UNIVERSITY OF MINNESOTA
Extension SERVICE

Department of Animal Science

205 Haecker Hall
1364 Eckles Avenue
St. Paul, MN 55108-6118

Beef Cattle Management Update

A REVIEW OF STUDIES OF TRENBOLONE ACETATE USE IN BEEF CATTLE

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Peter T. Anderson
Extension Beef Cattle Specialist

SUMMARY

Trenbolone acetate (TBA), the active compound in Finaplix implants, is a synthetic steroid that is used for promotion of growth of beef cattle. By itself, TBA exerts only moderate effects on growth, performance and carcass characteristics of steers and heifers. When used in combination with estrogen(E)-containing implants, TBA results in dramatically increased growth, improved feed conversion efficiency and enhanced muscle deposition. The TBA+E combination is the most potent muscle growth promotant available to cattle feeders. There are reports of reduced quality grade, increased aggressiveness and sexual behavior, difficult hide pulling and other problems associated with use of TBA+E. This paper contains a review of data from TBA experiments as well as suggestions for use of TBA-containing implants in beef cattle growing and finishing systems.

INTRODUCTION

Trenbolone has structural similarity to both testosterone and estradiol (Figure 1). In muscle, TBA initiates events that result in reduced protein degradation and synthesis, but the reduction in degradation exceeds the reduction in synthesis, resulting in a net increase in skeletal muscle protein accretion. Trenbolone is thought to have no direct effect on adipose tissue but could reduce fat deposition through altered nutrient partitioning. In addition, the combined treatment with trenbolone and estrogen, increases circulating somatotropin (growth hormone), resulting in further protein anabolic effects, and reduced fat deposition.

In the United States, Hoechst-Roussel markets two TBA-containing implants, Finaplix-S (for use in steers) and Finaplix-H (heifers). FDA approved sale of these products on July 2, 1987. Since that time, feedlot use of Finaplix implants has increased steadily.

Four TBA-containing implant products are currently available or in development:

Product name	Chemical component
Finaplix-S	140 mg TBA
Finaplix-H	200 mg TBA
Revalor	TBA + estradiol
Forplix	TBA + zeranol

Revalor and Forplix are not approved for use in the U.S. Final chemical composition of those products has not been described. Revalor (in separate S and H forms) is thought to be nearing approval.

TBA by itself is only marginally effective as a growth promotant in steers and slightly more effective in heifers. However, when administered with estradiol or the synthetic estrogen, zeranol, TBA dramatically increases growth, efficiency and muscle deposition of steers. Cattle feeders typically implant steers with Finaplix as well as with one of the estrogen containing implants (Synovex, Compudose, Steer-oid or Ralgro), either in the same ear or in opposite ears. TBA and E are not approved for concomitant use but use of the combination is common. FDA has ruled that no tissue residue concern exists as a result of simultaneous use of these products.

GROWTH AND CARCASS COMPOSITION

Effects on growing-finishing steers. Schanbacher et al. (1984; Table 1) were the first in the U.S. to compare TBA-containing implants to estrogenic implants. Finaplix improved growth of crossbred yearling steers but to a lesser extent than other implants (Ralgro, Synovex or Compudose). Combinations of TBA+E (Revalor) and TBA + zeranol (Forplix) were most effective at increasing growth, with ADG increased up to 25.8%. European researchers had been investigating use of TBA for years (Table 2).

Table 3 summarizes 13 studies in which 24 comparisons were made between steers implanted with TBA+E and nonimplanted controls. This is by no means a complete summary of all such trials, however it does include a representative sample. TBA+E increased ADG in all comparisons, by an average of 24.2%. ADFI was increase 4.4% in response to TBA+E while F/G was improved 15.4%. Effects on fatness were varied but usually minimal. Fat thickness of exotic breed cattle is often reduced while fat thickness of British breed steers is often unaffected by TBA+E. An increase in muscling (8.9%) was consistently observed.

Table 4 incudes 21 comparisons of TBA+E implanted cattle to E implanted cattle, taken from nine studies. In general, TBA+E improved growth, feed conversion leanness and muscling, compared to E alone, but differences were not large. These data must be assessed with some caution, however. For instance, in the study of Bartle et al. (1987) TBA+E cattle were not reimplanted, while the E cattle were. Furthermore, TBA+E is most effective when the E source is estradiol, rather than zeranol. If the comparisons in Table 4 are adjusted for these two factors, the advantage of combined TBA+E over E alone is doubled.

Reimplant studies. In the studies cited in Tables 1 through 4, cattle either received a single implant or were reimplanted at various intervals with the same compound throughout the trial. It should be clear from these studies that inclusion of TBA in an implant program makes timing of reimplant, and timing of marketing, in relation to day of implant, more critical than in programs involving E-containing implants alone. This is partly due to the fact that Finaplix implants have a useful life span of 63 days, shorter than other products. It also seems that the benefits of TBA can be lost during the latter part of a feeding period if TBA is not reimplanted, whereas benefits of traditional implants are thought to be maintained, even without reimplant. Because of this timely reimplantation of TBA is essential. Cattle feeders should be aware that use of TBA may limit marketing flexibility and possibilities.

Since TBA and the estrogens have differing mechanisms of action, it is reasonable to speculate that these compounds may be most efficacious during different phases of growth. Studies have been designed to investigate whether the program of TBA+E early, followed by E alone, or vice versa would be better than TBA+E, reimplanted. The thought is that one TBA+E implant, instead of two, may limit the reduction in quality grade, and/or staggy appearance seen when TBA+E is used. One theory is that TBA+E, a potent muscle growth promotant, should be given during the growing phase, followed be E alone during the finishing phase, when muscle growth has slowed and fat (marbling) deposition is required. Conversely, others have suggested that TBA+E should be used exclusively at the end of the feeding period, to avoid the slowdown in muscle growth that typically occurs.

