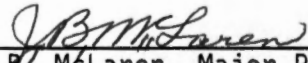


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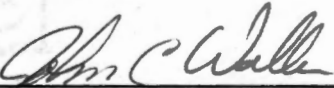
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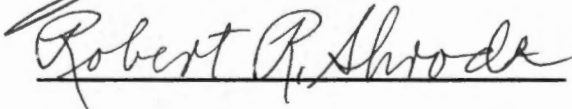
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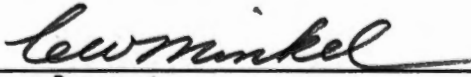
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EFFECT OF FREQUENCY OF PRE-WEANING ZERANOL IMPLANTS
ON PRE-WEANING AND POST-WEANING PERFORMANCE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Larry Allen Swabe

August 1986

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ABSTRACT

The data used in this study were collected from calves born at the University of Tennessee Highland Rim Experiment Station (HRES) near Springfield, Tennessee. The treatments involved various intervals at which calves were implanted with 36 mg zeranol at each implanting. The treatment groups were: 1) a control group of calves that were never implanted, 2) a group implanted at weaning only, 3) a group implanted at birth and weaning only, 4) a group implanted at birth and re-implanted at 90-day intervals thereafter until they were slaughtered.

This study was replicated over 7 trials, a trial using calves born in the spring of the year or calves born in the fall of the year. The experiment was a 2 x 4 factorial arrangement of treatments replicated in time. Responses to various frequencies of zeranol implant treatments were evaluated as increased gain during the various periods as compared to gain of non-implanted control calves. The response periods were: 1) birth to weaning, 2) weaning to first post-weaning weight, 3) post-weaning to slaughter, and 4) birth to slaughter.

During the pre-weaning response period, calves that received implants every 90 days performed significantly better than did control calves. Post-weaning performance indicated that gains of calves implanted at birth and at weaning and calves implanted every 90 days were not significantly different. However, both groups gained significantly more than did the control group. Re-implanting throughout life was evaluated. Gains of calves implanted at birth and

at weaning and calves implanted every 90 days were not significantly different, but were significantly greater than gains of calves implanted at weaning only and gains of control calves. Gains of calves implanted at weaning only and gains of control calves were not significantly different.

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CHAPTER I

INTRODUCTION

Recently, the use of hormonal and non-hormonal anabolic or synthetic implants has increased dramatically and is now a common management practice. One of the most popular growth stimulants on the market is the zeranol implant. Research results have established the efficacy of zeranol in promoting growth and increasing feed efficiency of cattle in varying stages of growth. The observed improvement in rate of gain has ranged from 10 to 15 percent and the improvement in feed efficiency has varied from 7 to 10 percent.

Ralgro[®], trade name for zeranol, a fermentation product of the mold Gibberella zeae belongs to a group of naturally occurring products known as the resorcylic acid lactones. Zeranol has been repeatedly shown to be effective in both heifer and steer calves during the growth and developmental stage. The implanting technique is simple, economical, and safe.

Zeranol implants consist of three 12-mg pellets for a total dosage of 36 mg that can be implanted in steers and heifers at any time from birth until they are finished for slaughter. Withdrawal time is 65 days before slaughter. No undesirable side effects have been reported when steers and heifers intended eventually for the slaughter market were implanted according to recommendations as to dosage, implant time, and management practices.

Zeranol implants offer producers the flexibility of re-implanting at 65- to 120-day intervals or at convenient times such as when cattle

are subjected to other essential management practices (branding, weaning, etc.). Re-implanting often results in growth enhancement in addition to that produced by the first or previous implants. This suggests that gains from the implanting are cumulative and additive.

Re-implanting is recommended to improve gains, but there is a need for information as to the frequency of re-implanting which might optimize the response from zeranol.

The objectives of this study were to: (1) evaluate the effect of zeranol implants on pre- and post-weaning performance; (2) to evaluate the effect of repeated pre-weaning zeranol implants; (3) to compare limited zeranol implants (birth and weaning) with re-implanting at 90-day intervals.

CHAPTER II

LITERATURE REVIEW

Zeranol is a non-hormonal anabolic agent which stimulates the pituitary to promote the production of growth hormone, prolactin, and cortisol, and decreases the production of insulin. Zeranol is produced by chemical synthesis from zearalenone, a fungal metabolite of the mold Gibberella zeae. Gibberella zeae is a naturally occurring mold which was originally isolated from maize grains by Stob et al. (1962) when feeding moldy corn to pigs in 1957 and 1958.

Efficacy of Zeranol

There is proof that zeranol increases weight gain in cattle. McClure (1979), Donovan et al. (1982), Dunn (1979), and Borger et al. (1973) all reported significant weight gains of implanted animals over those made by non-implanted controls. Weight gains were affected by sex of animal, stage of growth, and nutritional status. The International Mineral and Chemical Corporation (producers of Ralgr[®]) suggest that, according to research results, the increase in rate of gain is 10 to 15 percent accompanied by a 7- to 10-percent improvement in feed efficiency.

Implant Site

The traditional site for zeranol implantation was subcutaneously on the back surface of the mid-part of the ear. Research by Dewees (1980) suggested that an alternate implant site, just over the ring of cartilage at the base and lower portion of the ear, was as effective

as the traditional site and that implanting could be performed much more easily and with less strain on the workers. Brainine et al. (1981) reported no significant differences in gain between the traditional and alternate implant sites. Cain (1984) reported several advantages of using the alternate site, including increased gain, fewer application errors, and ease of implantation and recommended implanting in the "alternate site," which is now the recommended site.

Mode of Action

Growth stimulation following treatment with anabolic agents is normally associated with an increase in the rate of protein deposition. A common action of all anabolic agents is to increase nitrogen retention. Heitzman (1979) reported that anabolic agents, which are physiologically similar to sex steroids, may increase nitrogen retention and protein deposition in farm animals, but they do not alter absorption or metabolism in the alimentary tract.

A number of anabolic preparations were evaluated by Van der Wal et al. (1975) by measuring the difference of ingested nitrogen (in the feed) and excreted nitrogen (via urine and feces). Nitrogen balance was determined during five experimental periods consisting of four days each and performed between 4 and 29 days after implanting. A 36-mg dose of zeranol increased nitrogen retention by 103 g or 11 percent in the experimental calves. According to Buttery (1985), zeranol may behave like an estrogenic hormone because it has been shown to bind to the oestrogenic receptor. Dixon (1983) explained that the increased output of growth hormone from the anterior pituitary gland, a common mode of action of oestrogens, could explain the effects of zeranol.

The increased protein accretion results from the action of the increased growth hormone and insulin concentration.

Safety studies were performed to test the toxicity of zeranol. Monkeys were daily fed 75 mg zeranol per kg liveweight for 9 years, and dogs were daily fed 35 mg zeranol per kg liveweight for 7 years by Willemart and Bouffault (1983). They observed no signs of toxicity or carcinogenicity in either species. Therefore, it can be assumed that zeranol has a very low toxicity. The mode and rate of excretion of implanted zeranol (in steers) was studied by Sharp and Dyer (1972), and, of the initial 72-mg implant, only 10 mg remained intact at the implant site at 65 days post implant. They found that approximately 10 percent of the implant was excreted in urine, 45 percent in the feces, and 10 percent remained as residual pellets. They concluded that zeranol is removed from the blood via the liver then excreted via bile into the gut to be excreted in urine and feces.

