; Johns et al., 1988).

CHAPTER I. INTRODUCTION

Traditionally, beef producers have been concerned with total numbers of cattle being produced and sold every year with little regard to input costs. However, much like the automobile industry, which sacrificed power and durability for fuel economy when fuel costs increased rapidly in the early seventies, cattle producers became concerned with minimization of beef production costs in all segments of the industry. Over the past several years, heifers have been priced \$4-7 per hundred weight less than steers, which has stimulated the feeding of heifers to the choice quality grade. However, approximately 10-20% of heifers entering a feedlot are pregnant which causes severe financial and management problems. (Cory and Wade, 1981).

Ovariectomy in beef heifers

Heifers which are guaranteed non-pregnant are worth more to feedlot operators. In addition, cattle slaughter plants typically pay less for heifers on a live weight basis because of the high incidence of pregnancy. Ovariectomized heifers can be grazed with the breeding herd and guaranteed non-pregnant upon entry into feedlots. Benefit of ovariectomy can only be realized if performance and carcass quality of ovariectomized heifers are equal to intact heifers. (pubertal heifers (Sears et al., 1975)).

Now Ovariectomized (OVX) beef heifers do not gain as well as intact heifers while grazing (Kercher et al., 1960).

Differences in performance are recovered when OVX heifers are implanted with growth promotants (Grotelueschen et al., 1988; Johns et al., 1988). Consequently, OVX heifers with a growth promotant perform similarly to intact heifers while grazing. Results of feedlot studies are similar to grazing studies. When no implant is utilized, OVX heifers gain less than intact heifers (Dinusson et al., 1950; Ray et al., 1969; Lunt et al., 1986); however, when OVX heifers are implanted, gains are similar to intact heifers (Lunt et al., 1986; Grotelueschen et al., 1988). Similar results are obtained with dry matter intakes and feed conversion efficiencies.

Though differences in carcass traits are shown between OVX and intact females of other species (Wade, 1975; Wade and Gray, 1979; McElroy and Wade, 1987), ovariectomy in beef heifers has shown much smaller differences in carcass characteristics. Carcass lean and fat measurements are similar between OVX and intact heifers fed to different endpoints (Saul et al., 1983; Hamernik et al., 1985; Lunt et al., 1986).

Plasma levels of steroid sex hormones change as animals reach sexual maturity. Plasma levels of estrogens, androgens and progesterone are higher in pubertal heifers than prepubertal heifers (Gonzalez-Padilla et al., 1975). How heifers are affected by ovariectomy and growth

promotants may be influenced by the pubertal status of the individuals at the time of ovariectomy.

An experiment was designed to examine the main effect of ovariectomy on grazing and feedlot performance, carcass characteristics and compositional carcass gains of yearling crossbred beef heifers. The design examined interactions of ovariectomy with implants and stage of maturity at the time of ovariectomy on the same variables.

Estrogens, produced chiefly by the ovaries, function in female mammals as sex characterizing hormones and to stimulate secondary sex glands. Estrogens have an important role in the growth performance of females and males across many species. Other sources of natural occurring estrogens are produced and released from the adrenal cortex and placental membranes. Estrogens are also produced in the interstitial cells of the testes.

Estrogens produced by the follicles of the ovary, estrone, estradiol (17 β and 17 α) and estriol, represent the three major naturally occurring estrogens. Estradiol 17 β is considered the major and most active form of estrogen (Callow, 1955).

All estrogens contain an aromatic A ring and are synthesized from C-19 steroids. In most species, estradiol and estrone are interconvertible with equilibrium toward estrone. This reaction is catalyzed by a 17 β -hydroxysteroid dehydrogenase in the presence of NAD or NADP. Estrinol is a weakly active estrogen and estrone is the most active.

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an endproduct of estrogen metabolism in humans, dogs and rats.

CHAPTER II

REVIEW OF LITERATURE

Transport and Metabolism

Normal ovaries produce STEROID HORMONES. Producing small amounts of estradiol and estrone. GONADAL STEROIDS are synthesized and released into the plasma. Estrogens 85% is bound to albumin.

Description is free circulating. About half of the circulating Estrogens, produced chiefly by the ovaries, function in female mammals as sex characterizing hormones, and to stimulate secondary sex glands. Estrogens have an important role in the growth performance of females and males across many species. Other sources of naturally occurring estrogens are produced and released from the adrenal cortex and placental membranes. Estrogens are also produced in the interstitial cells of the testes. glucuronic acid. Certain target Estrogens produced by the follicles of the ovary, estrone, estradiol (17β and 17α) and estriol, represent the three major naturally occurring estrogens. Estradiol 17β is considered the major and most active form of estrogen (Callow, 1955).

All estrogens contain an aromatic A ring and are synthesized from C-19 steroids. In most species, estradiol and estrone are interconvertible with equilibrium toward estrone. This reaction is catalyzed by a 17β -hydroxysteroid dehydrogenase in the presence of NAD or NADP. Estriol is uterine contractions and assist during labor.

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an endproduct of estrogen metabolism in humans, dogs and rats. Location of bones (Vaughn, 1975). It has also been shown that estrogens increase weight gains and feed

Transport and Metabolism

Normal ovaries are continually producing small amounts of estradiol and estrone. Estrogens are synthesized and released into the plasma, where 50-65% is bound to albumin and 35-50% is free (circulating). About half of the circulating estrogens pass into the enterohepatic circulation. The remainder goes through the kidneys and is excreted via the urine. Metabolism and turnover of estrogens are very rapid, and is most responsible for perils. Although the kidneys, intestines and blood are responsible for some estrogen metabolism, the liver performs most of the transformations. One of these transformations is a conjugation with sulfuric or glucuronic acid. Certain target tissues are capable of using conjugated forms, but some must be further metabolized at tissue levels in order to be used. more sensitive to certain types of estrogens over others.

Sites of Action

Estrogens are responsible for physical and psychological characteristics of estrus or heat. Estrogens stimulate growth of epithelial ducts of the endometrium, vaginal epithelium, and mammary ductal tissue. Estrogens can moderate levels of oxytocin and prostaglandins during uterine contractions and assist during egg implantation. It

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has been found that estrogens stimulate calcium uptake and ossification of bones (Vaughn, 1975). It has also been shown that estrogens increase weight gains and feed efficiencies during exogenous administration of natural or synthetic estrogens in ruminants. Table 1 shows 3 synthetic estrogens and their relative reactivities in skeletal muscle growth response in rats (Dodds, 1955). Stilbesterol treated steers have elevated fasting metabolic rates and increased efficiency of utilization of metabolizable energy for tissue synthesis (Tyrell et al., 1975).

Even though estradiol is present in largest concentration in serum and is most responsible for peripubertal growth responses, other estrogen compounds may be more reactive at specific sites. Emmens (1955) showed effective doses (ED_{50}) for cornification of vaginal cells in rats was lowest for estrone, intermediate for estradiol and highest for estriol; however, estriol had the lowest ED_{50} for uterine cell growth. This suggests that different tissues are more sensitive to certain forms of estrogens over others.

Progesterone

Description

Progesterone along with two other naturally occurring progestogens 20 β -hydroxy-4-pregnen-3-one and 20 α -hydroxy-4-

TABLE 1. RELATIVE ACTIVITY OF SYNTHETIC ESTROGENS.*

Estrogen	Relative Reactivity
Stilbesterol	100%
Dienoestrol	90%
Hexoestrol	10%

* Taken from Dodds (1955)

Transport and Metabolism

In the corpus luteum, progesterone, a 21 carbon compound, is synthesized from 5^β-pregnen-3^β-ol-20-one (pregnenolone), which is formed after splitting stored fatty esters of 20, 22-di-hydroxycholesterol and fusion with isocaproic acid. Pregnenolone is oxidized to 5^β-3-ketosteroid (progesterone) by the enzyme 5^β-3^β-hydroxy-steroid dehydrogenase. Progesterone is a key intermediate in the biosynthesis of steroids with twenty-one or fewer carbon atoms. There is a limited conversion of progesterone to estrogens in the corpus luteum. However, some progesterone is hydroxylated in the 17^α position. The resultant 17^α-hydroxy-progesterone is converted to 4-androstenedione by a desmolase enzyme. Androstenedione may then be converted to estrogens or other androgens.

The small amount of progesterone found in the blood is bound to albumin, corticosteroid-binding globulin, and

pregnene-3-one are produced mainly from the corpus luteum and in small quantities from the placenta and adrenal cortex. Progesterone acts primarily on tissue that estrogen has already prepared, but some functions are simultaneous and synergistic with estrogen. Large quantities of either hormone may cause antagonistic effects. For example, progesterone in relatively large amounts (during pregnancy) inhibits uterine contractions while estrogen acts indirectly to stimulate contractions. adrenal cortex

Transport and Metabolism

In the corpus luteum, progesterone, a 21 carbon compound, is synthesized from δ^5 -pregnen-3B-ol-20-one (pregnenolone), which is formed after splitting stored fatty esters of 20, 22-di-hydroxycholesterol and fusion with isocaproic acid. Pregnenolone is oxidized to δ^4 -3-ketosteroidone (progesterone) by the enzyme δ^5 -3B-hydroxy-steroid dehydrogenase. Progesterone is a key intermediate in the biosynthesis of steroids with twenty-one or fewer carbon atoms. There is a limited conversion of progesterone to estrogens in the corpus luteum. However, some progesterone is hydroxylated in the 17 α position. The resultant 17 α -hydroxy-progesterone is converted to 4-androstenedione by a desmolase enzyme. Androstenedione may then be converted to estrogens or other androgens. The small amount of progesterone found in the blood is bound to albumin, corticosteroid-binding globulin and

α_1 -acid glycoprotein. The liver, kidneys, placenta, mammary gland and adrenal cortex further metabolize progesterone into useful compounds for each respective tissue or other target tissues. Progesterone metabolites (pregnanediol and pregnanetriol) are mainly excreted through the urine, but some are found in bile and feces. The metabolite levels in the urine are somewhat helpful in determining progesterone synthesis, but the metabolites may also be derived from deoxycorticosterone of the adrenal cortex.

Testosterone

Sites of Action, a C-19 steroid hormone, helps develop and maintain. Progesterone controls many functions related to pregnancy. It prepares the uterus for implantation of the egg. Once conception occurs, the corpus luteum persists and progesterone along with estrogen feedback to the anterior pituitary to slow the production of follicle stimulating and luteinizing hormones to prevent ovulation. with high test. Other functions of progesterone include stimulating alveolar mammary development and vaginal mucification, increasing basal temperature and decreasing motility within the fallopian tubes. Physiological doses of progesterone tend to increase excretion of sodium, whereas large doses cause sodium retention. It has been hypothesized that excessive levels are converted to deoxycorticosterone which acts as an anti-diuretic. It has also been shown that progesterone increases urea and total nitrogen excretion by stimulating protein catabolism (Leatham, 1964). Elevated

protein catabolism is most likely due to the increased metabolic rate associated with higher progesterone levels. At physiological levels, progesterone has not been implicated in having any direct effect on growth of bone, skeletal muscle or fat tissues (Berende and Ruitenburg, 1983). However, at pharmacological doses, progesterone and synthetic progestins have helped increase growth rates and feed efficiencies of growing heifers and steers.

Glucocorticoids

Glucocorticoids and Testosterone are produced by the adrenals. Testosterone, a C-19 steroid hormone, helps develop and maintain anatomic features unique to the intact male of a species. The interstitial or Leydig cells of the testes produce the androgens along with some estrogens. Other sources of androgens include the adrenal cortex and ovaries. In males, testosterone influences bone growth and lean tissue growth. Intact pubertal males, with high testosterone levels, cease bone growth at an earlier age than males with lower levels (Vaughn, 1975). Testosterone quickens the closure of the epiphyseal plates. Administration of pharmacological doses of testosterone in humans increased basal levels of growth hormone and somatomedins in peripubertal males (Penny and Blizzard, 1972). Increased ACTH secretion is also a normal response. Testosterone, at normal levels, has little effect on basal metabolism of females. However, abnormally high levels of testosterone, due to ovarian or adrenal

dysfunction, may stimulate growth characteristics of male counterparts. This can also be accomplished by administering exogenous forms of testosterone, in the way of anabolic growth-promoting implants (Heitzman and Chan, 1974). Masculinization may result from high levels of testosterone in heifers.

ADRENAL STEROIDS

Glucocorticoids are steroid hormones produced by the adrenal cortex. Cortisol (hydrocortisone) is the major glucocorticoid secreted and is the most biologically active in cattle. These hormones are responsible for moderation of many aspects of metabolism. Major glucocorticoid effects on intermediary metabolism (Munch, 1971) include decreased glucose uptake by most tissues, increased gluconeogenesis in the liver and increased protein catabolism in most tissues. Munch (1971) also reported high levels of cortisol have been associated with increased lipolysis.

Glucocorticoids are released by stimulus from adrenocorticotrophic hormone (ACTH). The release pattern of ACTH from the anterior pituitary is diurnal. Levels are higher in the morning just after sleep than during the daylight hours. Increased ACTH secretion is also a normal response to physical and psychological stress. Glucocorticoid production and action are inhibited by testosterone. Corticosterone synthesis in the adrenal

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cortex (Colby et al., 1972), ACTH secretion by the pituitary (Coyne et al., 1971) and glucocorticoid binding to receptors in muscle (Mayer and Rosen, 1975) are inhibited by testosterone. (1966; Franchimont, 1971). This suggests that GH has a general slowing of growth and maturation has been associated with high cortisol or corticosterone levels in immature rats (Munch, 1971). Higher blood levels of glucocorticoids have yielded lower weight gains in cattle (Trenkle and Topel, 1978). Cortisol is catabolic in skeletal muscle (Tomas et al., 1979) and has been positively correlated with fat thickness (Trenkle and Topel, 1978). Abnormally high levels of glucocorticoids have also been associated with decreased bone formation and increased bone resorption, a second substance, somatomedin, released from the liver (Vaughn, 1975).

PEPTIDE HORMONES

GROWTH HORMONE

Growth hormone (GH), which is secreted by somatotrophic cells of the anterior pituitary gland, is made up of 191 amino acid residues on a single peptide chain. Growth hormone releasing factor (GHRF) stimulates somatotrophs of the pituitary gland to secrete GH. Electrical stimulation of the hypothalamus causes secretion of growth hormone releasing factor. Somatostatin opposes GHRF and inhibits the release of growth hormone. Biogenic amines, sleep, prostaglandins and GH blood levels also have an influence on the release of growth hormone.

Insulin-induced hypoglycemia, elevated dietary protein, certain amino acids and increases in blood non-essential fatty acid levels influence the secretory levels of GH (Knopf et al., 1966; Franchimont, 1971). This suggests that GH has important roles in carbohydrate, protein and fat metabolism. Many of growth hormone effects are not direct, but mediated through and influenced by other hormones. Somatomedins and insulin assist GH in the utilization of nitrogen, while estrogens increase growth hormone through increased cell energy demands. Concentrations fall, allowing

Lack of growth hormone before sexual maturity leads to reduced bone growth, while an oversupply can lead to acromegaly. Growth hormone effects on bone growth are mediated by a second substance, somatomedin, released from the liver (Vaughn, 1975). hormone is presumed to be mediated by polypeptides synthesized mainly by the liver, and non-covalently bound to INSULIN proteins found in plasma

Insulin is secreted by the islets of Langerhans of the pancreas. It is made up of 51 amino acids and two chains linked by two disulfide bridges of cystine. One chain, the A-chain, is composed of 21 amino acid residues and the other, B-chain, is made of 30 residues.

Insulin is necessary for optimum growth. It is responsible for tissue uptake of glucose. Without such uptake, glucose is not utilized and is excreted from the body. Insulin is also partially responsible for maintaining fat stores in adipose tissue.