A number of studies have been conducted to evaluate various implant/reimplant strategies (see tables 5,6 for examples). While difficult to summarize neatly due to varying experimental design, there are a number of consistent observations in these studies. First, TBA+E early in the feeding period, followed by E alone, is no better than, and often poorer than consecutive E implants. This is true despite an advantage in growth during the TBA+E portion of the feeding period. Second, in many cases E alone, followed by TBA+E, is as effective as consecutive TBA+E implants. In many studies, E, followed by TBA+E, results in slightly less growth promotion than two TBA+E implants, but also diminishes quality grade to a lesser degree. Thus, in some situations, this may be the preferred implant program. The effects of cattle type, rate of gain and length of feeding period all contribute to results in these studies and more work needs to be done to identify ideal implant/reimplant programs.

Heifers. In general, TBA+E is the most effective implant combination for heifers, as well as steers, however, the improvements in performance are reduced, compared to steer. Keane and Drennan (1987; table 7) reported a direct comparison of TBA+E effects on steers and heifers. TBA+E increased ADG of heifers 12.0%, while steer performance was enhanced by 25.1%.

There is some question whether TBA alone will increase growth in heifers to the same extent that TBA+E does. Galbraith (1980; table 8) and Henricks et al. (1982; table 9) reported increases in heifer performance of greater than 20% in response to TBA alone. These workers used implants containing 300 mg TBA, whereas Finaplix-H contains 200 mg TBA. Moran et al. (1989; table 10) reported that TBA alone improved growth (for the effective life of the implant) more than TBA+E. It is conceivable that exogenous E administration to heifers is not required, but this may be true only in cases where 300 mg TBA is administered. However, administration of E alone has been shown to improve growth of heifers.

The work of Preston et al. (1987; table 11) represents the most complete characterization of the interaction between various levels of TBA and E in heifers. In this work, the most effective combination of TBA and E was 140 mg TBA/28 mg E, followed by 0/20 (with 200 mg progesterone), 200/20, 200/0 and 0/0. On day 70 of the 169 day experiment, cattle in the 0/20 treatment group were reimplanted, cattle that received treatments containing TBA were not. Prior to this reimplantation, the 200/20 treatment was superior to the 0/20 treatment.

Bulls. Table 12 includes data from representative studies of TBA+E administration to bulls. While not consistently observed, there is evidence that TBA+E increases performance of bulls, primarily through increasing fat deposition. This effect may be primarily due to E, which has been shown to increase growth and fatness of bulls. However, in some reports the increase due to TBA+E exceeds that expected with E alone.

Cull cows. Table 13 includes data of Garnsworthy et al. (1986) who implanted culled dairy cows with 300 mg TBA and slaughtered them after 60 or 100 days on feed. Implants increased ADG by 21 and 42% in the two groups with F/G reduced by 22 and 25%. The increased weight gain due to the implant was primarily due to increased muscle deposition in these cows that were in average condition at the start of the experiment. Implants are not approved for use in culled cows in the U.S. but it is likely that administration of TBA to cull cows would increase weight gains. It is not known whether E administration is required for maximum response to TBA, although this may be less likely in cows than in other types of cattle. Response of cows in thin or fat condition to TBA administration is also unknown. Due to the potential for favorable weight gain and feed conversion of thin cull cows, as well as the seasonal increase in cull cow price that typically occurs from October through March, feeding of cull cows for 45 to 90 days is often profitable. Implantation of cull cows merits serious consideration for cow/calf producers who have facilities to feed cows after weaning or can sort cows that will be culled prior to weaning. Feedlot operators may also consider purchasing, implanting and feeding culled cows, although this proposition is not without risk.

Veal calves. Grandadam et al. (1975) reported that implantation with TBA+E results in moderate improvements in performance of male veal calves, although results are somewhat ambiguous (Tables 14, 15). Veal calves are virtually never implanted but positive responses indicate that the possibility should be considered. Effects on appearance and quality of the veal have not been well described. A further consideration would be the response of consumers to knowledge that veal was from implanted calves.

DOES THE SOURCE OF ESTROGEN MATTER?

In the studies summarized above use of combined use of TBA + zeranol resulted in significantly improved performance over implanted or nonimplanted controls. However, in those studies that compared TBA + estradiol to TBA + zeranol, treatments containing estradiol typically improved performance 5 to 10 percentage units more than those containing zeranol. Data are insufficient to determine if a difference in marbling exists between estradiol or zeranol when used in combination with TBA.

DO ALL CATTLE TYPES RESPOND SIMILARLY?

Because of the differences among breeds in ability to deposit muscle and fat, differential responses to TBA+E may exist. Ainslie et al. (1990, table 16) and Fox et al. (1990; table 17) have reported that effects of TBA+E on Holsteins are significant, but less than the effects on beef breeds. Use of TBA+E in Holstein steers appears to provide a means of avoiding penalties for small ribeyes. Studies designed to compare the effects of TBA+E on various beef breed types have not been reported but some are underway.

CONCERNS WITH TBA+E USE

It can be suggested that TBA+E alters growth and carcass composition of steers such that implanted steers are intermediate between bulls and nonimplanted steers. This has obvious benefits but also brings some problems.