Effect of Zeranol on Animal Performance

Zeranol and its growth promoting properties have been studied in an attempt to identify and measure the response to zeranol implants by animals differing in age, sex, and nutritional status. Contradictory results concerning the magnitude of benefit from zeranol implants have been reported, but most reports agree, in general, that zeranol does promote improved feed efficiency and increased gain.

Few studies have included implantation of newborn calves with zeranol. To facilitate research, a less intensive management program of implanting all suckling calves in a group at a few weeks or months after birth was used by most researchers. Ralston (1978), however,

implanted newborn calves. During two of the three years of his research, calves that were implanted with 24 mg of zeranol at birth had higher weaning weights than non-implanted calves.

McClure and Fontenot (1979) conducted zeranol research with 27 suckling steer and heifer calves. At 2 to 3 months of age the calves were paired on the basis of sex and weight, and one of the calves in each pair was designated randomly to be implanted with 36 mg zeranol. Upon completion of the test in mid-December, the zeranol implant had increased rate of gain by 19% (1.24 vs. 1.47 lb/day). At weaning, the implanted calves were 34 pounds heavier than the control calves. These results agree with those reported by Thomas and Armitage (1970), who found that the average daily gain of zeranol-implanted calves was significantly greater than that of control calves, implanted calves gaining 3-6 kg more than controls during a 6-month period. Suckling calves also were implanted by Simms and Schalles (1984) at 2 to 3 months of age (branding). Calves were implanted and were divided into four groups: (1) non-implanted controls; (2) single zeranol implant at branding; (3) single zeranol implant at branding and midway through the suckling period; (4) competitive implant at branding. Upon weaning, the single implant of zeranol showed a 2.9 percent improvement, and the single implant at branding with a later implant during suckling showed a 6.3 percent improvement over the control.

Dunn (1979) implanted with 36 mg zeranol steer and heifer calves weighing approximately 138 pounds. Implanted calves gained 6.8 percent faster during the growing season and were 22.2 pounds heavier at weaning than non-implanted calves. Response of nursing heifer

calves to the zeranol implant was slightly lower than that of steer calves.

Five-month-old steers were implanted (Hembry et al., 1976) at the beginning of the growing phase and compared their gain to that of a similar group of non-implanted control steers. At the beginning of the finishing period, one-half of the steers in each group (implanted and control) were implanted. Total gain of steers implanted at the beginning of each phase was 13 percent greater than that of the non-implanted controls, compared to an 8-percent increase in the gain of steers implanted during the finishing period only; these results agree with those reported by McReynolds et al. (1979). Embry and Swan (1974) reported an 11 percent improvement in gain and an 8.2 percent improvement in feed efficiency in weaned calves implanted with zeranol.

Borger et al. (1973) utilized 36 steers to test the efficacy of zeranol implants and various dietary protein levels on animal performance. Three groups of steers were fed one of three diets containing 9.5 percent, 11.0 percent, or 12.5 percent protein. One-half of the steers in each group were implanted with 36 mg zeranol on day 1 and again on day 84. During the 169-day trial, implanted steers gained 7.8 percent faster (1.24 vs. 1.15 kg per day) than did control steers. Average daily gain and feed efficiency were less for steers fed the 9.5-percent diet, whereas, steers fed the 11.0-percent diet were the most efficient converters of feed to gain. The gain per unit of feed consumed by implanted steers was 11.6 and 17.5 percent greater than that of control steers within the 11.0- and 12.5-percent-protein

groups, respectively. Rate of gain of implanted steers was 4.2 percent less than that of control steers within the low-protein group. These findings are similar to those reported by Loy et al. (1981). Steers on high- and low-energy diets were assigned to the following treatments: (1) no implant; (2) one zeranol implant initially; (3) one zeranol implant followed by a second implant at 84 days on feed. The steers fed the high-energy diet were more efficient and gained faster than did those fed the low-energy diet. There was no significant difference between implanting once and implanting twice, but the zeranol implant did improve average daily gain over that of non-implanted animals.

Zeranol implants have been evaluated with respect to their effectiveness in animals on pasture. Prior to placing steers on pasture in the spring, Fontenot et al. (1973) allotted them to the following treatment groups: (1) implanted prior to being placed on pasture; (2) non-implanted controls, (3) 12 mg DES, and (4) 36 mg zeranol. After the grazing season, half of the steers within each of the spring-implant groups were implanted with 36 mg zeranol at the beginning of the finishing (feedlot) phase. The spring implant of zeranol resulted in a 22-percent improvement in gain over that of the non-implanted control steers. Steers which received a zeranol implant at the beginning of the feedlot phase gained 1.48 kg per day compared to 1.34 kg per day gain by steers not implanted at the start of the feedlot phase. Bennett et al. (1974) also reported that additional gain resulted from implanting cattle on pasture. They implanted grazing cattle once initially with 36 mg zeranol. After 65 days, gains of the

implanted cattle were 18 kg (35 percent) greater than those of the controls.

Effects of Zeranol on Carcass

Corah et al. (1979), Sharp and Dyer (1970), Parker et al. (1979), Perry et al. (1979) and Phillips (1983) all reported no consistent or significant improvement of carcass quality or weight when steers and bulls were implanted with zeranol. Sharp and Dyer (1971) reported increases in water and protein content and decreases in fat content of both the carcass and the whole empty body in steers implanted with 36 mg of zeranol. They suggested also that implanted animals were physiologically less mature and that the protein content of the whole body was increased only at the expense of fat in zeranol-implanted animals. Cooper and Kirk (1982) observed that carcasses from implanted Friesian bulls had more desirable conformation and were leaner as compared to those of non-implanted bulls. Ribeye areas were larger in the implanted animals, but the percentages of lean and fat in the carcass were not affected by implanting with zeranol.

Some positive effects on carcass characteristics of implanted animals have been reported. Borger et al. (1971) implanted steers and fed them diets containing different protein levels and compared their performance to that of control steers fed each diet. They observed an increased hindquarter weight in carcasses from zeranol-implanted steers. Roch and Keane (1983) implanted steers at the beginning of the finishing period and observed an increase in final carcass weight of 6 to 10 kg over carcass weights of non-implanted steers. Phillips (1983) suggested that the significant difference in carcass weights of

implanted and control steers is likely to be observed only when the effect of zeranol on daily weight gain is great.

Zeranol and Stress

Cain (1984) reported that implanting with zeranol caused no more stress than does a single vaccination. Lofgreen et al. (1981) also indicated that implanting is not stressful. In fact, it has been suggested that zeranol implants can help prevent or reduce stress. Donovan et al. (1982) compared implanted steers, non-implanted steers, and non-implanted bulls. During the first 56 days, the implanted steers gained faster than did the intact bulls. This indicates that either the anabolic effect of zeranol overcomes the stress of castration in calves castrated and implanted at four weeks of age or that this stress was not detrimental to weight gain. Riesen et al. (1977) suggested that zeranol implanted animals may react less to stress because of changes in various hormones including cortisol, luteinizing hormone, and thyroxin. Borger et al. (1973) reported that zeranol may maintain more nearly optimum blood parameters that increase the animal's ability to minimize metabolic compensation for stress. Therefore, not only is zeranol effective in increasing growth and feed efficiency, but it may be beneficial in reducing production-related stress as well.

