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Implanting Effects on Performance, Carcass Characteristics and Reproductive Parameters in Intact Beef Males

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IMPLANTING EFFECTS ON PERFORMANCE, CARCASS CHARACTERISTICS AND REPRODUCTIVE PARAMETERS IN INTACT BEEF MALES

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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PREFACE

The beef cattle industry, one of America's largest and most important businesses, is dynamic and changing. Beef cattle are one of our foremost replenishable natural resources. The ruminant effectively utilizes rangeland, wasteland, public lands, crop residues and by-products from food manufacturing. Economically, beef cattle are vital to the world (Good, 1982).

Good (1982) went on to add that the beef cattle industry has been in trouble because of overproduction, increased costs and low prices at the market place. Cattle producers have produced too much fat at too high a cost. The beef industry needs to shorten the turnover time and produce a leaner, yet high quality product. Maintenance costs of beef cattle are about 50 to 60% of the cost of production. Therefore, the most profitable animal is the one that can get through the production line in the shortest time.

Today's consumer is demanding leaner beef due to concerns with the health issues, fat and cholesterol (Cross, 1982). He also added that the trends toward leaner beef will become more pronounced with increased cost of meat.

The cattle production option of feeding young bulls for meat is utilized on a very limited basis in the United States (Unruh et al., 1986). However, bull beef production is the major system of beef production in Europe (O'Lamhna and Roche, 1983). Advantages of producing young bulls are that bulls grow faster and are more efficient red meat producers than steers (Nichols et al., 1964; Glimp et al.,

1971). However, bulls are not popular in feedlots due to increased management problems resulting from more aggressive behavior. Bulls may be more readily accepted in a feedlot if left intact to maintain their average in rate and efficiency of growth (Staigmiller et al., 1985) and implanted with anabolic agents to decrease aggressive behavior (Ralston, 1978). Seideman et al. (1982) indicated that meat production from intact males has encountered a strong resistance from packers because of the more difficult hide removal, heavier carcass weights and lower USDA quality grades. Cross and Allen (1982) added that intact male beef has not attracted the packers' approval due to an unsure consumer acceptance at the retail level because of differences in texture, color and fat. Cooked meat from young bulls is also less tender than steer beef.

Baker and Arthaud (1972) stated that the use of anabolic agents resulted in maximum growth for farm animals. A survey of the literature reveals the anabolic agents Ralgro, Synovex-S and Compudose may increase the growth of bulls from 0 to 10% (Price et al., 1983). They also reported that the increase in growth is accomplished by a slight increase in feed efficiency.

Jacob et al. (1977a) reported bulls yield 5.5% more boxed beef than steers and cut 17% less fat trim. Thus, yields showed bulls were higher in retail yield and worth 15% more to the retailer than steers (Jacob et al., 1977a).

There is some evidence that the anabolic agents Ralgro, Synovex-S and Compudose increase fat deposition in bulls (Johnson

et al., 1984). It is clear that all three implants inhibit testicular growth when administered to prepubertal bulls (Ralston, 1978; Greathouse et al., 1983; Price et al., 1983). After implanting testosterone levels decrease, but production capabilities are fully recovered by 14 wk after the last implant (Staigmiller et al., 1985).

Implanting at 215 d of age had no effect on scrotal circumference or testicle weight (Ford and Gregory, 1983; Staigmiller et al., 1985). Little work has been done on semen quality and spermatogenesis. Ballachey et al. (1985) reported that implantation preweaning had a detrimental effect on testicular development and spermatogenesis. Furthermore, they revealed the effects of implanting appeared to be permanent, which is in disagreement with research conducted by Juniewicz et al. (1985) who found a recovery of spermatogenic function in bulls 6 mo after implantation.

Good (1982) stated resistance to change is strong. He added it will take some time for the total industry (cattle producer, packer, retailer and consumer) to accept and implement the system of rearing intact males for beef production. Nevertheless, he revealed intact males can make beef production more profitable and competitive while providing consumers with the lean, high quality beef they have come to expect.

REVIEW OF LITERATURE

Mode of Action of Anabolic Agents

The metabolic processes of animals and therefore growth rates and speed of fattening are controlled and coordinated by hormones produced within the body (Scott, 1978). In recent years there has been an increased effort to enhance the growth processes through the manipulation of the endocrine system (Welsh, 1985). Scott (1978) indicated that anabolic agents have the capability of modifying or supplementing the effects of the endogenous hormones that control growth and fattening. The primary action of anabolic agents is via alterations of intermediary metabolism but not altering the absorption or metabolism of nutrients consumed (Preston, 1975; Heitzman, 1978a; Scott, 1978).

Welsh (1985) indicated the use of anabolic agents to promote efficient growth of livestock is an issue of interest to both the producer and consumer. Several review articles (Baker and Arthaud, 1971; Preston, 1975; Buttery et al., 1978; Heitzman, 1978b; Scott, 1978) have stated implanting farm animals with anabolic agents increased live weights and improved overall feed efficiency, resulting in more efficient production of meat.

Heitzman (1978b) noted anabolic agents used in animal production have functional properties similar to sex steroids and classed them into three classes, androgens, estrogens and progestins. The main action of all anabolic agents is to increase protein deposition and nitrogen retention (Baker and Arthaud, 1972; Preston,

1975; Heitzman, 1978b; Scott, 1978). Johnson (1984) revealed one basic tenet of using anabolic agents to promote growth is to manipulate the various metabolic processes such as protein, carbohydrate, lipid and energy metabolism in a manner conducive to the enhancement of growth. Given the complex interrelationships of these metabolic events with the total growth process, it is perhaps unrealistic to expect a comprehensive explanation of the precise mode of action of any anabolic agent (Johnson, 1984).

Some possible modes of action of estrogen anabolic agents through which growth might be enhanced are (1) increased growth hormone secretion, (2) increased thyroid activity, (3) increased adrenal and ACTH secretory cell number and (4) a direct effect at the tissue level.

Pituitary growth hormone has been recognized for over 50 yr as a factor critically important for normal growth. The actions of growth hormone on stimulating cell division, tissue growth, including increased protein synthesis, amino acid uptake and DNA and RNA synthesis, as well as the effects on energy metabolism are well known. The net result is positive nitrogen balance, body weight gain and increased skeletal growth (Wangsness, 1982). Numerous studies have revealed low correlations between growth rate and any variable of growth hormone secretion. However, Ohlson et al. (1981) reported that faster growing cattle (Simmental) exhibited greater secretory activity of growth hormone and prolactin than slower growing cattle (Hereford).

Estrogen treatments increased pituitary activity, total growth hormone in the anterior pituitary per unit of body weight and

circulating levels of growth hormone (Preston, 1975). Animals treated with Ralgro had showed increased pituitary weights and concentration of growth hormone (Borger et al., 1973a,b; Wiggins, 1976).

There appears from the literature to be three avenues by which Ralgro and possibly the other anabolic agents enhance growth hormone and therefore increase rate of growth. The three possible modes that Beverly (1984) presented include (1) Ralgro directly stimulating the release of growth hormone from the pituitary, (2) Ralgro stimulating the hypothalamic release of growth releasing factors or inhibiting somatostatin and thus allowing for the secretion of growth hormone and insulin and (3) Ralgro enhancing growth hormone release and thus stimulating the somatomedin status in the body.

In order to determine if Ralgro affected direct hormone production or release, Wangsness (1982) conducted experiments in which he isolated cells or tissue slices from the pancreas that were treated in vitro with Ralgro. The results with pancreatic cells were inconclusive. He also reported that, when pituitary cells of lambs were incubated with media flowing through the small chamber, the cells responded by releasing growth hormone into the media upon exposure to Ralgro. This phenomenon was more pronounced in younger lambs than older lambs. These results supported the theory that Ralgro can directly affect pituitary cells and also adds to the support of in vivo studies which have shown the blood of implanted animals to have higher concentrations of growth hormone than nonimplanted.

Beverly (1984) suggested that Ralgro might possibly stimulate the hypothalamic area to block the release of somatostatin (a strong inhibitor of growth hormone), allowing an increase in growth hormone and insulin levels. Insulin, like growth hormone, promotes protein synthesis (Wangsness, 1982). Also, an opposite mode of action may be operating through Ralgro, stimulating the action of growth hormone releasing factor to release growth hormone (Beverly, 1984).

The third means by which increased growth hormone may be potentiating a growth effect is through the enhanced release of somatomedin (Beverly, 1984). Somatomedins are peptides which in cartilage stimulate sulfate uptake, amino acid transport, synthesis of RNA and DNA, protein and chondroitin sulfate. In muscle, they enhance protein synthesis and glucose uptake. In fat, they promote glucose oxidation and decrease fat mobilization. These are insulin-like actions which suggest that there is some interaction between insulin and the somatomedins in terms of their effects on target tissues in the body. Somatomedins mediate growth but are released under the regulation of growth hormone, nutritional status and insulin.

The effects of anabolic agents on thyroid activity are inconclusive. In studies with Ralgro, Wiggins et al. (1976) reported increased thyroid weights, but studies relative to secretory activity showed a depression in activity (Rothenbacher et al., 1975). Contrasting to the above statement, Burgess and Lamming (1960) first proposed that increased thyroxine secretion was responsible for the increased growth rate when estrogens were administered. Johnson (1984)

concluded that Ralgro could conceivably enhance thyroid hormone secretions by increasing thyroid stimulating hormone secretions. Determining the effects of Ralgro and other anabolic agents on the thyroid gland function would be very useful, since thyroid hormones are necesesary for normal development, growth of the nervous system and bones (Johnson, 1984). Furthermore, he revealed that thyroid hormones may have some effect on gene transcription and protein synthesis.

Johnson (1984) reported that the effects of Ralgro upon the adrenal gland have not been studied adequately. However, the increase observed in adrenal gland weight of Ralgro-treated animals (Rothenbacher et al., 1975) suggested that glucocorticoids synthesis may be affected. Although high levels of glucocorticoids can suppress growth, at lower levels they may enhance the growth process. He also indicated that the ability of cortisol to enhance growth hormone synthesis in growth hormone-producing tumor cells in vitro suggest adrenal glucocorticoids may play a role in mediating the effect of Ralgro upon growth.

Other studies with Ralgro and other estrogens revealed an increase in adrenal weight and ACTH secretions. Beverly (1984) concluded that adrenal cortical steroid production may be increased directly by Ralgro or as a result of increased ACTH production and the anabolic effects of the adrenal steroids may account for a portion of the increased growth associated with Ralgro treatment.

The direct effect of anabolic agents upon muscle may be another avenue through which growth might be enhanced. There is presently

little or no experimental data to support this possibility. Ralgro has been reported to interact directly with the estrogen receptor of immature rat uterine cells in vitro (Katzenellenbogen et al., 1979). Further work is needed to establish the importance of direct effects of anabolic agents at the cellular level.

There is also a possibility that prolactin may be involved in mediating Ralgro and other anabolic agents, since it has been reported to have protein anabolic effects similar to those of growth hormone (Beck et al., 1964).

Effect of Anabolic Agents on Performance

Considerable research has been done to examine the efficiency of feeding young, intact males for slaughter (Calkins et al., 1986). Generally, it has been reported that young, intact males gain faster and more efficiently than do steers (Arthaud et al., 1977; Seideman et al., 1982). Bulls grow more rapidly and fatten slower than steers. Thus, they can be intensively fed from the time they are weaned and less efficient grow-out programs are avoided (Brethour, 1984). In addition, Brethour (1984) reported bulls can be fed to heavier weights without becoming excessively fat and produce more beef per cow unit. However, recent research emphasizes steers can attain the desired endpoint more quickly and efficiently than intact males when fed to the same compositional endpoint (Crouse et al., 1984).

A review of studies by Field (1971) gives bulls a 17% advantage in daily gain. Also, the review by Hedrick (1968) credits bulls with an advantage of 14% over steers in average daily gain. When expressed

in gain of edible product, Bidart et al. (1970) and Field (1971) saw a wide difference between bulls and steers. Bulls consumed 6.0 Mcal of digestible energy per kilogram of edible product compared with 12.8 Mcal for steers. The majority of these studies compared bulls to steers castrated at a young age. Bulls continued to surpass steers in average daily gain and percent retail product, even when castration was at 7 to 9 mo of age (Klosterman et al., 1954; Champagne et al., 1969; Landon et al., 1978).

Calkins et al. (1986) stated, in an effort to capitalize on the growth rates of young intact males and to produce meat of similar composition and palatability to steers, recent attention has focused on the use of growth-promoting implants in young males. Review of the literature on growth promotants in bulls revealed three regimens of implanting, (1) implanting during the finishing phase (Gregory et al., 1983; Johnson et al., 1984; Schanbacher et al., 1984), (2) at or near weaning, during the growing and finishing phase (Forrest, 1975; Johnson and Gee, 1982; Newland et al., 1984; Vanderwert et al., 1984) and (3) implanting close to birth and successive intervals throughout life (Ralston, 1978; Lamm et al., 1980; Brethour, 1982; Greathouse et al., 1983; Gray et al., 1984; Unruh et al., 1984). Most of the research pertains to Ralgro with few studies in bulls implanted with Synovex and Compudose.

Ralgro. Ralgro, also known as zeranol, is a natural metabolite of corn mold. It is not a hormone; however, it exhibits estrogenic and anabolic effects.

In studies by Brethour (1984), bulls gained nearly 45 kg more from birth to slaughter when they were implanted at birth, weaning and as yearlings. Corah et al. (1979) observed about 4% faster gains when bulls were implanted every 100 d from birth to slaughter. In New Zealand, McKenzie (1983) measured 4 to 14% response in gain among Ralgro-implanted bulls on pasture. Furthermore, Brethour (1984) reported implanting bulls at birth increased weaning weights about 5%. Similarly, Ralston (1978) reported weaning weights were heavier for implanted calves. In addition, Greathouse et al. (1983) indicated that implanting improved average daily gain and feed efficiency 6.5% to 10.4% and 7.9% to 8.1%, respectively, compared to nonimplanted bulls. Unruh et al. (1983) reported no difference in live weight and hip height in Simmental male calves implanted at birth and every 84 d. Gray et al. (1983) also found implanted bull calves, although heavier at birth, had similar weaning weights and hip heights. By 12 mo, nonimplanted bulls were faster gaining and more efficient, but by 16 to 18 mo there was no difference (Gray et al., 1983). Lamm et al. (1980) noted that suckling calves implanted with Ralgro, especially 36 mg, had a tendency to gain faster. Implanted calves gained faster (1.33 vs 1.16 kg/d) than nonimplanted calves (Cooper and Kirk, 1982).