Quality grade. In virtually all studies reported, use of TBA+E reduced either average quality grade, percentage of choice cattle or both, in comparison to nonimplanted or E implanted cattle. This has been observed in both steers and heifers, calves and yearlings and in both exotic and British breed steers, although the observed reductions are often more severe in studies involving exotic steers. While average quality grade is seldom reduced more than 1/3 of a grade, grade is usually reduced from low choice to high select, an economically important reduction. In some studies, as few as 40% of the TBA+E treated cattle have graded choice, while 70 to 80% of the cattle in other treatment groups graded choice. Typically, the percentage of choice cattle in a pen declined 5-15 percentage units with TBA+E use. This has often occurred with little difference in fat thickness. This has become a source of great consternation to cattle feeders and some have ceased use of TBA due to the reduction in quality grade they have observed.

There are two possible explanations for this effect. It may be that TBA+E exerts a marbling-specific effect, reducing marbling preferentially to other fat depots. This seems a bit far-fetched, although there are numerous accounts of reduced quality grade with equal external fat thickness. In the authors view, it is more likely that reduced quality grades are a function of the experimental design used by most experimenters. Since use of TBA+E increases muscle deposition by as much as 50 lb per carcass, treated cattle slaughtered after the same number of days on feed would not have the same carcass composition as controls, even if external fat thickness was the same. Under these circumstances, it makes little sense to expect treated cattle to have the same quality grade as controls, especially when it is considered that intramuscular fat is a late maturing fat depot. Since TBA+E increases muscle deposition and slightly depresses fat deposition, cattle treated with TBA+E will be substantially heavier at any given quality grade than controls. In addition to faster rates of gain, TBA+E treated cattle must be fed longer than controls to attain equal quality grades. TBA+E would actually have to **increase** the ability of cattle to marble for cattle to grade equally after the same number of days on feed.

If it is accepted that TBA+E treated cattle will grade choice eventually, the question becomes: How much heavier do cattle have to be to grade choice when treated with TBA+E? To date only Fox et al. (1990; table 17) have reported results of work designed to address this issue. These researchers utilized ultrasound to estimate marbling and slaughtered cattle when it was deemed that 70% in a pen would grade low choice. In Holstein steers, 46 lb greater final weight was required for TBA+E treated cattle to achieve quality grade equal to nonimplanted controls. At low choice, the difference between treated and control beef breed (Angus and Angus x Simmental) steers was 88 lb. Ongoing research at the University of Minnesota is utilizing regression analysis of data from TBA+E or nonimplanted cattle slaughtered at three different weights to assess this question.

The question is far from resolved but a possible reduction in quality grade in response to TBA+E should be considered when selecting an implant program. A corollary problem would be excessive carcass size in large framed cattle treated with TBA+E and fed until they grade choice.

Masculinity and increased sexual behavior. While not the same, these issues are related. Most cattle feeders report increased masculinity of cattle implanted with TBA+E, especially when cattle are reimplanted with the combination at least once. Foutz et al. (1990) reported an increase in visual "bullock score" of carcasses from steers implanted with Revalor or Synovex + Finaplix. Strohbehn et al. (1990) reported increased visual "masculinity score" of steers implanted with TBA+E, compared to nonimplanted or implanted with E alone. Others have reported increases in proportional head weight in response to TBA+E. Wood et al. (1986) observed a proportional increase in the weight of neck and

shoulder muscles in steers implanted with TBA+E. Indeed, the TBA+E-induced increase in muscle deposition is unfortunately greater in the lower valued cuts of the chuck than in any other part of the carcass.

Research studies have not reported increased aggressive or sexual behavior but cattle feeders suggest that this can be a problem, especially in cattle that are implanted with TBA+E more than once. A possible explanation for the discrepancy between feedlot experience and research studies is in the size of the pens utilized. Riding is typically reduce in small research pens, regardless of cattle type or treatment, while it may occur in large feedlot pens. If TBA+E increases riding, potential exists for both reduced performance and increased rate of injury, especially if pen surface is slippery. Destructive behavior, often a problem with bulls, does not seem to be increased noticeably with TBA+E use.

Implanting technique seems responsible for some of the reported behavioral problems. Steers that have crushed implants, and thus rapid payout of hormone into the bloodstream, seem to be the "riders." The "ridees," those cattle being ridden are those that have abscessed or walled-off implants and thus, less hormone than the average of the pen.

Hide pulling. An issue related to masculinity is the increased difficulty in hide removal due to TBA+E, as reported by some packers. This is common problem in bulls. Kansas researchers have reported increased difficulty in mechanical removal of hides of TBA+E implanted steers, compared to other implants (Hartman et al., 1989). Some cattle feeders have reported reluctance to purchase TBA+E treated cattle on the part of some packers, who attribute their stand to the increased chance of torn hides or damaged carcasses. While hide pulling is more difficult with TBA+E treated cattle, the incidence of hide or carcass damage is unknown.

Meat quality. Patterson and Salter (1985) reviewed the literature and reported no consistent reduction in eating quality of steers, bulls, heifers or veal calves treated with TBA+E. Trenkle (1990) reported no difference in sensory evaluation of rib steaks from steers treated with TBA+E or other implants. In contrast, Foutz et al. (1990; table 18) reported a tendency for TBA to increase shear force of steaks. In that study, 37.5% of steaks from steers implanted with Revalor and 35.7% of those from steers implanted once with Synovex and twice with Finaplix had shear values greater than 10 lb, while only 21.4% of control steaks exceeded that value. The incidence of dark cutters, a concern with bulls, apparently is not increased with TBA+E use.