With this in mind, one could conclude that implanting with zeranol would reduce stress before shipping. Brown et al. (1976) reported that blood prolactin levels of heat stressed-steers which had been implanted with zeranol returned to "normal" levels faster than did those of non-implanted steers. They suggested that zeranol is an

effective agent to moderate the effects of heat; thus, they concluded that it had an anti-stress effect in cattle exposed to heat or shipping stress. However, Mader et al. (1985) reported that, in cattle stressed during the first 24 to 48 hours after implanting, either the physiological response to the implant or the physical stress associated with implanting caused steers to lose significantly more weight during shipping or receiving.

Frequency of Implant

Conflicting results have been reported concerning the practice of re-implanting at various growth stages. Some researchers have indicated that the response to early implantation is permanent, whereas, others have concluded that the effect of a zeranol implant is limited to 84 to 112 days (Bowen, 1981).

Hembry et al. (1976) implanted 38 steers with 36 mg of zeranol and used 38 steers as non-implanted control animals. Both groups of steers grazed summer pasture for 112 days and then grazed winter annual pasture for 137 days. At the end of the grazing period, part of the steers from each group were randomly re-implanted with 36 mg of zeranol followed by an 84-day finishing period. Steers that were implanted prior to the grazing phase and re-implanted at the beginning of the finishing phase showed slightly less response to the second implant than did steers not implanted prior to the pasture phase. Total gain was improved by 13 percent in steers implanted twice during the entire program and by 8 percent in steers implanted only during the finishing phase. Lowman et al. (1982) also reported a favorable response to re-implanting steers during the growing and finishing

phase. The performance of cattle implanted at the start of the growing period and at the start of the finishing period was not reduced during the finishing period when compared with that of cattle not implanted during the growing period. These results support the hypothesis that the response to zeranol is additive.

McReynolds et al. (1979) evaluated the effect of implants from nursing to finishing. Their research indicated that cattle can be implanted in each of the nursing, postweaning, growth and finishing phases without a diminished response to subsequent implantation. This is in agreement with the findings of Ward et al. (1978).

In contrast to the previously mentioned trials which support re-implanting for improved growth, other researchers have reported contradictory results. Nicholson et al. (1973) compared the effects of different intervals of implanting on growth. Calves implanted with 36 mg of zeranol every 112 days, every 56 days, and every 28 days, over a period of 224 days, showed a significant increase in average daily gain over non-implanted calves. However, there were no significant differences in total weight gain among the implanted groups. Research by Loy et al. (1981) indicated that zeranol increases mature size and market weight as compared to those traits in non-implanted controls and suggested little benefit from re-implanting small-to-medium frame Angus steers. Parker et al. (1979) reported that re-implanting has no advantage over implanting once with 36 mg at the beginning of the feedlot phase if the rate of growth prior to being placed on full feed is rather low.

Mader et al. (1985) reported that implants administered to suckling calves at 1 to 2 months of age may depress the subsequent response of implants administered at regular intervals from weaning to slaughter.

Overall, researchers have reported increases in gains from a single zeranol implant ranging from 7.8 percent to more than 35 percent. Their opinions and reports vary as to how much zeranol increases gain and improves efficiency, but most conclude that it is beneficial to some extent. Some researchers have suggested that one implant is sufficient and that subsequent implants do not promote gain and may, in fact, inhibit the response of the earlier implant. Others have suggested that re-implanting is often profitable, but few researchers agree as to when to re-implant to produce optimum performance.

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CHAPTER III

EXPERIMENTAL PROCEDURE

Extensive research has been conducted with respect to the effect of zeranol on weight gain and feed efficiency in growing-finishing beef animals. It has been repeatedly shown that zeranol increases weight gain; however, the optimum time to implant young calves has not been established. Most cow-calf producers handle their young calves infrequently between birth and weaning. At birth, or shortly thereafter, calves are usually identified, castrated (if a male), and dehorned (when needed). Unless health problems occur with the cow or calf, or the producer has a preventative health program (vaccinations, etc.), the cow-calf pair is usually pastured, and the calf is not handled again until weaning. Weaning is a stressful time, and the calf usually loses weight during this period. Implanting with zeranol may help overcome the stress of weaning. At weaning, calves are usually marketed through auction sales or placed on a backgrounding and/or finishing diet.

The data used in this study were collected between the fall of 1981 and the summer of 1985 at the University of Tennessee Highland Rim Experiment Station (HRES), near Springfield, Tennessee. The treatments involved various intervals at which calves were implanted with 36 mg zeranol at each implanting. The treatment groups were: 1) a control group of calves that were never implanted, 2) a group implanted at weaning only, 3) a group implanted at birth and weaning

only, 4) a group implanted at birth and re-implanted at 90-day intervals thereafter until they were slaughtered.

The calves were born on the Experiment Station predominantly to Hereford x Angus crossbred cows but some by Hereford cows. Four sire breeds were used; Angus, Hereford, Simmental, and Red Poll. All calves that were born during each calving season that were not assigned to other experiments or not selected as possible herd replacements were randomly assigned to the four implant treatments on a within-sex basis.

All calves assigned to this study were subjected to similar management and nutrition practices within each calving season. In general, all calves nursed their dams and did not receive supplemental feed. Cows were given supplemental hay only when experimental pastures could not sustain them, and they were wintered uniformly on roughage. Cows were wormed with Thiabendazole each fall and vaccinated against leptospirosis each spring. Castration of male calves and dehorning (when needed) were done at birth or soon thereafter. Birth weights were taken within 24 hours after birth. Calves were vaccinated against blackleg at 2 to 3 months of age and again at weaning. Fly control was accomplished by systemic eartags and spraying as needed. All animals had access to salt, minerals, water, and shade at all times and to windbreaks in the winter. Supplemental magnesium was made available from December 1 to May 1 each year. The magnesium was supplied in protein blocks or in salt-molasses-cotton seed meal (CSM)-magnesium oxide mixtures.

After weaning, all calves were placed on a backgrounding diet. The backgrounding diet consisted of corn silage fed free-choice, one pound of CSM, and four pounds of cracked shelled corn per calf per day. A free-choice mineral mix containing Ca, P, and salt (or trace mineralized salt and a commercial mineral mix) was provided at all times. After the backgrounding period, which lasted about 140 days, all groups were fed whole shelled corn free-choice plus 1.1 pound of Tend-R-Lean[®] per head per day until they were ready for slaughter. Feed records were maintained by implant-sex groups (when possible). The calves were weighed at about 56-day intervals and daily feed intake was recorded by pen. Average daily gain was calculated for the following periods: birth to slaughter, birth to weaning, weaning to the first post-weaning weight, and post-weaning to slaughter.

Statistical Analysis

The experiment was a 2 x 4 factorial arrangement of treatments replicated in time. Primary factors analyzed were sex of calf and frequency of implant. Secondary factors analyzed were trial (season, year), age of dam, birth weight, and breed-of-sire of the calf. Responses to various frequencies of zeranol implant were evaluated as increased gain during the various periods over that of non-implanted calves. The response periods were 1) average daily gain from birth to weaning, 2) average daily gain from weaning to post-weaning, 3) average daily gain from post-weaning to final weight (slaughter), and 4) average daily gain from birth to final weight (slaughter).