Insulin stimulates protein synthesis in both the liver and muscle (Leatham, 1964), although in the liver there is greater synthesis of export proteins (albumin and somatomedins) than intracellular proteins. Cheek et al. (1975) showed insulin increases body cell size and cell protein to DNA ratios more than numbers of cells. Insulin appears to be the major anabolic hormone of the fed state, where it decreases muscle proteolysis and promotes amino acid flux from the liver to muscle (Phillips, 1981). In the fasted state, insulin concentrations fall, allowing proteolysis and lipolysis to produce replacement metabolic fuels for glucose (Cahill et al., 1972). Higher levels

of SMS have been correlated with fast growing (Suffolk-cross) as compared to SOMATOMEDINS or growing (Finn-cross)

The action of growth hormone is presumed to be mediated by polypeptides synthesized mainly by the liver, and non-covalently bound to carrier proteins found in plasma (Daughaday et al., 1972). These peptides are termed somatomedins (SMS) or insulin-like growth factors (IGFs). Several different types: SMA, SMB, SMC, IGFI and IGFII, have been identified, however for this discussion, all of the types will be referred to as somatomedins. There are differences and similarities in receptors and actions of each. They are formed originally from tyrosine, which is

Chemically, somatomedins are very similar to insulin, but have somewhat different functions. Much of the evidence today supports the idea that somatomedins function in

concert with GH. For example, both are involved in cell division, of cartilage growth and protein synthesis. Somatomedins have been shown to aid in the incorporation of amino acids into protein of fibroblasts and rat diaphragm, transportation of glucose into muscle, conversion of glucose into glycogen, transportation of glucose into adipocytes and incorporation of glucose into lipids (Zapf et al., 1978; Zapf et al., 1981). It is believed that deficiencies cause retarded growth rates of farm animals, has been equated with levels of somatomedins in the blood. High levels of SMS activity have been reported in the fast growing pigs (Lund-Larsen and Bakke, 1975). In addition, higher levels of SMS have been correlated with fast growing (Suffolk-cross) as compared to slower growing (Finn-cross) lambs (Wangsness et al., 1981). electrolytes. In addition, many clinical malfunctions involving the nervous and circulatory systems.

THYROID HORMONES

Thyroid hormones are unique, because each structure contains at least one inorganic ion. Thyroxine (T_4) a tetraiodinated thyronine and triiodothyronine (T_3), a triiodinated thyronine are hormones produced in the thyroid gland. Thyroxine is most metabolically active. Thyroxine and T_3 are formed originally from tyrosine, which is metabolized to thyronine and then iodinated. Thyroxine is deiodinated to T_3 by peripheral tissue. The hypothalamus signals the release of thyrotropic-releasing factor (TRF)

from the anterior pituitary which in turn signals the release of T_4 and T_3 . Both are bound to either thyroxine-binding globulin, thyroxine-binding prealbumin, or albumin (Spencer, 1983). Recent demonstration of high affinity. Many of the functions of thyroid hormones are involved or required for cellular responses to other hormones. Functions have been determined in states where thyroid hormone production is halted. Deficiencies cause retardation of long bone growth, degeneration of epiphyseal cartilage, degenerated hair and fingernail growth and disturbances of pigmentation in the skin. Metabolic dysfunctions due to lack of T_4 and T_3 have included overall decreased oxygen consumption, general slowing of metabolism, decreased deposition of protein and fat in all tissues and disturbances of body water and electrolytes. In addition, many clinical malfunctions involving the nervous and circulatory systems have been reported. One of the common

xenobiotic steroid hormones are zeranol, diethylstilbestrol (DES), and trans-**EFFECTS OF ANABOLIC STEROIDS**

The simplest and most accurate method of delivering a Manipulation animal is orally. For several years, diethyl. It is possible to manipulate normal growth in meat animals by administration of sex steroid hormones. Androgens and estrogens are most commonly used for this purpose. Androgens will increase growth rate by binding to specific muscle receptors and increasing protein deposition. Estrogens also increase growth rates and feed efficiency in

ruminants. Mechanism of action of estrogens is not clear, however, increased growth hormone secretion, and increased thyroid activity or direct effects on muscle have been implicated (Spencer, 1985). Recent demonstration of high affinity of receptors in muscles for estradiol supports the concept of a direct effect at the tissue level (Meyer and Rapp, 1985). It is coated with micronized crystals of the steroid. There are two general types of hormones that can be given to animals to stimulate growth: endogenous hormones and xenobiotics. The natural endogenous hormones most commonly given to farm animals for increased performance are estradiol-17 β , testosterone, and progesterone. Estradiol benzoate and testosterone propionate are two ester forms of endogenous steroid hormones used in growth-promoting implants.

Xenobiotics include hormones produced by other animals, plants, or synthesized hormones. Three of the common xenobiotic steroid hormones are zeranol, diethylstilbesterol (DES), and trenbolone acetate. Androgen receptors have been identified in muscle tissue. The simplest and most accurate method of delivering a drug to an animal is orally. For several years, diethylstilbesterol was fed to cattle in confinement. However, oral dosage of estrogenic compounds required large amounts of the drug, whereas parenteral implants delivered active dosage at very small levels. DES can no longer be fed or administered to cattle. Steroid binding proteins and coagulation factors (Dube et al., 1978). Naturally

Currently, implants are produced in two general forms. One is a compressed tablet implant placed subcutaneously in the ear. These implants deliver efficacious dosages of steroid over periods of 60 to 120 d. This assumes that the implants will degrade and emit the most useful dosage of compound. The second type of implant is a solid silicone cylinder that is coated with micronized crystals of the steroid compound. Length of efficacy can vary with the dosage required and release rate.

Sex steroid hormones are circulating in the blood bound to a specific protein. Plasma sex hormone binding protein facilitates the entry of the hormone into its target cell. Inside the cell, hormone and receptor form a complex that triggers a chemical reaction and causes further cell metabolism.

Androgens have target cells in many organs and tissues including muscle. Testosterone acts directly on cells; however, in some tissue, it must be converted to another metabolite in order to be active. Androgen receptors have been found in muscle (Jung and Baulieu, 1972) and are linked directly with muscle protein synthesis (Powers and Florini, 1975).

Estrogens The precise mechanism of estrogens is not well understood. Administration to farm animals causes an anabolic effect. Protein synthesis is stimulated as indicated by increases in sex steroid binding protein and coagulation factors (Dube et al., 1976). Naturally

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occurring estrogens have an affinity for androgen receptors; however, synthetic hormones act indirectly through other receptors. This may explain the additive anabolic effects between estrogens and androgens given simultaneously (Heitzman, 1976).

Progesterones also have anabolic properties. Mechanisms of action are not well documented. However, progesterone may interact with androgen receptors and stimulate the synthesis of metabolically active proteins. Kreig (1976) showed that a derivative of progesterone (nortestosterone) is bound to the androgen receptor.

Exogenous estrogens stimulate improved weight gains and nitrogen balance in male beef and veal calves (Patton and Ralston, 1968; Martin and Stob, 1978). Other experiments have evaluated combinations of estrogens with testosterone, progesterone and trenbolone acetate. These combinations gave pronounced growth effects as confirmed by Grandadam et al. (1975) and Gropp et al. (1976). A combination of trenbolone and hexestrol (another estrogenic hormone) was found to increase weight gain (Galbraith, 1982). Ruitenburg, 1983. Anabolic hormones are not usually used in older intact male cattle, because of the presence of natural hormones. However, studies have demonstrated that zeranol is effective in bulls of different ages (Brown, 1983).

Most work with anabolic steroids has been done with steers. Preston and Willis (1974) report 12-18% improvement of gains with steers given a stilbesterol implant. Zeranol

given concurrently with DES, increased N₂ retention which would suggest enhanced protein synthesis (Berende et al., 1973). Some experiments performed with the androgen, trenbolone showed performance gains of 15-24% (Roche and Davis, 1978) which animals become capable of reproducing.

Results from DES administration in heifers has been inconsistent (Ralston et al., 1968; Utley and McCormick, 1974). Preston and Willis (1962) reported increased weight gains between 0 to 50% as compared to controls. Androgens have improved weight gains of heifers by 40% (Heitzman, 1974). Positive results have been reported with the use of the combination of diethylstilbestrol and the androgen (estradiol/testosterone) in heifers (Ralston, 1968; Ray et al., 1969; Szumowski and Grandadam, 1976).

Changes associated with metabolism are also reflected in carcass quality (van Weerden et al., 1981; Berende and Ruitenburt, 1983). Markedly decreased fat deposition has been reported in bulls and steers with the addition of growth promotants. Weight of kidney, heart and pelvic fat was much lower in treated animals (Berende and Ruitenburt, 1983). Anabolic steroid hormones appear to delay maturity which lengthens the time for lean tissue growth, however lean tissue growth rate is increased.

Blood progesterone level.

During the prepubertal period, progesterone levels are low before pubertal estrus. Progesterone levels in heifers remain low. Levels range from 0.1 to 0.5 ng/ml.

time draws near PUBERTAL STATUS OF HEIFERS. progesterone levels become erratic. A rise and decline sequence is

Definition many times (Gonzalez-Padilla et al., 1975).

Puberty can be defined as the condition of being or period at which animals become capable of reproducing sexually. Females of all species reach puberty before males of the same species. Many hormonal and physical changes are associated with the onset of puberty and these hormonal changes remain until the animal becomes sexually inactive.

(Berardinelli et al., 1978). Conception rates of heifers

Indicators first behaviors: estrus are low (Surfenberg, 1979).

The exact time and conditions leading to the onset of puberty are unknown. In many species there is a surge of luteinizing hormone (LH) before the onset of puberty, followed by a pulsatile LH pattern in the blood. In heifers there is a decrease in the magnitude of LH peaks approximately one week before the first ovulation (Gonzalez-Padilla et al., 1975). There is little correlation between levels of follicle-stimulating hormone (FSH), estrogens or gonadotropin-releasing hormone (GNRH) and the onset of puberty; however, increased estrogens are necessary for the surges of LH during the pubertal phase. The first ovulatory surge of LH is associated with higher blood progesterone level.

During the prepubertal period, more than 4 to 5 weeks before pubertal estrus, progesterone levels in heifers remain low. Levels range from near zero to 0.2 ng/ml. As

time draws nearer to the first ovulation, progesterone levels become erratic. A rise and decline sequence is repeated many times (Gonzalez-Padilla et al., 1975). Immediately following the onset of puberty, progesterone levels are 0.5-0.7 ng/ml (Berardinelli et al., 1979). The peaks of progesterone directly follow the phasic pattern of LH secretion into the plasma. a low plane of nutrition may cause. Following the first ovulation, levels of progesterone rise well above 1.0-1.5 ng/ml, but return to 0.7 ng/ml (Berardinelli et al., 1979). Conception rates of heifers bred at first behavioral estrus are low (Burfening, 1979). Consequently, normal corpora luteal function does not always occur at first ovulation. The excised ovaries of the heifers ovulating for the first time did contain luteal tissue. However, the tissue was small, 1.5-6 mm in diameter and did not appear to represent a normal luteinized follicle cavity lined with luteal tissue. Normal cycling heifers have larger corpora lutea and maintain progesterone levels about 1.0-1.5 ng/ml. ce of a mature bull failed to hasten puberty in 12-14 mo old beef heifers (Berardinelli et al., 1979).

Phenomena Affecting Puberty

In cattle, puberty occurs at approximately 12-15 mo of age. Beef heifers have reached 45-55% of their adult weight, while dairy heifers are closer to 30-40% of the adult weight (Roy et al., 1975). Three factors that affect the occurrence of puberty are: breed, nutrition and social factors. western and midwestern beef heifers have

Heifers of British breeds usually reach puberty earlier than heifers of continental breeding. Also, crossbred heifers generally are earlier maturing than heifers from the parent breeds (Wiltbank et al., 1969; Nelsen et al., 1982).

A high plane of nutrition causes accelerated growth in heifers, as well as other species, thus tending to cause early onset of puberty, while a low plane of nutrition may cause a delay in sexual maturity (Wiltbank et al., 1969; Short et al., 1971).

Socialization of females affects age of puberty. Puberty occurs earlier in gilts reared in a group than those reared alone. The presence of an adult boar during rearing hastens puberty in both situations (Mavrogenis and Robison, 1976). Cattle are also known to exhibit similar behavioral and physiological responses (Nelsen et al., 1985). Puberty and non-pubertal estrus activity in heifers (behavioral estrus without ovulation or formation of a corpus luteum) were affected by genotype, age, and presence of mature cows. However, the presence of a mature bull failed to hasten puberty in 12-14 mo old beef heifers (Berardinelli et al., 1978).

Ovariectomized heifers can be grouped with breeding herds without the risk of pregnancy. This improves the flexibility of

METHODS OF OVARECTOMY

Ovariectomy (OVX) Ovariectomized heifers should not

Ovariectomizing heifers is a common management practice in the western and midwestern United States. Like

castration, it is used as a means of separating breeding animals from those whose destiny is the feedyard and eventual slaughter. Reasons for ovariectomy include: pregnancy prevention, less estrus activity, more flexible pasture management, Brucellosis control and price premiums. Pregnant heifers pose problems to the feedlot and slaughter plant. In the feedlot, pregnant heifers are aborted to eliminate the complications of pregnancy and parturition. The additional handling and treatment of heifers that undergo parturition in the feedlot are an economic liability. The packer may in turn reduce the live-weight price given for the pregnant heifers which were not successfully aborted. In the slaughter, purveyor may request purchase on a carcass weight basis rather than live-weight basis. The external abdominal oblique muscles. A common problem associated with heifers in the feedlot is increased sexual activity due to estrus. This increased physical activity has a negative effect on efficiency of gains. Melengesterol acetate is fed to suppress estrus and reduce related physical activity. and skin are sutured to complete Ovariectomized heifers can be grazed with breeding herds without the risk of pregnancy. This improves the flexibility of pasture management for many cow-calf operations. with any surgical procedure, infections can occur Properly identified ovariectomized heifers would not have to be vaccinated or blood tested for Brucellosis. Interstate restriction for transporting heifers, could be

relaxed which would allow heifers to be shipped across state lines under the same regulations as steers. The carcass may be Ovariectomy used as a management tool to eliminate problems associated with handling stocker and feeder heifers could be beneficial. Therefore, a premium price for OVX heifers over intact heifers could be realized by stockers and feedlot operators. Some of these adverse effects associated with the flank spraying, other methods were

Flank Method The one to be described was developed by Rupp and The first ovariectomies were performed by surgically removing the ovaries through an incision in the left flank region. After anesthetizing a small area near the thick muscular fold of the internal obliques, a 10 cm dorso-ventral incision is made. The incision transverses and penetrates the external abdominal oblique muscles. Internal oblique muscle fibers are physically separated without cutting the tissue. Abdominal cavity entry is made by penetration of the peritoneum. The ovaries are excised with an ecraseur or other safe cutting instrument. The external oblique muscles, fascia and skin are sutured to complete the procedure. of the ovary once it has been cut away. The flank method has a few disadvantages. First, flank spraying requires about 15-20 min to complete the procedure. Secondly, as with any surgical procedure, infections can occur. Approximately .5 to 1% of the heifers will die from the surgery. Lastly, price discounts may be encountered at slaughter because of adhesions found during the healing

process. During slaughter many hides are torn because of adhesions between the hide and the wound. The carcass may be docked because of scar tissue resulting from the operation. ovaries, or a free-martin).

Heifers are restrained in a headgate, the rectum is Kimberling-Rupp Technique area is washed and the area is

In order to eliminate some of these adverse effects associated with the flank spaying, other methods were developed. The one to be described was developed by Rupp and Kimberling (1982). ginal wall and peritoneum into the

This procedure involves the use of an instrument¹ developed and patented by Kimberling and Rupp (herein known as the KR tool) which provides a fast and effective means of ovariectomizing heifers and has relatively few adverse effects. The KR tool is essentially two steel tubes; consisting of an outer guide tube and an inner cutting tube. Each tube has small holes with sharp edges, which trap the ovary, cut the connecting tissue and excise the ovary. The holes are located near the sharp end of the instrument which penetrates the vaginal wall. There is also a plunger that aides in manipulation of the ovary once it has been cut away. The whole apparatus is 45 cm in length.

Heifers must be large enough to allow rectal manipulation of the reproductive tract. Feed and water small portions until the whole tract has been removed.

¹ Lane Manufacturing, Inc., Denver, CO.

should be withheld 30 h before the procedure. A reproductive examination should be performed before the surgery to identify unsuitable females (e.g., pregnancy, over-sized ovaries, or a free-martin).

Heifers are restrained in a headgate, the rectum is cleared, the vulva-rectal area is washed and the area is disinfected. Next the KR tool is inserted into the vagina with one hand while the other hand inserted into the rectum guides it to the cervico-vaginal wall. The tool is then pushed through the vaginal wall and peritoneum into the abdominal cavity.

One ovary is guided into the cutting chamber with the hand in the rectum, being careful not to trap part of the rectal wall or intestines. The tissue surrounding the ovary is cut by rotating the inner chamber and is stored by pushing the plunger forward. This traps the excised ovary, allowing removal of the other ovary without removing the instrument from the abdominal cavity. The KR instrument is withdrawn from the vagina, ovaries removed, cleaned, and rinsed in a series of cold disinfectants and ready to be used again.

This procedure has allowed skilled technicians to spay 30-50 heifers/h. It is difficult to do large ovaries that have corpora lutea. Large ovaries are removed by excising small portions until the whole ovary has been removed. However, there are several other instruments that operate

under the same principles as the KR tool, that can handle larger ovaries. In grafting a small portion of the excised

The procedure results in very few death losses, no hide damage and can dramatically reduce time involved in spaying. Death losses that have occurred are results of peritonitis associated with intestinal perforation. Anal growth would be

similar to intact heifers, but without the undesirable Ovarian-Drop Technique us and pregnancy.

