Growth-promoting implants 101

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Abstract
Growth-promoting implants serve a very important purpose in the United States beef cattle industry. Despite being recognized as providing the greatest return-on-investment of any animal health technology in the feedlot segment, there is still much unknown about implants and where and when they should be applied. There are 27 FDA-approved growth-promoting implants marketed today. They all work, and they all serve a purpose. There are a few keys rules that can help narrow down the 27 available options to fit a specific situation: 1) match implant potency to the stage of cattle growth and nutrients available (in other words, don't over-implant), 2) don't run out of implant, particularly when cattle are near harvest, and 3) apply implants correctly. By understanding what implants are available, how they can best be administered, and what implants fit certain situations, producers and practitioners can take advantage of this valuable tool to optimize performance of cattle in the suckling, stocker, and feedlot segments.

Key words: growth-promoting implants, cattle

Introduction
Growth-promoting implants have been widely used in the beef cattle industry for over 60 years. The first growth-promotant for beef cattle, diethyl stilbestrol (DES), gained FDA approval as an oral feed additive in 1954 and as an implant in 1957. Since the first growth-promoting implants were approved, the technology has evolved from conventional estradiol-only implants to trenbolone acetate (TBA) implants (Finaplix®-S and Finaplix®-H, Merck Animal Health, Madison, NJ) in 1987, TBA-estradiol combination implants in 1991 (Revalor®-S, Merck Animal Health, Madison, NJ), and long-acting (200-day) combination implants in 2007 (Revalor®-XS, Merck Animal Health, Madison, NJ). The history and key milestones in implant development have been well-reviewed.[11] Today, it is estimated that greater than 90% of fed cattle receive at least one implant during the course of their lives.1 The percentage of suckling calves receiving growth-promoting implants is much lower (29.5%).16

The performance response to growth-promoting implants varies with the type of implant used, baseline performance of cattle, stage of production, and various other factors. Steers receiving an implant regimen with two combination (TBA + estradiol) implants had 20% greater average daily gain (ADG), 13.5% greater feed efficiency, and 7.5% greater hot carcass weight (HCW) compared with non-implanted steers.[6] For suckling calves and stocker calves the response to implants may vary greatly due to variation in forage type and availability, variation in dam milk production for suckling calves, and other factors. In suckling calves, implants resulted in a 0.11 lb. average increase in ADG compared with non-implanted suckling calves.[17] In stocker calves, implants resulted in a 0.15 lb. average increase in ADG compared with non-implanted stocker calves.[12] Because of these large responses, growth-promoting implants are recognized as the animal health technology that offers the greatest monetary return in the feedlot segment and the second-largest monetary return (behind dewormers) in the cow-calf and stocker segments.[13]

Despite implants being available for over 60 years, there are still many unknowns with this technology. Part of this is likely due to the large quantity (27 as of this writing) of different implants available. This paper will address many of the unknowns related to implanting as well as other basic topics related to utilizing growth-promoting implants in beef cattle.

How do implants work?
Implants are placed subcutaneously in the posterior side of the animal's ear. Once properly inserted, the hormones contained within the implant begin to release into the bloodstream in a biphasic manner (Figure 1). Most implants contain either an androgen (TBA or testosterone), an estrogen (estradiol 17-beta or estradiol benzoate) or a combination of TBA and estrogen. Some implants also contain progesterone. One exception to the hormones listed above is Ralgro® (Merck Animal Health, Madison, NJ), which contains zeranol. Zeranol is not technically an estrogen but produces estrogen-like responses and therefore is often classified as an estrogenic implant. The active ingredients are contained within a carrier (or excipient) which is designed to slowly release the active ingredients into the bloodstream.

The specific mode-of-action of growth-promoting implants has been characterized, including in a recent review.[18] In brief, the primary effect of estrogenic implants is thought to be an indirect effect through an altered somatotropic axis. This is accomplished through an increase in pituitary size, which increases insulin-like growth-factor I (IGF-I) production and alters IGF-I and somatotropin (ST) binding characteristics. These alterations increase circulating ST, create a more efficacious release pattern, and a more responsive muscle, resulting in stimulus of muscle growth.[11]

Conversely, androgens have a more direct effect on muscle growth through stimulation of quiescent satellite cells. Satellite cells are capable of fusing to existing muscle fiber and ultimately donating their nuclei to support increase protein synthesis.[11] Further, TBA has been shown to decrease cortisol, which results in decreased protein degradation.[9]