Vanderwert et al. (1984) and Calkins et al. (1986) reported implanting weanling calves increased average daily gain. Also, Price et al. (1983) stated bulls implanted with Ralgro at 5 to 7 mo of age had a larger (6.1%) rate of gain than nonimplanted bulls, but the difference was not significant ($P>.05$).

In contradicting data, Brethour (1984) reported a 4% response to implanting yearling bulls but found no response in a second trial. Implanting at 1 yr of age had no effect on average daily gain or feed efficiency (Ford and Gregory, 1983). Intact males from two Ralgro implant treatment groups did not differ (P>.05) from each other in gain but averaged 11.1% more during the trial than males from the intact treatment not implanted (Gregory and Ford, 1983).

Unlike the previous reports, Staigmiller et al. (1985) reported growth rates were not increased by implanting at either 48 d or 215 d but were decreased in animals implanted at both times.

Synovex. Synovex implants' active components are natural hormones that are hormones similar to those produced by the animals' endocrine system (Neumann, 1977). Synovex-C, a new product recommended for calves, contains 100 mg of progesterone and 10 mg of estradiol benzoate. Synovex-H, approved for heifers, contains 200 mg of testosterone proprionate and 20 mg of estradiol benzoate. Synovex-S, recommended for use in steers, contains 200 mg of progesterone and 20 mg of estradiol benzoate.

There are few studies using Synovex in intact males. However, Synovex implants available for steers and heifers did not enhance growth rate, feed efficiency or lean content of young feedlot bulls (Forrest, 1968; Preston et al., 1975).

Gill et al. (1986) reported Synovex improved gains of calves 10.4% more than nonimplanted calves. A study in Canada by Basarab et al. (1984) found Synovex-implanted yearlings grew faster than

controls. Kahl et al. (1978) stated daily gains of Synovex-implanted steers (320 kg) were greater than nonimplanted steers. Other studies have shown Synovex improved feedlot performance of steers and heifers (Ray et al., 1969; Kahl et al., 1978; Rumsey, 1978).

Compudose. Compudose contains estradial-17β encased in silicone rubber. Like Synovex, studies are limited on the use of Compudose on intact males.

Fifteen trials were conducted in the United Kingdom to investigate the effects of Compudose implanting on the growth performance of fattening beef bulls. A summary of the pooled data showed treated calves (139 kg) grew faster than controls (1.379 and 1.338 kg/hd/d, respectively), gaining an extra 6.2 kg by the end of the trials (Mould, 1985).

Comparison of Anabolic Agents on Performance. Moffitt (1980) stated estrogens or the combination of estrogenic material with progesterone or testosterone did not produce a positive response in average daily gain. In a study by O'Lamhna and Roche (1983), there was no difference between daily live weight gains of implanted animals (Ralgro, Synovex-S, Compudose, Estradiol-17β and Trenbolone acetate) and controls. They did find reimplantation of young bulls with hormones beginning at 8 to 10 wk of age increased live weight gain 0 to 15%. Furthermore, bulls implanted with Compudose, Synovex-S and Ralgro increased gains by a mean of 6.8 kg (6.2%). Feed intake was increased with Compudose and Synovex-S implants, but only Ralgro improved feed

efficiency (Gill et al., 1983). Calkins et al. (1986) reported lifelong implantation of intact males with Ralgro and Compudose did not alter the gain or efficiency between bulls receiving the different implant treatments during the finishing period or the growing and finishing period combination. Cattle implanted with Ralgro did not gain faster than those implanted with Compudose but were more efficient during the growing period (Calkins et al., 1986).

Effects of Anabolic Agents on Carcass Characteristics

Cross and Allen (1982) reported that part of the price difference between carcasses from bulls and steers is due to the belief that bullock beef has lower consumer acceptance at the retail level because of the difference in lean color, lean texture and fat distribution.

Carcasses from intact males managed similar to steers have less subcutaneous fat at the 12th rib (Hedrick et al., 1969: Jacob et al., 1977a; Landon et al., 1978; Tanner et al., 1970), less body cavity fat (Jacobs et al., 1977a; Landon et al., 1978; Tanner et al., 1970) and less intramuscular fat in the longissimus muscle (Arthaud et al., 1977; Champagne et al., 1969; Hedrick et al., 1969). Because intact male carcasses are leaner than steer carcasses and perhaps more muscular, they have a higher proportion of lean (Breidenstein, 1982). Several studies have shown there is no difference in dressing percentage between bulls and steers (Hedrick, 1968; Rhodes, 1969a; Field, 1971; Jacobs, 1975a).

Cross (1982) stated that the boxed beef and retail segments of the meat industry place price constraints on bullock beef with too little fat (less than .20) and carcasses over 363.6 kg.

Bidart et al. (1970) concluded intact males produced 38% more edible product. In addition, Jacobs et al. (1977a) reported intact Hereford males produced about 16% more edible meat than castrated males when slaughtered at 18 mo of age. Studies vary but Hedrick (1968) concluded bulls yield more meat than steers compared on a major cut or total carcass basis because of less finish. Jacobs et al. (1977a) reported bull carcasses yield 5.5% more boxed beef than steers and cut 17% less trim. Thus, bulls were higher in retail yield and worth 15% more to the retailer than steers (Jacob et al., 1977a).

A review of literature by Field (1971) showed meat obtained from bulls was less tender when compared with meat from steers. Other studies reported bull meat was slightly less tender than steer meat, but bull meat had acceptable tenderness (Glimp et al., 1971; Albaugh et al., 1975; Forrest, 1975; Arthaud et al., 1977; Ntunde et al., 1977; Stout, 1980). Klosterman et al. (1954) and Brown et al. (1962) reported only slight differences in tenderness between bulls and steers.

Cross and Allen (1982) identified nine previous studies which indicated that lean color of bullock beef is darker and less desirable than steers. Similar results were found by Seideman et al. (1982).

Ralgro. Implanting with the anabolic agent Ralgro varies in effects on carcass characteristics. Studies where bulls were implanted early in life until slaughter indicated a greater effect on carcass traits than bulls implanted later in life. Calkins et al. (1986) reported bulls implanted at birth and continually until slaughter had greater external fat and more desirable quality grades. Other studies also reported implanting with Ralgro increased fat thickness (Brethour, 1982; Greathouse et al., 1983; McKenzie, 1983; Vanderwert et al., 1984; Staigmiller et al., 1985; Gray et al., 1984; Unruh et al., 1986).

Ralgro-implanted bulls had lighter carcass weights than nonimplanted bulls (Greathouse et al., 1983; Staigmiller et al., 1985; Gray et al., 1984; Unruh et al., 1986). Greathouse et al. (1983) revealed bulls implanted near birth and every 106 d reached slaughter weights 42 d sooner than nonimplanted bulls. Marbling score, quality grade, longissimus cooking loss and juiciness score were not affected by implantation (Greathouse et al., 1983). Taste panel flavor and longissimus steak tenderness were higher for implanted bulls.

Unruh et al. (1986) reported final maturity was similar in nonimplanted and implanted bull calves. At 12 mo of age, the lean color for both treatments was brighter and texture finer than at 18 mo. In addition, implanted bulls had higher marbling scores, greater fat thickness and similar hot carcass weights (Gray et al., 1984; Unruh et al., 1986). Kidney, heart and pelvic fat were similar, but nonimplanted bulls had larger longissimus muscle areas than implanted bulls (Unruh et al., 1986). Gray et al. (1984) reported implanted

bulls had more desirable yield grades, while Unruh et al. (1986) found yield grades less desirable for implanted bulls than for nonimplanted bulls. Bulls slaughtered at 16 to 18 mo were lower in cutability than bulls slaughtered at 12 to 14 mo of age (Unruh et al., 1986).

In contrast, implanting with Ralgro later in life had minimal effects on carcass traits (Ford and Gregory, 1983; Gregory and Ford, 1983; Price et al., 1983; Gray et al., 1984; Johnson et al., 1984). Implanting increased fat thickness in Angus bulls implanted at weaning and implanting with 36 mg Ralgro resulted in greater fat thickness than implanting with 72 mg Ralgro (Vanderwert et al., 1984). They found bulls implanted with 36 mg Ralgro had less skeletal maturity and more desirable lean color than bulls implanted with 72 mg Ralgro. Vanderwert et al. (1984) treated all 36 mg treatment cattle with a second 36 mg on day 112, while 72 mg cattle received only a single implant.

Ford and Gregory (1983) and Gregory and Ford (1983) noted dressing percentage and scores for carcass secondary sex characteristics, marbling, final maturity, lean color, lean texture and palatability characteristics were not affected by implanting at 13 mo of age.

Synovex. Alterations of carcass traits are minimal due to Synovex implants (Koers et al., 1974a,b) and Utley et al. (1976) found carcass traits did not differ due to hormonal implants. Differences in carcass characteristics were small between implanted and nonimplanted steers, but implanted cattle tended to have slightly more subcutaneous

fat, larger longissimus muscle area and less marbling and kidney fat (Embry and Gates, 1976). A slight increase in longissimus muscle area and slightly decreased marbling level and quality grades in steers and heifers due to Synovex implants were noted by Stout (1980).

Limited studies have been conducted using Synovex in slaughter bulls. Forrest (1968) reported the effect of exogenous hormones in bulls is unclear, but when reported in bulls it has increased rate of gain and increased fat deposition (Cahill et al., 1956; Bailey et al., 1966) which is opposite to the effect in steers. Forrest (1978) found a slight increase in fat deposition, while Forrest (1976) reported implanting improved carcass lean yield by depressing fat thickness in Holstein-Friesian steers. Forrest (1968) indicated hormone implanting had no measurable effect on carcass composition but recommended young bulls reared for meat production be implanted with hormones, since these hormones increase deposition of fat to a more desirable level. Furthermore, Johnson et al. (1986) and Paterson et al. (1983) indicated Synovex had a tendency to increase fat thickness of young bulls. O'Lamhna and Roche (1983) reported young bulls implanted with Synovex had heavier carcass weights, higher fat scores and lower conformation scores than nonimplanted bulls.

Compudose. Keane (1982) and O'Lamhna and Roche (1983) found young bulls implanted with Compudose had carcass weights similar to controls. A summary of data from the United Kingdom showed bulls (139 kg) implanted with Compudose produced heavier carcasses, improved

carcass conformation and fat classification remained similar to the controls (Mould, 1985).

Comparison of Anabolic Agents on Carcass Characteristics.

Johnson et al. (1984) reported Synovex-implanted bulls had higher adjusted fat than nonimplanted and Ralgro-treated bulls, while carcasses of Compudose-implanted bulls were intermediate in fat and yield grade to the other groups. The Hereford implanted bulls produced carcasses classed as "steers."

Implanting with Compudose, Synovex and Ralgro increased carcass weights in weanling bulls (Gill et al., 1983). Bulls implanted with Ralgro had less internal and external fat, and carcass characteristics remained largely unchanged by implanting (Gill et al., 1983). Calkins et al. (1986) found quality grades to be higher in Ralgro-implanted bulls than controls or Compudose-implanted bulls. They found no difference in tenderness. Brethour (1982) concluded Ralgro-implanted cattle had more fat and higher quality grades than nonimplanted or Compudose-treated cattle. Johnson et al. (1986) reported the treatments of Ralgro and Synovex had no effect on hot carcass weight, longissimus muscle area, kidney, heart and pelvic fat, maturity score, marbling or USDA quality grade. Nonimplanted and Ralgro-implanted bulls had greater estimated carcass cutability than Synovex-implanted bulls.

Effects of Anabolic Agents on Reproductive Parameters

Although anabolic agents are not widely used in bulls, a renewed interest in the utilization of intact males for red meat production (Seideman et al., 1982) has recently provided the need for studies focusing on the effects of anabolic agents on reproductive traits. The importance of establishing the effects of Ralgro upon testicular function is obvious since anabolic testicular steroids are presumably the primary agent responsible for the superiority of bulls over steers for rate of gain, feed efficiency and higher yields of retail product (Arthaud et al., 1969, 1977; Field, 1971; Galbraith et al., 1978; Ford and Gregory, 1983; Gregory and Ford, 1983).

Several researchers have reported reduced testicle development in bulls implanted with Ralgro (Ralston, 1978; Corah et al., 1979). Those effects were noted in bulls implanted throughout the suckling and finishing periods. Staigmiller et al. (1985) results showed restricted testicle development when implantation was started at a young age. Also, testicle size was restricted from a single 72-mg implant at branding or repeated 36-mg implant starting at 3 wk of age (Staigmiller et al., 1985). Similarly, Unruh et al. (1986) reported scrotal circumference was smaller for bulls implanted with Ralgro at 8, 12, 14 and 16 mo but not different at 18 mo. Furthermore, testicular weights were lighter for implanted bulls, except no difference ($P>.05$) was seen at 18 mo of age (Cooper and Kirk, 1983). Animals implanted at 40, 140 and 240 d of age with Ralgro resulted in reduction of testicular diameter (Cooper and Kirk, 1983). Corah et al. (1979) reported

implanting bull calves reduced testicle weight, penis weight, scrotal circumference and increased pelvic area. Ralgro has been shown to reduce testicle size and masculinity scores in both beef and dairy bulls (Kirk and Cooper, 1983; McKenzie, 1983). Ralston (1978) found nonimplanted bulls had a higher libido score. Therefore, implanted bulls should not be kept for breeding, but infertility may be an advantage in rearing bulls for meat production (Brethour, 1982).

Results from implanting yearling bulls are inconclusive. In contrast, Gregory and Ford (1983) noted that testicular weights were not reduced when intact males were implanted with Ralgro at 1 yr of age. Ralgro also had no effect on male behavior characteristics (Gregory and Ford, 1983). Price et al. (1983) also found Ralgro had no significant effect on sexual development on bulls implanted at 5 to 7 mo of age. Juniewicz et al. (1985) concluded implantation of young bulls with Ralgro causes a suppression of testicular function, whereas no effects were observed in older bulls.