Another technique used for ovariectomizing heifers is the ovarian-drop method. The ovaries are palpated through the rectum with one hand and a slender metal tool² with a hole and cutting edge is inserted into the vagina and through the vaginal wall. One ovary is manipulated into the instrument's oval opening with the hand in the rectum and the tool is withdrawn. The withdrawing action forces the ovarian attachments into a cutting slit and the ovary is cut free and falls into the body cavity. The other ovary is done likewise and the instrument is cleaned and disinfected, ready for the next heifer.

studies using no implants. Intact heifers gained from 1.45 day then 67% better. Average

Rumen-Autograft Technique show

The relatively new rumen-autograft technique was introduced and has been tested in research trials in the

implanted with growth promotants. In the twelve studies, OVX heifer gained from 4.25 to 4.55 more weight

On the second 600 pounds with imple²Willis Veterinary Supply, Fresno, S.D.

United States. This method involves flank spaying the heifer and then grafting a small portion of the excised ovary tissue into the outer lining of the ruminal wall. The premise of this procedure is that the graft will become functional tissue and produce hormones from the nutrients in the vast blood supply to this area. Animal growth would be similar to intact heifers, but without the undesirable characteristics of estrus and pregnancy.

Source	Group	Imp	OVX	Intact
Cameron et al. (1977)	75/23	RAL	.96	.95
	74/25	SYN-H	.98	.98
Rush and Reese (1981)	47		.70	.71
EFFECTS OF OVARECTOMY				
Rush and Reese (1981)	32/33	RAL	.9	.86
	35	SYN-H	.9	.84

Grazing Performance

Differences between ovariectomized and intact heifer performance while grazing have been well documented. Table 2 summarizes several grazing studies of intact and ovariectomized heifers with and without anabolic growth implants. An average of these studies showed intact and OVX heifers gained similarly (.75 vs .75 kg/d). In the five studies using no implants, intact heifers gained from 1.25 to 13.43% more weight per day than OVX heifers. Averages show intact heifers gained 6.94% (.77 vs .72 kg/d) more than OVX heifers. Results are different when heifers are implanted with growth promotants. Across the twelve studies, OVX heifer gained from -9.23 to +7.25% more weight than intact heifers. On the average, OVX heifers with implants gained 2.63% more (.76 vs .74 kg/d) than intact

heifers. Therefore, it appears that weight gain losses in
 TABLE 2. EFFECTS OF OVARIECTOMY ON WEIGHT GAINS
 OF GRAZING HEIFERS

Source	Animals/ Group ^a	Impl ^b	Average Daily Gains (kg)	
			OVX	Intact
Kercher et al. (1960)	10	several	.58	.67
Cameron et al. (1977)	75/25		.88	.94
Cameron et al. (1977)	75/23	RAL	.96	.95
	74/25	SYN-H	.98	.98
Rush and Reece (1981)	47		.70	.71
	36	OVX	.79	.80
Rush and Reece (1981)	32/33	RAL	.9	.86
	35	SYN-H	.9	.84
Shoop et al. (1982 unpublished)	54/27		.67	.71
Shoop et al. (1982 unpublished)	54/27	RAL	.78	.74
	54/27	2-RAL	.79	.74
Kuhl et al. (1987)	98/46	RAL	.77	.74
	99/48	RAL	.56	.60
Laudert et al. (1987)	133/65	RAL	.62	.64
Grotelueschen et al. (1988)	24	RAL	.51	.50
Johns et al. (1988)	48/24	HEF	.59	.65
	50	RAL	.74	.69
Average ^c (total)			.75±.14	.75±.13
Average (no implant)			.72±.10	.77±.10
Average (implant)			.76±.15	.74±.14

^a Two values indicate unequal group size OVX/intact.

^b Implant: HEF: Heifer-oid

RAL: Ralgro
 SYN-H: Synovex-H

^c Mean ± standard deviation.

heifers. Therefore, it appears that weight gain losses in OVX grazing heifers are recovered by implants. GAINS OF HEIFERS WITHOUT AN EXOGENOUS SOURCE OF HORMONE AND FED IN CONFINEMENT

Feedlot Performance

Differences in growth rates of ovariectomized and intact beef heifers in the feedyard have been extensively studied. Table 3 summarizes several feedlot studies of OVX and intact heifers. Differences between OVX heifer gains in individual studies ranged from +12.30 to -25.71% of intact heifers. On average, intact heifers gained 5.32% (.99 vs .94 kg/d) more weight than OVX heifers. In 12 of the 16 studies, intact heifers outgained OVX heifers.

Table 4 summarizes feedlot studies of OVX and intact heifers given anabolic growth-promoting implants. Differences between treatments in individual studies ranged from -6.86 to +7.45% improvement for OVX heifers. For heifers given a growth-promoting implant OVX heifers gained 2.38% (1.26 vs 1.23 kg/d) more weight than intact heifers. This indicates that anabolic growth-promoting implants improve gains of beef heifers lacking ovarian steroid hormones. Ovariectomized Holstein heifers respond in a similar manner to implant treatments in the feedlot as beef heifers (Peters et al., 1983).

* Type of ration: F - finishing ration

Feed Intake

Feed intake in ovariectomized adult rats is increased (Beatty et al., 1975; Wade and Gray, 1979; Dohm and Beecher,

TABLE 3. EFFECTS OF OVARECTOMY ON WEIGHT GAINS OF
HEIFERS WITHOUT AN EXOGENOUS SOURCE OF HORMONE
AND FED IN CONFINEMENT

Source	Animals/ Group ^a	Animals/ Group ^a	Average	
			Daily Gains (kg) OVX	Intact
Dinusson et al. (1950)	34 G	5 F	0.87	0.94
Embry (1955)	34 G	SYN-H	0.82	0.85
Clegg and Carroll (1956)	24 F	7 F	0.82	0.85
	24 F	SYN-H	1.02	1.05
Langford and Douglas (1956)	30 F	6 F	0.85	0.87
	30 F	RAL	1.16	1.12
Kercher et al. (1960)		10 F	0.81	.89
Rupp et al. (1960)	101/117 F	10 FL	0.70	0.88
	37/44 F	SYN-H	1.82	1.80
Nygaard and Embry (1966)	24 G-H	24 G-H	0.42	0.47
	39/38 F	23 FRAL	0.83	0.98
Ray et al. (1969)	32/33 F	16 FL	0.79	0.95
	35 F	SYN-H	1.82	1.89
Yamamoto et al. (1978)		29 F	1.22	1.07
Lunt et al. (1980)	15/14 F	SYN-H	0.91	0.85
Rupp et al. (1980)		115 F	1.71	1.76
Rush and Reece (1981)	63 F	47 F-H	0.94	0.93
	(1987)	36 F	1.09	1.04
Hamernik et al. (1985)	24 F	19 F	1.02	1.05
Perry and Horstman (1985)		10 F	1.04	1.06
Lunt et al. (1986)		10 F	.55	.72
Perry and Horstman (1987)	equal	10 F	1.38	1.36
Average ^b			.94 $\pm$.30	.99 $\pm$.27

^a Type of ration: F - finishing ration
SYN-H - growing ration

^b Mean $\pm$ standard deviation.

1981; Richard, 1986), as well as fat and total body weight gains.

TABLE 4. EFFECTS OF OVARECTOMY ON WEIGHT GAINS OF HEIFERS GIVEN AN EXOGENOUS SOURCE OF HORMONES AND FED IN CONFINEMENT

and feed conversion of OVX and intact heifers. Even though ovariectomy resulted in differences of -5.31 to 1.85 from

Source	Animals/ Group ^{a,b}	Implant ^c	Average Daily Gains (kg)	
			OVX	Intact
Nygaard and Embry (1966)	24 G	DES	.52	.55
	24 G	SYN-H	.52	.55
	24 F	DES	1.07	1.06
	24 F	SYN-H	1.02	1.05
Yamamoto et al. (1978)	30 F	RAL	1.16	1.12
Rupp et al. (1980)	101/117 F	RAL	1.88	1.74
	37/44 F	SYN-H	1.82	1.80
	35/38 F	SYN-S	1.93	1.82
	39/38 F	2-RAL	1.85	1.78
Rush and Reece (1981)	32/33 F	RAL	1.09	1.03
	35 F	SYN-H	1.02	1.09
Lunt et al. (1986)	15/14 F	SYN-H	.91	.85
Laudert et al. (1987)	132/63 F	SYN-H	1.36	1.34
Grotelueschen (1988)	24 F	RAL	1.44	1.47
Average ^d			1.26±.46	1.23±.42

^a Two values indicate unequal group size OVX/intact.

^b Type of ration: F - finishing ration
G - growing ration

^c Implant: DES: diethylstilbesterol-(stilbesterol)

RAL: Ralgro

SYN-H: Synovex-H

SYN-S: Synovex-S

^d Mean ± standard deviation.

1981; Richard, 1986), as well as fat and total body weight gains. Beef heifers in feedlots do not respond in a similar manner to ovariectomy. Table 5 summarizes daily feed intake

and feed conversion of OVX and intact heifers. Even though ovariectomy resulted in differences of -5.31 to +7.20% from intact heifers, average dry matter intake did not differ between the two treatments.

Author	Animals	DMI (kg)	Feed/gain
Rush and Reece	48/48	8.39	8.21
Hamernik et al. (1985)	19	8.10	8.53
Ferry and Horstman	10	7.99	8.13

Feed Conversion

Lunt Early evidence of the effects of ovariectomy on feed conversion of feedlot heifers showed differences between

treatment groups (Gramlich and Thalman, 1930; Hart et al., 1940; Dinusson et al., 1950; Clegg and Carroll, 1956).

Intact heifers had a slight tendency to require less feed per kilogram of weight gain.

Recent studies show little difference in feed conversion between OVX and intact heifers in the feedlot

(Table 5). Over the seven trial summary, ovariectomized heifers required from -8.22% to +6.03% more feed per kilogram of gain. Varying results from studies have led to

no definite conclusion about how ovariectomy effects feed conversion efficiency. However, much of the data suggests a slight improvement in feed conversion for OVX heifers.

Carcass Characteristics

TABLE 5. EFFECTS OF OVARIECTOMY ON DAILY FEED INTAKE AND FEED CONVERSIONS OF HEIFERS FED IN CONFINEMENT

Larger fat cells and fat depot size is increased in females

Source ^a	Year	Animals/ Group ^a	DMI (kg)		Feed/gain	
			OVX ^b	Intact	OVX ^b	Intact
Rush and Reece (1981)	early studies	48/46	8.39	8.21	8.96	8.85
Hamernik et al. (1985)	1981; Hamernik et al., 1985; Lunt, 1986; Grotelueschen et al., 1988	19	8.10	8.53	7.94	8.12
Perry and Horstman (1985)	ovariectomy appears to have little or no effect	10	7.99	8.13	6.00	5.80
Lunt et al. (1986)	heifers were fed to near 1.22 cm of backfat. Saul et al. reported no difference in fat depth, carcass weight,	15/14 ^b	12.38	12.68	9.08	9.46
Laudert et al. (1987)	reported no difference in fat depth, carcass weight,	132/63 ^b	8.49	7.92	6.15	5.80
Perry and Horstman (1987)	ovariate slaughter group. Heifers were slaughtered at 18 or	10	8.49	7.92	6.15	5.80
Grotelueschen et al. (1988)	age and backfat depths were 5.8 mm or 7.5 mm.	24 ^c	9.86	9.69	6.84	6.58
Average ^c			9.12±1.45	9.11±1.55	7.76±1.33	7.82±1.64

^a Two values indicate unequal group size OVX/intact.^b Synovex-H implant.^c Ralgro implant.^d Mean ± standard deviation.

EFFECTS OF OVARIECTOMY ON THE ENDOCRINE SYSTEM

Estrogen

Beck et al. (1976), using Holstein heifers (302 kg), showed that ovarian hormone activity decreased after

Carcass Characteristics

Ovariectomy in rats has an overall fattening effect. Larger fat cells and fat depot size is increased in females without the presence of ovarian steroids (Wade, 1975, Wade and Gray 1979; McElroy and Wade, 1987). Results with heifers do not show the same pattern.

In early studies (Dinussion et al., 1950; Clegg and Carroll, 1956) and in more recent trials (Rush and Reece, 1981; Hamernik et al., 1985; Lunt, 1986; Grotelueschen et al., 1988) ovariectomy appears to have little or no effect on carcass characteristics of heifers (Table 6). All heifers were fed to near 1.22 cm of backfat. Saul et al. (1983) reported no difference in fat depth, carcass weight, dressing percentage, or marbling scores in either an early or late slaughter group. Heifers were slaughtered at 18 or 22 months of age and backfat depths were 5.8 mm or 7.5 mm, respectively. It appears that ovariectomy does not effect carcass characteristics in heifers fed to a slaughter endpoint based on a constant weight, age or amount of fatness.

EFFECTS OF OVARIECTOMY ON THE ENDOCRINE SYSTEM

Estrogen

Beck et al. (1976), using Holstein heifers (308 kg), showed that ovarian hormone activity decreased after

Iter

Car

Dre

Bac

Rib

KPH

Mar

Mat

Yie

a

b

c

TABLE 6. EFFECTS OF OVARIECTOMY ON CARCASS
CHARACTERISTICS OF GROWING-FINISHING HEIFERS

Item	OVX	Intact
Carcass wt, kg	267.0 $\pm$ 19.3	269.6 $\pm$ 16.6
Dressing %	60.82 $\pm$ 1.72	60.56 $\pm$ 1.38
Backfat, cm	1.19 $\pm$ 0.21	1.25 $\pm$ 0.25
Ribeye area, cm ²	72.74 $\pm$ 4.40	73.09 $\pm$ 3.46
KPH %	2.32 $\pm$ 0.73	2.50 $\pm$ 0.74
Marbling ^b	13.6 $\pm$ 2.9	13.4 $\pm$ 2.6
Maturity ^c	14 $\pm$ 0.0	14 $\pm$ 0.0
Yield grade	2.68 $\pm$ 0.33	2.64 $\pm$ 0.28

^a Mean $\pm$ standard deviation.

^b Marbling scores based on 13=small minus, 14=small average, etc.

^c Maturity scores based on 14=A^o, 13=A⁺, etc.

ovariectomy and could be replaced by steroid hormone implantation. Estrogen and progesterone levels were reduced in non-implanted ovariectomized heifers compared to levels before ovariectomy. However, estrogen and progesterone levels did not decrease in steroid implanted heifers until the implants were removed six days after ovariectomy.

Plasma levels of estrogen in Charolais and Red Poll crossbred heifers (323 kg) diminished from 50 to 10 pg/ml or lower after OVX (Welsh et al., 1986). There were similar findings in adult mice, 145 pg/ml to 366 pg/ml, in ovariectomized and intact females, respectively (Puah and Bailey, 1985). Day et al. (1986) found that mean serum concentrations of estradiol in 270 d old heifers decreased to nondetectable levels 8 d after ovariectomy. Previous basal levels had been recorded at 6 pg/ml.

Progesterone

Puah and Bailey (1985) recorded plasma progesterone differences of adult ovariectomized and intact mice at 58 ng/ml and 154 ng/ml respectively. Hamernik et al. (1985), using crossbred heifers, similarly demonstrated that ovariectomy depleted serum progesterone to nondetectable levels (<0.35 ng/ml) and intact levels fluctuated from 1 to 4 ng/ml. Progesterone levels of ovariectomized Charolais and Red Poll crossbred heifers compared to intact heifers (Welsh et al., 1987), were 0.5-1.0 and 1.5-3.0 ng/ml, respectively. Progesterone levels decreased in Holstein

heifers after ovariectomy, however, ovarian steroid implants elevated serum progesterone near intact levels (Beck et al., 1976).

Growth Hormone and Somatomedin-C

Growth hormone was found to increase for a few days after ovariectomy in Holstein heifers (Beck et al., 1976). However levels began to decline 7 d after the operation. This corresponds to the diminished estrogen levels recorded in the same study. Shulman et al. (1987) reported serum increases in growth hormone and somatomedin-C in ovariectomized adult rats. Pituitary levels of GH increased as well. However, data presented by Welsh et al. (1987) did not support an increase plasma level of SMC after ovariectomy.

Insulin

By isolating the soleus muscle in adult mice, Puah and Bailey (1985) studied the relationship of ovariectomy and insulin response. No difference in glucose concentration was found in the blood, even though insulin levels were slightly lower in ovariectomized females. This is contrary to findings of Bailey and Ahmed-Sorour (1980), who showed a 40% decrease in plasma glucose concentration due to ovariectomy. Puah and Bailey (1985) showed no difference in soleus muscle weight between OVX and intact animals, but protein content (mg/muscle) was lower and extracellular

volume was smaller for ovariectomized mice. Percentage of insulin bound to muscle protein and percent insulin weight of muscle are both lower in OVX females. These findings suggest that sex steroids participate in glucose metabolism.