Reproductive ability of bulls and heifers. Bulls or heifers intended for breeding should not be implanted with TBA. Silcox et al. (1986) and Henricks et al. (1988) reported reduced scrotal circumference, testis weight, sperm production and response (LH production) to a GnRH challenge in implanted bulls, compared to controls. Moran et al. (1989; table 10) reported that TBA, but not E, impeded normal mammary development in heifers. Effects of TBA on fertility of heifers are unknown but the safest strategy would be to avoid use of TBA+E in any cattle intended for reproduction.

PROFITABILITY

Differences in performance alone do not justify adoption of technology, a profit motive must exist. Given the cost (Finaplix-S = $2, Finaplix-H = $2.85, E-containing implants = $1-2.50) and the potential for reduction in quality grade, profit is not guaranteed with these products, in fact improper use could cause serious losses. The relatively short effective life of Finaplix implants, and the stress, shrink and

labor charge associated with reimplanting, all must be considered. Trenkle (1990; table 5) has estimated differences in profit between implant based on results of an experiment that compared several possible combinations. Despite a substantial reduction in the percentage of cattle that graded choice, use of Revalor was the most profitable choice. This was true whether a $5 or 10 discount for select grade cattle was assigned, although increasing the penalty for selects narrowed the difference. Rust (1990) reported that the probability of attaining a profit increased from 50 to 70% when cattle were implanted with E alone or with TBA+E. TBA+E resulted in greater potential profit than E alone.

A factor that should be considered when interpreting research data regarding TBA, as well as planning implanting programs, is the ease of administration of the implants. Wagner et al. (1990) reported that only 61% of Finaplix-S implants were placed correctly, while over 80% of Synovex-S implants were properly placed. Obviously, performance or carcass effects attributed to TBA would be underestimated in this study, perhaps in others. The difficulty in placing Finaplix implants could reflect the fact that the person who placed the implants had not used Finaplix before and was unfamiliar with the implant gun. Some cattle feeders have also reported greater problems when Finaplix was added to their programs. When two implants are administered to the same animal, in opposite ears, which is the most common case in TBA+E implant programs, the implanter will likely place one implant one right-handed, the other left-handed. This may contribute to observed problems.

This brings up the question of whether the implants should be placed in the same ear or opposite ears. While this may seem at first an unusual question, the data of Heitzman et al. (1981; table 2) suggest that it may not be. These authors suggest that presence of TBA in an ear sustains the release of E from an implant in the same ear, resulting in a prolonged effect. Since cattle feeders (and researchers, with a few exceptions) usually implant TBA and E in opposite ears, this area may warrant further study.

CONCLUSIONS

1. TBA, when used in combination with an estrogenic implant (Synovex, Ralgro, Compudose or Steer-oid), will improve ADG of steers by 5-25%, of heifers by 5-15%. Improvements in ADG are usually greater in growing than finishing cattle. ADFI is increased slightly, expect cattle to consume approximately .5 to 1.0 lb/hd more feed per day. F/G is improved by 10-15%.

2. All measures of muscling are increased with TBA+E use, effects on external fatness are unclear but are minimal in most cases. Marbling is usually reduced when compared to control cattle fed the same number of days, TBA+E treated cattle must be fed to greater weights than those implanted with E alone. Effects are greater on beef breed steers than Holsteins. Other breed differences are not well characterized.

3. TBA appears to be more effective when used with estradiol compared to use with the synthetic estrogen, zeranol. Zeranol, in combination with TBA is more effective than estrogen-containing implants alone.

4. TBA+E is more effective in steers than heifers.

5. Caution should be exercised when using TBA+E since quality grade of carcasses is often reduced.

6. TBA+E is an effective growth promotant in other species as well (data not shown).

UNRESOLVED QUESTIONS

1. Is Revalor different from the combination of Synovex-S + Finaplix-S?
   Most likely answer: NO

2. Should combined implants be placed in the same ear or opposite ears?
   Most likely answer: If a difference does exist, same ear may be best.

3. Should Finaplix-H be used in steers instead of Finaplix-S?
   Most likely answer: NO

4. Is estrogen really needed when TBA is used in heifers?
   Most likely answer: Uncertain

5. What are the effects of TBA, with or without E, in suckling calves?
   Most likely answer: Should promote growth.

6. How do cattle types that differ in ability to deposit muscle (i.e., Limousin vs. Jersey) respond to TBA+E?
   Most likely answer: Do not know, need to find out.

7. Does use of TBA+E alter nutrient requirements (especially protein).
   Most likely answer: Probably increases protein requirement.

SUGGESTIONS FOR USE OF TBA+E

1. Use TBA in conjunction with an estrogen-containing implant.

2. Once cattle have been implanted with TBA, continue use of TBA until slaughter. Reimplant every 60-80 days. However, use of three successive TBA+E implant combinations in beef breed steers may not be wise.

3. Feed cattle implanted with TBA+E to heavier weights than cattle implanted with other products or non-implanted cattle. It appears that cattle implanted with TBA+E must weigh from 40 to 100 lb (amount depends on cattle type) more than non-implanted cattle to attain the same quality grade.

4. Timing of marketing is critical. TBA+E implanted cattle should not be marketed within 60 days of receiving implants but should be marketed within 110 days, or much of the implant benefit may be lost. The 60 to 110 day window may be too wide, further research will allow more specific recommendations.

5. Consider cattle type and sex in TBA implant programs. British breed steers and heifers are best suited to TBA+E use. Exotic heifers and smaller framed exotic steers are well suited to TBA+E use. Large framed exotic breed steers may not be well suited to TBA+E use. Performance and muscling of large framed steers will be improved, but quality grade may be poor at acceptable market weights. While use of TBA+E in small framed cattle may allow a feeder to avoid discounts for carcasses that are too light, TBA+E will increase the possibility that large framed cattle will produce carcasses that are discounted because they are too heavy.