Effect of implants on sexual development of bulls and social behavior may be as important as weight gain responses (Brethour, 1982). McKenzie (1983) noted a marked reduction in riding when bulls had fewer encounters for passive bunting, mounting attempts and facility rubbing and a lower activity score than control bulls. Implanting with Ralgro early in life (<6 mo) reduced aggressive behavior as measured by mounting activity (Corah et al., 1979), head bunts and attempted mounts (Baker and Gonyou, 1984). In contrast, aggressive behavioral traits were similar for bulls implanted later in life and for control bulls

(Gregory and Ford, 1983; Price et al., 1983). O'Lamhna and Roche (1983) reported estrogens given repeatedly reduce aggressive behavior.

Testicular growth follows a slow pattern early in life and rapid growth occurs during latter phases of development as puberty approaches (Rawlings et al., 1978; MacMillan and Hafs, 1979; McCarthy et al., 1979a,b). In beef bulls rapid testicular growth begins at 30 to 35 wk of age (Rawlings et al., 1978; Schanbacher, 1979). Thus, Staigmiller et al. (1985) reported that it appears, when the testicles enter the phase of rapid growth, the endocrine mechanism regulating testicular growth is well established so Ralgro can no longer suppress testicular growth. Juniewicz et al. (1983) also reported steriodogenic and spermatogenic functions of the testis were recoverable following the treatment of young bulls with Ralgro. In contrast, Ballachey et al. (1985) noted the effects of implants on testicular development were permanent. The varying results due to different ages of implanting may be attributed to the greater sensitivity of the pituitary-hypothalamic axis of young bulls near birth to negative feedback effects of Ralgro and(or) the dilution of circulating levels of Ralgro because of the increased size of the postweaning bull (Unruh et al., 1986). Studies in laboratory animals and data reported by Juniewicz et al. (1985) have shown Ralgro may act directly on the Leydig cells to inhibit steriodgenesis. Other studies with estradiol-treated bulls, Schanbacher (1981) demonstrated that, although peripheral LH concentrations were similar between control and treated bulls, episodic secretion of LH was absent in estradiol-treated

animals. Based upon those results, he proposed that estradiol inhibited testicular development and function of young bulls by interfering with the normal episodic secretory function of LH. This proposal was further supported by the demonstration that pulsatile GnRH administration to estradiol-treated bulls led to a resumption of normal testicular function (Schanbacher et al., 1982). Further studies are needed to resolve the mechanism by which anabolic agents suppress normal testicular function.

Flow Cytometry

Flow cytometry is a relatively new means used in cellular analyses. Cells in suspension may be labeled with a macromolecular-specific fluorochrome and then passed in a sample stream intersected by a laser beam. The fluorescent signal is detected by photomultiplier tubes and converted to a digital analog for processing. The advantages of flow cytometry are rapid measurement of large numbers of cells and ease of counting cell types. Studies on male reproductive function have utilized flow cytometry to characterize the changes in testicular and sperm cells (Evenson et al., 1980a,b, 1983, 1985, 1986). Therefore, flow cytometry may be a means to measure the effects of anabolic agents on testicular and sperm cells.

Effects of Anabolic Agents on Luteinizing Hormone and Testosterone

Desjardins (1981) and Oltner et al. (1979) noted intact males show an episodic pattern of LH secretion and a pronounced daily variation which is attributed to negative feedback by gonadal steroid

in intact animals. Schanbacher (1976) revealed the episodic pattern of LH is necessary for normal testicular functions. In order to measure LH levels, a sampling schedule allowing for frequent blood sampling is necessary since studies show LH is released in a pulsatile manner.

Oltner et al. (1979) reported the highest LH levels were found in 5-mo-old animals which agreed with a study done by Lacroix and Pelletier (1979). Amann and Walker (1983) concluded that LH samples from Holstein bulls before 8 wk were undetectable but between 12 and 20 wk LH was greatly elevated. They also noted that the initiation of LH discharges every 90 to 120 min starting around 12 wk of age. Several studies have presented data that showed an increase in LH concentration after about 6 mo of age (MacMillan and Hafs, 1968; Rawlings et al., 1972; Gombre et al., 1973; Moss and Moody, 1974; Lunstra et al., 1978; Schanbacher, 1979). Contrasting, Oltner et al. (1979) reported a decrease in LH with advancing age, decreasing rapidly between 5.5 and 7.5 mo, then decreasing slowly.

Marked variations in testosterone and LH levels in pubertal bulls have been reported (Katongole et al., 1971; Mongkonpunya et al., 1975; Thibier, 1976; McCarthy et al., 1979a,b; Welsh et al., 1979). These variations may be explained by differences in blood sampling intensity, sampling procedure and stress which reduces LH and testosterone. LH secretions were always followed after 40 to 80 min by a testosterone surge (Welsh et al., 1979; McCarthy et al., 1979a,b).

Testosterone is known to play an important role in the behavioral aspect of reproduction, in development and maintenance of

the male secondary sex characters and in maintenance and regulation of testicular function (Oltner et al., 1979). The mean plasma testosterone level is low in young bulls and then gradually increases (Rawlings, 1972; Karg et al., 1976; Secchiari et al., 1976; Lunstra et al., 1978; Oltner et al., 1979). Thibier (1976) reported short term variation in testosterone and along with other authors noted two peaks of testosterone during the day. Secchiari et al. (1976) determined testosterone levels in bulls the first 14 mo of age. Testosterone increased gradually between 4.0 and 5.5 mo (Rawlings et al., 1972; Secchiari et al., 1976; Karg et al., 1976; McCarthy, 1979a,b). After 6.5 mo, plasma testosterone oscillated between 200 and 400 ng/100 ml at intervals of 2.5 mo (Secchiari et al., 1976). In addition, Hafs et al. (1971) concluded puberty begins at 5 mo and is completed by 10 mo of age. Spermatogenesis was initiated at 5 mo and by 10 to 12 mo of age the rate of spermatogenesis was at levels typical of a mature bull.

The main effect of the implants was to erase pulsatile surges of LH while exerting only a minor depressing effect upon average LH levels. Thus, concentrations of circulating testosterone were drastically reduced (D'Oochio et al., 1982; Fabry et al., 1983; Schanbacher, 1984). Juniewicz et al. (1985) saw a decrease in testosterone levels in young bulls treated with Ralgro. Similar results were found by Deschamps (1984) where Ralgro implanted at birth and every 3 mo reduced LH and suppressed synthesis of testosterone by the Leydig cells. Also, various studies using estradiol implants reported a near normal LH concentration but markedly reduced serum

testosterone concentration (Schanbacher et al., 1982; Schanbacher, 1984). Staigmiller et al. (1985) noted a drop in testosterone following each implant, but the testosterone capabilities had fully recovered in Ralgro-implanted bulls by 14 wk after the last implant. A study by Schanbacher (1981) had similar results but used Compudose and found reduced testicular development and testosterone concentration up to 38 wk of age, with normal growth and function after implant removal. The data presented by Staigmiller et al. (1985) provide evidence that testicular function is delayed only briefly by implants after 260 d of age. By 120 d after the final implant, they noted testosterone levels were equal to those in control bulls.

Effects of Anabolic Agents on Growth Hormone

Growth hormone is a protein hormone produced by the somatotrophs of the anterior pituitary gland (Joahimsen and Blom, 1976). Scanes and Lauterio (1984) reported growth hormone is required for normal growth, acting in part by increasing somatomedin production. Yet, they added plasma growth hormone concentrations do not necessarily correlate with growth rates (Purchas et al., 1970; Trenkle, 1970, 1977; Hafs et al., 1971). In contrast, other researchers suggested that there is a positive relationship between measures of growth hormone secretions and growth rate in domestic ruminants (Ohlson et al., 1981; Verde and Trenkle, 1982; Dodson et al., 1983). Welsh (1985) stated that growth hormone promotes protein deposition, hyperglycemia, lipolysis and skeletal growth. He went on to add that secretions of growth hormone increased during sleep, stress and trauma. Growth

hormone levels in sexually mature bulls vary during the day and are the lowest at morning and afternoon feeding and between 1000 and 1200 hr (Blom et al., 1976). It is difficult to obtain accurate estimates of growth hormone because of the episodic nature of growth hormone in sheep (Davis and Borger, 1974; Davis et al., 1977a) and cattle (Anfinson et al., 1975).

In short term growth hormone decreased blood glucose, while in long term increased free fatty acids and increased amino acid transport and amino acid catabolism decreased with growth hormone treatment (Welsh, 1985). Growth hormone treatments also stimulate DNA, RNA, protein synthesis and increase somatomedins (peptides that mediate bone and muscle growth) (Welsh, 1985).

Results show increased growth hormone and ratios of growth hormone to body weight are highest in newborn calves with a tendency for blood levels to decline during the first few months of life and then level off (Purchas et al., 1970; Trenkle, 1970, 1971; Hafs et al., 1971; Blom et al., 1976; Joakimsen and Blom, 1976). Generally, growth hormone declines with advancing age with a transcient increase at 6 and 8 mo of age and then declines up to 12 mo (Joakimsen and Blom, 1976).

Gopinath and Kitts (1984) reported growth hormone concentrations in steers appeared to be higher in all implanted groups (DES, Synovex-S and Ralgro) compared to controls. Furthermore, the secretion rate of growth hormone was increased in steers implanted with anabolic compounds when compared to control steers (Gopinath and Kitts, 1984). All three anabolic compounds were equally effective in

increasing growth hormone on day 20 following implantation. Metabolic clearance rate of growth hormone was not affected by the implants. Also, they suggested the growth promoting properties of DES, Ralgro and Synovex-S are mediated through increased growth hormone secretion from the pituitary. They hypothesized that the increased growth hormone secretions may cause alterations in metabolism of estrogen implanted steers in such a way that there is an efficient utilization and better partitioning of absorbed nutrients and may facilitate more protein accretion. Other endogenous hormones via prolactin, insulin, thyroid hormone and somatomedins either alone or along with growth hormone may be involved in the growth process mediated by anabolic compounds in meat-producing animals.

Borger et al. (1973b) saw increased growth hormone levels in steers implanted with Ralgro. They noted that growth hormone levels tended to rise following implanting and then decrease. Average growth hormone levels for control and implanted steers were 10.69 and 21.62 ng/ml, respectively. Trenkle (1971) reported the average secretion of growth hormone for bulls to be 24.7 ng/ml.

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JOURNAL ARTICLE

Abstract

Sixty-six Angus bulls averaging 282 kg were utilized to study the effects of implants on performance, carcass characteristics and reproductive parameters of intact males. Bulls were randomly assigned to one of four treatments, nonimplanted (N), 36 mg of Ralgro (R), 220 mg of Synovex-S (S) and 24 mg of Compudose (C). Treatments S and R were reimplanted every 60 to 70 d and C after 180 d. Body weights were taken at 28-d intervals and blood samples collected via jugular venipuncture weekly for 9 wk and then monthly for 4 mo with the final sample taken at slaughter. Blood was analyzed for testosterone, growth hormone (GH) and luteinizing hormone (LH). Bulls remained on test 217 d. Final average weight and hip height were 519 kg and 125.93 cm, respectively. Nonimplanted bulls had larger ($P<.01$) scrotal circumference (39.0 vs 37.7 cm) than S-implanted bulls but were not different ($P>.05$) for R (38.8 cm) or C (38.6 cm). There were no differences ($P>.05$) in ADG (1.10, 1.08, 1.03 and 1.15 kg), increase in hip height (15.6, 13.8, 14.4 and 14.3 cm), testicular weights (602, 584, 581 and 522 g), testosterone values (7.68, 8.09, 8.93 and 8.71 ng/ml) or LH (.129, 1.04, .113 and .137 ng/ml) for N, C, R or S groups, respectively. S-implanted bulls had higher GH levels ($P<.01$), 54.8 ng/ml compared to 32.02, 44.55 and 46.84 ng/ml for N, C and R groups, respectively. Carcasses were heavier ($P<.01$) from treatments C (331 kg) and S (332 kg) than R (307 kg) but not different ($P>.05$) from N. Fat thickness at the 12th rib was greater ($P<.05$) for S (11.55 mm)

than N (9.03 mm), C (8.82 mm) and R (8.32 mm). The greater fat thickness of S bulls increased the yield grade to 2.82 compared to 2.43 for N ($P<.05$), 2.44 for C and 2.38 for R-treated bulls ($P<.01$). No difference ($P>.05$) was present for longissimus muscle, KPH, sperm chromatin structure and USDA quality grade. A negative relationship existed between testicle weight and yield grade ($r = -.44$) and mm fat ($r = -.46$), among testosterone and mm fat ($r = -.40$) and within yield grade and longissimus muscle ($r = -.49$). Also, there was a positive correlation between ADG and carcass weight ($r = .72$) and longissimus muscle ($r = .47$), within yield grade and fat ($r = .84$) and KPH ($r = .33$), between testicle weight and testosterone ($r = .44$) and among longissimus muscle and carcass weight ($r = .72$). In sperm quality, a negative relationship existed between the standard deviation and testicle weight ($r = .27$) and comp ($r = -.31$) and among the correlation coefficient and KPH ($r = -.25$). Results suggest that implanting postweaning increases GH levels but has minimal effects on performance, reproductive parameters and carcass characteristics in intact bulls.

Introduction

The future of the livestock industry depends on the efficient production of wholesome, palatable, nutritious meat products with less fat. Increased profits from livestock production can be achieved by increasing daily live weight gain and feed conversion efficiency while maintaining carcass composition, quality and palatability acceptable to the consumer (Unruh et al., 1986).

Bulls have the advantage over steers in growth rate, feed efficiency and carcass leanness (Field, 1971; Seideman et al., 1982). Intact males produce 38% more edible product than steers per unit of digestible energy consumed (Oltjen, 1982). Hodge (1982) reported bulls yield 2.1% more in steaks, 1.5% in roasts, 1% in miscellaneous, .4% less boneless trimmings and 4.2% less waste than steers.

The agonistic behavior among feedlot bulls requires increased management and offsets some of the production efficiency advantages of young bulls (Oltjen, 1982; Seideman et al., 1982). Furthermore, bullock carcasses are frequently inadequately finished and have lower quality grades than steers (Binger, 1982; Seideman et al., 1982; Smith, 1982). Tenderness ratings are generally lower for bulls than steers of the same age (Cross, 1982; Seideman et al., 1982). Bulls are often rejected from the boxed beef trades due to dark and coarse textured lean, excessive thickness of the neck, large pizzle eyes, jump muscles and round rib eyes (Binger, 1982).