The study was replicated over 7 trials, a trial consisting of calves born in the spring of the year or the fall of the year.

All statistical analyses were performed using SAS (Statistical Analysis Systems). A general-linear-model analysis was performed on data from each trial to evaluate the effect of the main effects (sex and implant treatment) on the dependent response variables. Overall analyses of accumulated data over the 7 trials were performed. The main effects were trial, implant treatment, sex, age of dam, birth weight of calf, and breed-of-sire of calf. Various interactions among the main effects were included in the analysis to determine significant differences in response to zeranol treatment during various years, in various sexes, and in calves sired by bulls of different breeds. When inspection of the means indicated that there was no need for an interaction term in the model, that interaction was removed from subsequent analyses. Linear contrasts were used to separate response to implant treatments (Table 1). Where linear contrasts were not possible, a Student-Newman-Keuls Multiple Range Test was conducted to separate means as to significant differences in each respective analysis.

Table 1. Linear contrasts.

Contrasts	Zeranol Implant Treatment Group			
	Control	Weaning Only	Birth & Weaning	Every 90 days
(Pre-weaning performance and response to weaning stress)				
A1	+1	+1	-1	-1
A2	0	0	+1	-1
(Post-weaning performance and performance from birth to slaughter)				
B1	+3	-1	-1	-1
B2	0	-1	+2	-1
B3	0	+1	0	-1

Comparisons:

A1 = Implanted vs. non-implanted

A2 = Implanted at birth vs. implanted every 90 days

B1 = Control vs. implanted

B2 = Implanted at birth and weaning vs. implanted every 90 days

B3 = Implanted at weaning only vs. implanted every 90 days

CHAPTER IV

EFFECT OF FREQUENCY OF PRE-WEANING ZERANOL IMPLANTS
ON PRE-WEANING AND POST-WEANING PERFORMANCEIntroduction

Extensive research has been conducted on the anabolic agent, zeranol, since its discovery by Stob et al. (1962). Zeranol is a non-hormonal anabolic agent which stimulates the pituitary to increase the production of growth hormone, prolactin, and cortisol, and decreases the production of insulin. Zeranol is produced by chemical synthesis from zearalenone, a fungal metabolite of the mold Gibberellea zeae (Heitzman, 1979; Sharp and Dyer, 1971; Van der Wal et al., 1975).

Zeranol and its growth-promoting properties have been studied in an attempt to identify and measure response to zeranol implant in calves differing in age, sex, and nutritional status. Contradictory results concerning the benefit of the zeranol implant have been reported, but, in general, most results indicate that zeranol promotes increased feed efficiency and gain (Ralston, 1978; Hembry et al., 1976; Borger et al., 1973; Loy et al., 1981; Fontenot et al., 1973; Bennett et al., 1974).

Zeranol implants offer producers the flexibility of reimplanting every 65 to 120 days or when working the cattle for other essential management practices (branding, weaning, etc.). Re-implanting often yields effects in addition to those of the first or previous implanting. This suggests that gains are cumulative and additive. Re-implanting is recommended to improve gains, but there is a need for

information on extensive re-implanting which might lead to optimization of the use of zeranol.

The objectives of this study were to: (1) evaluate the effect of zeranol implants on pre- and post-weaning performance; (2) to evaluate the effect of repeated pre-weaning zeranol implants; (3) compare limited zeranol implants (birth and weaning) with re-implanting at 90-day intervals.

Procedures

The data used in this study were collected between the fall of 1981 and the summer of 1985 at the University of Tennessee, Highland Rim Experiment Station (HRES) near Springfield, Tennessee. The treatments involved various intervals at which calves were implanted with 36 mg zeranol at each implanting. At birth, calves were assigned to one of four implant-treatment groups. The treatment groups were: 1) a control group of calves never implanted, 2) a group implanted at weaning only, 3) a group implanted at birth and weaning only, 4) a group implanted at birth and re-implanted at 90-day intervals thereafter until they were slaughtered. The calves were born during the fall (Sept. - Nov.) or during the spring (Feb. - April) to predominantly Hereford x Angus crossbred cows but some by Hereford cows. All calves born during each calving season that were not assigned to other experiments or not selected as possible herd replacements, were randomly assigned to the four implant treatments on a within-sex basis.

Birth weights were taken within 24 hours after birth. In general, all calves nursed their dams without supplemental feed. At

weaning, all groups of calves were fed a backgrounding ration. The backgrounding diet consisted of corn silage fed free choice, one pound of cotton seed meal per calf per day, and four pounds of cracked shelled corn per calf per day. A mineral mix containing Ca, P, and salt (or trace mineralized salt and a commercial mineral mix) was provided free choice at all times. Feed records were maintained by implant-sex groups (when possible).

This study was replicated over 7 trials, a trial consisting of calves born in the spring of the year or the fall of the year. The experiment was a 2 x 4 factorial arrangement of treatments replicated in time. The main effects were trial, implant treatment, sex, age of dam, birth weight of calf, and breed-of-sire of calf. Various interactions among the main effects were included in the analysis to determine significant differences in response to zeranol treatment during various years, in various sexes, and in calves sired by bulls of different breeds. Responses to various frequencies of zeranol implanting were measured as calf average daily gain during various response periods. The response periods were: 1) average daily gain from birth to weaning, 2) average daily gain from weaning to the first post-weaning weight, 3) average daily gain from the first post-weaning weight to slaughter weight, and 4) average daily gain from birth to slaughter. Linear contrasts were used to separate responses to implant treatments.

Results

Effect of zeranol on pre-weaning gain. Differences in mean pre-

weaning performance (average daily gain from birth to weaning) of calves in each zeranol implant treatment group are presented in Figure 1. Performance of calves that received repeated implants at 90-day intervals (1.49 pounds per day) was significantly higher (.10 pounds per day) than that of non-implanted control calves (1.39 pounds per day). Calves implanted with zeranol at birth had average daily gains (1.44 pounds per day) that were intermediate between those of the control calves and those of calves implanted every 90 days. These results are similar to those reported by Ralston (1978).

Effect of zeranol on gain at weaning and the early post-weaning phase. Post-weaning performance also was measured (average daily gain from weaning to the first post-weaning weight) and is presented in Figure 2. Post-weaning performance of calves implanted every 90 days (1.77 pounds per day) and calves implanted at birth and weaning (1.84 pounds per day) were not significantly different, but the gains of both of these groups were significantly higher than that of the control group (1.46 pounds per day). The post-weaning average daily gains of calves implanted at weaning only (1.65 pounds per day) were intermediate between those of the control calves and those of the other implant groups (birth and weaning, and every 90 days). This may be evidence that implanting at weaning reduces weaning stress.