6. Consider marketing programs. TBA+E may be the wrong choice for cattle that will be marketed in May or June, months when the discount for select grade carcasses is typically greatest. Cattle that will be marketed during other months, when the penalty for failure to grade choice is reduced, should receive TBA+E. Specialty programs such as Certified Angus Beef or Limousin Supreme, which have specific marbling requirements, may dictate use or nonuse of TBA+E.

7. Consider the effects of TBA+E when projecting breakevens and marketing dates.

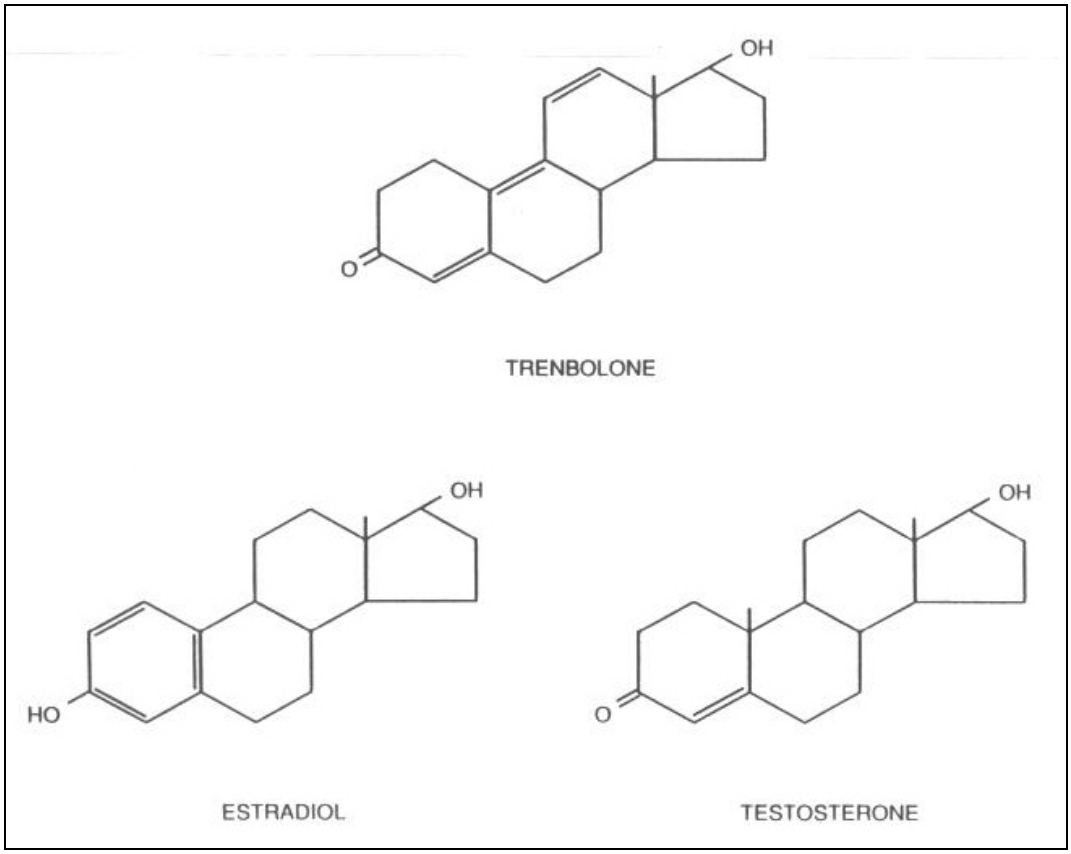

FIGURE 1. CHEMICAL STRUCTURE OF TRENBOLONE, TESTOSTERONE AND ESTRADIOL

TABLE 1. COMPARISON OF IMPLANTS IN YEARLING STEERS

	68d		109d	
Compound	ADG, lb	Increase, %	ADG, lb	Increase, %
Control	2.11	2.71		
Finaplix	2.36	+10.8	2.75	+1.8
Ralgro	2.38	+12.7	2.80	+2.7
Synovex-S	2.47	+16.8	2.91	+6.8
Compudose	2.49	+18.4	2.91	+7.2
Forplix	2.56	+21.7	2.95	+9.1
Revalor	2.64	+25.8	3.02	+11.1

Schanbacher et al., 1984.

TABLE 2. THE EFFECT OF TBA AND ESTRADIOL, ALONE OR IN COMBINATION ON GROWTH OF BEEF STEERS

		Treatment group[a]			
	Control	E	TBA	E/TBA	E+TBA
ADG d 0-35, lb	1.59	2.29	2.00	2.97	2.57
ADG d 0-98, lb	1.74	1.94	1.96	2.16	2.53
F/G d 0-98	9.30	8.78	8.45	8.13	6.92

[a] E = 20 mg estradiol; TBA = 140 mg TBA; E/TBA = E and TBA in opposite ears; E+TBA = E and TBA in same ear.

Heitzman et al., 1981.