Various studies have indicated implanting young bulls from birth to slaughter improved the traits most often cited by producers and packers excluding bulls from the production system and the retail box beef trade (Unruh et al., 1986). Implanting bulls early in life until slaughter improves performance, behavior and carcass characteristics (Greathouse et al., 1983; McKenzie, 1983). Also, it may improve marbling scores, lean texture (Greathouse et al., 1983) and palatability traits (Gray et al., 1984) compared with nonimplanted cattle. In contrast, postweaning implanting of young bulls during the

feedlot period has produced varying performance responses (Gregory and Ford, 1983; Price et al., 1983) and minimal effects on carcass characteristics (Ford and Gregory, 1983; Johnson et al., 1984) and palatability (Gregory and Ford, 1983; Gray et al., 1984). Heitzman (1979) noted that optimum concentrations of anabolic agents in the blood over a long period of time are required for maximum increased growth in farm animals.

The use of anabolic agents in intact males implanted at <90 d of age or throughout the suckling and finishing periods is hypothesized to reduce testicular function by inhibiting the production of gonadotropin releasing hormone (Baker and Gonyou, 1986). However, further studies are necessary to find the exact mechanism by which anabolic agents suppress testicular function. Ralgro inhibited testicular development in bulls (Ralston, 1978; Corah et al., 1979; Unruh et al., 1984) and decreased testosterone levels (Juniewicz et al., 1985; Staigmiller et al., 1985). Concentrations of LH are similar between control and treated bulls, but the episodic secretion of LH was absent in estradiol-treated animals (Schanbacher, 1981). Juniewicz et al. (1985) reported the effects of postweaning implanting on testicular development and spermatogenesis are not permanent. This is in disagreement with Ballachey et al. (1985) where preweaning implants resulted in impairment of testicular development and spermatogenesis. The physiological effects of implanting appear to depend upon age at implantation (Staigmiller et al., 1985) and possibly behavioral effects as well.

The primary mode of action of anabolic agents is increased growth hormone levels. Steers implanted with DES, Synovex-S and Ralgro had increased growth hormone levels 20 d after implantation (Gopinath and Kitts, 1984). Borger et al. (1973) noted after implanting steers with Ralgro growth hormone levels tended to rise following implantation and then decrease.

The greatest benefit of implanting may not be increased lean product of bulls but instead may be increased fat cover to a more acceptable finish and increased quality and palatability traits. Brethour (1982) concluded that implanting bulls reared for meat production may be the most economical program available today to produce the lean, acceptable quality beef desired by today's consumer.

The research presented herein was designed to determine the effects of postweaning implanting on performance, carcass characteristics, hormonal profile and reproductive parameters.

Experimental Procedure

Sixty-six postweaned Angus bulls averaging 282 kg were randomly assigned to four treatments, (1) nonimplanted, (2) Ralgro (36 mg of zeranol), (3) Synovex-S (200 mg of progesterone and 20 mg of estradiol benzoate) and (4) Compudose (24 mg of estradiol-17β).

After weaning the calves were trucked to the Southeast Experiment Station, Beresford, South Dakota, where they commenced an implanting trial on November 21, 1984. Each treatment was divided into 8 or 9 bulls per pen with similar treatments penned side by side. The

bulls were housed in outdoor drylots where they remained on test for 217 d.

All cattle were started on an ad libitum diet of 45% corn and 55% alfalfa hay. The diet was increased progressively to a final finishing diet of 73% corn, 22% corn silage and 5% mineral supplement.

Individual body weights were recorded at 28-d intervals following the initial weighing on November 21, 1984. Hip height, measured in centimeters at the hip, and scrotal circumference, recorded using scrotal tape, were taken for all individuals at initiation and termination of the trial. In addition, at the beginning of the trial the bulls in the treated groups were implanted with their appropriate implant on the backside of the ear. The implanted bulls were reimplanted every 60 to 70 d for Ralgro and Synovex and every 180 d for Compudose.

Blood samples were collected weekly starting November 21, 1984, for 9 wk and then monthly for 3 mo with the final collection just prior to slaughter. The bulls were restrained in a squeeze chute and bled by venipuncture. Blood samples were collected in labeled vacutainer tubes and placed on ice until returning to the reproductive physiology lab. The samples were collected at approximately the same time each bleeding at 1000 to 1200 hr. The blood was centrifuged for 45 min at 2500 rpm. The serum was decanted into duplicate plastic labeled tubes and stored at -24 C and later assayed for testosterone, growth hormone and luteinizing hormone.

The testosterone assays prepared by Diagnostics Products Company were a solid-phase radioimmunoassay based on a testosterone specific antibody immobilized to the wall of the polyproylene tubes. All samples were analyzed in duplicate. Testosterone labeled with (125 I) iodide had a high specific activity, with total counts of approximately 60,000 cpm. The maximum binding was approximately 45%. Also, the antiserum was specific for testosterone with a cross reactivity of .10% and sensitivity of .11 ng/ml. The standard curve was linear between .3 ng/m and 30 ng/ml. Increasing volumes of steer serum paralleled the standard curve. Recovery was determined by adding 1 ng/ml of testosterone (Sigma) to steer serum and was 103%.

An aliquot of 25 µl was used for each sample. After 3 hr of incubation at 37 C, the separation of the bound and free fraction and termination of the competition was accomplished by decanting the supernatant. The remaining bound fraction in the tube was counted in a gamma counter for 1 min.

Spiked steer serum served as a check for recovery. Intra- and interassay coefficients were determined with the use of pooled steer serum and spiked steer serum with correlation coefficients of .23 and .38, respectively.

Luteinizing hormone assays were analyzed for each bleeding. The concentrations of LH were determined by the double antibody radioimmunoassay procedure described by Niswender et al. (1969) with modifications. Purified antigen labeled with (125 I) iodide was obtained from Diagnostics Products Corporation. Dr. G. D. Niswender

provided the primary antibody. The maximum binding ranged from 40 to 55%. Cross reactivity existed between ovine and bovine LH. Increasing steer serum paralleled the standard curve which ranged from 25 ng/ml to .063 ng/ml. Also, the interassay and intraassay coefficients were .02 and .46, respectively.

All samples were run in duplicate. From each sample 100 l of serum was added to properly labeled tubes containing LH antibody diluted with 1:300 NRS/PBS and labeled antigen. After 3 d of incubation in the refrigerator, the second antibody was added and allowed to incubate for an additional 2 d. The assay was stopped and centrifuged for 20 min. The supernatant was carefully decanted and precipitate counted for 1 min in a gamma counter.

The growth hormone levels were determined in each blood sample by a double antibody radioimmunoassay procedure reported in the appendix. The standard curve was paralleled by increasing volumes of steer serum. Ovine growth hormone cross reacts with bovine growth hormone. In addition, a specificity check was run to determine specific for ovine growth hormone. Intra- and interassay coefficients were .35 and .58, respectively.

On July 15, 1985, one pen per treatment was transported to a commercial packing plant. The remaining bulls were slaughtered July 22, 1985. To avoid preslaughter stress which results in lower quality grades, all bulls were slaughtered immediately upon arrival at the plant.

The vas deferens were removed from testes at the slaughter plant. Semen was milked from the vas deferens into labeled tubes to be analyzed later by flow cytometry. Also, at this time hot carcass weights and testes were acquired from each individual bull. Prior to placing on ice, the vas sperm were mixed with TNE (.01 M Tris-buffer, .15 M NaCl and .001 M dissodium ethylenediamine teraacetate (EDTA), pH 7.4) and glycerol. The testes were also placed on ice to be transported back to the lab. Vas sperm was frozen at -20 C for 8 hr and then later -100 C for later flow cytometry measurement. The testes weights were recorded at the lab.

In preparation for measurement by flow cytometry, all the sperm samples were stained using a two-step acridine procedure as described by Evenson et al. (1983). The acridine orange (AO) stain fluorescence green when associated with double-stranded (ds) nucleic acids and red with single-stranded (ss) nucleic acids (Darzynkiewicz, 1979). In maturing sperm, the staining procedure induces denaturation of DNA in sperm and the varying levels of green and red fluorescence determines if the DNA content is ds or ss. The susceptibility of sperm to denaturation is quantified by alpha-t (t = red/(red + green fluorescence) and considerable variation has been observed among individuals (Ballachey et al., 1985). Immediately after AO staining, fluorescence measurements were taken on an Ortho Diagnostics S Cytoflurograf II interfaced to a Ortho 2150 D handle[1]. Recorded

[1]Ortho Diagnostics, Inc., Westwood, MO.

measurements began 3 min after staining. Red fluorescence (F>600)[2] and green fluorescence (F 530)[2] were measured based on 5000 cells per sample. Alpha-t was calculated for each cell and the t distribution was recorded by a computer disk.

Carcass data were obtained 24 hr postmortem with the assistance of a USDA grader. The data collected consisted of marbling, maturity score, final quality grades, adjusted fat thickness and kidney, heart and pelvic fat. The longissimus muscle was traced at the 12th rib for each carcass and later the area was determined by a compensating polar planimeter.

Statistical analyses were evaluated by analysis of variance using General Linear Models (GLM) procedure of Statistical Analysis Systems (SAS, 1982). Significant differences among least-squares means were determined by the predicted different statement (PDIFF). Simple correlation coefficients were calculated for carcass, performance, hormonal profile and reproductive parameters.

Results and Discussion

Performance Traits. The performance data (initial, final and total weight gain, table 1) did not differ (P>.05) due to treatments. Ralgro-implanted bulls had the lowest initial and final body weights. They also had the lowest weight gain and average daily gain. The heavier initial weight of the Compudose-implanted bulls resulted in the

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[2]F 530 = fluorescence at 530 nm; the band between 515 and 530 is measured. F<600 = fluorescence greater than 600 nm.

TABLE 1. LEAST-SQUARES MEANS FOR PERFORMANCE

Item	No. of observations	Control	Ralgro[a]	Synovex[a]	Compudose[b]
Initial wt, kg	66	280 ± 5.4	274 ± 2.2	282 ± 5.2	289 ± 5.4
Final wt, kg	64	521 ± 9.9	497 ± 9.3	531 ± 9.3	524 ± 9.9
Wt gain, kg[c]	64	241 ± 8.1	223 ± 7.6	249 ± 7.6	235 ± 8.1
Avg daily gain, kg/d	64	1.11 ± .04	1.03 ± .04	1.14 ± .04	1.08 ± .04

[a] Implanted at day 0 and every 60 to 70 d.
[b] Implanted at days 0 and 180.
[c] Total weight gained over the trial period.

second lowest average daily gain. Synovex-implanted bulls had the highest final weight (531 kg), weight gain (249 kg) and average daily gain (1.14 kg/d). The controls were higher in average daily gain (1.11 kg/d) than Compudose (1.08 kg/d) and Ralgro (1.03 kg/d). The lack of difference in the performance parameters was consistent with the results obtained by Price et al. (1983) and Vanderwert et al. (1984). However, Gill et al. (1983) concluded implanting feedlot bulls with Compudose, Ralgro and Synovex improved live weight gains by a mean of 15.5 kg. In agreement with the above statement, bulls implanted postweaning had increased growth rates (Gregory and Ford, 1983).

Skeletal growth was measured by hip height at initiation and termination of the trial (table 2). Control bulls exhibited the greatest increase in hip height (15.7 cm), Ralgro (14.4 cm), Synovex (14.3 cm) and Compudose (13.7 cm) the least. Yet there was no difference ($P>.05$) between treatments. Previous studies also indicated implanting had little effect on hip height (Staigmiller et al., 1985; Unruh et al., 1986).

Least-squares means and standard errors for testicular parameters are included in table 2. Initial scrotal circumference was 25.8 cm for controls, 25.8 cm for Ralgro, 26.1 cm for Synovex and 27.6 cm for Compudose. At the termination of the trial, control bulls had the largest scrotal circumference. Implanted reduced ($P<.05$) testicular diameter compared to controls, with Synovex having the greatest effect. The only statistical difference ($P<.05$) noted in

TABLE 2. LEAST-SQUARES MEANS FOR HIP HEIGHT AND TESTICULAR PARAMETERS

Item	No. of observations	Control	Ralgro[a]	Synovex[a]	Compudose[b]
Hip height, cm					
Initial	66	110.8 ± 1.08	109.7 ± 1.05	112.1 ± 1.05	112.6 ± 1.08
Final	64	126.8 ± .79	124.1 ± .74	126.4 ± .74	126.6 ± .79
Gain[c]	64	15.7 ± 1.00	14.4 ± .97	14.3 ± .97	13.7 ± 1.00
Scrotal circumference, cm					
Initial	66	25.8 ± .60	25.8 ± .59	26.1 ± .59	27.6 ± .60
Final*	64	39.6[e] ± .44	38.8[ef] ± .41	37.8[f] ± .41	38.6[ef] ± .44
Gain[d]	64	13.5 ± .76	13.0 ± .72	11.7 ± .72	10.8 ± .76
Testicular wt, g	64	602.1 ± 27.20	581.7 ± 25.50	522.3 ± 25.50	584.3 ± 27.20

[a] Implanted at day 0 and every 60 to 70 d.
[b] Implanted at days 0 and 180.
[c] Increase in height during the trial.
[d] Gain in scrotal circumference during the trial.
[e,f] Means in the same row not bearing a common superscript differ (P<.05).
*P<.05.

final scrotal circumference was between control and Synovex-implanted bulls. Final scrotal circumferences were 39.6, 38.8, 37.8 and 38.6 cm for controls, Ralgro-, Synovex- and Compudose-implanted bulls, respectively. There was no difference (P>.05) in scrotal circumference gain among the four groups. Controls had the largest scrotal circumference gain over the trial period, 13.5 cm compared to 13.0 cm for Ralgro, 11.7 cm for Synovex and 10.8 cm for Compudose-implanted bulls. The larger initial scrotal circumference for the Compudose group and similar final scrotal circumference measurements for all three implanted groups explains the lower scrotal circumference gain for Compudose-implanted bulls. Most of the research conducted in postweaned implanted bulls has resulted in no measurable effects on scrotal circumference (Gregory and Ford, 1983; Price et al., 1983; Unruh et al., 1983; Staigmiller et al., 1985). These results agree somewhat with studies where lifelong implanting beginning at birth decreased scrotal circumference (Corah et al., 1979; Cooper and Kirk, 1982; Deschamps et al., 1982; Unruh et al., 1983; Staigmiller et al., 1985). The small variation in total scrotal circumference could be explained by the balance between gonadal steroids and gonadotropins. These results showed a reduction in testosterone approximately 1 wk after implantation. This may permit an increased gonadotropin release, resulting in a faster rate of testicular growth in implanted bulls to compensate for the reduction in testosterone. Thus, the implanted bulls caught up in total scrotal circumference gain with the controls by the end of the trial, resulting in no difference (P>.05).