Effect of zeranol on gain during the finishing phase. Finishing performance (post-weaning to final weight) of calves in different zeranol treatments are presented in Figure 3. The average daily gain of calves implanted every 90 days (2.25 pounds per day) was

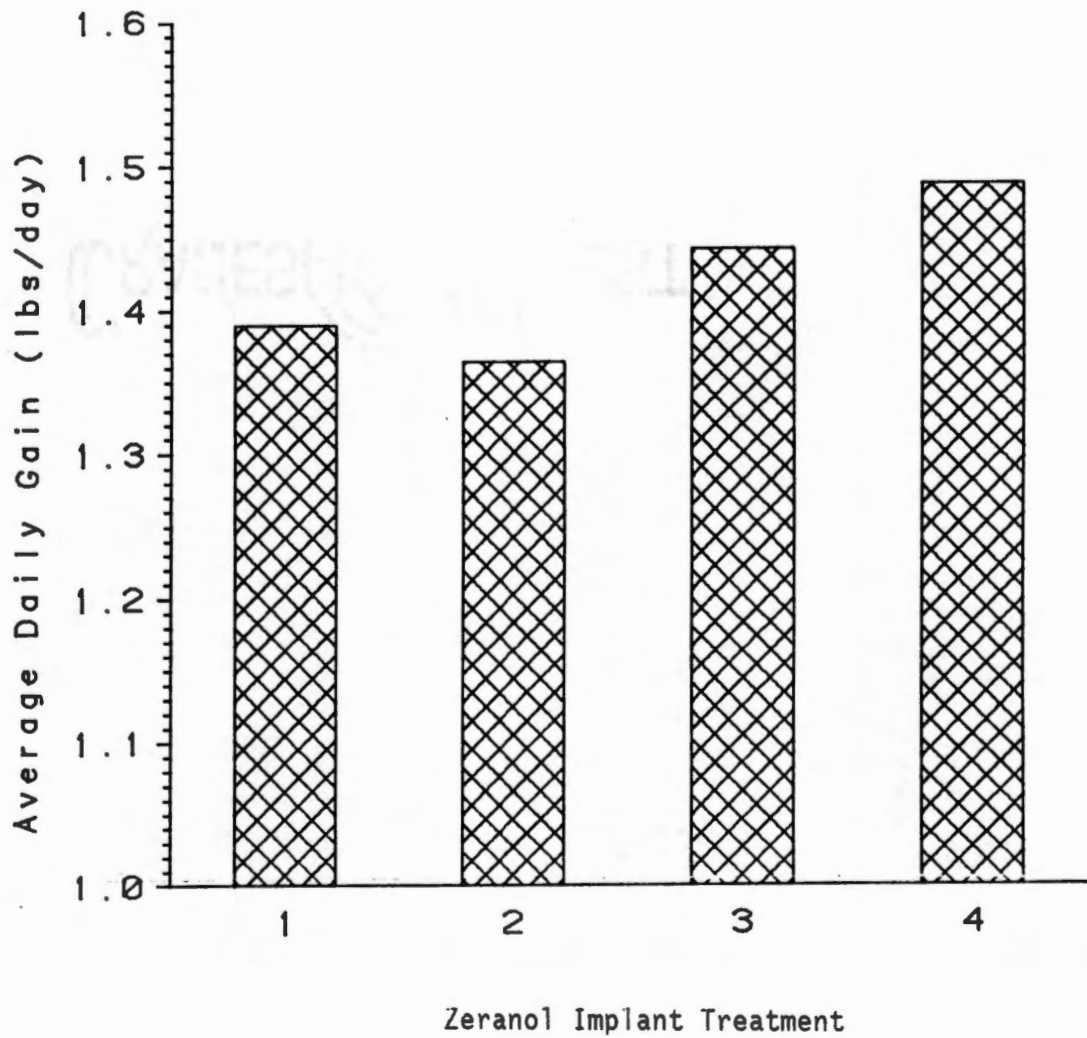


Figure 1. Mean birth-to-weaning average daily gains.

Zeranol Implant Treatment:

1 = Control

2 = Implanted at weaning only

3 = Implanted at birth and at weaning

4 = Implanted at birth and every 90 days thereafter

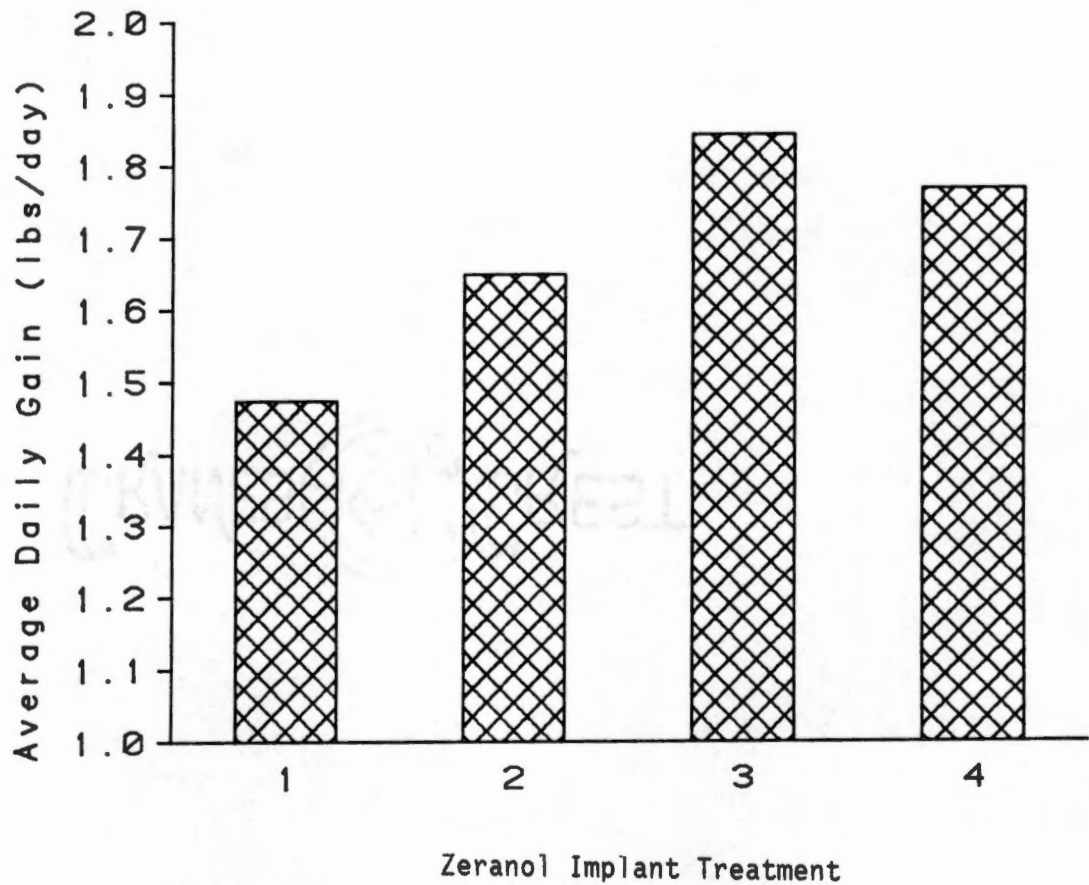


Figure 2. Mean weaning-to-post-weaning average daily gains for all trials.