TABLE 3. THE EFFECT OF TBA AND ESTRADIOL ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF STEERS, COMPARED TO NONIMPLANTED CONTROL

Reference	TBA, mg	E, mg	Days	ADG	F/G	ADFI	Fat	Muscle
				---------- Control = 100 ----------				
Heitzman et al., 1977	140	20	63	142.1	---	---	---	---
Lobley et al., 1985	140	20	70	168.8	62.8	105.9	---	---
	140	20	70	149.3	67.5	100.8	---	---
Keane et al., 1986	300	36[a]	168[b]	128.3	81.4	104.4	95.7	
	300	20	168[b]	133.8	78.8	105.5	98.0	
Bartle et al., 1988	140	28	144	127.3	86.5	109.9	---	---
Bartle et al., 1988	140	28	115,153	127.2	81.8	106.1	---	---
	140	28	153	134.3	76.9	104.2	---	---
Steen, 1988	300	20	157[c]	129.2	83.2	107.5	96.7	100.7
	300	20	157[c]	144.6	76.0	109.9	86.2	127.7
Apple et al., 1990	140	20	249[d]	114.9	94.2	---	85.2	116.5
	140	36[a]	249[d]	109.3	100.0	---	100.0	110.7
Eversole et al., 1989	140	28	140	119.1	87.7	103.6	110.5	103.0
	140	28	140	128.1	81.4	103.6	89.5	110.8
	140	28	140	121.3	84.7	102.3	105.3	108.4
Foutz et al., 1990	140	20	126	104.3	95.6	99.6	89.8	107.0
	140	20	126	106.5	91.5	97.2	93.2	107.8
	140	20	126[e]	108.0	92.0	99.2	96.6	107.8
Rouse et al., 1990	140	20	125[g]	106.5	---	---	100.0	100.8
Strohbehn et al., 1990	140	20	150	111.7	---	---	---	---
	140	36[a]	150	105.8	---	---	---	---
Trenkle, 1990	140	20	175	111.0	97.7	108.1	108.8	101.5
	140	20	175[f]	121.0	88.3	106.7	98.2	110.0
Wagner et al., 1990	140	20	123[g]	127.2	---	---	133.9	111.7
Unweighted mean	124.2	84.6	104.4	99.2	108.9			

[a] Zeranol.
[b] Reimplanted on d 84.
[c] Reimplanted on d 77.
[d] Holstein steers, reimplanted on d 56, 112 and 168.
[e] Reimplanted (TBA only) on d 56.
[f] Reimplanted on d 80.
[g] Reimplanted on d 60.

TABLE 4. THE EFFECT OF TBA AND ESTRADIOL ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF STEERS, COMPARED TO IMPLANTED CONTROL

Reference	TBA	E	Days	ADG	F/G	ADFI	Fat	Muscle
				---------- Control = 100 ----------				
Bartle et al., 1987[a]	140	28	161	97.6	102.0	99.5	---	---
	140	28	161	95.2	104.8	99.5	---	---
	140	20	161	95.9	104.8	100.5	---	---
Bartle et al., 1988	140	28	115,153	108.8	89.9	99.8	---	---
	140	28	115,153	106.7	87.6	93.9	---	---
Hartman et al., 1989	140	20	---	105.4	---	---	94.3	106.1
	140	20	109	103.4	---	---	94.3	102.4
	140	36[b]	109	100.6	---	---	98.1	100.0
	140	20	97	104.6	---	---	104.3	97.8
	140	36[b]	97	103.1	---	---	100.0	102.3
	140	36[b]	77	105.3	---	---	---	---
Apple et al., 1990	140	20	249[c]	104.4	98.5	---	82.1	107.1
	140	36[b]	249[c]	99.3	106.2	---	93.1	104.6
Foutz et al., 1990	140	20	126	110.1	96.9	106.6	86.9	105.4
	140	20	126	112.3	92.8	104.0	90.2	106.2
	140	20	126[d]	114.0	93.2	106.2	93.4	106.2
Strohbehn et al., 1990	140	20	150	107.2	---	---	---	---
	140	36[b]	150	103.3	---	---	---	---
Trenkle, 1990	140	20	175[d]	109.3	93.8	102.3	107.7	105.1
Wagner et al., 1990	140	20	123[e]	112.6	---	---	102.0	109.9
Weichenthal, et al., 1990	140	20	110	104.4	97.7	102.2	91.8	---
Unweighted mean	104.9	97.4	101.5	95.2	104.4			

[a] Control were reimplanted at d 70, TBA+E cattle were not reimplanted, prior to reimplant, TBA+E cattle were heavier than control.

[b] Zeranol.

[c] Holstein steers, reimplanted on d 56, 112 and 168.

[d] Reimplanted on d 80.

[e] Reimplanted on d 60.

TABLE 5. COMPARISON OF PERFORMANCE AND PROFITABILITY OF VARIOUS IMPLANT/REIMPLANT STRATEGIES INCLUDING TBA AND E[a]

	Treatment[b]				
Day 0 implant	None	R	R	R	S
Day 80 implant	None	None	R	S	S+F
ADG, lb	3.11	3.44	3.74	3.44	3.52
F/G	6.75	6.59	5.96	6.35	6.24
#choice/#select	26/4	22/8	14/16	14/16	25/5
Yield grade	3.1	3.3	3.0	2.9	3.2
Profit,$/hd[c]	36.62	55.69	93.23	64.83	77.69
Profit,$/hd[d]	31.62	45.10	71.04	43.65	70.97

[a] Charolais crossbred steer calves (660 lb), slaughtered after 175 days on feed.

[b] R = Revalor, S = Synovex-S, F = Finaplix-S.

[c] Feeder cattle = $93.50/cwt; non-feed costs = $.40/hd/d; corn = $2.50/bu; corn silage = $22.40/t; supplement = $200/t; choice carcasses = $120/cwt, select = $115/cwt, yield grade 4 = $110/cwt.

[d] As above except select carcasses = $110/cwt.

Trenkle, 1990.