Other Hormones

Swanson et al. (1971) found several changes in blood hormone levels in OVX Holstein heifers. Pituitary weights, FSH, LH and prolactin levels in sham operated heifers were all different from ovariectomized heifers (Table 7). Increases in plasma LH following ovariectomy have been shown by other researchers (Beck et al., 1976; Shulman et al., 1987). Pituitary LH content of rats increase as ovarian hormones decrease (Shulman et al., 1987). Negative feedback of sex steroid hormones on gonadotropins is interrupted by removal of the ovary. Grotelueschen et al. (1988) found that OVX heifers had lower serum testosterone levels than intact heifers (60.8 vs. 71.2 pg/ml, respectively).

Other Blood Constituents

Studies by Dinusson et al. (1950) indicated differences in blood lipid concentrations between intact and ovariectomized heifers while on finishing rations. There were no differences between erythrocyte counts, cholesterol levels, inorganic phosphorus nor serum calcium, as indicated by Table 8. However, percentage blood lipids were higher in ovariectomized heifers. Other OVX heifers with the same

TABLE 7. PITUITARY AND BLOOD PLASMA LEVELS OF
SHAM OPERATED AND OVARIECTOMIZED HOLSTEIN HEIFERS.^a

	Sham	Ovariectomized
Pituitary wt. (gm)	2.16 ^b	1.90 ^c
Plasma FSH (ug/mg)	0.19 ^b	0.41 ^c
Plasma LH (ng/ml)	1.0 ^b	2.0 ^c
Plasma Prl (ng/ml)	10.0 ^b	52.0 ^c

^a Taken from Swanson et al. (1971).

^{b, c} Means within rows with unlike superscripts differ ($p < .05$).

TABLE 8. SUMMARY OF BLOOD CONSTITUENTS OF
INTACT AND OVARIECTOMIZED BEEF HEIFERS^a

Constituent	Intact	Ovariectomized
Erythrocytes (millions per cc)	8.53 ± 0.19	8.73 ± 0.19
Cholesterol (mg %)	116.4 ± 3.3	113.3 ± 3.5
Lipid (mg %)	226.5 ± 9.7	285.0 ^b ± 9.1
Inorganic Phosphorus (mg %)	8.2 ± 0.04	8.1 ± 0.06
Serum Calcium (mg %)	11.99 ± 0.14	11.84 ± 0.72

^a Extracted from Dinusson et al., 1950.

^b Difference significant from controls $p < 0.05$.

trial were treated with stilbesterol and testosterone. These heifers had lipid values similar to controls.

Valette et al. (1986) reported that parametrial fat depots are heavier and fat cell volumes are larger for ovariectomized adult rats. These studies also showed higher activity for lipoprotein lipase (LPL) and a lower activity of hormone-sensitive lipase in ovariectomized rats. These studies suggest an overall increase in lipid metabolism without the presence of ovarian steroids.

EFFECTS OF AUTOGRAFT

Grazing and Feedlot Performance

A five trial summary of grazing performance of OVX rumen-autografted (AUG) and OVX heifers is presented in Table 9. Average daily gains for all studies were similar and showed no significant differences between AUG and OVX heifers. Grotelueschen et al. (1988) found that intact, implanted heifers gained 18.3% (1.10 vs .93 kg/d, $p < .05$) more weight than AUG, however, AUG implanted heifers gained similarly to intact implanted heifers (1.13 vs 1.10 kg/d, respectively).

Average daily gains, dry matter intakes and feed conversions for AUG and OVX heifers from six feeding studies are summarized in Table 10. No significant differences were seen between treatments. Daily gains for AUG heifers ranged from +9.80% to -12.58% as compared to OVX heifers. The

TABLE 9. COMPARISON OF DAILY WEIGHT GAINS OF
AUTOGRAFTED AND OVARIECTOMIZED HEIFERS ON PASTURE

Source	Animals/ Group ^{a b}	Average Daily Gain (kg)	
		OVX	Autograft
Whittington (1986)	48/46	1.01	.99
Laudert et al. (1987)			
Trial 1	133/283	.62	.65
Trial 2	64/73	.61	.62
Grotelueschen et al. (1988)			
Trial 1	28	.62	.64
Trial 2	24	.51	.51
Average ^b		.67 $\pm$.17	.68 $\pm$.16

^a Two values indicate unequal group size; OVX/autograft.

^b Mean $\pm$ standard deviation.

TABLE 10. SUMMARY OF FEEDLOT PERFORMANCE
IN AUTOGRAFTED AND OVARIECTOMIZED HEIFERS

Source	Animals/ Group	Item	OVX	Autograft
Perry and Horstman (1985)	10	ADG ^a	1.04	.96
		DMI ^a	7.99	7.93
		F/G	6.00	6.20
Brethour (1986)	20	ADG	1.56	1.55
		DMI	10.96	10.74
		F/G	7.02	6.92
Lunt et al. (1987)	15	ADG	.92	1.02
		DMI	8.62	9.07
		F/G	9.37	8.89
Perry and Horstman (1987)	10	ADG	1.38	1.33
		DMI	8.50	8.30
		F/G	6.15	6.25
Grotelueschen et al. (1988) Trial 1	28	ADG	.97	.94
		DMI	8.71	8.84
		F/G	8.98	9.40
Trial 2	24	ADG	1.44	1.28
		DMI	9.84	9.80
		F/G	6.84	7.66
Average ^b		ADG	1.22 $\pm$.25	1.18 $\pm$.22
		DMI	9.1 $\pm$ 1.0	9.11 $\pm$.94
		F/G	7.39 $\pm$ 1.32	7.55 $\pm$ 1.23

^a ADG=kg/d; DMI=kg/d.

^b Mean $\pm$ standard deviation.

average of all studies showed that OVX heifers gained 3.39% (1.22 vs 1.18 kg/d) more weight than AUG heifers. Daily intakes were similar in all studies. Feed conversion for AUG heifers ranged from 5.40% to -10.70% as compared to OVX heifers. The average of all studies showed that OVX heifers converted 2.12% (7.39 vs 7.55 kg feed/kg gain) more efficiently than AUG heifers.

Carcass Characteristics

Differences in carcass characteristics between AUG and OVX heifers are summarized in Table 11. All characteristics were similar between the two treatments. It appears that kidney, pelvic and heart percentages are different, however, only two trials were averaged. In one trial AUG heifers had 24.6% (1.77 vs 1.42%, $p < .05$) more KPH% than OVX heifers.

Blood Constituents

Welsh et al. (1987) found AUG and OVX heifers differed in plasma estrogen and progesterone, however SMC levels in plasma and anterior pituitary weights were similar to intact heifers. Mean plasma concentrations of estrogen and progesterone were similar in the AUG and OVX groups, however, both were significantly lower than levels in intact heifers. Somatomedin-C levels were not different among the three treatments. Mean pituitary weights were slightly lower for AUG and OVX heifers. Conclusions from this study

TABLE 11. COMPARISON OF CARCASS CHARACTERISTICS OF
AUTOGRAFTED AND OVARIECTOMIZED HEIFERS

Item	OVX	Autograft
Carcass wt, kg	283.2 $\pm$ 28.4 ^a	280.5 $\pm$ 26.7
Dressing %	61.77 $\pm$ 1.39	61.87 $\pm$ 0.95
Backfat, cm	1.22 $\pm$ 0.22	1.16 $\pm$ 0.22
Ribeye area, cm ²	73.90 $\pm$ 5.70	73.15 $\pm$ 6.35
KPH %	1.89 $\pm$ 0.47	2.14 $\pm$ 0.37
Marbling ^b	13.00 $\pm$ 2.92	13.25 $\pm$ 2.59
Yield grade	2.60 $\pm$ 0.35	2.49 $\pm$ 0.27

^a Mean $\pm$ standard deviation.

^b Marbling scores based on 13=small minus, 14=small average, etc.

demonstrated the ineffectiveness of the rumen autograft technique to alter the endocrine status of the OVX animal.

Contrary to the previous study, Grotelueschen et al. (1988) found differences in plasma estradiol between AUG and OVX heifers. Table 12 shows that AUG plus implant heifers had the highest ($p < .01$) serum estradiol levels and OVX heifers had the lowest. Autografted plus implant heifers had higher (2.08 vs 1.40 pg/ml, $p < .01$) serum estradiol levels than OVX plus implant heifers, as did AUG only over OVX heifers (1.19 vs .88 pg/ml, $p < .01$). Apparently, the autografts are producing estradiol. Serum testosterone levels did not differ between treatments in this trial or a second trial conducted by the same group. However, testosterone levels were reduced in AUG and OVX heifers when compared to intact counterparts.

Performance of ovariectomized heifers was variable across studies, however, the author concludes that ovariectomy decreases gain performance, unless heifers are given an anabolic growth implant. It is undetermined whether differences in carcass composition exist between OVX and intact heifers. It may be shown that protein and fat are deposited at different rates between the two groups. A portion of the variation observed with ovariectomized heifers may depend upon state of maturity at the time of ovariectomy.

TABLE 12. LEVEL OF ESTRADIOL AND TESTOSTERONE
IN SERUM OF OVARIECTOMIZED AND AUTOGRAFTED HEIFERS^a

Treatment	Estradiol (pg/ml)	Testosterone (pg/ml)
AUG + implant	2.08 ^b	73.1
AUG	1.19 ^c	63.1
OVX + implant	1.40 ^c	68.3
OVX	.88 ^d	67.7

^a Taken from Grotelueschen et al. (1988)

^{b, c, d} Means with different superscripts are different
($p < .01$).

CHAPTER III

EFFECT OF OVARIECTOMY AND GROWTH PROMOTANTS ON GROWING AND FINISHING BEEF HEIFERS

SUMMARY

Four hundred ten yearling crossbred heifers (256 kg) were utilized to evaluate the effects of ovariectomy and growth promotant implants on rate, efficiency and composition of gain and carcass characteristics. Heifers were randomly assigned to one of four treatments: (1) intact ovaries without implant; (2) intact ovaries with implant; (3) ovariectomized without implant; and (4) ovariectomized with implant. Heifers were grazed on native bluegrass pastures. After the grazing period (156 d), heifers were placed in the feedyard. Finishing diets consisted of 80% high moisture corn, 15% corn silage and 5% supplement. The trial was terminated when 70% of the heifers were evaluated to grade USDA Choice. Protein and fat accretion estimates were obtained from 9-10-11 rib section analysis from preselected heifers post-grazing and at slaughter. In the grazing study an ovariectomy x implant interaction ($p < .05$) occurred for average daily gains across the total grazing period. During the feedlot phase, an ovariectomy by implant interaction ($p < .01$) occurred for average daily gains as well as dry matter intakes. Ovariectomized heifers gained 6.3% (.128 vs .136, $p < .05$)

less efficiently than intact (IN) heifers. Implanted heifers gained 6.3% (.136 vs .128, $p < .05$) more efficiently than non-implanted heifers. Ovariectomized heifers had lower dressing percents than IN heifers. An ovariectomy x implant interaction was found for carcass weights ($p < .01$), liver weights ($p < .01$) and ribeye area ($p < .05$). Implanted heifers had less KPH fat ($p < .001$) and lower marbling scores ($p < .01$) than control heifers. Ovariectomized heifers accreted less carcass fat (570.5 vs 633.1 gm/d, $p < .01$) and less carcass protein plus fat (663.6 vs 733.9, $p < .005$) than intact heifers. Implanted heifers gained 16.5% (104.6 vs 89.8 gm/d, $p < .005$) more carcass protein than non-implanted heifers. Results from the study suggest that ovariectomized heifers given a growth promoting implant will perform similarly to intact heifers but produce a leaner carcass.

INTRODUCTION

Ovariectomized (OVX) beef heifers may gain less weight than intact heifers while grazing (Kercher et al., 1960). Difference in performance is recovered when OVX heifers are implanted with growth promotants (Grotelueschen et al., 1988; Johns et al., 1988). When implanted, grazing performance in OVX heifers is similar to intact heifers.

Results of feedlot studies are similar to grazing studies. When no implant is utilized, OVX heifers gain less than intact heifers (Dinusson et al., 1950; Ray et al.,

1969; Lunt et al., 1986); however, when OVX heifers are implanted, gains are similar to intact heifers (Lunt et al., 1986; Grotelueschen et al., 1988). Similar results are obtained with dry matter intake and feed conversion.

Though differences in carcass traits are shown between OVX and intact females of other species (Wade, 1975; Wade and Gray, 1979; McElroy and Wade, 1987); ovariectomy in beef heifers has not been shown to effect carcass characteristics. Carcass lean and fat measurements are similar between OVX and intact heifers fed to different endpoints (Saul et al., 1983; Hamernik et al., 1985; Lunt et al., 1986). The effects of ovarian hormones on protein and lipid gain has not been determined.

The objectives of this study were to evaluate (1) the effect of ovariectomy and (2) the interaction of ovariectomy and growth promoting implants on grazing and feedlot performance, carcass characteristics and tissue accretion in beef heifers.

EXPERIMENTAL PROCEDURE

Allotment

Four hundred ten yearling crossbred heifers (256 kg) were utilized over three years to evaluate the effects of ovariectomy and growth promotant implants on rate, efficiency and composition of gain and carcass characteristics. Heifers were randomly assigned to one of

four treatments: (1) intact ovaries without an implant; (2) intact ovaries with an implant; (3) ovariectomized without an implant; and (4) ovariectomized with an implant. Heifers on the implant³ treatments received 20 mg estradiol benzoate and 200 mg testosterone propionate at the beginning of the pasture and finishing phases.

Ovariectomy

One half of the heifers were supravaginally ovariectomized. Feed was withheld 24 h prior to the surgery. Heifers were restrained in a hydraulic squeeze chute. The perineal area was washed with a mild detergent, rinsed thoroughly with water and finally rinsed with diluted Novasan⁴ (chlorhexidine diacetate - bactericide, virucide and fungicide).

After the scrubbing procedure, the vagina was infused with 100-150 ml of cold, fresh antiseptic solution. This was done to prevent infection and distend the vagina, thus allowing the surgeon more freedom for hand movement.

The surgeon's hand was covered with sterile lubricant jelly and inserted into the vagina. At the junction of the cervix and vaginal wall a small incision was made with a

³Boehringer Ingelheim, St. Joseph, MO.

⁴Fort Dodge Laboratories, Inc., Fort Dodge, IA.

retractable, double edged knife.⁵ The incision through the vaginal wall and peritoneum was made dorso-cranially from the cervico-vaginal crypt. The surgeon's hand was forced through the incision to allow manipulation of the ovaries.

Each ovary was placed through the loop at the tip of the ovariectomizing tool,² ovarian attachments were severed and ovaries were removed to the exterior of the animal. Each ovary was visually inspected to ensure all ovarian tissue was removed.

The tool, made of solid, cylindrical, surgical steel, is 52 cm long and 2.2 cm in circumference. The handle end is blunt and bent at 90°, leaving a 7 cm handle. The working end is pointed and flattened out with an oval opening (2.5 x 1.8 cm) that tapers into a channel toward at the tip. There is a cutting edge at the end of the channel.

Heifers were released into holding pens and observed for surgical complications while the remaining heifers were ovariectomized. Heifers were then observed for an additional week for signs of vaginal bleeding or infection due to the surgery. Heifers were removed from the trial when complications were observed.

⁵ Sharper Image, Inc., Santa Barbara, CA.

Animal Management

Heifers within the four groups were comingled in two groups and placed at two locations on northern Michigan pastures. Pastures are primarily native bluegrass with a variety of other grasses and legumes present. Since there were no treatment by location interactions, the results were pooled across locations. Heifers grazed from mid-May to early October. Weights were taken every 30 d. After cattle were weighed of the pasture phase, heifers were transported to the feedyard, processed, and readministered treatments.

In the feedlot, heifers were allowed free access to hay and water for 12 to 24 hr before processing. After processing, heifers were allotted to pens and remained there until the completion of the trial. Pens were located in a slotted floor facility (5.6 m²/animal) with full overhead cover. Heifers were adjusted to the finishing diet in 12 to 15 d and fed ad libitum once daily for the remainder of the trial (approximately 150 d.) The finishing diet and supplement are shown in Table 13. Weights were taken every 30 d at which time refused feed was collected and weighed. Heifers were slaughtered when 70% were estimated to have achieved USDA Choice quality grade. Initial and final weights were taken on two consecutive days and averaged. Final weights were adjusted by dividing carcass weights by a standard 62% dress. Daily gains and feed efficiencies were calculated using adjusted final weights.