The net effect of the modes-of-action of growth-promoting implants is an increase in lean muscle mass and an increase in mature body weight with limited effect on body fat deposition.[10,11] The functional significance of an increase in mature body weight is that immature cattle can more efficiently deposit lean muscle than mature cattle. Because of the lack of effect on fat deposition, if implanted cattle are to be fed to a desired fatness (as a percentage of empty body fat, for example), they will need to be fed to heavier weights than non-implanted cattle. Chemically mature body weight is the weight at which cattle reach at least 28% empty body fat and is thought to be increased by approximately 100 lbs. through the use of implants.[8,19]

One potential drawback to growth-promoting implants is the effect on reproduction if heifers are implanted as suckling calves. Several studies have been conducted to assess the effect of suckling calf implants on subsequent breeding and reproduction, with mixed results.[17] In general, it appears that implanting heifer calves shortly after birth may be detrimental to subsequent breeding, and multiple implants prior to breeding may also be detrimental. Implanting at branding (30-90 days-of-age) has minimal impact on breeding.[17]

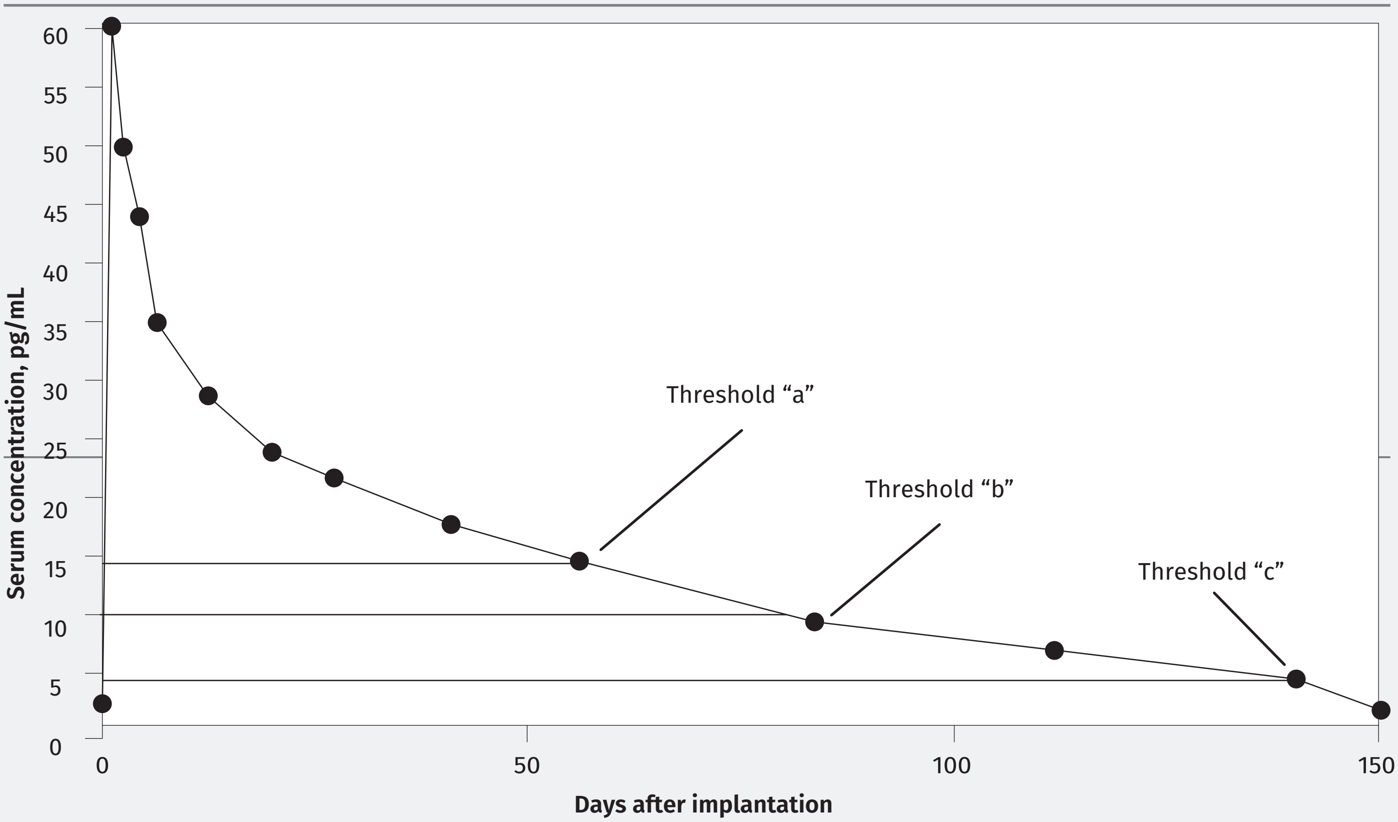
How long will implants last?