Zeranol Implant Treatment:

1 = Control

2 = Implanted at weaning only

3 = Implanted at birth and at weaning

4 = Implanted at birth and every 90 days thereafter

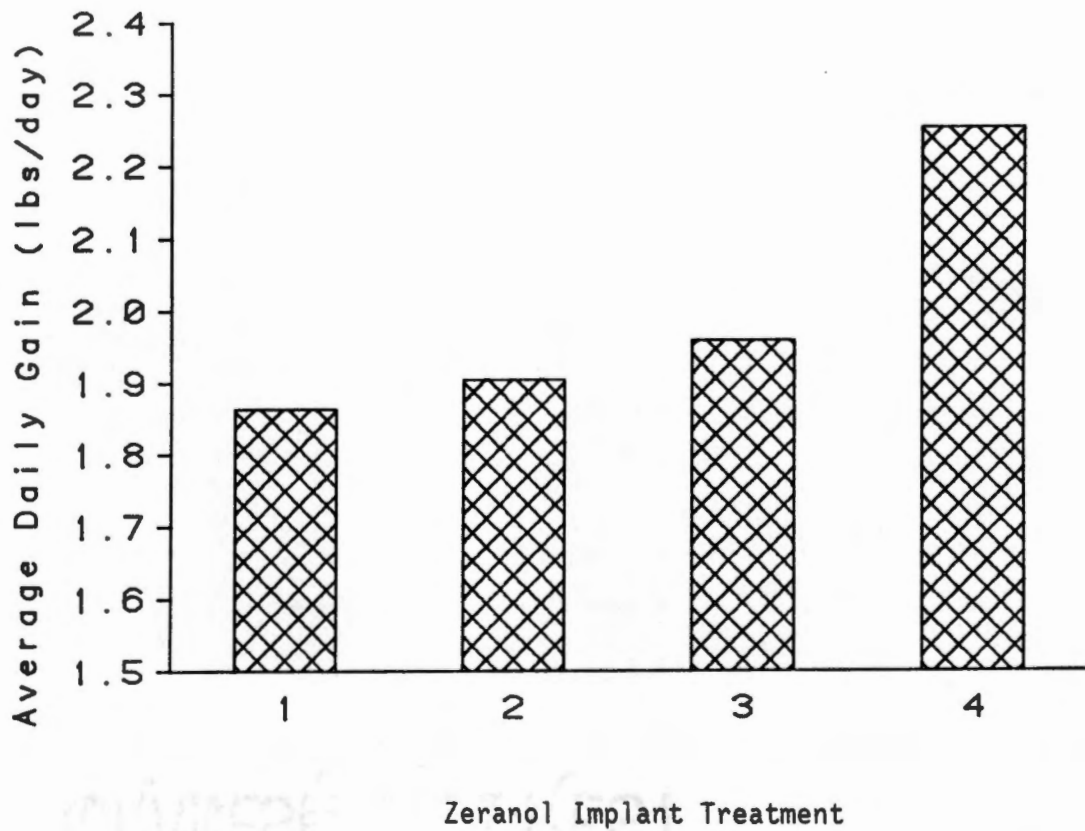


Figure 3. Mean post-weaning-to-slaughter average daily gains for all trials.

Zeranol Implant Treatment:

1 = Control

2 = Implanted at weaning only

3 = Implanted at birth and at weaning

4 = Implanted at birth and every 90 days thereafter

significantly higher than that of non-implanted control calves (1.86 pounds per day), that of calves implanted at weaning only (1.90 pounds per day), and that of calves implanted at birth and at weaning (1.96 pounds per day). A possible explanation for this difference during the finishing period is that calves implanted at weaning only and those implanted at birth and re-implanted at weaning received their last (or only) implant at weaning, and since a subsequent implant was not administered, the effectiveness of the implants at weaning to promote additional gain had diminished and the gains of these animals were not significantly different from those of the controls. However, gains of both groups were only slightly higher than those of the control animals. A partial explanation of the absence of significant responses with respect to post-weaning and finishing average daily gain may be due to the relatively low gain of both implanted and control animals. The quality of corn silage fed during the time this study was conducted was only medium, which probably reduced all gains .4 to .5 pounds per day. It has been shown that greater response to zeranol implants results when feed quality is high (Borger et al., 1973).

Effect of zeranol on gain from birth to slaughter. To evaluate the effectiveness of re-implanting throughout life, differences in overall average daily gain (birth to slaughter) of calves subjected to the various implant treatments were calculated and are presented in Figure 4. Even though average daily gains during the finishing period of calves implanted repeatedly (1.82 pounds per day) were significantly higher than those of control calves (1.61 pounds per day) and

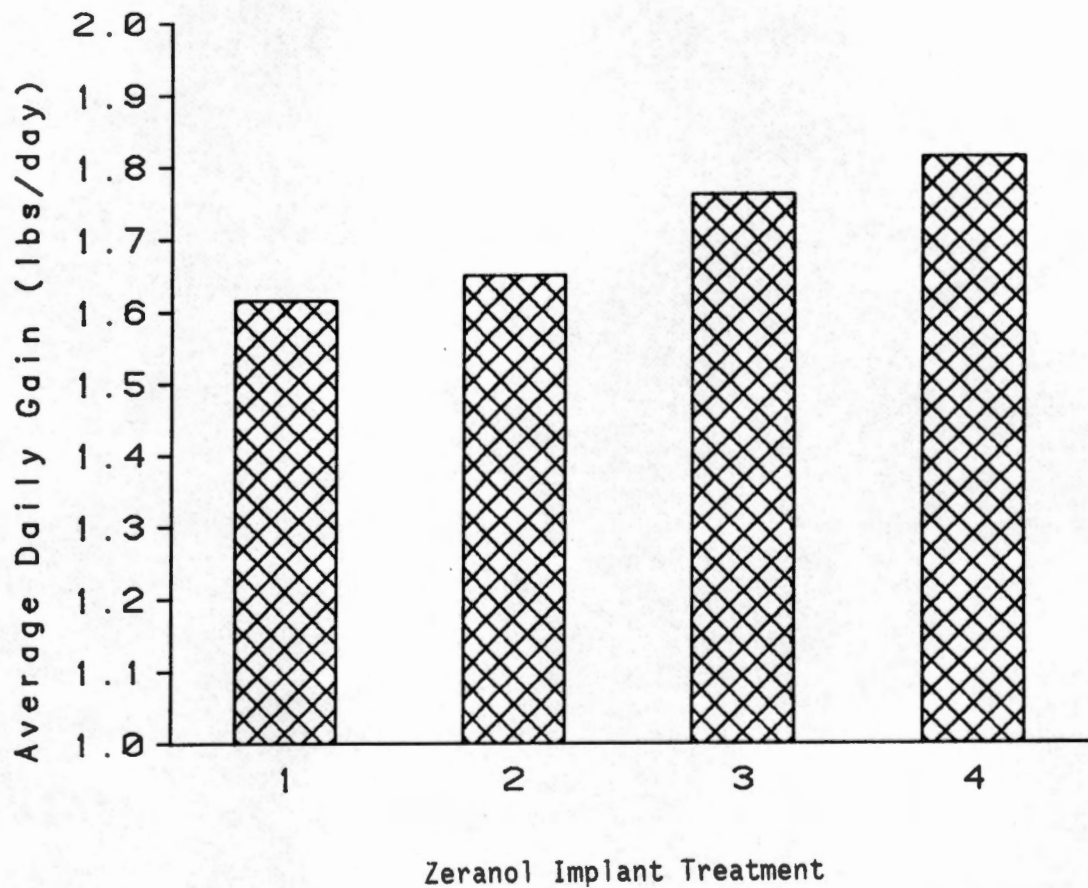


Figure 4. Mean birth-to-slaughter average daily gains for all trials.