TABLE 13. EXPERIMENTAL FINISHING DIET^{a b}

Feed Ingredient	Percent in diet
High moisture corn	80.0
Corn silage	15.0
Soybean meal	2.5
Limestone	1.2
Corn	.6
Potassium chloride	.36
Selenium 90	.06
Vitamin A premix	.008
Vitamin D premix	.01
Rumensin 60	.024
Iodized salt	.25

^a Diet formulated to provide 11% crude protein, .5% Ca, .35% P, .7% K, NE_g=1.2 Mcal/kg DM, and .1 ppm Se. Rumensin 60 was added to provide .62 mg of monensin/kg of diet.

^b Dry matter basis.

Collection of Slaughtered Carcass Information

Heifers with weights closest to average weights of treatment groups were selected as initial and final slaughter groups for the grazing and feedlot phases. Initial slaughter groups were slaughtered of the grazing and feedlot phase. Rib sections were obtained for initial body composition determinations. The remaining heifers were slaughtered when 70% were estimated to meet the minimum specifications for USDA Choice quality grade. Heifers were transported 115 km to the slaughter plant and slaughtered within 150 min after departure from the feedlot.

Carcass information was collected after carcasses were chilled for 24 h. Left side rib sections containing ribs 8 through 12 from representatives of treatment groups were removed and transported in plastic bags to the Michigan State University Meat Laboratory. The 9-10-11 rib section was excised from the whole rib, adopted from Hankins and Howe (1946). Soft tissue was separated from bone and ground twice with a Hobart meat grinder⁶ fitted with a 4 mm diameter plate. Tissue was thoroughly mixed between grindings. A 250 g sample was taken from the ground tissue and stored at -30°C. Samples were later powdered with

⁶Hobart Corp., Troy, OH.

addition of dry ice in a Tech-mar industrial strength blender.⁷

Samples were dried in aluminum pans at 100°C for 24 hours to determine moisture content (AOAC, 1984). Percentage fat was determined by ether extraction of triplicate samples. Samples for year one were extracted for 5 hr in a Goldfisch apparatus (AOAC, 1984). Samples for years two and three were extracted in a modified Soxhlet apparatus for 12 h. (AOAC, 1984). Crude protein percentage was calculated from total nitrogen as determined by micro Kjeldahl procedures (AOAC, 1984) of duplicate samples. Percentage carcass protein and fat were estimated from rib protein and fat using equations of Hankins and Howe (1946). Accretion rates of carcass soft tissue were calculated using the equation shown in Figure 1 (Anderson, 1987).

Statistical Analysis

Data from three years were combined and analyzed. No two or three way interactions occurred with respect to year. Data from the three years were pooled and year was included in the design model. Feedlot information was analyzed on a pen replicate basis, while tissue accretion and carcass characteristics were analyzed on an individual heifer basis.

⁷Tekmar, Co., Cincinnati, OH.

$$a = ((bc) - (def)) / g$$

where:

a = accretion rate of fat or protein (g/d) for a particular heifer

b = carcass weight (kg)

c = estimated carcass percentage fat or protein

d = initial live weight (kg)

e = average dressing percentage of initial slaughter group

f = estimated initial carcass percentage fat or protein

g = number of days on trial

FIGURE 1. FORMULA USED TO CALCULATE SOFT TISSUE
ACCRETION RATES

Statistical analyses were conducted with the (1982) General Linear Model subroutine of SAS (1982). Orthogonal contrasts were conducted to analyze selected treatment comparisons. Contrasts of interest were main effects of ovariectomy and implant and the interaction between ovariectomy and implant. main effects and ovariectomy x implant interactions.

RESULTS AND DISCUSSION

Grazing Performance

Grazing performance summary is shown in Table 14. Ovariectomized heifers had a tendency ($p=.08$) to gain more weight than IN heifers during the first and second weigh period. However, an ovariectomy x implant interaction ($p<.05$) occurred for average daily gains across the total trial. Implanted OVX heifers gained 15.2% more weight per day than non-implanted OVX heifers (.76 vs .66 kg/d), while daily gains for intact heifers were similar between implanted (IMP) and non-implanted heifers (C) (.69 vs .67 kg/d). Similar results have been reported by several authors (Rush and Reece, 1981; Kuhl et al., 1987; Laudert et al., 1987; Grotelueschen et al., 1988; Johns et al., 1988). Kercher et al. (1960) and Cameron et al. (1977) reported non-implanted OVX heifers gained less weight than IN non-implanted heifers. These findings were not supported by these results.

TABLE 14. THE EFFECTS OF OVARECTOMY AND GROWTH PROMOTANTS
ON GRAZING PERFORMANCE OF CROSSBRED HEIFERS

Item	Intact		Ovariectomized		SEM ^a	Probability ^b		
	Control	Implant	Control	Implant		OVX	IMP	OVX x IMP
No. of heifers	83	100	74	105				
Initial weight, kg	257.5	256.8	253.4	252.5	3.6	NS ^c	NS	NS
Final weight, kg	327.5	329.5	324.0	332.6	4.1	NS	p=.10	NS
<u>Average daily gain, kg</u>								
Weigh Period 1	.67	.74	.77	.78	.05	p=.08	NS	NS
Weigh Period 2	.69	.73	.66	.77	.06	NS	NS	NS
Weigh Period 3	.59	.62	.62	.68	.03	p=.08	NS	NS
Overall	.67	.69	.66	.76	.02	p=.05	p<.001	p<.05

^a Standard error of the mean.

^b OVX = ovariectomy; IMP = implant; OVX x IMP = ovariectomy by implant interaction.

^c NS = Not significant.

Soft tissue carcass composition and composition of gains for grazing are shown in Table 15. There were no differences in carcass protein percent, carcass fat percent nor protein and fat daily gains between ovariectomized and intact heifers. Since there were no differences in soft tissue accretion rates, results were pooled and used to calculate compositional gains of heifers during the feedlot phase of the trial.

Feedlot Performance

Feedlot performance over the three weigh periods is shown in Table 16. Implanted heifers tended ($p < .10$) to gain more than non-implanted heifers in period one (1.35 vs 1.27 kg/d). Dry matter intakes followed the same trend with IMP heifers consuming 3.8% more ($p < .05$) feed per day than non-implanted heifers (7.49 vs 7.21 kg/d) in period one. A trend was observed in period two. However, in period three, an ovariectomy x implant interaction occurred for average daily gain ($p < .05$) and dry matter intake ($p < .01$). Average daily gains and dry matter intakes between non-implanted and implanted IN heifers were similar. However, implanted OVX heifers gained 20% more weight (.96 vs .80 kg/d) and consumed 1.05 kg more feed per day than non-implanted OVX heifers. No differences in feed efficiency were found between treatments.

An ovariectomy by implant interaction ($p < .01$) for overall average daily gains occurred (Table 17). While

TABLE 15. THE EFFECT OF OVARIECTOMY ON CARCASS
COMPOSITION OF GAIN IN CROSSBRED HEIFERS ON PASTURE

Item	INTACT	OVX	SEM ^a	Significance
No. of carcasses	6	6		
Carcass protein, %	15.4	15.2	.4	NS ^b
Carcass fat, %	22.6	23.1	.8	NS
Carcass protein gain, g/d	68.1	65.3	4.9	NS
Carcass fat gain, g/d	197.2	211.4	14.6	NS

^a Standard error of the mean.

^b NS = not significant.

TABLE 16. THE EFFECTS OF OVARIETOMY AND GROWTH PROMOTANTS
ON FEEDLOT PERFORMANCE OF CROSSBRED HEIFERS: INTERMEDIATE WEIGH PERIODS

Item	Intact			Ovariectomized			Probability ^b		
	Control	Implant		Control	Implant	SEM ^a	OVX	IMP	OVX x IMP
No. of pens	12	16		12	16				
<u>Average daily gain, kg/d</u>									
Weigh Period 1	1.29	1.31		1.24	1.39	.07	NS ^c	p<.10	NS
Weigh Period 2	1.13	1.16		.95	1.23	.10	NS	p<.05	p<.10
Weigh Period 3	.96	.94		.80	.96	.06	p<.10	NS	p<.05
<u>Dry matter intake, kg/d</u>									
Weigh Period 1	7.30	7.42		7.11	7.56	.17	NS	p<.05	NS
Weigh Period 2	8.45	8.50		7.95	8.63	.28	NS	p<.10	NS
Weigh Period 3	8.69	8.64		7.93	8.98	.26	NS	p<.05	p<.01
<u>Gain/feed</u>									
Weigh Period 1	.173	.180		.177	.181	.008	NS	NS	NS
Weigh Period 2	.136	.137		.119	.142	.012	NS	NS	NS
Weigh Period 3	.110	.107		.099	.106	.005	NS	NS	NS

^a Standard error of the mean.

^b OVX = ovariectomy; IMP = implant; OVX x IMP = ovariectomy by implant interaction.

^c NS = Not significant.

TABLE 17. THE EFFECTS OF OVARIECTOMY AND GROWTH PROMOTANTS
ON FEEDLOT PERFORMANCE OF CROSSBRED HEIFERS: OVERALL

Item	Intact		Ovariectomized		SEM ^a	Probability ^b		
	Control	Implant	Control	Implant		OVX	IMP	OVX x IMP
No. of pens	12	16	12	16				
Initial weight, kg	314.5	313.6	309.3	314.1	16.5	NS ^c	NS	NS
Final weight, kg	485.8	460.1	437.1	467.3	9.8	NS	p=.02	p<.05
Average daily gain, kg/d	1.07	1.08	.89	1.11	.05	p<.05	p<.01	p<.01
Dry matter intake, kg/d	7.99	7.99	7.46	8.27	.23	NS	p=.01	p<.01
Gain/feed	.134	.137	.121	.134	.005	p<.05	p<.05	NS

^a Standard error of the mean.

^b OVX = ovariectomy; IMP = implant; OVX x IMP = ovariectomy by implant interaction.

^c NS = Not significant.

there were no differences between IN, non-implanted and IN implanted heifers, OVX implanted heifers gained 24.7% (1.11 vs .89 kg/d) more weight than OVX non-implanted heifers. Weight gain response of non-implanted heifer is similar to previously reported studies (Dinusson et al., 1950; Kercher et al., 1960; Lunt et al., 1987). Ovariectomized IMP heifers gained similarly to IN implanted heifers. Similar results have been reported by other authors (Yamamoto et al., 1978; Rupp et al., 1980; Rush and Reece, 1981; Laudert et al., 1986; Grotelueschen et al., 1988).

An ovariectomy x implant interaction ($p < .01$) occurred for overall dry matter intake. Intakes were 10.9% greater for implanted OVX heifers than non-implanted OVX heifers (8.27 vs 7.46 kg/d), while intakes were similar for both intact groups. This suggests ovarian hormones have a positive influence on DM intakes. The results are in agreement with several studies (Perry and Horstman, 1985, 1987; Lunt et al., 1986; Laudert et al., 1987; Grotelueschen et al., 1988). It is unknown whether the ovarian effects on intake result from a direct effect on the satiety center in the brain or on indirect effect mediated through another target tissue.

Ovariectomized C heifers gained weight 10.7% less efficiently than intact C or OVX implanted heifers. The negative effects of ovariectomy on weight gains and feed efficiency appears to be mediated through depressed dry matter intake.

The lower feed efficiency in OVX heifers has been reported in other studies (Rush and Reece, 1981; Perry and Horstman, 1985, 1987; Grotelueschen et al., 1988). In all cases, OVX non-implanted heifers are the least efficient utilizers of consumed nutrients. In this study implants aided in recovering lost performance due to lack of ovarian hormones. These results are similar to other studies (Hamernik et al., 1985; Lunt et al., 1986; Laudert et al., 1987).

Carcass Characteristics

Carcass characteristics for heifers are shown in Table 18. Backfat thickness, maturity score, quality grade and yield grade determinations were similar for all treatment groups. In agreement with these results, several researchers (Rush and Reece, 1981; Saul et al., 1983; Hamernik et al., 1985) have reported similar external fat measurements between OVX and IN heifers.

Ovariectomized heifers had lower average dressing percentages (61.4 vs 62.1, $p < .001$) than IN heifers. An ovariectomy x implant interaction ($p < .01$) was found for carcass weights and liver weights. While OVX implanted heifers had 7.5% heavier carcasses (289 vs 269 kg) than OVX non-implanted heifers, there were no differences between intact heifer groups. Szumowski and Grandadam (1976) reported implanted heifers had heavier carcass weights than non-implanted heifers. Differences in carcass weights

TABLE 18. THE EFFECTS OF OVARIECTOMY AND GROWTH PROMOTANTS
ON CARCASS CHARACTERISTICS OF CROSSBRED HEIFERS

Item	Intact		Ovariectomized		SEM ^a	Probability ^b		
	Control	Implant	Control	Implant		OVX	IMP	OVX x IMP
No. of carcasses	67	87	71	83				
Carcass wt, kg	287.2	287.5	268.7	289.0	4.1	p<.05	p<.01	p<.01
Dressing %	62.00	62.22	61.20	61.59	.24	p<.001	NS ^c	NS
Bactfat, cm	1.27	1.34	1.27	1.26	.06	NS	NS	NS
Ribeye area, cm ²	80.3	80.6	74.3	79.5	1.3	p<.01	p<.05	p<.05
KPH, %	2.36	2.23	2.48	2.15	.06	NS	p<.001	NS
Maturity ^d	14.1	14.1	14.6	14.08	.4	NS	NS	NS
Marbling ^e	13.8	13.7	13.8	13.5	.1	NS	p<.01	NS
Quality grade ^f	12.0	11.9	12.2	11.8	.2	NS	NS	NS
Yield grade ^g	2.65	2.67	2.81	2.65	.10	NS	NS	NS
Liver weight, kg	5.98	6.10	5.55	6.32	.12	NS	p<.001	p<.01

^a Standard error of the mean.

^b OVX = ovariectomy; IMP = implant; OVX x IMP = ovariectomy by implant interaction.

^c NS = Not significant.

^d 14 = A; 15 = A-.

^e 13 = small minus; 14 = small average.

^f 11 = high good; 12 = low choice.

^g Yield grades were calculated from USDA equations.

parallel differences in live weight gains which are the result of increased dry matter intakes. Liver weights also parallel changes in DM intake. An ovariectomy x implant interaction ($p < .05$) occurred with respect to ribeye areas. Ribeye areas were 7.0% smaller for OVX control heifers compared to OVX implanted heifers (79.5 vs 74.3 cm²), while ribeye areas were similar for both groups of intact groups. It is of interest that intact or OVX control heifers had similar marbling scores even though live weight gains, dry matter intakes and carcass weights were lower for OVX heifers. This may suggest other factors other than metabolizable energy intake have a major impact on internal fat deposition.

Implanted heifers had lower kidney, pelvic and heart fat percentage (2.19 vs 2.42, $p < .001$) and lower marbling scores (13.6 vs 13.8, $p < .01$) than non-implanted heifers. Berende and Ruitenburg (1983) reported decreased fat deposition in steers with addition of growth promotants. In support of their observations are lower kidney, pelvic and heart fat and intramuscular fat in this trial.

Soft tissue carcass compositions and composition of gains are shown in Table 19. Carcass protein percentages were similar for all treatment groups. Ovariectomized heifers tended ($p < .10$) to have lower carcass fat content than intact heifers. Ovariectomized heifers gained less carcass fat (570.5 vs 633.0 gm/d, $p < .01$) and less carcass protein plus fat (663.6 vs 733.9, $p < .005$) than intact

TABLE 19. THE EFFECTS OF OVARIECTOMY ON GROWTH PROMOTANTS
ON CARCASS COMPOSITION OF GAIN IN CROSSBRED HEIFERS

Item	Intact		Ovariectomized		SEM ^a	Probability ^b	
	Control	Implant	Control	Implant		OVX	IMP OVX x IMP
No. of carcasses	28	31	31	26			
Carcass protein, %	13.6	13.6	13.6	13.9	.2	NS ^c	NS
Carcass fat, %	38.6	37.3	36.6	35.7	1.2	p<.10	NS
Carcass protein gain, g/d	93.5	107.4	86.4	101.3	5.8	NS	p<.005
Carcass fat gain, g/d	618.3	646.5	564.9	577.1	24.9	p<.01	NS
Carcass protein plus fat gain, g/d	711.7	753.9	651.3	678.4	26.4	p<.005	NS

^a Standard error of the mean.

^b OVX = ovariectomy; IMP = implant; OVX x IMP = ovariectomy by implant interaction.

^c NS = Not significant.

heifers. These findings relate closely to differences in dressing percentages of the two groups. Implanted heifers gained 16.5% more carcass protein (104.6 vs 89.9 gm/d, $p < .005$) than non-implanted heifers. Heitzman (1974) showed with a combination of estradiol and testosterone used in heifers caused improved protein gain.