Control bulls had the greatest testicular weight and the Synovex bulls the smallest testicular weights. From the testicular data it is concluded that implanting reduces testicle weight but not statistically (P>.05). Similar results were reported by Gregory and Ford (1983) and Juniewicz et al. (1985). Implanting bulls early in life until slaughter has proven to restrict testicle development (Ralston, 1978; Corah et al., 1979; Brethour, 1982; Greathouse et al., 1983; Calkins et al., 1986).

Carcass Traits. Least-squares means and standard errors for carcass data are presented in table 3. Carcass weights for Compudose (331 kg) and Synovex (332 kg) implanted bulls were heavier (P<.01) than Ralgro (307 kg) and control bulls (318 kg). Ralgro reduced carcass weight compared to the other three treatments. Johnson et al. (1984) reported no difference in carcass weight in postweaned bulls implanted with Ralgro, Synovex and Compudose. However, Mould (1985) revealed Ralgro-implanted bulls had lighter carcass weights than controls. Similar to these data, Calkins et al. (1986) indicated that Compudose-implanted bulls had heavier carcass weights than nonimplanted bulls.

Longissimus muscle area, kidney, heart and pelvic fat, marbling and USDA quality grades were similar among treatments. Compudose-implanted bulls had the largest longissimus muscle area (81.0 cm^2) compared to controls (78.8 cm^2), Synovex (78.7 cm^2) and Ralgro (76.2 cm^2). The Compudose-implanted bulls also had the highest estimated kidney, heart and pelvic fat, measuring 1.6%, Synovex at 1.5%

TABLE 3. LEAST-SQUARES MEANS FOR CARCASS TRAITS

	Control	Ralgro[a]	Synovex[a]	Compudose[b]
No. of observations	15	17	17	15
Hot carcass wt, kg*	318[fg] ± 6.5	307[g] ± 6.1	332[f] ± 6.1	331[f] ± 6.5
Longissimus muscle area, cm^2	78.8 ± 1.9	76.2 ± 1.7	78.7 ± 1.7	81.0 ± 1.9
Fat thickness, mm**	9.05[g] ± .71	8.32[g] ± .66	11.55[f] ± .66	8.72[g] ± .71
Est. KPH fat, %[c]	1.4 ± .11	1.4 ± .10	1.5 ± .10	1.6 ± .11
USDA yield grade*	2.43[g] ± .11	2.38[g] ± .18	2.82[f] ± .11	2.44[g] ± .19
Marbling score[d]	4.36 ± .19	3.90 ± .18	4.19 ± .18	4.26 ± .19
USDA quality grade[e]	6.00 ± .25	5.00 ± .24	6.00 ± .24	6.00 ± .25
Dressing percentage*	61.1[g] ± .47	61.7[g] ± .44	62.6[fg] ± .44	63.2[f] ± .46

[a] Implanted at day 0 and every 60 to 70 d.
[b] Implanted at days 0 and 180.
[c] Estimated kidney, pelvic and heart fat.
[d] Marbling 1-8, 1 = practically devoid, 4 = small, 8 = moderately abundant.
[e] Quality grade 1-8, 1 = Low standard, 5 = High good, 8 = High choice.
[f,g] Means in the same row not bearing a common superscript differ ($P<.05$).
*$P<.05$.
**$P<.01$.

and Ralgro and controls at 1.4%. The bulls implanted with Ralgro exhibited the lowest quality grade (good) and marbling score (slight 90) which coincides with less fat thickness. The remaining three treatments had small marbling scores and graded low choice. In contrast, Calkins et al. (1986) noted that quality scores were higher in Ralgro-implanted cattle than nonimplanted or Compudose-implanted cattle. Johnson et al. (1984) reported there was no difference in longissimus muscle area, kidney, heart and pelvic fat, marbling score and quality grades. However, Corah et al. (1979) indicated implanting young bulls improved quality grades compared to nonimplanted cattle. Implanting bulls later in life had little effect on quality grades (Gregory and Ford, 1983).

Fat thickness measured at the 12th rib was greater ($P<.05$) for Synovex (11.55 mm) than controls (9.05 mm), Compudose (8.72 mm) and Ralgro (8.32 mm). These results were consistent with previous studies where Synovex implants tended to increase fat thickness in young bulls (Forrest, 1968, 1978; Stout, 1980; Johnson, 1984; Johnson et al., 1983, 1986; Paterson et al., 1983). The lack of difference in fat thickness among Ralgro-treated bulls and controls and Ralgro- and Compudose-implanted bulls was noted in studies by Gregory and Ford (1983) and Johnson et al. (1984). Furthermore, Gill et al. (1983) reported Ralgro-implanted bulls had less external fat thickness, which agrees with the data presented in table 3. Contrasting the above, Price et al. (1983) reported a slight increase in fat thickness in postweaned Ralgro-implanted bulls. Similar results were noted when

bulls were implanted from birth to slaughter (Greathouse et al., 1983; McKenzie, 1983; Vanderwert et al., 1984; Gray et al., 1986; Unruh et al., 1986).

The greater fat thickness exhibited by the Synovex-implanted bulls increased the USDA yield grade to 2.82 compared to control bulls with 2.43, Compudose-implanted 2.44 ($P<.05$) and Ralgro-implanted 2.38 ($P<.01$) bulls. Johnson et al. (1984) obtained similar results. The difference in yield grade was due to the variation in fat thickness. Furthermore, the Compudose-implanted bulls had the highest dressing percentage (63.2%) followed by Synovex (62.6%), Ralgro (61.7%) and controls (61.1%).

Sperm Variables. Sperm variables (peak, mean, standard deviation, coefficient of variation and comp) are measurements made by a flow cytometer to determine semen quality. These measurements are based on alpha t (t = red/red + green fluorescence).

The effect of the four treatments on sperm variables were minimal. These data are presented in table 4. The Synovex-implanted bulls had the lowest alpha t peak range (196.48), Ralgro (201.15), Compudose (202.42) and controls (203.48). The mean for the t distributions was highest for Compudose (212.15) and Ralgro (212.28) than Synovex (205.17) and controls (203.57). Ralgro-implanted bulls had the highest standard deviation from the mean for t distribution. Therefore, the Ralgro-implanted bulls had greater amount of the population away from the mean. They also had the highest t-comp (cells

TABLE 4. LEAST-SQUARES MEANS FOR SPERM VARIABLES

	Control	Ralgro[a]	Synovex[a]	Compudose[b]
		Relative cell number		
No. of observations	15	17	17	15
Peak[c]	203.48 ± 3.05	201.15 ± 2.95	196.48 ± 3.16	202.42 ± 3.16
Means[d]	203.57 ± 5.39	212.28 ± 5.22	205.17 ± 5.58	212.15 ± 5.58
Standard deviation[e]	37.64 ± 4.46	43.72 ± 4.32	38.31 ± 4.62	37.17 ± 4.62
Coefficient of variation[f]	19.17 ± 1.98	20.16 ± 1.92	18.33 ± 2.05	17.22 ± 2.05
Comp[g]	6.12 ± 1.91	8.67 ± 1.85	5.72 ± 1.98	7.74 ± 1.97

[a] Implanted at day 0 and every 60 to 70 d.
[b] Implanted at days 0 and 180.
[c] Peak at the t distribution.
[d] Mean of the t distribution.
[e] Standard deviation of the t distribution.
[f] Coefficient of variation for the alpha-t distribution.
[g] Comp-cells that fall outside the main population.

that fall outside the main population) and t-coefficient of variation, indicative of a poorer quality semen sample. The higher values correspond to decreased sperm quality and reduced fertility. Furthermore, there was little variation in t-standard deviation, t-coefficient of variation and t-comp in the other three treatments. Sperm variables were not affected by implants similar to Juniewicz et al. (1985) results, while Ballachey et al. (1985) concluded implants had a permanent effect on testicular development in bulls implanted preweaning.

Figure 1 is an example of flow cytometry data on vas sperm from two bulls in this study. Little variation was noted in all the flow cytometry measurements. The graphs presented are examples of the best (1a,b) and poorest (1c,d) semen samples. The cytograms of green vs red fluorescence in figures 1b and 1d correspond to the alpha t frequency histogram 1a and 1c. Sperm nuclei have an asymmetrical shape and high refractive index. The fluorescence detected depends upon the orientation of the nucleus in the flow cell at the time of meaurement. Cytogram 1d shows an animal with greater red fluorescence than 1b. Thus, 1d has a greater number of the population closer to the origin, which is characteristic of a poorer quality sample. The more ideal sample is displayed in 1b where variables in the cytogram are closely clustered around the mean. Histogram 1a notes a large amount of the population around the mean as seen by the high peak and no evidence of a second peak. Figure 1c presents a similar first peak but reveals a small amount of the population falling outside the mean as seen by a

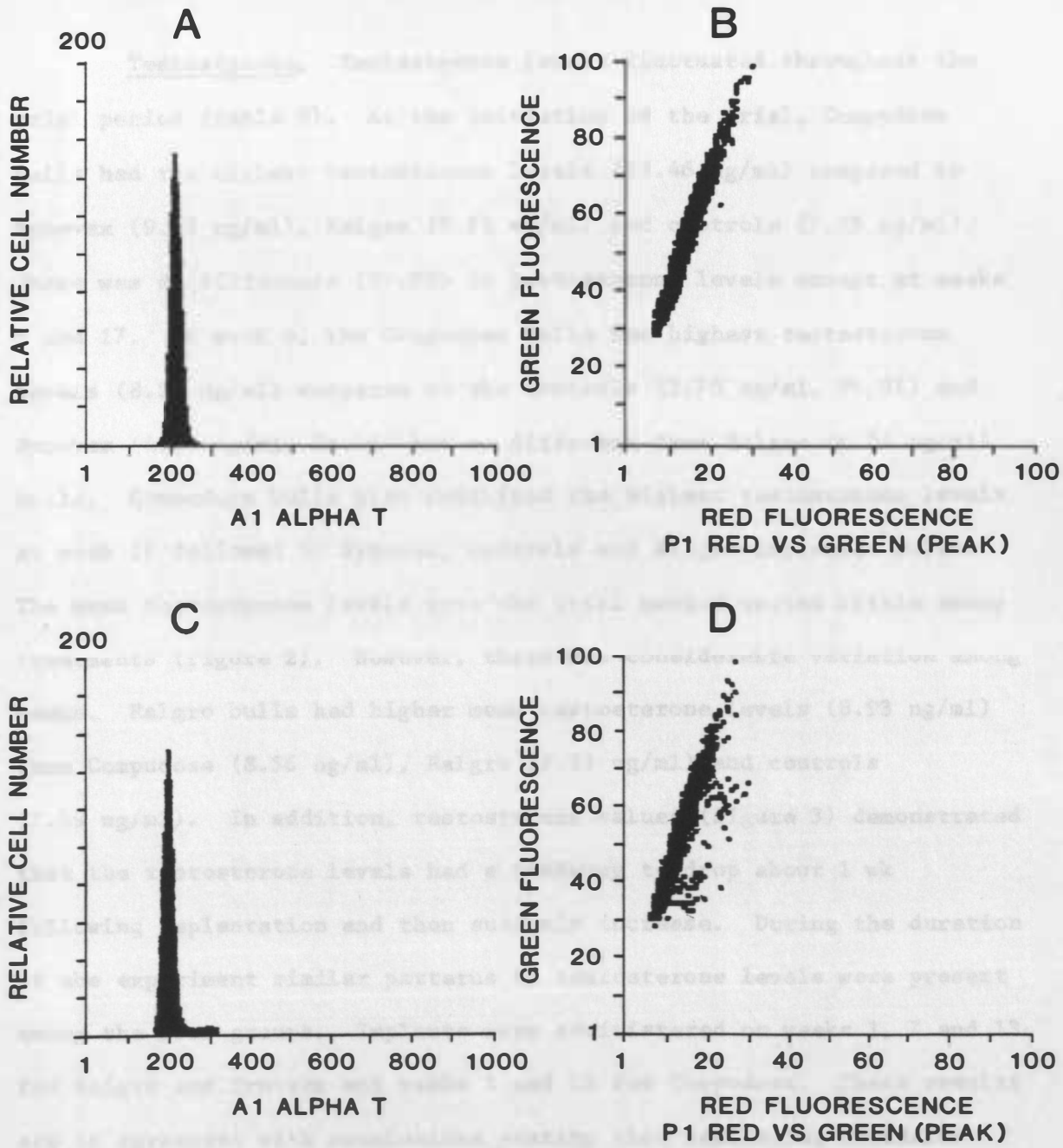

Figure 1. Flow Cytometry Measurements of Sperm Variables

second peak. Therefore, the greater first peak and smaller second peak are indicative of a higher quality sample.