TABLE 6. THE EFFECT OF VARIOUS REIMPLANT STRATEGIES ON PERFORMANCE AND CARCASS CHARACTERISTICS OF CROSSBRED STEERS

	Implant administered[a]			
Day 0	None	Sy-S	Sy-S	Sy-S
Day 75	None	Sy-S	Fplx-S	Sy+Fplx
No. of pens	12	12	12	12
Initial wt, lb	689.2	690.5	689.0	690.7
Final wt, lb	1139.6	1201.1	1177.1	1209.4
ADG d 0-75, lb	3.15	3.44	3.19	3.37
ADG d 75-slaughter, lb	2.36	2.80	2.75	3.00
ADG d 0-slaughter, lb	2.82	3.13	3.00	3.19
ADFI d 0-75, lb	18.3	18.1	17.6	18.9
ADFI d 75-slaughter, lb	19.8	22.0	20.7	21.6
ADFI d 0-slaughter, lb	18.9	20.0	19.2	20.3
F/G d 0-75	5.8	5.3	5.6	5.7
F/G d 75-slaughter	8.8	8.1	7.7	7.4
F/G d 0-slaughter	7.0	6.5	6.5	6.4
Dressing percentage	64.2	64.4	64.2	64.5
Fat thickness, in	.50	.52	.55	.50
REA, in^2	12.8	13.3	13.1	13.5
Yield grade	2.9	2.9	2.9	2.8
Marbling	547	533	555	531
Quality grade[b]	18.7	18.3	18.9	18.2

[a] Sy-S = Synovex-S; Fplx-S = Finaplix-S.

[b] 18 = Select+; 19 = Choice-

Rust, 1990.

TABLE 7. EFFECTS OF REPEATED TBA + ZERANOL IMPLANTS ON GROWTH OF STEERS AND HEIFERS

	Heifers		Steers	
	Control	Implanted	Control	Implanted
ADG, lb[a]	1.54	1.72	1.70	2.11
Percent increase	---	12.0	---	25.1

[a]ADG reported is from d 395 to d 731 of age, TBA (300 mg) + zeranol (36 mg) were administered on d 395, 491, 583 and 658. Implant treatment group had been previously implanted with zeranol (36 mg) on d 81 and 171.

Keane and Drennan, 1987.

TABLE 8. EFFECTS OF TBA ON GROWTH OF HEIFERS[a]

	Control	Implanted	Percent change
ADG, lb	2.07	2.56	23.4
ADFI, lb	15.6	15.6	---
F/G	7.55	6.12	18.9

[a] Hereford x Friesian heifers (804 lb) were implanted with 300 mg TBA, or not implanted, fed moderate energy diets and slaughtered after 60 d.

Galbraith, 1980.

TABLE 9. EFFECTS OF TBA (300 mg) ON GROWTH AND CARCASS TRAITS OF HEIFERS[a]

	Length of implant period		
	Control	99 days	62 days
ADG, lb	1.96	1.98	2.36
F/G	8.04	7.64	6.48
Quality grade[b]	10.8	9.4	11.2
Yield grade	3.0	2.7	2.7

[a] Crossbred heifers (660 lb) fed high energy diets.

[b] Standard+ = 9, Select- = 10, Select+ = 11.

Henricks et al., 1982.

TABLE 10. EFFECTS OF TBA AND ESTRADIOL, ALONE OR IN COMBINATION ON PERFORMANCE AND MAMMARY DEVELOPMENT OF CROSSBRED BEEF HEIFERS[a]

	Control	TBA	E	TBA+E
ADG d 1-70, lb	1.89	2.14	1.89	1.98
ADG d 71-140, lb	2.33	2.38	2.38	2.49
ADG d 1-140, lb	2.11	2.25	2.14	2.22
Mammary score[b]				
d 70	1.7	1.1	1.6	1.4
d 140	1.6	1.5	1.8	1.3

[a] Crossbred heifers (660 lb) were implanted on d 0 with TBA (200 mg), E (20 mg), or both implants or were not implanted.

[b] Subjective score (1 = no mammary development, 3 = moderate to pronounced development).

Moran et al., 1989.

TABLE 11. EFFECT OF VARIOUS DOSES OF TBA AND ESTRADIOL ON PERFORMANCE AND CARCASS CHARACTERISTICS OF HEIFERS[a]

TBA	0	200[b]	200[c]	140	200	0
E	0	0	0	28	20	200[d]
ADG, lb	2.09	2.16	2.11	2.40	2.27	2.38
DMI, lb	15.2	15.2	14.8	16.5	15.6	16.1
F/G	7.3	7.0	7.0	6.9	6.9	6.8
REA, in^2	10.9	11.4	11.5	11.7	11.5	11.1
Fat th, in^2	.63	.51	.55	.47	.51	.55

[a] Crossbred heifers (595 lb), fed 169 days.

[b] Cholesterol based implant.

[c] Lactose based implant.

[d] Also contained 200 mg progesterone, reimplanted on d 70.

Preston et al., 1987.

TABLE 12. THE EFFECT OF TBA AND ESTRADIOL ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF BULLS, COMPARED TO NONIMPLANTED CONTROL

Reference	TBA	E	Days	ADG	F/G	ADFI	Fat	Muscle
				---------- Control = 100 ----------				
Grandadam et al., 1975	200	20	50	128.3	---	---	---	---
	200	20	77	171.4	59.7	101.0		
	200	20	81	144.0	---	---	---	---
Galbraith, 1982	300	45	70	126.4	81.3	102.4		
	300	45	70	118.1	84.1	98.9		
Fisher et al., 1986	140	20	400[a]	99.4	102.4	102.1	121.1	96.8
Rouse et al., 1990	140	20	125[b]	101.2	---	---	100.0	102.9
Unweighted mean	127.0	81.9	101.1	110.6	99.9			

[a] Implanted on d 44 and 300.