IMPLICATIONS

In conclusion, ovariectomy does not adversely effect weight gain of heifers while grazing. A growth implant does enhance growth rates of OVX and intact heifers while grazing. If heifers are ovariectomized, implants should be used to assure adequate growth rates.

Dry matter intakes of non-implanted ovariectomized heifers were lower than other treatment groups. Consequently, weight gains and carcass fatness reflected the reduced metabolizable energy intake. Ovariectomy may be beneficial as a management technique to lessen to fat gain without sacrificing USDA quality grade or feed conversion efficiency.

CHAPTER IV

EFFECT OF OVARIECTOMY AND PUBERTAL STATUS ON GROWING AND FINISHING BEEF HEIFERS

SUMMARY

One hundred fifty-four yearling crossbred heifers (282 kg) were assigned to one of two groups according to ovarian growth and serum progesterone. The groups included: (1) pubertal (P) heifers with follicular activity and progesterone levels ≥ 1 ng/ml for two consecutive 14 d periods; and (2) prepubertal (PP) heifers with no follicular activity and no sustained progesterone levels. Heifers within pubertal status groups were randomly assigned to one of four treatments: (1) intact ovaries without implant; (2) intact ovaries with implant; (3) ovariectomized without implant; and (4) ovariectomized with implant. Heifers grazed native bluegrass pastures for 80 d before placement in a feedyard for 138 d. Feedlot phase was terminated when 70% of the heifers were evaluated to grade USDA Choice. Protein and fat accretion estimates were obtained from 9-10-11 rib section analysis from preselected cattle at slaughter. In the grazing phase, PP heifers gained 12.7% (.71 vs .63 kg/d, $p < .01$) more weight than P heifers. During the last portion of the feedlot phase, pubertal status x ovariectomy interaction occurred for ADG ($p = .07$) and feed efficiency ($p = .05$). Prepubertal intact heifers gained less

(.63 vs .70 kg/d) than PP ovariectomized heifers, while P intact heifers gained more (.72 vs .59 kg/d) than P ovariectomized heifers. Prepubertal intact heifers gained less efficiently (.079 vs .086) than PP ovariectomized heifers; while P intact heifers gained more efficiently (.086 vs .075) than P heifers. A three way interaction ($p < .05$) was found with respect to ADG in period one. A pubertal status x implant interaction ($p = .05$) occurred for dry matter intake over the entire trial. Prepubertal implanted and non-implanted heifers consumed similar amounts of feed (7.44 vs 7.31 kg/d) whereas P implanted heifers consumed .90 kg/d more (7.83 vs 6.93 kg/d) than P non-implanted heifers. A three way interaction ($p = .08$) was found with respect to overall feed efficiency. A pubertal status x implant interaction ($p < .01$) occurred for ribeye area and yield grade. Prepubertal implanted heifers had larger (83.3 vs 76.6 cm²) ribeye areas than PP non-implanted heifers. However, P implanted heifers had similar (78.8 vs 79.4 cm²) ribeye areas than P non-implanted heifers. Implants increased the yield of closely trimmed retail cuts in PP heifers to a greater extent than in P heifers. A pubertal status x implant interaction occurred for carcass protein ($p = .05$) and carcass fat content ($p < .05$). Original pubertal status of heifers has little affect on heifer feedlot performance, carcass characteristics or compositional gains.

INTRODUCTION

Ovariectomized (OVX) beef heifers do not perform as well as intact (IN) heifers while grazing (Kercher et al., 1960) or in the feedlot (Dinusson et al., 1950; Ray et al., 1969; Lunt et al., 1986); however, when OVX heifers are implanted, gains are similar to IN heifers (Lunt et al., 1986; Grotelueschen et al., 1988; Johns et al., 1988). Similar results have been obtained with dry matter intake and feed conversion.

Ovariectomy in beef heifers has not been shown to effect carcass characteristics. Carcass lean and fat measurements are similar between OVX and IN heifers fed to different endpoints (Saul et al., 1983; Hamernik et al., 1985; Lunt et al., 1986).

Plasma levels of steroid sex hormones change as animals reach sexual maturity. Plasma levels of estrogens, androgens and progesterone are higher in pubertal heifers than prepubertal heifers (Gonzalez-Padilla et al., 1975). Response of heifers to ovariectomy and growth promotants may be influenced by the initial pubertal status of the individuals.

The first objective of this study was to evaluate the effects of original pubertal status on grazing and feedlot performance, carcass characteristics and tissue accretion in beef heifers. A second objective was to evaluate the

interaction of pubertal status, ovariectomy and implants on the mentioned variables.

EXPERIMENTAL PROCEDURE

In a two year study, one hundred fifty four yearling mixed breed and crossbred heifers (282 kg) were assigned to one of two groups according to ovarian growth and serum progesterone levels. The groups were: (1) pubertal (P) heifers with follicular activity and progesterone levels ≥ 1 ng/ml for two consecutive 14 d periods; and (2) prepubertal (PP) heifers with no follicular activity and no sustained progesterone levels. Heifers were randomly assigned to one of four treatments within each pubertal status group. Treatments included (1) intact ovaries without an implant; (2) intact ovaries with an implant; (3) ovariectomized without an implant; and (4) ovariectomized with an implant.

One half of the heifers within each of the pubertal status groups were supravaginally ovariectomized. The procedure of ovariectomy is described in Chapter III. Heifers on the implant treatments received 20 mg estradiol benzoate - 200 mg testosterone propionate³ at the beginning of the pasture and finishing phases.

The first year, ninety heifers were bled by jugular veni-puncture at 14 d intervals beginning April 30. Blood samples were analyzed for progesterone by the method described by Spicer (1981). Serum progesterone levels of

≥ 1 ng/ml for two consecutive 14 d periods indicated estrus cyclicity and heifers were assigned to the pubertal group (figure 2). Heifers with progesterone levels remaining below 1 ng/ml were assigned to the prepubertal group (Figure 3). When P and PP heifer numbers were near equal (July 15), heifers were randomly assigned to ovariectomy and implant treatments. Heifers with questionable serum progesterone levels (Figure 4) were examined closely at the time of ovariectomy. At the time of ovariectomy, ovaries from OVX and intact heifers were visually inspected or rectally palpated, respectively, as the final decision on pubertal status. Final results found 53 hd pubertal and 37 hd prepubertal heifers.

After treatment assignment, heifers grazed from July 16 to September 11 (58 d). Initial and final weights were taken on two consecutive days and averaged. After the final weigh day, heifers were transported to the feedyard, processed and treatments readministered. Heifers were adjusted to finish rations in 21 d and fed ad libitum from September 17 to January 25 (130 d). Initial and final weights were taken on two consecutive days and averaged. Intermediate weights were taken every 30 days. Final weights were adjusted by dividing carcass weights by a standard 62% dress. Average daily gains and feed efficiencies were calculated using adjusted final weights. Feedlot diet and supplement are shown in Table 20.

30-Apr Period 1	12-May Period 2	27-May Period 3	13-Jun Period 4	26-Jun Period 5	15-Jul Period 6
0.27	0.26	0.37	0.12	1.24	1.10
0.28	0.53	2.90	0.41	7.10	5.30
0.51	0.40	0.21	0.63	0.65	4.80
0.50	0.43	0.11	0.31	3.90	3.30
0.50	0.43	0.11	0.31	3.90	3.30
2.50	0.32	4.25	2.13	1.53	0.70
0.34	0.33	0.14	0.08	4.70	5.60
0.00	0.38	6.83	1.69	1.50	0.45
0.50	0.34	0.10	0.07	3.26	1.80
0.19	0.36	0.18	1.42	1.28	0.60
0.62	0.47	6.30	3.30	4.60	0.46
0.10	0.16	0.22	0.02	0.52	2.30
0.21	0.15	0.43	0.56	5.28	4.10
0.24	0.16	0.23	0.54	3.75	2.50
0.17	0.13	0.18	0.15	2.35	1.20
0.07	0.80	4.31	2.60	1.25	0.60
3.31	1.19	0.22	0.22	4.30	5.60
0.07	0.59	0.43	0.52	0.73	3.10
0.43	0.09	0.38	2.93	1.15	0.55
1.02	0.17	0.47	0.53	1.13	8.40
0.56	0.33	0.22	0.27	1.01	4.96
0.11	0.21	0.10	0.21	1.11	1.60
0.09	0.20	0.15	0.52	2.09	5.10
0.08	0.36	0.59	4.93	4.93	2.80
0.38	0.15	0.07	0.23	2.24	1.00
0.42	0.13	0.09	1.53	0.33	2.80
0.28	0.15	0.07	0.23	2.24	1.00
0.50	0.35	0.40	4.30	1.71	1.16
0.43	0.11	0.11	2.40	2.73	1.10
0.26	0.32	0.13	0.67	4.47	1.10
0.11	0.20	0.17	0.28	6.86	2.60
0.40	0.20	0.11	0.17	0.89	3.70
0.67	3.43	0.78	3.63	0.69	1.80
0.56	0.37	0.22	4.00	1.41	3.60
0.61	0.18	0.15	0.29	0.55	4.70
0.15	0.49	0.28	0.37	0.63	7.10
0.46	0.29	0.29	4.93	4.02	6.10
0.16	0.31	0.88	8.01	2.30	0.60
0.26	0.13	0.17	0.25	5.14	6.70
0.64	5.32	0.84	5.95	1.00	2.20

FIGURE 2. SERUM PROGESTERONE LEVELS IN CROSSBRED
HEIFERS INDICATING PUBERTAL ACTIVITY

30-Apr Period 1	12-May Period 2	27-May Period 3	13-Jun Period 4	26-Jun Period 5	15-Jul Period 6
0.41	0.32	0.27	0.02	0.32	0.24
0.36	0.44	0.27	0.09	0.35	0.32
0.20	0.33	0.39	0.04	0.37	0.41
0.62	0.36	0.31	0.10	0.30	0.34
0.36	0.65	0.12	0.07	0.29	0.26
0.12	0.40	0.28	0.02	0.49	0.32
0.32	0.24	0.19	0.00	0.30	0.50
0.16	0.23	0.28	0.10	0.39	0.52
0.13	0.16	0.44	0.38	0.65	0.70
0.27	0.13	0.44	0.48	0.53	0.36
0.52	0.19	0.32	0.12	0.36	0.30
0.08	0.10	0.17	0.10	0.62	0.50
0.39	0.26	0.24	0.22	0.64	0.60
0.51	0.20	0.63	0.19	0.43	MISS
0.04	0.08	0.32	0.49	0.38	0.30
0.07	0.26	0.41	0.54	0.41	0.10
0.32	0.23	0.26	0.77	0.59	0.60
0.52	0.30	0.21	0.22	0.79	0.57
0.26	0.25	0.17	0.42	0.32	0.40
0.21	0.31	0.30	0.62	0.79	0.50
0.13	0.19	0.16	0.49	0.41	MISS
0.17	0.20	0.08	0.37	0.40	0.20
0.09	0.21	0.28	0.40	0.59	0.26
1.00	0.13	0.16	0.33	0.32	0.23
0.35	0.07	0.25	0.31	0.34	0.14
0.23	0.07	0.18	0.59	0.45	0.61
0.38	0.22	MISS	2.16	0.52	0.29
0.11	0.37	0.26	0.53	0.39	0.39
0.10	0.33	0.12	0.18	0.93	0.39
0.40	0.28	0.16	0.17	0.37	0.70
0.19	0.15	0.06	0.21	0.53	0.30
0.28	0.21	0.11	0.29	0.46	0.20
0.17	0.36	0.11	0.44	0.49	0.40
0.42	0.58	0.12	0.42	1.18	0.60
0.18	0.42	0.09	0.44	0.49	0.40
0.32	0.47	0.14	0.33	0.82	0.45
0.56	0.51	0.15	0.42	0.85	0.30
0.21	0.91	0.24	0.36	0.67	0.50
0.26	0.35	0.17	0.21	0.46	0.30

FIGURE 3. SERUM PROGESTERONE LEVELS IN CROSSBRED HEIFERS INDICATING LACK OF PUBERTAL ACTIVITY

30-Apr Period 1	12-May Period 2	27-May Period 3	13-Jun Period 4	26-Jun Period 5	15-Jul Period 6
0.42	0.82	7.44	3.37	0.73	0.60
0.53	0.28	0.29	1.10	0.57	0.82
0.65	0.54	0.36	0.05	1.02	MISS
0.41	0.07	0.25	0.38	0.48	1.99
0.45	0.25	0.27	1.30	0.69	0.53
0.11	0.28	0.09	0.39	0.66	1.80

FIGURE 4. SERUM PROGESTERONE LEVELS IN CROSSBRED
HEIFERS WITH QUESTIONABLE PUBERTAL ACTIVITY

TABLE 20. EXPERIMENTAL FINISHING DIET^{a b}

Feed Ingredient	Percent in diet
High moisture corn	80.0
Corn silage	15.0
Soybean meal	2.5
Limestone	1.2
Corn	.6
Potassium chloride	.36
Selenium 90	.06
Vitamin A premix	.008
Vitamin D premix	.01
Rumensin 60	.024
Iodized salt	.25

^a Diet formulated to provide 11% crude protein, .5% Ca, .35% P, .7% K, NE_g=1.2 Mcal/kg DM, .1 ppm Se. Rumensin 60 was added to provide .62 mg of monensin/kg of diet.

^b Dry matter basis.

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Heifers (64 hd) from the second year were rectally palpated and assigned to pubertal status groups on the basis of ovary size and structures. Heifers with ovaries with a corpus luteum and many active follicles on either ovary were pubertal and heifers with ovaries with little follicular activity and no corpus luteum were prepubertal. Other pubertal status groups were established, heifers within each group were randomly assigned to an intact or ovariectomized treatment group. Ovaries from OVX heifers were visually inspected as a final decision on pubertal status. Final results showed 38 hd pubertal and 47 hd prepubertal.

Heifers grazed northern Michigan pastures from June 1 to September 3 (94 d). After the final weigh date, heifers were transported to the feedyard, processed and treatments readministered. Heifers were adjusted to the finish ration in 21 d and fed ad libitum from September 9 to February 2 (146 d). The diet and supplement (Table 20) were the same as the first year. Initial and final weights were taken on two consecutive days and averaged for both the grazing and feedlot phases. Intermediate weights were taken every 30 d. Final weights were adjusted to a standard 62% dress. Average daily gains and feed efficiencies were calculated using adjusted final weights.

At the beginning of the feedlot phase in each year, initial kill groups were slaughtered and carcass information was collected to establish initial carcass composition for later tissue accretion analysis. Heifers selected for

initial kill groups were nearest respective group average weight. Heifers in both years were slaughtered when 70% of each groups were estimated to meet specifications for USDA Choice quality grade. Heifers were transported 115 km to the slaughter plant and slaughtered within 150 min after departure from the feedyard.

Carcass data was collected after carcasses were chilled for 24 h. Whole left side rib sections from representatives of treatment groups were removed and transported in plastic Michigan State University Meat Laboratory. The 9-10-11 rib section was obtained from the whole rib and soft tissue was prepared and analyzed for percentage moisture and protein as described in Chapter III. Percentage fat was determined by ether extraction of triplicate samples using a Soxhlet apparatus (AOAC, 1984). Accretion rates of carcass soft tissue were calculated using the equation shown in Figure 1, Chapter III.

Results from the two years were combined and analyzed. No two or three way interactions occurred with respect to year. Consequently, year was not a variable in the model. Feedlot data were analyzed on a pen replicate basis, while other data were analyzed on an individual heifer basis. Since ovariectomy and implant effects were part of the pooled results discussed in only the main effects and interactions involving Chapter III, pubertal status are discussed in this chapter.

Statistical analyses were conducted with the General Linear Model subroutine of SAS (1982). Orthogonal contrasts were conducted to analyze pubertal status main effects, pubertal status x ovariectomy interaction, pubertal status x implant interaction, and pubertal status x ovariectomy x implant interaction.

RESULTS AND DISCUSSION

Grazing Performance

For the grazing phase, initial weights for P heifers were 11 kg (270.1 vs 281.1 kg, $p=.01$) heavier than PP heifers (Table 21). It would seem reasonable to assume heifers in the pubertal group were older and consequently, weighed more. Therefore, analysis of the treatment effects was performed with initial weight as a covariate. Ovariectomized (OVX) and intact (IN) heifers performed similarly on grass. Prepubertal heifers gained 12.7% (.71 vs .63 kg/d, $p<.01$) more weight than P heifers.