Testosterone. Testosterone levels fluctuated throughout the trial period (table 5). At the initiation of the trial, Compudose bulls had the highest testosterone levels (11.46 ng/ml) compared to Synovex (9.45 ng/ml), Ralgro (9.71 ng/ml) and controls (7.83 ng/ml). There was no difference ($P>.05$) in testosterone levels except at weeks 6 and 17. At week 6, the Compudose bulls had highest testosterone levels (8.20 ng/ml) compared to the controls (3.75 ng/ml, $P<.01$) and Synovex (4.84 ng/ml, $P<.05$) but no different from Ralgro (6.94 ng/ml) bulls. Compudose bulls also exhibited the highest testosterone levels at week 17 followed by Synovex, controls and Ralgro-implanted bulls. The mean testosterone levels over the trial period varied little among treatments (figure 2). However, there was considerable variation among weeks. Ralgro bulls had higher mean testosterone levels (8.93 ng/ml) than Compudose (8.56 ng/ml), Ralgro (8.93 ng/ml) and controls (7.39 ng/ml). In addition, testosterone values (figure 3) demonstrated that the testosterone levels had a tendency to drop about 1 wk following implantation and then suddenly increase. During the duration of the experiment similar patterns in testosterone levels were present among the four groups. Implants were administered on weeks 1, 7 and 13 for Ralgro and Synovex and weeks 1 and 13 for Compudose. These results are in agreement with conclusions stating that implanting decreases testosterone after implantation (Staigmiller et al., 1985). Serum

TABLE 5. LEAST-SQUARES MEANS FOR TESTOSTERONE LEVELS

Item	No. of observations	Control	Ralgro[a]	Synovex[a]	Compudose[b]
		Testosterone levels (ng/ml)[c]			
Week 1	66	7.83 ± 1.5	9.71 ± 1.5	9.45 ± 1.5	11.46 ± 1.5
Week 2	66	6.93 ± 1.7	6.87 ± 1.7	8.57 ± 1.7	4.49 ± 1.7
Week 3	66	5.81 ± 1.3	6.86 ± 1.3	9.76 ± 1.3	5.41 ± 1.3
Week 4	65	4.00 ± 1.2	4.91 ± 1.2	7.11 ± 1.2	4.92 ± 1.2
Week 5	66	5.89 ± 1.1	8.42 ± 1.1	7.83 ± 1.1	8.21 ± 1.1
Week 6**	66	3.75[d] ± .94	6.94[e] ± .91	4.84[de] ± .91	8.20[e] ± .94
Week 7	66	4.70 ± 1.6	9.03 ± 1.5	6.79 ± 1.5	7.14 ± 1.6
Week 8	66	9.73 ± 2.0	9.77 ± 2.0	10.13 ± 2.0	11.00 ± 2.0
Week 9	66	5.51 ± 1.0	5.34 ± 1.0	4.96 ± 1.0	5.45 ± 1.0
Week 13	65	10.05 ± 2.3	13.31 ± 2.2	9.24 ± 2.2	13.32 ± 2.3
Week 17*	66	6.29[de] ± 1.2	3.60[e] ± 1.1	7.97[d] ± 1.1	8.00[d] ± 1.1
Week 21	63	13.43 ± 2.5	18.08 ± 2.4	13.53 ± 2.5	13.26 ± 2.7
Week 25	65	11.04 ± 1.1	9.74 ± 1.1	8.43 ± 1.1	10.11 ± 1.1
Week 34	64	9.08 ± 1.3	7.89 ± 1.2	11.70 ± 1.2	8.17 ± 1.3
Mean	66	7.39 ± .76	8.93 ± .74	8.27 ± .74	8.56 ± .76

[a] Implanted at day 0 and every 60 to 70 d.
[b] Implanted at days 0 and 180.
[c] Testosterone levels at various weeks after trial initiation.
[d,e] Means in the same row not bearing a common superscript differ (P<.05).
*P<.05.
**P<.01.

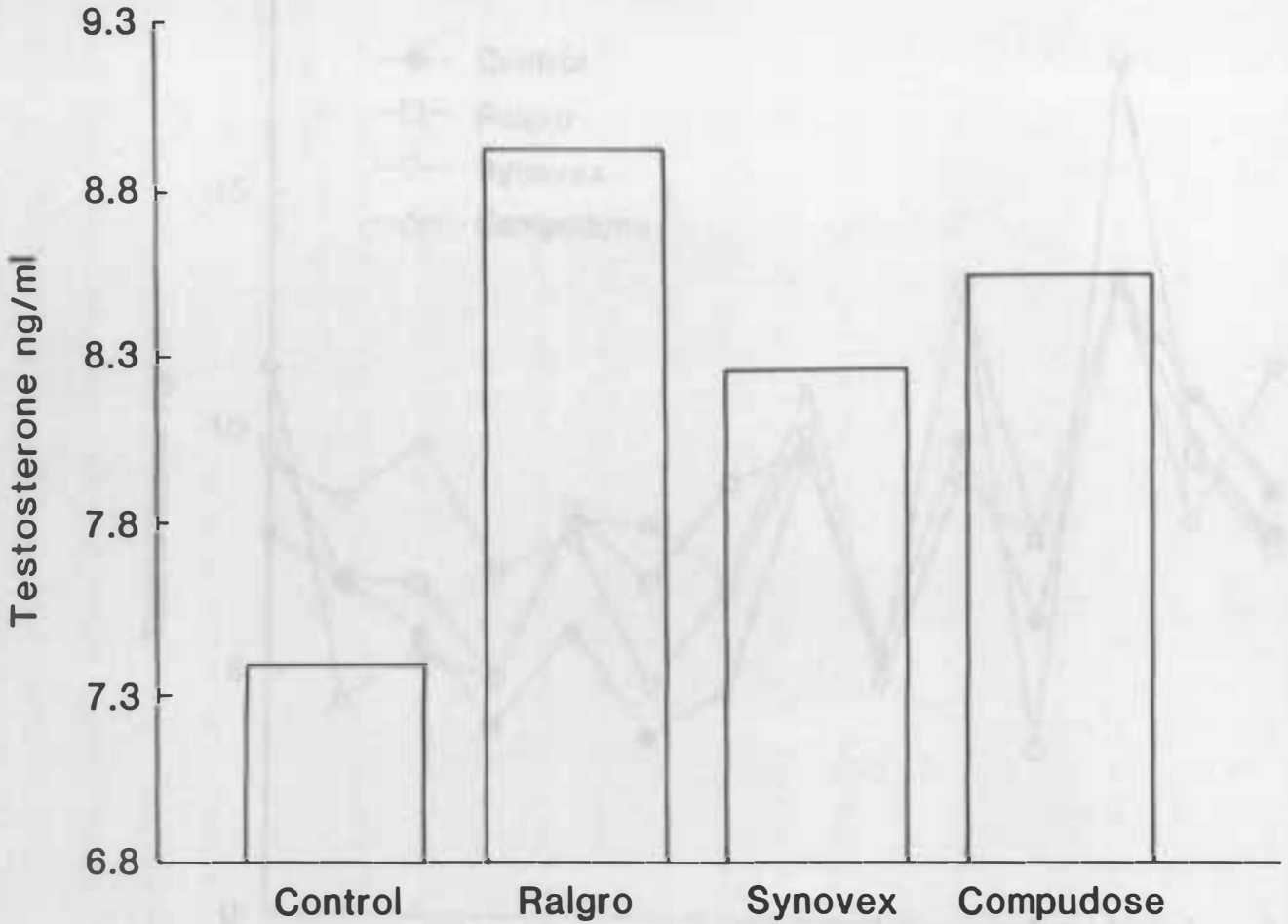

Figure 2. Testosterone Means for Treatments

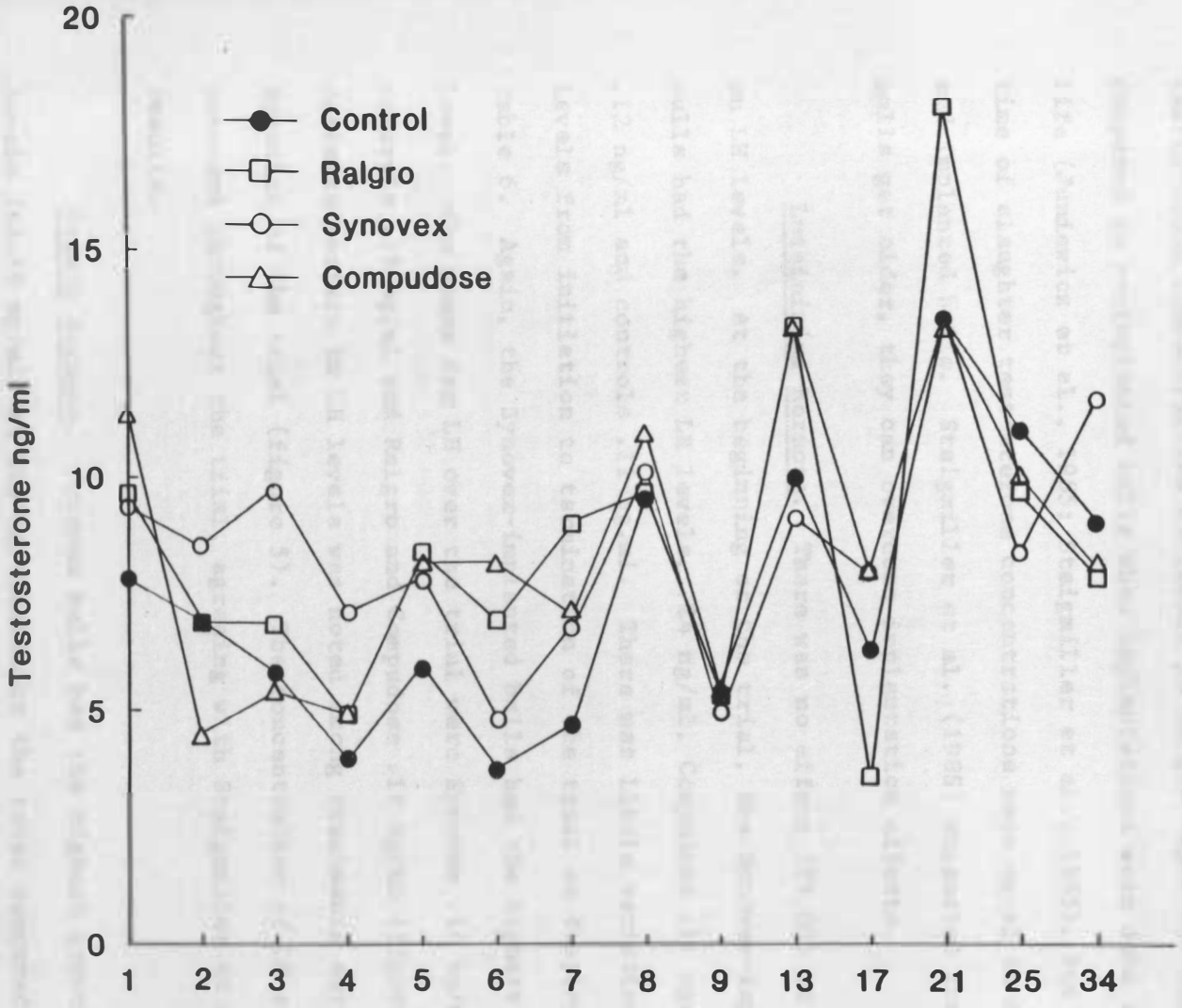

Figure 3. Testosterone Levels by Week for Treatments

testosterone concentrations decreased in Ralgro-implanted bulls compared to nonimplanted bulls when implantations were done early in life (Juniewicz et al., 1985; Staigmiller et al., 1985), but by the time of slaughter testosterone concentrations were equal in controls and implanted bulls. Staigmiller et al. (1985) suggested that, as bulls get older, they can overcome implantation effects.

Luteinizing Hormone. There was no effect (P>.05) of implants on LH levels. At the beginning of the trial, the Synovex-implanted bulls had the highest LH levels, .24 ng/ml, Compudose .14 ng/ml, Ralgro .12 ng/ml and controls .11 ng.ml. There was little variation in LH levels from initiation to termination of the trial as displayed in table 6. Again, the Synovex-implanted bulls had the highest average LH level. The means for LH over the trial were Synovex .14 ng/ml, controls .13 ng/ml and Ralgro and Compudose .11 ng/ml (figure 4). No definite pattern in LH levels was noted among treatments during the duration of the trial (figure 5). The concentration of LH remained constant throughout the trial, agreeing with Staigmiller et al. (1985) results.

Growth Hormone. Synovex bulls had the highest growth hormone levels (62.18 ng/ml) at the initiation of the trial compared to Compudose, controls and Ralgro bulls with growth hormone concentrations of 57.19, 55.18 and 52.88 ng/ml, respectively (table 7). On week 3, Ralgro-implanted bulls had an excessively high growth hormone level (112.13 ng/ml), while the other treatments were in the range of 29 to

TABLE 6. LEAST-SQUARES MEANS FOR LUTEINIZING HORMONE LEVELS

Item	No. of observations	Control	Ralgro[a]	Synovex[a]	Compudose[b]
			Luteinizing levels, ng/ml[c]		
Week 1	66	.11 ± .04	.12 ± .04	.24 ± .04	.14 ± .04
Week 2	66	.14 ± .03	.16 ± .02	.11 ± .02	.07 ± .03
Week 3	66	.14 ± .02	.13 ± .02	.14 ± .02	.11 ± .02
Week 4	65	.03 ± .01	.02 ± .01	.04 ± .01	.04 ± .01
Week 5	66	.08 ± .03	.02 ± .03	.12 ± .03	.04 ± .03
Week 6	66	.04 ± .02	.06 ± .02	.07 ± .02	.06 ± .02
Week 7	66	.17 ± .04	.13 ± .04	.19 ± .04	.10 ± .04
Week 8	66	.14 ± .05	.24 ± .04	.17 ± .04	.14 ± .05
Week 9	66	.07 ± .03	.16 ± .03	.10 ± .03	.08 ± .03
Week 13	65	.04 ± .04	.12 ± .04	.07 ± .04	.11 ± .04
Week 17	66	.39 ± .19	.04 ± .18	.04 ± .18	.05 ± .19
Week 21	63	.07 ± .09	.10 ± .09	.35 ± .09	.09 ± .10
Week 25	65	.09 ± .04	.10 ± .04	.03 ± .04	.11 ± .04
Week 34	64	.27 ± .10	.16 ± .09	.27 ± .09	.35 ± .10
Mean	66	.13 ± .02	.11 ± .02	.14 ± .02	.11 ± .02

[a] Implanted at day 0 and every 60 to 70 d.
[b] Implanted at days 0 and 180.
[c] Luteinizing levels at various weeks after trial initiation.