Zeranol Implant Treatment:

1 = Control

2 = Implanted at weaning only

3 = Implanted at birth and at weaning

4 = Implanted at birth and every 90 days thereafter

those of calves implanted at weaning only (1.65 pounds per day), overall gains of calves implanted at birth and at weaning (1.76 pounds per day) and those implanted every 90 days were similar. Gains of calves implanted at weaning only were slightly higher than those of control calves, but this difference was not significant. Gains of calves implanted at birth and weaning and those implanted every 90 days were significantly higher than those of the control group and those of calves implanted at weaning only. This suggests that maximum average daily gain may be achieved (under certain conditions) by only 2 implants (birth and weaning) in contrast to implanting repeated at 90-day intervals from birth to slaughter. This is of economic importance to most producers since only 2 implantings would require much less labor and management. These data indicate also that an implant at birth is necessary to induce optimum performance of calves.

Effect of sex of calf on gain from birth to slaughter. The evaluation of the effect of calf sex on gain from birth to weaning are presented in Figure 5. These results indicate that the response to zeranol implants was greater in steers than in heifers at all evaluation times. The performance of heifers were similar in all implant groups, but the gains were slightly higher in calves implanted at birth and weaning and in those implanted every 90 days. The response to various implant systems by steers was similar to that for the overall evaluation. Gains of control steer calves and of those implanted at weaning only were similar, but the gains of calves implanted at birth and at weaning and of those implanted at 90-day

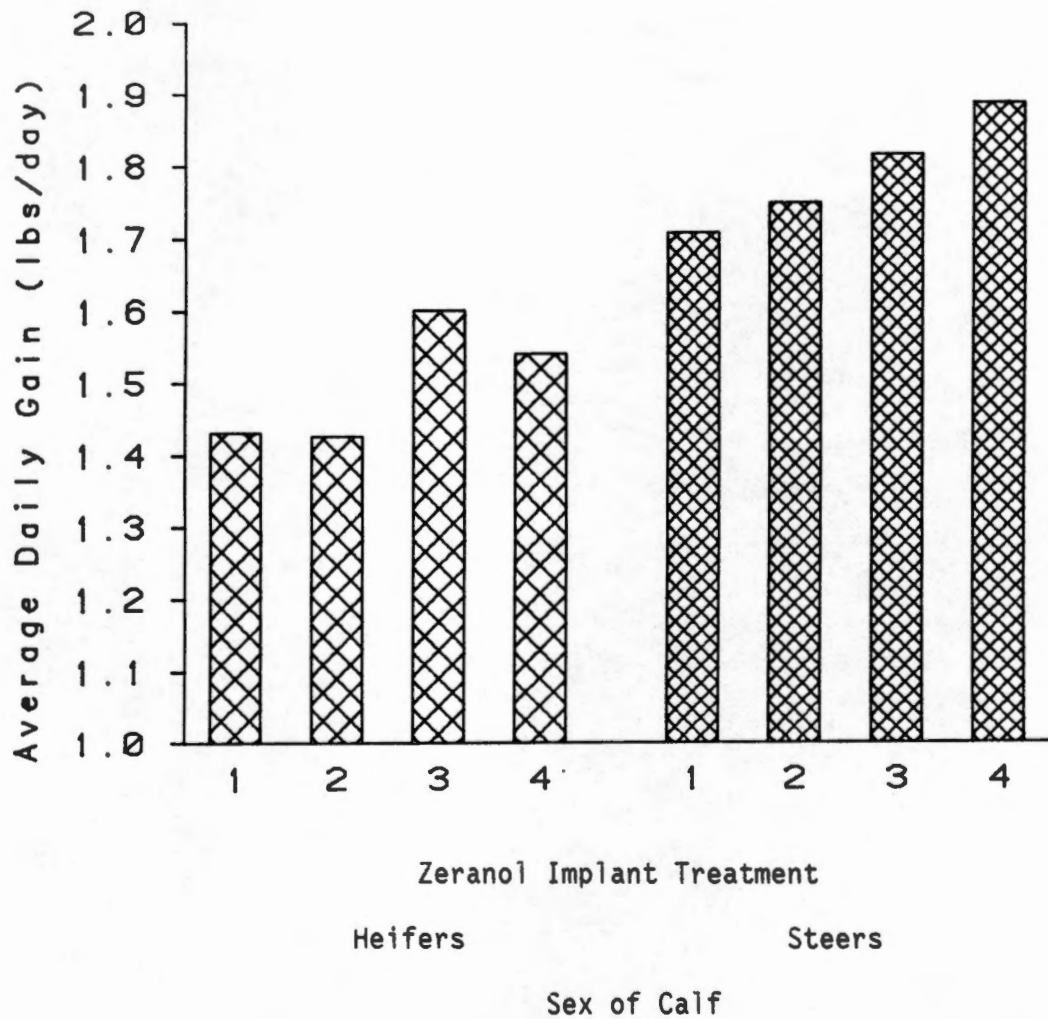


Figure 5. Mean birth-to-slaughter average daily gains for steers and heifers for all trials.

Zeranol Implant Treatment:

1 = Control

2 = Implanted at weaning only

3 = Implanted at birth and at weaning

4 = Implanted at birth and every 90 days thereafter

intervals were significantly higher than gains of the other two groups.

Effect of age of dam and calf birth weight. The effects of variation in age of dam and calf birth weight on the response to zeranol were evaluated. Mean average daily gains by each implant treatment group are presented in Table 2. The greatest response to any treatment was that of calves whose dams were three or four years old. The calves in these two age-of-dam groups that were implanted every 90 days gained significantly faster than did control calves. Calves from two-year-old dams (first-calf heifers) showed the least response to implanting. Although implanted calves of five-year-old dams and mature dams gained slightly faster than did control calves, the differences were not significant. Responses in all other age groups were inconsistent with respect to gain from birth to weaning. Mean average daily gains of calves in each discrete birth-weight group by zeranol implant treatment are presented in Table 3. Calves with lighter birth weights had consistently lower average daily gain than did calves with higher birth weights. In the low-birth-weight (40 to 59 pounds) group, the increases in gains attributable to zeranol implants were not significant. Within the 70-to-79-pound-birth-weight group, calves implanted every 90 days gained significantly faster than did all control calves, and gains of calves implanted at birth and at weaning and at weaning only were intermediate. Within the 60-to-69 and the over-80-pounds birth weight groups, average daily gain was not significantly different among implant treatment groups.

Table 2. Overall average daily gains of calves from dams of different ages from birth to slaughter by zeranol implant treatment groups.

Age of Dam	Zeranol Implant Treatment Group			
	Control	Weaning Only	Birth & Weaning	Every 90 days
Two Years Old	1.31	1.35	1.32	1.49
Three Years Old	1.66 ^b	1.76 ^{ab}	1.88 ^{ab}	2.03 ^a
Four Years Old	1.77 ^{ab}	1.63 ^b	1.99 ^{ab}	2.18 ^a
Five Years Old	1.67	1.86	1.92	1.87
Six to Ten Years Old	1.65	1.76	1.77	1.76
Greater than Ten Years Old	1.60	1.60	1.64	1.86

^{ab} Means within a row with different superscripts are significantly different ($P < .05$).