Feedlot Performance

Pubertal heifers weighed 10.4 kg more than (319.2 vs 308.8 kg, $p<.01$) P heifers at the beginning of the feedlot phase. Therefore, analysis of the treatment effects was performed with initial weight as a covariate. Final weights and overall average daily gains were similar between treatment groups. However, a pubertal status x ovariectomy interaction ($p=.07$) occurred for average daily gain in the

TABLE 21. THE EFFECTS OF PUBERTAL STATUS, OVARIECTOMY AND GROWTH PROMOTANTS ON GRAZING PERFORMANCE OF CROSSBRED HEIFERS

Item	Prepubertal				Pubertal				Probability ^a			
	Intact		Ovariectomized		Intact		Ovariectomized		Pub		PubxOVX PubxImp PxOxI	
	Control	Implant	Control	Implant	Control	Implant	Control	Implant	SEM ^b			
No. of heifers	18	17	17	17	21	21	21	22				
Initial wt, kg	275.1	270.7	267.8	266.6	279.0	281.4	281.7	282.1	6.5	p=.01	NS	NS
Final wt, kg	329.8	331.4	327.9	340.9	327.3	327.2	322.8	331.2	8.3	p<.01	NS	NS
Average daily gain, kg/d	.67	.70	.64	.83	.64	.64	.56	.69	.12	p<.01	NS	NS

^a Standard error of the mean.

^b Pub = Pubertal status; PubxOVX = Pubertal status by ovariectomy interaction; PubxImp = Pubertal status by implant interaction; PxOxI = Pubertal status by ovariectomy by implant interaction.

^c NS = Not significant.

third period (Table 23). Prepubertal IN heifers gained less (.63 vs .70 kg/d) than prepubertal OVX heifers, while pubertal IN heifers gained more (.72 vs .59 kg/d) than pubertal OVX heifers. A pubertal status x ovariectomy interaction ($p=.05$) was found for feed efficiency in the third period. Prepubertal intact heifers gained less efficiently (.079 vs .086) than prepubertal OVX heifers; while pubertal IN heifers gained more efficiently (.086 vs .075) than pubertal OVX heifers. A pubertal status x ovariectomy x implant interaction ($p<.05$) occurred in period one for average daily gain.

There were no differences between treatments with respect to dry matter intake during the various periods of the finishing phase. However, a pubertal status x implant interaction ($p=.05$, Table 22) for total dry matter intake was observed. Prepubertal implanted and non-implanted heifers consumed similar amounts of feed (7.44 vs 7.31 kg/d) whereas, pubertal IMP heifers consumed .90 kg more (7.83 vs 6.93 kg/d) than pubertal non-implanted heifers.

A pubertal status x implant interaction ($p<.05$) occurred in period two with respect to feed efficiency (Table 23). Prepubertal non-implanted gained less efficiently (.106 vs .126) than prepubertal IMP heifers. However, pubertal non-implanted heifers gained more efficiently (.127 vs .119) than pubertal IMP heifers. Over the entire finishing phase, a pubertal status x ovariectomy

TABLE 22. THE EFFECTS OF PUBERTAL STATUS, OVARIECTOMY AND GROWTH
PROMOTANTS ON FEEDLOT PERFORMANCE OF CROSSBRED HEIFERS: TOTAL WEIGH PERIOD

Item	Prepubertal				Pubertal				Probability ^b			
	Intact		Ovariectomized		Intact		Ovariectomized		Pub		PubxOVX PubxImp	
	Control	Implant	Control	Implant	Control	Implant	Control	Implant	SEM ^a			PxOxI
No. of pens	4	4	4	4	4	4	4	4				
Initial wt, kg	311.9	309.1	297.2	316.9	319.2	321.8	317.6	318.2	5.2	p<.01	NS	NS
Final wt, kg	464.5	451.8	446.2	471.3	446.2	473.0	439.7	467.2	8.4	NS	NS	NS
Average daily gain, kg/d	1.10	1.01	.88	1.13	1.00	1.16	.86	1.06	.06	NS	NS	NS
Dry matter intake, kg/d	7.66	7.14	6.97	7.75	7.41	7.98	6.45	7.68	.26	NS	p=.05	NS
Gain/feed	.144	.143	.127	.146	.135	.145	.133	.139	.004	NS	NS	p=.08

^a Standard error of the mean.

^b Pub = Pubertal status; PubxOVX = Pubertal status by ovariectomy interaction; PubxImp = Pubertal status by implant interaction; PxOxI = Pubertal status by ovariectomy by implant interaction.

^c NS = Not significant.

TABLE 23. THE EFFECTS OF PUBERTAL STATUS, OVARIECTOMY AND GROWTH PROMOTANTS
ON FEEDLOT PERFORMANCE OF CROSSBRED HEIFERS: INTERMEDIATE WEIGH PERIODS

Item	Prepubertal				Pubertal				Probability ^a			
	Intact		Ovariectomized		Intact		Ovariectomized		Pub		PubxOVX PubxImp	
	Control	Implant	Control	Implant	Control	Implant	Control	Implant	SE ^b	SEM ^c	Pub	PxOxI
No. of pens	4	4	4	4	4	4	4	4				
Average daily gain, kg/d												
Weigh period 1	1.44	1.32	1.25	1.49	.130	1.59	1.24	1.46	.07	NS ^c	NS	p<.05
Weigh period 2	.97	1.06	.81	1.16	.99	1.03	.93	1.05	.11	NS	NS	NS
Weigh period 3	.72	.54	.67	.72	.72	.71	.47	.71	.07	NS	p=.07	NS
Dry matter intake, kg/d												
Weigh period 1	7.27	6.71	6.41	7.23	7.24	7.46	6.40	7.24	.20	NS	NS	NS
Weigh period 2	8.77	8.32	7.85	9.20	8.13	8.79	7.11	8.64	.41	NS	NS	NS
Weigh period 3	8.25	7.62	7.67	8.39	8.08	8.64	6.91	8.47	.42	NS	NS	NS
Gain/feed												
Weigh period 1	.199	.198	.197	.206	.179	.215	.194	.202	.008	NS	NS	p<.10
Weigh period 2	.109	.127	.102	.125	.122	.117	.131	.121	.009	NS	NS	NS
Weigh period 3	.087	.070	.086	.086	.090	.082	.065	.084	.007	NS	p=.05	NS

^a Standard error of the mean.

^b Pub = Pubertal status; PubxOVX = Pubertal status by ovariectomy interaction; PubxImp = Pubertal status by implant interaction; PxOxI = Pubertal status by ovariectomy by implant interaction.

^c NS = Not significant.

x implant interaction ($p=.08$) for feed efficiency was observed.

Carcass Characteristics

Carcass weights, dressing percents, kidney, pelvic and heart fat percents, maturity, marbling and quality grades were similar between treatment groups (Table 24). A pubertal status x ovariectomy x implant interaction ($p<.05$) occurred with respect to backfat. Pubertal ovariectomized heifers had more KPH than pubertal intact heifers. Implants reduced KPH in prepubertal, intact. A pubertal status x implant interaction ($p<.01$) occurred with respect to ribeye areas. Prepubertal IMP heifers had larger (83.3 vs 76.7 cm²) ribeye areas than prepubertal non-implanted heifers. However, pubertal implanted heifers had similar (78.8 vs 79.4 cm²) ribeye areas compared to pubertal non-implanted heifers. Implants increased for yield of closely trimmed retail cuts (yield grade) in prepubertal heifers to a greater extent than in pubertal heifers ($p<.01$).

Compositional Gain

Soft tissue carcass composition and composition of gain is shown in Table 25. Daily carcass protein and protein plus fat accretions were similar between treatment groups. A pubertal status x implant interaction ($p=.05$) was found for carcass protein and fat content. Prepubertal

TABLE 24. THE EFFECTS OF PUBERTAL STATUS, OVARIETOMY AND GROWTH PROMOTANTS ON CARCASS CHARACTERISTICS OF CROSSED HEIFERS

Item	Prepubertal				Pubertal				Probability ^a			
	Intact		Ovariectomized		Intact		Ovariectomized		Pub		PubxOVX PubxImp	
	Control	Implant	Control	Implant	Control	Implant	Control	Implant	SEM ^b			PxOxi
No. of carcasses	16	16	15	14	17	17	19	21				
Carcass wt, kg	288.3	280.3	265.3	290.1	281.6	291.0	261.6	287.1	7.5	NS ^c	NS	NS
Dressing %	62.7	63.1	61.9	62.2	61.7	62.1	61.5	61.4	.4	NS	NS	NS
Backfat %	1.42	1.09	1.19	1.21	1.09	1.26	1.42	1.34	.10	NS	p<.10	p<.05
Ribeye area, cm ²	75.9	83.0	77.5	83.7	80.8	80.2	77.9	77.4	1.7	NS	NS	NS
KPH %	2.26	2.03	2.48	1.99	2.49	2.21	2.34	2.12	.13	NS	NS	NS
Maturity ^d	14.1	13.7	14.0	13.4	14.0	13.6	14.1	13.5	.2	NS	NS	NS
Marbling ^e	13.8	12.9	15.0	13.3	14.7	13.3	15.3	13.4	.7	NS	NS	NS
Quality grade ^f	11.9	11.3	12.4	11.2	12.4	11.5	12.5	11.4	.4	NS	NS	NS
Yield grade ^g	2.95	2.22	2.69	2.31	2.42	2.57	2.87	2.77	.16	NS	p<.10	p=.01

^a Standard error of the mean.

^b Pub = Pubertal status; PubxOVX = Pubertal status by ovariectomy interaction; PubxImp = Pubertal status by implant interaction; PxOxi = Pubertal status by ovariectomy by implant interaction.

^c NS = Not significant.

^d 14 = A; 15 = A-.

^e 13 = small minus; 14 = small average.

^f 11 = high good; 12 = low choice.

^g Yield grades were calculated from USDA equations.

TABLE 25. THE EFFECTS OF PUBERTAL STATUS, OVARIECTOMY AND GROWTH PROMOTANTS ON CARCASS COMPOSITION AND COMPOSITION OF GAIN IN CROSSBRED HEIFERS

Item	Prepubertal				Pubertal				Probability ^a		
	Intact		Ovariectomized		Intact		Ovariectomized		Pub	PubxOVX	PubxImp
	Control	Implant	Control	Implant	Control	Implant	Control	Implant			
No. of carcasses	8	8	8	8	9	9	9	9			
Carcass protein, %	13.5	14.3	13.8	14.0	14.2	13.7	13.9	13.9	NS ^c	NS	P=.05
Carcass fat, %	40.1	36.1	38.1	35.8	37.3	40.3	37.4	36.7	NS	NS	P<.05
Carcass protein gain, g/d	84.2	100.2	76.5	91.3	92.7	90.5	72.9	82.8	NS	NS	NS
Carcass fat gain, g/d	689.6	588.2	581.3	580.6	629.6	690.5	580.4	582.3	NS	NS	P<.10
Carcass protein plus fat gain, g/d	773.8	688.3	657.7	671.9	722.3	781.0	653.3	665.1	NS	NS	NS

^a Standard error of the mean.

^b Pub = Pubertal status; PubxOVX = Pubertal status by ovariectomy interaction; PubxImp = Pubertal status by implant interaction; PxOxI = Pubertal status by ovariectomy by implant interaction.

^c NS = Not significant.

non-implanted heifers had less (13.7 vs 14.2%) carcass protein than prepubertal IMP heifers. Conversely, pubertal non-implanted heifers had more (14.1 vs 13.8%) carcass protein than pubertal IMP heifers. Prepubertal non-implanted heifers had more carcass fat (39.1 vs 35.9%) than PP implanted heifers whereas, pubertal non-implanted and implanted heifers had similar carcass fat (37.4 vs 38.5%). Daily carcass fat accretions tended ($p < .10$) to follow trends observed with carcass fat content. Prepubertal non-implanted heifers gained more daily carcass fat (635 vs 584 gm/d) than prepubertal IM heifers. However, pubertal non-implanted and implanted heifers gained similar carcass fat (605 vs 636 gm/d).

CONCLUSIONS

Prepubertal heifers outgained pubertal heifers while grazing, but this advantage was not carried over to the feedlot. Pubertal status x ovariectomy and pubertal status x implant interactions occurred in feedlot performance and were carried over to carcass characteristics and carcass gains. Based on these findings, original pubertal status of heifers does not seem to affect heifer performance or carcass composition.

Further studies may need to focus on pubertal status of heifers destined for ovariectomy. Intact heifers had a chance to become pubertal after assigning heifers to a

pubertal status treatment group. However, once heifers are ovariectomized, heifers designated prepubertal never have a chance to reach puberty and growth responses of exogenous hormones may affect them differently than heifers allowed to reach puberty.

CHAPTER V

RECOMMENDATIONS

Findings from this series of experiments suggest that ovariectomized heifers given a growth implant gain weight similarly to intact implanted heifers while grazing and while fed in a confinement system. Ovariectomized non-implanted heifers consumed less feed, gained less live-weight and carcass weight than intact non-implanted. Ovariectomized heifers gained less carcass fat, and had lower dressing percentages, than intact heifers, but had carcasses similar in quality.

Further studies should focus on serum hormone concentrations of ovariectomized heifers and relate hormone levels to growth rates, growth efficiencies and composition of carcass gains. Another question that must be answered is why do ovariectomized non-implanted heifers consume less than implanted and intact counterparts? Do sex steroid hormones have direct or indirect effects on satiety centers of the brain or do they trigger other mediators?

An important question which relates to an applied view is, how does ovariectomizing heifers fit into different management schemes. Economic breakdowns should be calculated for several management situations and several locations around the country. If there is no economic gain

for ovariectomizing heifers, then there is little need for further applied research in this area.

The question of whether heifers ovariectomized prepubertally perform differently than those ovariectomized after puberty is still not answered. More emphasis should be put on ovariectomized heifers. Intact heifers, though prepubertal at the beginning of an experiment, eventually become pubertal and hormonal changes occur. It would be interesting to know changes in blood hormones of ovariectomized heifers through growing and finishing phases and apply the information for developing an implant designed explicitly for ovariectomized heifers.

APPENDIX A

COLLATERAL STUDY I

APPENDIX A
COLLATERAL STUDY I

TWO MANAGEMENT SCHEMES FOR GROWING BEEF HEIFERS

SUMMARY

One hundred ninety yearling crossbred heifers (227 kg) were divided into two management groups: stockers (ST; 144 hd) and initial feedlot (IF; 36 hd). Stocker heifers were assigned to native bluegrass pastures and IF heifers were placed in the feedyard. After grazing (147 d), stockered heifers were placed in the feedyard. Feedlot finishing diets consisted of 80% high moisture corn, 15% corn silage and 5% supplement. The trial was terminated when 70% of the heifers were evaluated to grade USDA Choice quality grade. Protein and fat accretion estimates were obtained from 9-10-11 rib section analysis from preselected cattle initially, post-grazing and at slaughter. Weight gains for stocker and IF heifers were similar in the feedlot; however, ST heifers had 7.11% (9.19 vs 8.58 kg/d, $p < .05$) greater dry matter intakes than IF heifers. Initial feedlot heifers had 5.8% (79.0 vs 74.7 cm², $p < .05$) larger ribeye areas, more (p < .01) KPH fat and lower (p < .01) yield grades than ST heifers. Stocker heifers had more carcass fat (p < .01) and gained more (p < .01) carcass fat per day than IF heifers. Results from this study show stockered heifers perform similarly in the feedyard to heifers sent directly

to the feedlot. These two groups appear to have similar carcass characteristics.

EXPERIMENTAL PROCEDURE

One hundred ninety yearling crossbred heifers (227 kg) were utilized to evaluate the effects of management system on rate, efficiency and composition of gain and carcass characteristics. Heifers were divided into two management groups such that body type and weight were similar. One group [stocker (ST), 144 hd] was allowed to graze for 147 days before placement into the feedlot and the second group [initial feedlot (IF), 36 hd] was placed directly into the feedlot. Ten heifers were randomly selected to serve as an initial slaughter group.

Stocker heifers were placed at two locations on northern Michigan pastures (location 1: 96 hd, location 2: 48 hd). Pastures are previously described in Chapter III. Initial feedlot heifers were originally housed in a partially covered facility with a solid concrete floor for 90 d, then moved to a slotted floor facility with 5.2 m²/animal.

Stocker heifers grazed from May 17 to October 11 (147 d). Weights were taken every 30 d. After the final weigh day, heifers were transported to the feedlot. Stocker heifers were fed from October 24 to January 18 (86 d). The diet and supplement for these heifers are shown in Table 26.

TABLE 26. EXPERIMENTAL FINISHING DIET^{a b}

Feed Ingredient	Percent in diet
High moisture corn	80.0
Corn silage	15.0
Ground corn	3.5
Soybean meal	.9
Trace Mineral Salt	.45
Selenium 200	.045
Vitamin A premix	.007
Vitamin D premix	.003
Rumensin 60	.025

- ^a Ration formulated to provide 11% crude protein, .5% Ca, .35% P, .7% K, NE^g=1.2 Mcal/kg DM, and .1 ppm Se. Rumensin 60 was added to provide .62 mg of monensin/kg of diet.
- ^b Dry matter basis.