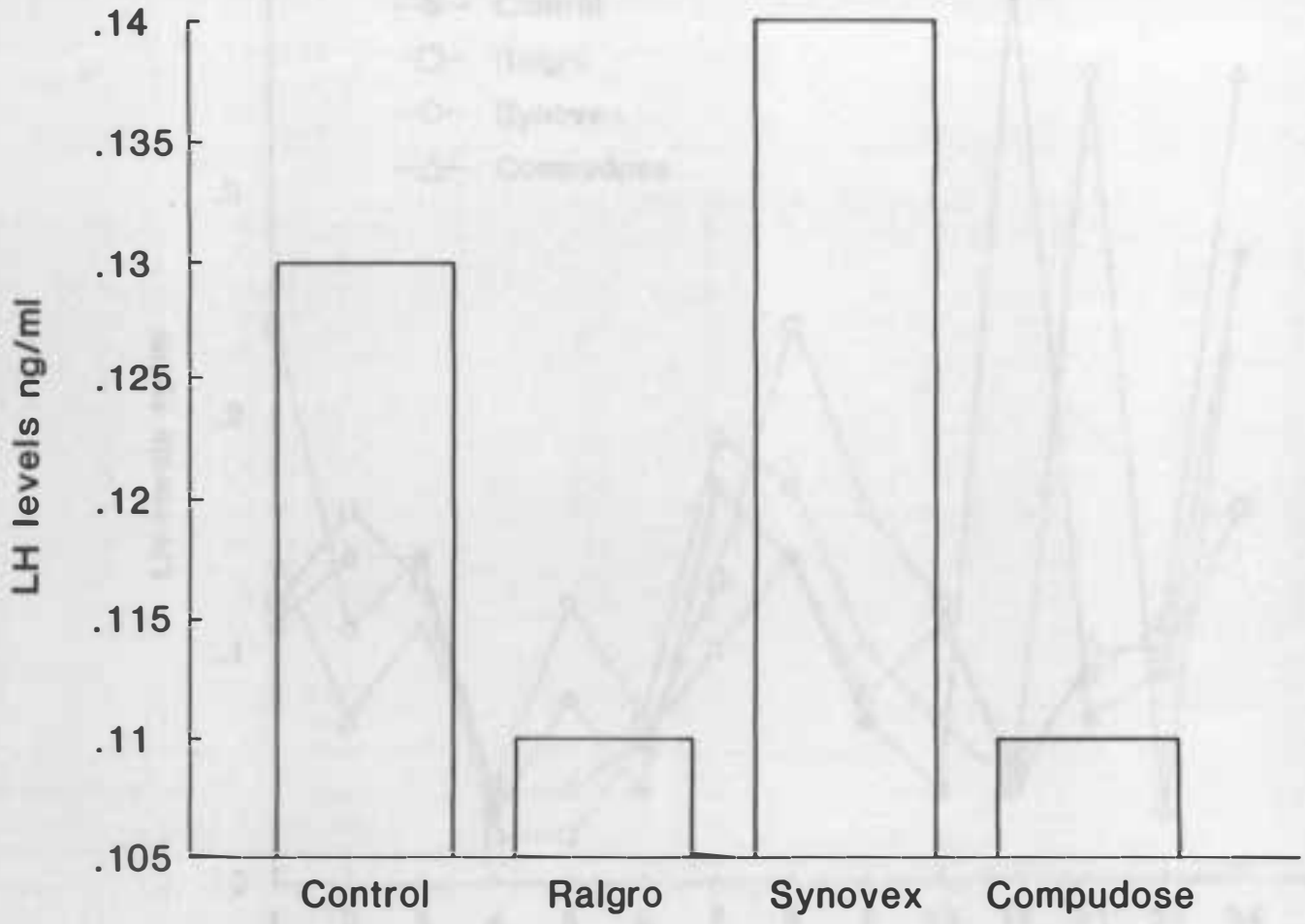

Figure 4. Luteinizing Hormone Means for Treatments

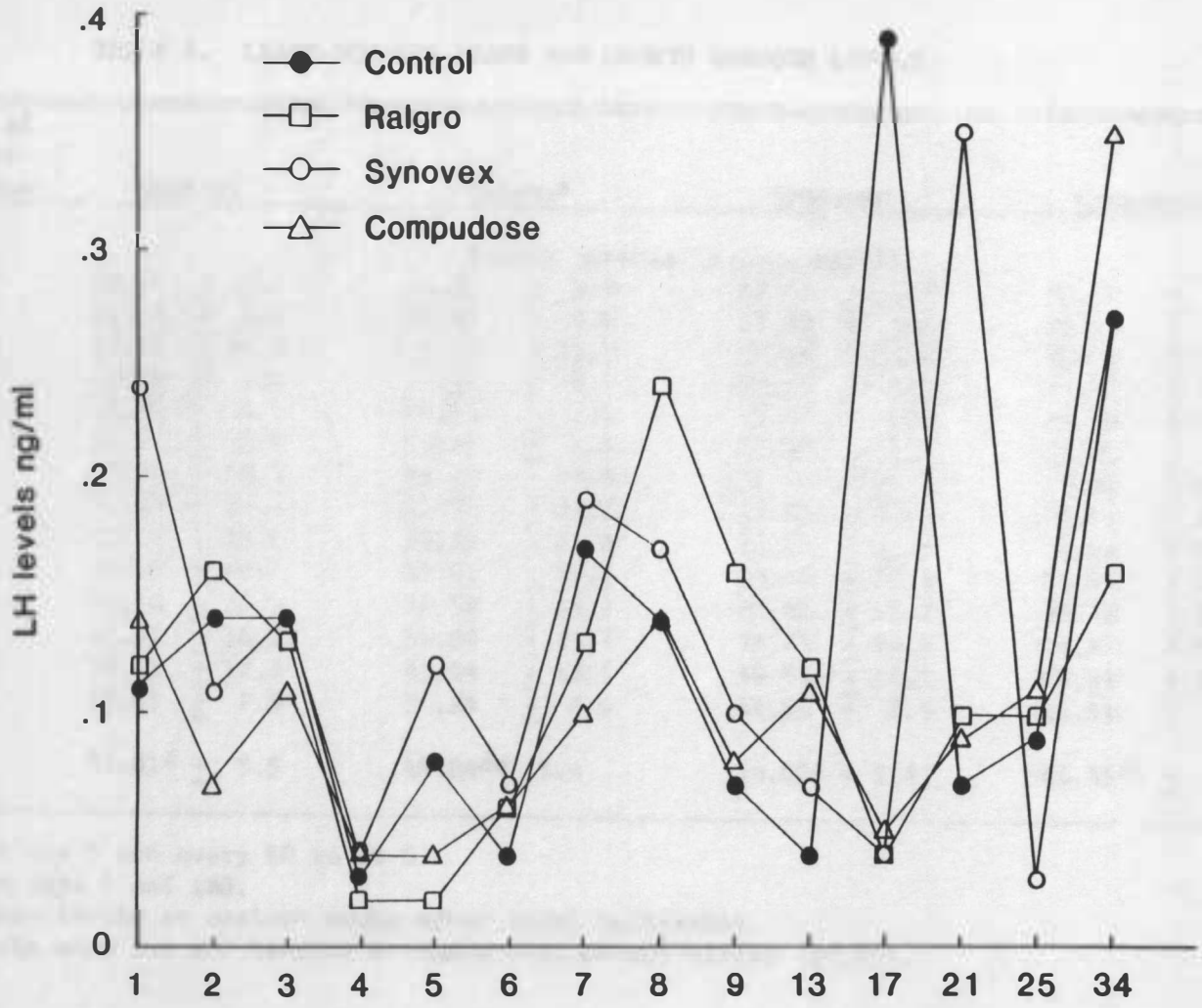

Figure 5. Luteinizing Hormone Levels by Week for Treatments

TABLE 7. LEAST-SQUARES MEANS FOR GROWTH HORMONE LEVELS

Item	No. of observations	Control	Ralgro[a]	Synovex[a]	Compudose[b]
		Growth hormone levels, ng/ml[c]			
Week 1	66	55.18 ± 9.1	52.88 ± 8.8	62.18 ± 8.8	57.19 ± 9.1
Week 2	66	23.28 ± 4.7	22.97 ± 4.6	32.39 ± 4.6	25.05 ± 4.7
Week 3	66	29.18 ± 35.0	112.13 ± 33.9	37.95 ± 33.8	40.60 ± 35.0
Week 4	65	19.39 ± 4.1	24.43 ± 4.0	23.85 ± 4.0	31.75 ± 4.2
Week 5	66	19.49 ± 7.1	28.59 ± 7.0	13.46 ± 7.0	16.78 ± 7.2
Week 6	66	12.74 ± 5.6	32.45 ± 5.5	22.80 ± 5.5	23.50 ± 5.6
Week 7	66	24.04 ± 30.9	53.32 ± 29.9	121.18 ± 29.9	58.96 ± 30.9
Week 8	66	66.90 ± 23.4	62.22 ± 22.7	122.82 ± 22.7	59.60 ± 23.4
Week 9	66	10.13 ± 13.1	59.45 ± 13.3	36.88 ± 13.3	38.99 ± 13.7
Week 13	66	14.19 ± 10.7	37.91 ± 10.3	29.06 ± 10.3	32.55 ± 10.7
Week 17	66	56.44 ± 17.9	38.58 ± 15.7	80.82 ± 17.3	90.48 ± 17.9
Week 21	63	37.01 ± 16.2	54.50 ± 15.7	93.73 ± 16.2	64.37 ± 17.3
Week 25	65	29.63 ± 12.5	48.04 ± 12.1	49.59 ± 12.1	67.31 ± 12.9
Week 34	65	50.65 ± 7.8	28.35 ± 7.6	41.58 ± 7.6	25.51 ± 8.1
Mean*	66	32.01[d] ± 5.5	46.84[de] 5.4	54.80[f] + 5.4	44.55[de] ± 5.5

[a] Implanted at day 0 and every 60 to 70 d.
[b] Implanted at days 0 and 180.
[c] Growth hormone levels at various weeks after trial initiation.
[d,e] Means in the same row not bearing a common superscript differ ($P<.05$).
*$P<.05$.

40 ng/ml). Synovex-implanted bulls had higher levels of growth hormone concentration on weeks 7 (121.18 ng/ml) and 8 (122.82 ng/ml). Growth hormone levels increased in Ralgro- and Synovex-implanted bulls after implantation. At trial termination, growth hormone levels were lowest for Compudose at 25.5 ng/ml than Ralgro (28.35 ng/ml), Synovex (41.58 ng/ml) and highest in control bulls (50.65 ng/ml). The only difference ($P<.05$) in growth hormone levels was present in average growth hormone levels for the duration of the trial. The mean growth hormone levels throughout the trial are displayed in figure 6. Synovex-implanted bulls had the highest mean growth hormone levels (54.80 ng/ml) compared to controls (32.01 ng/ml, $P<.05$) but were not different from Compudose (44.55 ng/ml) or Ralgro (46.84 ng/ml). Implanting increased growth hormone levels which agreed with Gopinath and Kitts (1984) results. Figure 7 is the graph of the growth hormone means for each treatment. The control bulls were lowest in week 6 to 13. Considerable variation in growth hormone levels is present among treatments.

Correlation Coefficients. Hot carcass weight was related ($r = .72$, $P<.01$) to longissimus muscle area (table 8). Furthermore, a relationship existed between USDA yield grade and longissimus muscle area ($r = -.49$), fat thickness ($r = .84$) and kidney, heart and pelvic fat ($r = .33$, $P<.01$). The only other related carcass traits were marbling and USDA quality grade ($r = .94$, $P<.01$).