Table 3. Overall average daily gain of calves of varying birth weights from birth to slaughter by zeranol implant treatment groups.

Calf Birth Weight Group	Zeranol Implant Treatment Group			
	Control	Weaning Only	Birth & Weaning	Every 90 days
40 lb to 59 lb	1.48	1.41	1.54	1.64
60 lb to 69 lb	1.64	1.70	1.80	1.70
70 lb to 79 lb	1.69 ^b	1.87 ^{ab}	1.89 ^{ab}	1.94 ^a
80 lb and over	1.83	1.96	1.86	1.99

^{ab} Means within a row with different superscripts are significantly different ($P < .05$).

Effect of trial. Performance data during each trial are presented in Table 4 by zeranol implant treatment. Significant differences in rate of gain among zeranol-implant groups were observed in only two trials, even though the trends with respect to average daily gains agreed with overall analysis in the individual trials. This emphasizes the importance of sufficient replication in experimentation. One individual trial would not provide conclusive findings, but the combination of all trials does.

Summary

During the pre-weaning response period, calves that received implants every 90 days performed significantly better than did control calves. Post-weaning performance data indicated that gains of calves implanted at birth and at weaning and calves implanted every 90 days were not significantly different. However, both groups gained significantly more than did the control group. Re-implanting throughout life was evaluated. Gains of calves implanted at birth and at weaning and calves implanted every 90 days were not significantly different, but were significantly greater than gains of calves implanted at weaning only and gains of control calves. Gains of calves implanted at weaning only and gains of control calves were not significantly different.

Table 4. Overall average daily gains of calves during each trial from birth to slaughter by zeranol implant treatment groups.

Trial	Zeranol Implant Treatment Group			
	Control	Weaning Only	Birth & Weaning	Every 90 days
(1) Spr. 1981	1.52	1.62	1.58	1.70
(2) Fall 1981	1.66	1.72	1.78	1.72
(3) Spr. 1982	1.56 ^a	1.69 ^{ab}	1.79 ^{ab}	1.91 ^b
(4) Fall 1982	1.63	1.67	1.76	1.72
(5) Fall 1983	1.67 ^a	1.59 ^a	1.68 ^b	1.72 ^b
(6) Spr. 1984	1.66	1.57	1.92	1.97

^{ab} Means within a row with different superscripts are significantly different ($P < .05$).

CHAPTER V

SUMMARY

The data used in this study were collected from calves born at the University of Tennessee Highland Rim Experiment Station (HRES) near Springfield, Tennessee. The treatments involved various intervals at which calves were implanted with 36 mg zeranol at each implanting. The treatment groups were: 1) a control group of calves that were never implanted, 2) a group implanted at weaning only, 3) a group implanted at birth and weaning only, 4) a group implanted at birth and re-implanted at 90-day intervals thereafter until they were slaughtered.

This study was replicated over 7 trials, a trial using calves born in the spring of the year or calves born in the fall of the year. The experiment was a 2 x 4 factorial arrangement of treatments replicated in time. Responses to various frequencies of zeranol implant treatments were evaluated as increased gain during the various periods as compared to gain of non-implanted control calves. The response periods were: 1) birth to weaning, 2) weaning to first post-weaning weight, 3) post-weaning to slaughter, and 4) birth to slaughter.

During the pre-weaning response period, calves that received implants every 90 days performed significantly better than did control calves. Post-weaning performance indicated that gains of calves implanted at birth and at weaning and calves implanted every 90 days were not significantly different. However, both groups gained

significantly more than did the control group. Re-implanting throughout life was evaluated. Gains of calves implanted at birth and at weaning and calves implanted every 90 days were not significantly different, but were significantly greater than gains of calves implanted at weaning only and gains of control calves. Gains of calves implanted at weaning only and gains of control calves were not significantly different.

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APPENDIX

Table A1. Analysis of variance of the effect of trial, zeranol treatment, sex, and cow age on calf average daily gain.

Source	Birth to slaughter		Birth to weaning		Weaning to post-weaning		Post-weaning to slaughter	
	df	mean sq.	df	mean sq.	df	mean sq.	df	mean sq.
Trial	5	.0569	6	.6104***	4	1.6469***	4	.3106
Zeranol Implant	3	.0386	3	.1321*	3	1.9665***	3	.3854
Calf Sex	1	.1734*	1	.0353	1	.3287	1	.6516
Cow Age Group	5	.0947**	5	.3044***	5	.0745	5	.2173
Calf BWT Group	3	.2728***	3	.1169*	3	.2883	3	.4987*
Calf Breed Type	4	.0713	4	.3613***	4	.8899***	4	.3257
Imp. x Sex	3	.0028	3	.0260	3	.0496	3	.4962*
Trial x Sex	5	.0791*	6	.0408	4	.1417	4	.1383
Trial x Implant x Sex	12	.0283	16	.0400	9	.0862	9	.2308
Imp. x Age Group	15	.0183	15	.0542	15	.1448	15	.2015
Imp. x BWT Group	9	.0326	9	.0994**	9	.2809	9	.3407
Imp. x Breed Type	12	.0333	12	.2046***	12	.6183***	12	.2192
Error	93	.0317	135	.0396	62	.1541	68	.1805

* (P < .05)

** (P < .01)

*** (P < .001)

Table A2. Mean squares for various linear contrasts performed.

Contrasts	Response Period			
	Birth to slaughter	Birth to weaning	Weaning to post-weaning	Post-weaning to slaughter
(Pre-weaning performance and response to weaning stress)				
A1	1.1234***	.4578*	2.1719*	1.8577
A2	.0558	.0555	.0903	1.4815
(Post-weaning performance and performance from birth to slaughter)				
B1	.6427**	.0897	2.5472**	1.0056**
B2	.0265	.0104	.3987	.3393*
B3	.6023**	.4153*	.2463	2.2042**

* (P < .05) ** (P < .01) *** (P < .001)

Comparisons:

A1 = Implanted vs. non-implanted

A2 = Implanted at birth vs. implanted every 90 days

B1 = Control vs. implanted

B2 = Implanted at birth and weaning vs. implanted every 90 days

B3 = Implanted at weaning only vs. implanted every 90 days

VITA

Larry Allen Swabe, was born to Fred and Hattie Swabe August 8, 1962 in Sweetwater, Tennessee. He was graduated from Madisonville High School, Madisonville, Tennessee in June, 1980. He enrolled in September, 1980 at The University of Tennessee at Martin (UTM), where he majored in Animal Science. While at UTM, he was a member of Alpha Phi Omega National Service Fraternity and Charter President of UTM 4-H Alumni Service Corps. He was awarded the Bachelor of Science degree in Agriculture in August, 1984. Immediately thereafter he entered the Master of Science program in Animal Science at The University of Tennessee, Knoxville. During this period, he held the positions of Graduate Teaching Assistant and Graduate Research Assistant. He was married to Catherine Murphy of Friendsville in September, 1985. He was awarded the Master of Science degree in Animal Science in August, 1986.