[b] Reimplanted on d 60.

TABLE 13. THE EFFECTS OF TBA ON PERFORMANCE AND CARCASS CHARACTERISTICS OF CULLED DAIRY COWS FED FOR 60 OR 100 DAYS[a]

	Fed 60 days		Fed 100 days	
	Control	Implanted	Control	Implanted
ADG, lb	2.47	2.97	2.03	2.89
ADFI, lb	25.6	26.2	28.4	32.4
F/G	10.1	7.9	12.7	9.5
Carcass wt, lb	597.6	618.5	626.0	662.5
Lean wt, lb	380.2	404.4	391.2	419.4
Total fat wt, lb	106.8	101.5	124.2	133.0

[a] Implanted with 300 mg TBA, average condition score of all cows = 2.18 (1 = thin, 4 = fat) at beginning of experiment.

Garnsworthy et al., 1986.

TABLE 14. EFFECTS OF TBA (140 mg) AND ESTRADIOL (20 mg) ON PERFORMANCE OF MALE VEAL CALVES SLAUGHTERED AFTER 104 DAYS ON EXPERIMENT

	Time of implant			
	Control	Day 62	Day 0	Day 0 and 62
Initial wt, lb	85.2	84.8	85.2	85.2
Gain, lb/104 days	221.4	246.5	228.4	274.0
% increase	---	11.4	3.2	1.2
Carcass wt, lb	197.6	214.3	202.4	197.8
% increase	---	8.5	2.5	0.1

Grandadam et al., 1975.

TABLE 15. EFFECTS OF TBA (140 mg) AND ESTRADIOL (20 mg) ON PERFORMANCE OF MALE VEAL CALVES, AVERAGES OF SIX FIELD TRIALS (161 CALVES)

Item	Response to treatment
Gain	+ 6.5%
Feed/Gain	- 7.9%
Carcass weight	+ 5.7%
Dressing percentage	+ 1.3 units

Grandadam et al., 1975.

TABLE 16. THE EFFECT OF SEQUENTIAL RALGRO AND REVALOR IMPLANTS ON PERFORMANCE OF HOLSTEIN STEERS[a]

	Control	Implanted	Difference
Period 1			
ADG, lb	2.67	2.91	9.1%
F/G	4.95	4.55	8.1%
Period 2			
ADG, lb	2.58	3.04	17.9%
F/G	7.24	6.40	11.6%
Total			
ADG, lb	2.58	2.97	15.4%
F/G	6.37	5.70	10.5%
Slaughter wt, lb	1126.0	1162.1	36.1 lb (3.2%)

[a] Steers placed on feed at 350 lb, implanted with Ralgro during period 1 (98 days), followed by Revalor, slaughtered when deemed 70% choice by ultrasound evaluation. Each group also included dietary treatments (10, 30 or 50% alfalfa). Significant treatment x implant interactions were not observed.

Ainslie et al., 1990.

TABLE 17. COMPARISON OF EFFECTS OF REVALOR ON HOLSTEIN AND BEEF BREED STEERS

	Holstein			Beef breeds		
	Control	Revalor	Change	Control	Revalor	Change
ADG, lb	2.44	2.86	17.1%	2.97	3.70	26.7%
ADFI, lb	17.3	18.6	7.5%	18.0	19.8	10.0%
F/G	7.08	6.50	8.2%	6.06	5.26	13.2%
Weight at low choice, lb	1128	1174	46 lb	1079	1168	88 lb
Protein gain, lb/d	.24	.33	36.4%	.24	.35	45.5%
Fat gain, lb/d	1.01	1.15	13.0%	1.34	1.67	24.6%

Fox et al., 1990.

TABLE 18. COMPARISON OF SYNOVEX-S, FINAPLIX-S AND REVALOR IN YEARLING FEEDLOT STEERS

	Treatment group[a]				
	C	S	R	ST	STT
N	28	27	27	27	28
Weights, lb					
Initial	776	779	778	777	777
Final[b]	1172	1156	1192	1199	1206
ADG, lb/d	3.24	3.07	3.38	3.45	3.50
ADFI, lb	19.9	18.6	19.9	19.4	19.8
F/G 6.15	6.07	5.88	5.63	5.66	
Calculated NEg					
MCal/cwt	63.7	65.0	66.2	68.7	68.3
Carcass weight, lb	751	740	763	767	771
Fat thickness, in	.59	.61	.53	.55	.57
REA, in^2	12.8	13.0	13.7	13.8	13.8
Yield grade	3.2	3.1	2.8	2.8	2.8
Percent YG 4	7.1	14.2	0	7.7	10.7
Lean maturity	139	139	138	140	139
Lean color score	6.3	6.3	6.3	6.3	6.4
Bullock score	4.6	4.6	4.3	4.4	4.1
Skeletal maturity	145	158	169	160	157
Marbling score	463	435	418	447	438
Percent choice	82.1	82.1	51.8	85.7	71.4
Shear force, lb	8.82	9.77	9.52	9.08	9.72
Percent tough[c]	21.4	37.5	37.5	25.8	35.7

[a] Treatment groups: C = control; S = Synovex-S on d 1; R = Revalor on d 1; ST = Synovex-s + Finaplix-S on d 1; STT = Synovex-S + Finaplix-S on d 1, Finaplix-S reimplanted on d 58.

[b] Slaughtered after 119 or 126 d on feed.

[c] Shear values 10 lb or greater.

Foutz et al., 1990.