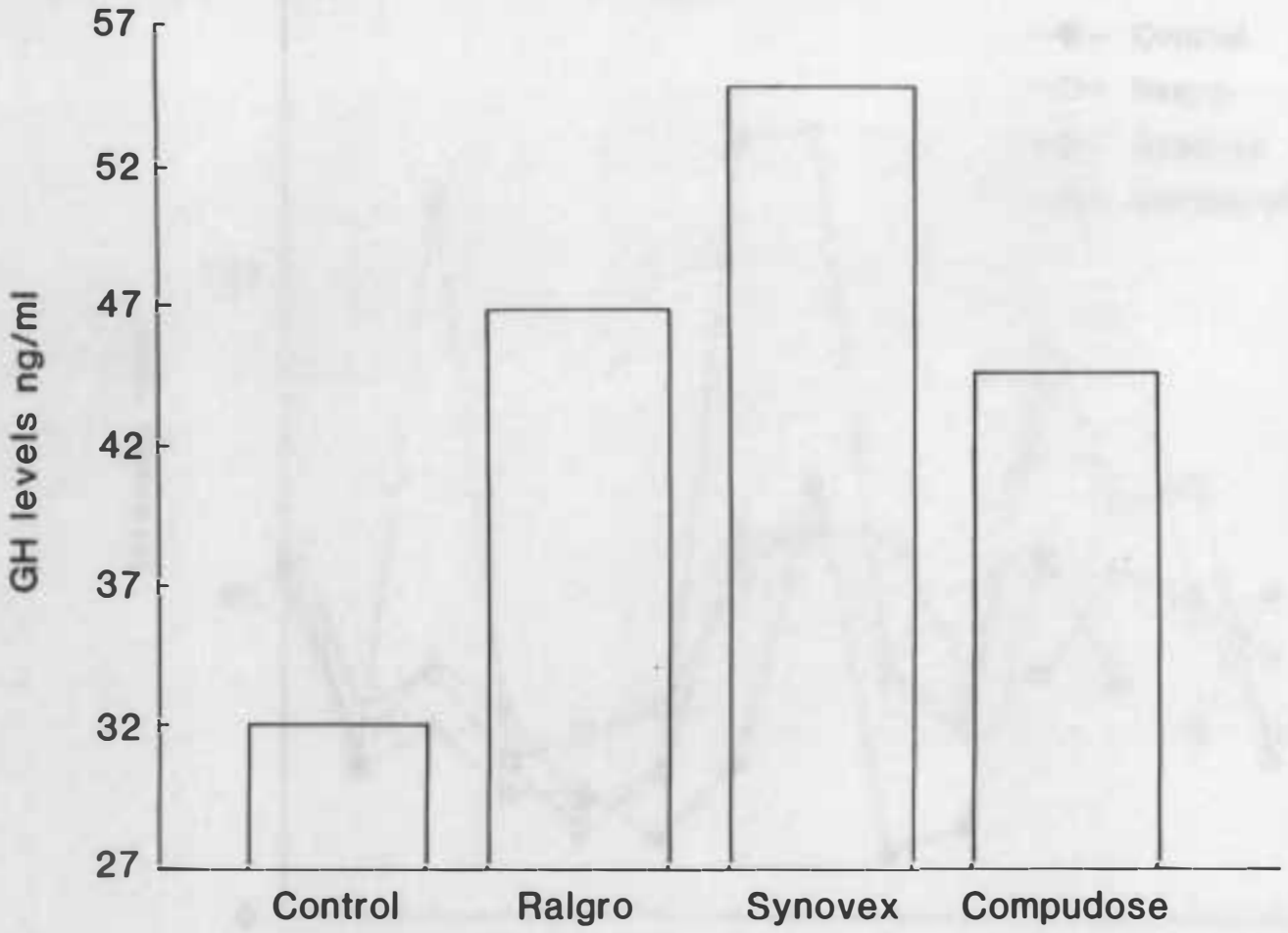

Figure 6. Growth Hormone Means for Treatment

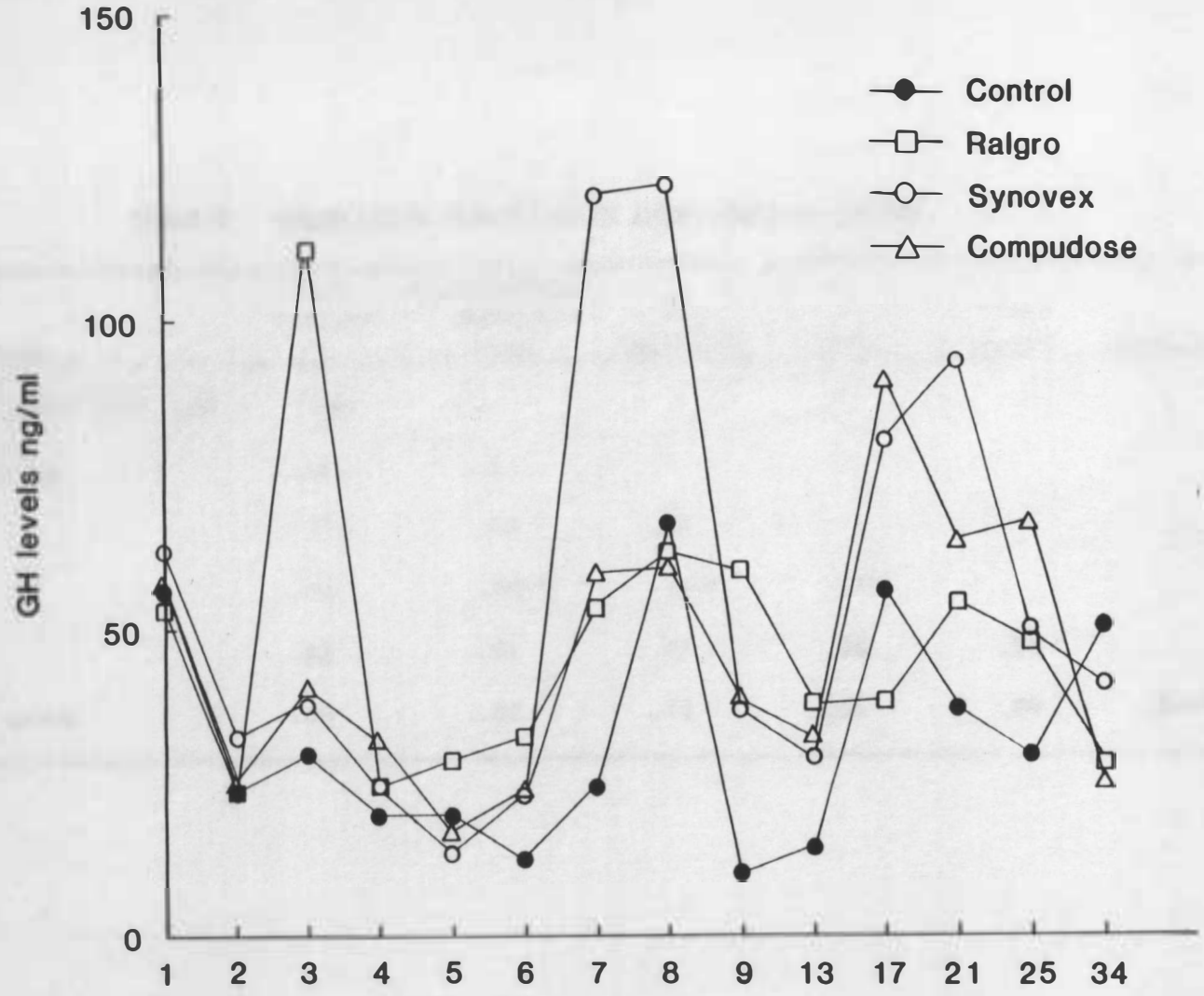

Figure 7. Growth Hormone Levels by Week for Treatments

TABLE 8. CORRELATION COEFFICIENTS AMONG CARCASS TRAITS

Item	Hot carcass wt	Longissimus muscle area	Fat thickness	KPH	Yield grade	Marbling
Longissimus muscle area, cm^2	.72**					
Fat thickness, mm	.20	-.13				
Est. KPH, %	.17	.03	.13			
Yield grade	.08	-.49**	.84**	.33**		
Marbling	.02	.01	.07	.08	.05	
USDA quality grade	.04	.02	.13	.06	.09	.94**

**P<.01.

Table 9 displays the correlation coefficients among performance and testicular parameters. Testicular weights were positively correlated with total testosterone levels (r = .44, P<.01). A negative relationship existed between standard deviation of t distribution (table 10) and testicular weight (r = -.27, P<.05). Furthermore, coefficients of variation of alpha t was negatively related with kidney, heart and pelvic fat (r = -.25) and a positive relationship existed among t-comp and testicular weight (r = .31, P<.05).

TABLE 9. CORRELATION COEFFICIENTS AMONG PERFORMANCE AND TESTICULAR PARAMETERS

Item	Avg daily gain	Total hip height	Total scrotal circum-ference	Total tes-ticular wt	Lutein-izing hormone
Total hip height	.20				
Total scrotal circumference	.22	.15			
Growth hormone	.14	-.02	-.21		
Total testosterone	-.12	-.21	-.01		
Total testosterone levels	.14	-.08	-.08	.44**	-.02

**P<.01.

Correlation coefficients for performance, carcass traits and testicular parameters are displayed in table 11. Average daily gain was positively related to carcass weight (r = .72) and longissimus muscle area (r = .47, P<.01). Testosterone and testicular weight had a negative relationship with fat thickness (r = -.40 and -.46, respectively, P<.01). Testicular weight also displayed a relationship with yield grade (r = -.44, P<.01).

TABLE 10. CORRELATION COEFFICIENTS BETWEEN TESTOSTERONE, PERFORMANCE AND CARCASS CHARACTERISTICS AND SPERM VARIABLES

Item	Peak	Mean	SD	Coeff. of variation	Comp
	Alpha t values for sperm variables				
Testosterone	.005	-.12	-.18	-.23	-.19
Avg daily gain	.06	-.0006	.09	.09	.14
Hip height, gain	.14	.10	.06	.09	.15
Scrotal circumference, gain	.13	.03	.06	.10	.07
Carcass wt	-.04	-.008	-.15	-.21	.03
Longissimus muscle area	-.08	-.05	-.12	.10	-.02
Fat thickness	.09	.19	.21	.09	.20
KPH	-.10	.05	-.13	-.25*	.01
USDA yield grade	.82	.18	.13	-.008	.16
Marbling	-.08	-.13	-.19	-.21	-.09
USDA quality grade	-.04	-.12	-.18	-.19	-.13
Testicular wt	-.16	-.01	-.27*	-.22	.31*

*P<.05.

TABLE 11. CORRELATION COEFFICIENTS AMONG PERFORMANCE, CARCASS AND TESTICULAR PARAMETERS

Item	Avg daily gain	Hip height, gain	Scrotal circum-ference, gain	Total tes-ticular wt	Mean testos-terone level
Hot carcass wt	.72**	-.06	-.03	.05	.16
Longissimus muscle area	.47**	-.15	.01	.21	.10
Fat thickness	.19	-.11	.05	-.46**	-.40**
Estimated KPH	.02	.09	-.08	-.06	.11
Yield grade	.10	.02	.004	-.44**	-.23
Marbling	-.81	.20	-.01	.12	-.01
USDA quality grade	-.09	.20	-.08	.08	-.04

**P<.01.

According to this study implanting bulls postweaning has minimal effects on performance, carcass characteristics, reproductive parameters, testosterone and LH levels. The greatest response occurred in growth hormone levels, which increased in all implanted treatments. Therefore, the results of this study conclude implanting postweaned bulls is not beneficial.

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APPENDIX

RADIOIMMUNOASSAY FOR GROWTH HORMONE

Reagents

1. Growth hormone standard (GH, 24 µg) is diluted in gel buffer to 1ug/ml. From the 1ug/ml solution, two standards are set up ranging from 1000 ng/ml to .5 ng/ml.
2. Growth hormone antiserum (National Institute of Arthritis and Digestive Kidney Disease) is diluted in 3% Normal Rabbit sera/phosphosaline buffer.
3. Iodination was conducted by Diagnostic Products Corporation using the lactoperoxidase method.

Procedure

1. A double antibody radioimmunoassay procedure is performed in duplicate for each blood sample.
2. Label glass tubes for total counts, background, zero, standards and unknowns.
3. Add 100 µl of labeled GH to total count tubes.
4. In background tubes, add 100 µl of labeled GH and 400 µl of gel buffer.
5. Add 100 µl of labeled GH, 100 µl antiserum and 300 µl gel buffer to properly marked zero tubes.
6. To standard tubes, add 100 µl labeled GH, 200 µl of gel buffer, 100 µl of antiserum and 100 µl of each standard.

7. In duplicate of unknowns, add 100 µl of labeled GH, 100 µl antiserum, 100 µl blood serum and 200 µl of gel buffer.
8. Cover all tubes with foil and allow to incubate for 24 hr at room temperature.
9. Add 1 ml polyethene glucol (PEG) and second antibody to each sample.
10. Centrifuge all samples for 20 min to stop the assay.
11. Decant supernatant.
12. Count precipitate for 1 min in a gamma counter.

TABLE 1. MEAN SQUARES FOR INITIAL BODY WEIGHT, HIP HEIGHT AND SCROTAL CIRCUMFERENCE

Source of variation	df	Mean squares: Init. body wt, kg	Init. hip height, cm	Init. scrotal circum-ference, cm
Treatment	3	779.45	27.35	11.38
Error	62	502.28	18.58	5.84
Total	65			

TABLE 2. MEAN SQUARES FOR PERFORMANCE

Source of variation	df	Mean squares: Final body wt, kg	Total wt gain, kg	Avg daily gain kg/d	Final hip height, cm	Hip height gain, cm
Treatment	3	3789.99	2084.90	.044	24.75	9.95
Error	60	1479.54	984.91	.021	9.38	16.01
Total	63					

TABLE 3. MEAN SQUARES FOR TESTICULAR PARAMETERS

Source of variation	df	Mean squares: Final scrotal circum-ference, cm	Total scrotal circum-ference, cm	Testicular wt, g
Treatment	3	7.96*	22.78	19835.41
Error	60	2.85	8.69	11060.02
Total	63			

*P<.05.

TABLE 4. MEAN SQUARES FOR CARCASS TRAITS

Source of variation	df	Mean squares: Hot carcass wt, kg	Longissimus muscle area, cm^2	Fat thickness, mm	Est. % KPH	USDA yield grade	Marbling	USDA quality grade
Treatment	3	2399.72*	62.38	35.74**	.19	.69*	.62	1.36
Error	60	641.00	51.89	7.55	.18	.19	.53	.96
Total	63							

*P<.05.
**P<.01.

TABLE 5. MEAN SQUARES FOR SPERM QUALITY

Source of variation	df	Mean squares: Peak	Mean	Standard deviation	Coefficient of variation	Comp
Treatment	3	139.73	311.05	143.56	23.15	28.63
Error	5	139.53	435.18	298.39	58.75	54.80
Total	58					

TABLE 6. MEAN SQUARES FOR TESTOSTERONE LEVELS AT DIFFERENT WEEKS

Source of variation	df	Mean squares: Testosterone, ng/ml: Weeks 1	2	3	5	6	7	8	9	17	34	Avg
Treatment	3	35.51	46.24	64.23	21.70	65.35**	52.02	5.63	1.03	72.05*	52.93	6.98
Error	60	37.48	46.87	26.75	20.74	14.20	38.58	65.39	17.33	21.20	24.48	9.24
Total	63											

*P<.05.
**P<.01.

TABLE 6 CONTINUED

Source of variation	df	Mean squares Testosterone, ng/ml Weeks 4	13	25
Treatment	3	29.18	52.93	19.30
Error	61	23.59	24.48	20.51
Total	64			

TABLE 7. MEAN SQUARES FOR GROWTH HORMONE LEVELS FOR DIFFERENT WEEKS

Source of variation	df	Mean squares: Growth hormone, ng/ml: Weeks 1	2	3	5	13	17	Avg
Treatment	3	265.89	327.91	24795.52	713.53	1683.62	9182.80	1462.24*
Error	62	1315.41	358.41	19618.97	809.14	1817.85	5131.71	489.58
Total	65							

*P<.05.

TABLE 7 CONTINUED

Source of variation	df	Mean squares: Growth hormone, ng/ml: Weeks 6	7	8	9
Treatment	3	1069.03	27799.47	15255.97	6728.25
Error	62	507.06	15263.54	8760.48	3021.40
Total	63				

TABLE 7 CONTINUED

Source of variation	df	Mean squares: Growth hormone, ng/ml: Weeks 4	25	34
Treatment	3	402.89	3674.76	2194.39
Error	61	265.31	2504.17	969.45
Total	64			

TABLE 8. MEAN SQUARES FOR LUTEINIZING HORMONE LEVELS AT DIFFERENT WEEKS

Source of variation	df	Mean squares LH level, ng/ml Weeks 1	2	3	5	6	7	8	9	17	Avg
Treatment	3	.056	.025	.003	.029	.005	.026	.041	.028	.484	.003
Error	61	.030	.010	.006	.012	.007	.031	.033	.016	.559	.006
Total	64										

TABLE 8 CONTINUED

Source of variation	df	Mean squares LH level, ng/ml Weeks 4	13	25
Treatment	3	.002	.020	.023
Error	60	.001	.029	.021
Total	63			

TABLE 8 CONTINUED

Source of variation	df	Mean squares LH level, ng/ml Week 21
Treatment	3	.270
Error	58	.138
Total	61	

TABLE 9. MEAN SQUARES FOR HORMONES AT DIFFERENT WEEKS

Source of variation	df	Mean squares GH level, ng/ml	Testosterone, ng/ml	LH, ng/ml
		Week 21	21	34
Treatment	3	9041.90	90.33	.113
Error	59	4183.82	98.88	.141
Total	62			