Two diets were given to IF heifers. The first, shown in Table 27, was a growing diet, fed from May 17 to August 28. Finish was similar for IF and ST groups (Table 26). Both groups of heifers were fed ad libitum once daily. Weights were taken every 30 days at which time refused feed was collected and weighed. Groups were slaughtered when 70% achieved USDA Choice quality grade. Initial and final weights were taken on two consecutive days and averaged. Adjusted final weights were obtained by dividing carcass weights by a standard 62% dress. Adjusted final weights were used to calculate feedlot performance.

Carcass data collection and procedures for carcass protein and fat analysis is described in Chapter III. The same statistical analyses used in Chapter III were used to analyze this data set.

RESULTS AND DISCUSSION

Results of Stocker Program

Feedlot performance for the initial feedlot and stocker heifers are shown in Table 28. Initial and final weights for the two groups differed ($p < .05$). The difference was due to body weight gains by stockered heifers before entering the feedlot. Average daily gains and feed efficiencies were similar for the two groups. Stockered heifers consumed 7.11% (9.19 vs 8.58 kg, $p < .05$) more feed than initial feedlot heifers.

TABLE 27. EXPERIMENTAL GROWING DIETS FED TO
INITIAL FEEDLOT HEIFERS^{a b}

Feed Ingredient	Percent in diet
High moisture corn	55.0
Corn silage	40.0
Ground corn	3.55
Soybean meal	.91
Trace Mineral Salt	.45
Selenium 200	.045
Vitamin A premix	.007
Vitamin D premix	.008
Rumensin 60	.041

- ^a Ration formulated to provide 11.5% crude protein, .44% Ca, .24% P, .7% K, NE^g=1.09 Mcal/kg DM, and .1 ppm Se. Rumensin 60 was added to provide .62 mg of monensin/kg of diet.
- ^b Dry matter basis.

TABLE 28. THE EFFECT OF MANAGEMENT SYSTEM ON
FEEDLOT PERFORMANCE OF CROSSBRED HEIFERS

Item	Initial Feedlot	Stockers	SEM ^a
No. of pens	6	18	
Days in stocker program	0	159	
Days in feedlot	165	86	
Total days	165	245	
Initial weight, kg	220.7	341.9*	3.20
Final weight, kg	421.5	457.0*	4.68
Average daily gain, kg	1.12	1.16	.03
Feed DM intake, kg	8.58	9.19*	.21
Gain/feed	.130	.126	.003

*Different from initial feedlot group ($p < .05$).

^aStandard error of the mean.

Stocker heifers were expected to consume more feed and gain at a faster rate than initial feedlot heifer, because of heavier weights upon entry into the feedlot and greater GIT volume. Adjustment of weight gain to a common dressing percent, suggests placement of heifers directly into a feedlot or onto pasture before the feedlot have similar weight and feed conversion efficiency.

Table 29 summarizes carcass characteristics of initial feedlot and stockered heifers. Dressing percent, backfat thickness, marbling scores and quality grade were similar between the two groups. Stocker heifers had heavier ($p < .01$) carcass weights than initial feedlot heifers. This result was expected from the differences in final body weights. However, the difference in ribeye areas between the two groups was not expected. Initial feedlot heifers had 5.8% (79.0 vs 74.7 cm², $p < .05$) larger ribeye areas than ST heifers. Kidney, pelvic and heart fat percent was lower ($p < .01$) for ST heifers. Maturity scores were lower ($p < .01$) for initial feedlot heifers, indicating more mature carcasses. Fewer numbers of initial feedlot heifers and a few heifers with very low maturity scores may have skewed the data enough to cause this difference. Initial feedlot heifers had 15.1% (2.45 vs 2.94, $p < .05$) lower yield grades than ST heifers. This difference was probably due to larger ribeye areas and numerically less backfat in IF heifers.

Carcass composition and compositional gains of IF and ST heifers are shown in Table 30. Carcass protein content

TABLE 29. THE EFFECT OF MANAGEMENT SYSTEM ON
CARCASS MEASUREMENTS OF CROSSBRED HEIFERS

Item	Initial Feedlot	Stockers	SEM ^a
No. of carcasses	36	104	
Carcass weight, kg	256.0	273.0	5.25
Dressing %	61.7	61.2	.3
Backfat, cm	1.25	1.33	.09
Ribeye area, cm ²	79.0	74.7**	1.9
KPH %	2.50	2.20*	.09
Maturity ^b	13.1	13.9*	.6
Marbling ^c	15.2	14.3	.1
Quality grade ^d	12.3	11.9	.3
Yield grade ^e	2.45	2.82**	.16

*Different from initial feedlot group ($p < .01$).

**Different from initial feedlot group ($p < .05$).

^aStandard error of the mean.

^b13=A+; 14=A.

^c14=small average; 15=small plus.

^d12=low choice; 13=average choice.

^eYield grades calculated from USDA equations.

TABLE 30. THE EFFECT OF MANAGEMENT SYSTEM ON CARCASS
COMPOSITION AND COMPOSITIONAL GAIN IN CROSSBRED HEIFERS

Item	Initial Feedlot	Stockers	SEM ^a
No. of carcasses	24	24	
Carcass protein, %	13.6	13.5	.2
Carcass fat, %	33.9	36.9*	.80
Carcass protein gain, g/d	113.1	110.3	6.6
Carcass fat gain, g/d	601.6	684.5	22.4
Carcass protein + fat gain, g/d	714.7	794.8**	25.1

*Different from initial feedlot group ($p < .01$).

**Different from initial feedlot group ($p < .05$).

^aStandard error of the mean.

and grams of carcass protein gained per day were similar between the two groups. Stocker heifers had 8.8% (36.9 vs 33.9%, $p < .01$) more carcass fat than IF heifers. Grams of carcass fat and protein plus carcass fat gained per day were greater for ST heifers. Stocker heifers accreted 13.8% (684.5 vs 601.6 gm/d, $p < .01$) more carcass fat and 11.2% (794.8 vs 714.7 gm/d, $p < .01$) more carcass protein plus fat than IF heifers. The carcass gain differences between groups reflect differences in yield grades between groups.

In conclusion, the decision whether to allow heifers to graze before entering the feedlot would depend on availability of grazing land, feed resources, expected slaughter prices, cost of gain and target weight of carcasses. Since performance in the weight gain adjusted to a common dressing percentage and carcass quality were similar for ST and IF heifers the producer should consider other factors to determine the type of management scheme for a given group of cattle.

APPENDIX B

COLLATERAL STUDY II

APPENDIX B

COLLATERAL STUDY II

EFFECT OF PUBERTAL STATUS AND GROWTH PROMOTANTS ON PERFORMANCE OF OVARIECTOMIZED GROWING BEEF HEIFERS

SUMMARY

Forty Simmental and Charolais yearling crossbred heifers (308 kg) were ovariectomized when pubertal (P) and prepubertal (PP) groups were estimated to be equally represented, based on rectal ovary palpation. Heifers with active follicles and distinct corpora lutea were classified as pubertal and heifers with little follicular activity and no corpora lutea were termed prepubertal. Heifers grazed northern Michigan pastures for 100 d. In the feedlot, half of the heifers in each group received 20 mg estradiol benzoate - 200 mg testosterone propionate implants. Heifers were fed a finishing diet consisting of 80% high moisture corn, 15% corn silage and 5% supplement for 148 d. The trial was terminated when 70% of heifers were evaluated to grade USDA Choice. Protein and fat accretion estimates were obtained from 9-10-11 rib section analysis from preselected heifers at slaughter. In the grazing study, prepubertal heifers gained 23.3% (.74 vs .60 kg/d, $p < .01$) more weight than P heifers. In the feedlot, pubertal heifers gained 7.8% (1.10 vs 1.02 kg/d, $p = .06$) more weight than PP heifers. Implanted heifers had lower ($p < .05$) dressing percentages than non-implanted heifers. Pubertal heifers had .35 cm (1.33 vs .98 cm, $p < .05$) more backfat than PP heifers. A

pubertal status by implant interaction ($p < .05$) occurred for marbling scores and quality grades. Pubertal heifers gained 10.1% (706.9 vs 641.9 g/d, $p < .05$) more protein plus fat than PP heifers. Results of this study suggest though prepubertal status may enhance weight gain of grazing ovariectomized heifers, however, the advantage was not observed in the feedlot. In the feedlot it may affect them in an opposite manner. While performance of pubertal heifers was lower while grazing, live-weight and carcass gains were greater in the feedlot.

EXPERIMENTAL PROCEDURE

Forty Simmental and Charolais yearling crossbred heifers (308 kg) were ovariectomized when pubertal (P) and prepubertal (PP) groups were estimated equally represented, based on rectal ovary palpation. Pubertal status was established at the time of ovariectomy. Heifers with ovaries with active follicles and/or corpora lutea were termed pubertal and heifers with ovaries with little follicular activity were termed prepubertal. Heifers grazed northern Michigan pastures from May 5 to August 13 (100 d). After the final day of the grazing phase, heifers were transported to the feedlot. Half of the heifers within each pubertal status group received 20 mg estradiol benzoate - 200 mg testosterone propionate implants.³ Heifers were adjusted to a finishing diet and fed ad libitum from August 17 to January 12 (148 d). The diet and supplement

(Table 26) are the same as those in appendix A. Initial and final weights were taken on two consecutive days and averaged for both the grazing and feedlot phases. Intermediate weights were taken every 30 d. Adjusted final weights were corrected to a standard 62% dress. Feedlot performance was calculated using adjusted final weights.

Heifers were slaughtered when 70% of the heifers were estimated to meet requirements for USDA Choice quality grade. Protein and fat accretion estimates were obtained from 9-10-11 rib section analysis previously described in Chapter III.

RESULTS AND DISCUSSION

Table 31 shows results of the grazing phase. Initial weights of pubertal and prepubertal heifers were not significantly different, however, P heifers had numerically higher (313 vs 302 kg) initial weights than PP heifers. This is similar to the finding in Chapter III. Prepubertal heifers gained 23.3% (.74 vs .60 kg/d, $p < .01$) more weight than P heifers. The results are in agreement with results presented in Chapter III.

Table 32 summarizes the results of heifer pubertal status at time of ovariectomy on feedlot performance. Pubertal status of OVX heifers appeared to have no effect on feedlot performance. Implanted heifers had numerically heavier (522 vs 504 kg) final weights than non-implanted

TABLE 31. THE EFFECT OF PUBERTAL STATUS ON GRAZING
PERFORMANCE OF OVARIECTOMIZED CROSSBRED HEIFERS

Item	Prepubertal	Pubertal	SEM ^a
No. of heifers	20	20	
Initial weight, kg	302	313.2	6.6
Final weight, kg	375.8	373	6.3
Average daily gain, kg/d	.74	.60*	.03

*Different from prepubertal group ($p < .01$).

^a Standard error of the mean.

TABLE 32. THE EFFECTS OF PUBERTAL STATUS AND GROWTH PROMOTANTS ON
FEEDLOT PERFORMANCE OF OVARIECTOMIZED CROSSBRED HEIFERS

Item	Prepubertal		Pubertal		SEM ^a	Probability ^b	
	Control	Implant	Control	Implant		PS	IMP PS x IMP
No. of pens	2	2	2	2			
Initial weight, kg	347.6	353.9	353.6	342.8	9.5	NS ^c	NS
Final weight, kg	500	524	507.6	520.7	15.0	NS	NS
Average daily gain, kg/d	.96	1.07	1.09	1.11	.04	p=.06	NS
Dry matter intake, kg/d	6.66	7.50	7.52	7.31	.62	NS	NS
Gain/feed	.144	.142	.145	.154	.01	NS	NS

^a Standard error of the mean.

^b PS = pubertal status; IMP = implant; PS x IMP = pubertal status by implant interaction.

^c NS = Not significant.

heifers. Pubertal heifers gained 7.8% (1.10 vs 1.02 kg/d, $p=.06$) more weight than prepubertal heifers. This may be due to compensatory gains of pubertal heifers after leaving pasture conditions. Dry matter intakes and feed efficiencies were similar between all treatment groups.

Table 33 summarizes the carcass information from the 40 heifers. Carcass weights, ribeye areas, KPH fat, maturity scores and yield grades were similar between all treatment groups. Implanted heifers had lower dressing percentages (61.3 vs 62.5%, $p<.05$) than non-implanted heifers. Pubertal heifers had .35 cm (1.33 vs .98 cm, $p<.05$) greater backfat than PP heifers. This difference in backfat did not cause significant differences in yield grades, however the average yield grade for P heifers was close to three, while the average yield grade for PP heifers was 2.72. A pubertal status by implant interaction ($p<.05$) existed for marbling scores and quality grades. Implants increased intramuscular fat in prepubertal heifers and decreased intramuscular fat in pubertal heifers.

Carcass composition and composition of gain of heifers are summarized in Table 34. Carcass protein and fat percentages were similar between all treatment groups. Pubertal heifers had numerically higher (118.9 vs 108.1 g/d) carcass protein gain and numerically higher (588.1 vs 533.6 kg/d) carcass fat gain than PP heifers. Pubertal heifers gained 10.1% (706.9 vs 641.9 g/d, $p<.05$) more carcass protein plus fat than PP heifers. Carcass protein

TABLE 33. THE EFFECTS OF PUBERTAL STATUS AND GROWTH PROMOTANTS ON CARCASS CHARACTERISTICS IN OVARIECTOMIZED CROSSBRED HEIFERS

Item	Prepubertal				Pubertal				Probability ^b			
	Control	Implant	Control	Implant	Control	Implant	SEM ^a	PS	IMP	PS x	IMP	IMP
No. carcasses	8	8	8	8	8	8						
Carcass wt, kg	303.5	317	313.6	314.2	314.2	314.2	10.1	NS ^c	NS			NS
Dressing %	62	61.1	63	61.	61.	61.	5.5	NS	p<.05			NS
Backfat, cm	.91	1.06	1.25	1.41	1.41	1.41	.15	p<.05	NS			NS
Ribeye area, cm ²	76.4	78.5	80.2	81.3	81.3	81.3	2.9	NS	NS			NS
KPH %	2.5	2.56	2.56	2.88	2.88	2.88	.18	NS	NS			NS
Maturity ^d	13.9	13.8	13.9	13.8	13.8	13.8	.15	NS	NS			NS
Marbling ^e	13.9	15.4	16.9	13.6	13.6	13.6	1.0	NS	NS			p<.05
quality grade ^f	11.9	12.6	13	12	12	12	.4	NS	NS			p<.05
Yield grade ^g	2.64	2.82	2.89	3.06	3.06	3.06	.27	NS	NS			NS

^a Standard error of the mean.

^b PS = pubertal status; IMP = implant; PS x IMP = pubertal status by implant interaction.

^c NS = Not significant.

^d 14 = A; 15 = A-.

^e 13 = small minus; 14 = small average.

^f 11 = high good; 12 = low choice.

^g Yield grades were calculated from USDA equations.

TABLE 34. THE EFFECTS OF PUBERTAL STATUS AND GROWTH PROMOTANTS
ON CARCASS COMPOSITION AND COMPOSITION OF GAIN IN OVARIECTOMIZED CROSSBRED HEIFERS

Item	Prepubertal		Pubertal		SEM ^a	Probability ^b	
	Control	Implant	Control	Implant		PS	IMP PS x IMP
No. of carcasses	6	6	6	6			
Carcass protein, %	14.8	14.7	14.7	14.8	.3	NS ^c	NS
Carcass fat, %	34.6	34.9	35.7	36.3	1.4	NS	NS
Carcass protein gain, g/d	105.4	110.8	114.2	123.5	9.9	NS	NS
Carcass fat gain, g/d	518.9	548.8	576.7	599.5	32.9	NS	NS
Carcass protein plus fat gain, g/d	624.3	659.6	690.8	723	30.0	p<.05	NS

^a Standard error of the mean.

^b PS = pubertal status; IMP = implant; PS x IMP = pubertal status by implant interaction.

^c NS = Not significant.

and fat accretion per day was similar between implant treatments.

In conclusion, pubertal status of heifers before ovariectomy may effect grazing performance of ovariectomized heifers, but the advantage may be lost due to compensatory gain in the feedlot. Prepubertal heifers gained more weight than P while grazing, but gained less than P heifers in the feedlot. Pubertal status may effect composition of gain of heifers. Pubertal heifers had numerically more protein and fat gain and clearly had more protein plus fat gain than PP heifers. Implants may aid in growth rates of ovariectomized heifers in both groups, but had little influence on carcass quality.

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