The mode-of-action discussion often leads to one of the primary questions regarding implants: How long do they last? There are several factors that can impact any estimation of implant "payout", or the time, in days, that the implant will elicit a growth response in cattle. Effective payout of growth-promoting implants was proposed to be dependent upon threshold serum or plasma hormone concentration for an implant response.[3] It was further suggested that suckling calves will likely have a lower threshold of implant response than finishing cattle that are nearing physiological maturity (Figure 1).[3] This means that a suckling calf will respond to a lower dose of hormone than a finishing steer or heifer. Three scenarios were described where cattle may have a threshold serum or plasma hormone concentration for an implant response of 5, 10, of 15 pg/mL.[3] Based on these theoretical thresholds, the same implant may last 55, 80 or 140 days. A functional example of this is Ralgro. In finishing cattle, Ralgro is often recognized to have an effective payout of only 60-70 days. However, in suckling calves Ralgro may have an effective payout of 100 days or more. This response may also be due to a potentially slower release rate of implants in younger cattle.[3]

Effective implant payout may also be affected by the implant carrier. Carriers utilized for growth-promoting implants consist of lactose (Ralgro, Finaplix-S, and Finaplix-H), polyethylene glycol (PEG; Synovex® implants, Zoetis Animal Health, Parsippany, NJ), cholesterol (Revalor® implants, Merck Animal Health, Madison, NJ), and silastic rubber (Encore® and Compudose®, Elanco Animal Health, Greenfield, IN). The silastic rubber carrier is insoluble, meaning that the rubber carrier will remain present in the ear of cattle even after the hormone active ingredient has depleted. All other carriers are soluble and will degrade over time. The lactose carrier is often recognized as having a faster payout than other carriers. Though some suggest that PEG may have a faster payout than cholesterol, there have been no studies to support any performance differences when equal hormone concentrations are compared in implants with either a PEG or cholesterol carrier. Finally, silastic rubber implants are designed to extend implant payout and as such have a longer payout than cholesterol, PEG or lactose-based implants.

Keeping in mind the various factors that affect implant payout listed in the paragraphs above, common estimates of payout for various implants are listed in Table 1. In general, traditional implants payout over a course of approximately 130 days, while extended-release implants have a payout of approximately 200 days (Compudose, Revalor-XS, Revalor-XH, Synovex One Feedlot, and Synovex One Grass) or 400 days (Encore). However, it is important again to remember the biphasic nature of implant payout. Though implants may elicit a growth response at the end of the payout period, that response is not optimal. For instance, research was recently conducted in heifers5 and steers[14] to determine the ideal payout window for Revalor-200. Each study consisted of 180 days-on-feed and Revalor-200 being applied on day 20, 60, 100, or 140 of the feeding period, resulting in terminal implant windows of 160, 120, 80, and 40 days. The results suggested the ideal window to optimize ADG, feed efficiency, and HCW was between 90-100 days-on-feed.

Figure 1: Biphasic nature of hormone absorption from a growth-promoting implant. Thresholds "a", "b", and "c" depict theoretical thresholds of implant response below which cattle will not receive a benefit from the implant. Adapted from Brandt et al (1997).



The advent of long-acting or extended-release combination implants for feedlot cattle (Revalor-XS and XH, Synovex One Feedlot) has allowed for flexibility in implanting due to the extended hormone release. In many cases, the payout of these implants will cover the entire days-on-feed for a group of cattle, thereby reducing labor needs, facility needs and risk of injury to cattle.

Proper implanting technique and common implanting abnormalities

An excellent overview of implant best practices has recently been published.[15] In addition to being implanted, a steer or heifer being processed in the working chute may receive 1-2 (or more) vaccines, 1-2 dewormers and/or external parasiticides, an antibiotic, a live microbial drench, and an eartag. When considering the value of all of these practices, one could argue that implanting should be the rate-limiting step at cattle processing. If implants are applied correctly, the results quoted in previous sections can be realized. However, lack of care and/or sanitation can reduce the gains realized from implanting. Research in a commercial feedlot in Oklahoma analyzed implanting technique from 1,183 steers and correlated implant abnormalities to ADG of individual steers.[2] It was found that 81% of the implants identified were normal and 19% abnormal. The most common abnormality was partial implants. The steers that were deemed to have a partial implant gained 0.11 lbs./day less than steers with a normal implant, though this difference was not statistically significant. Missing implants represented the second-most common abnormality and resulted in a decreased ADG of 0.49 lbs./day compared with steers receiving a normal implant. The causes of missing and partial implants could be due to operator error (implants pellets being pushed through the ear or the implant gun being pulled out too quickly), an empty implant cartridge, or abscesses that are developed due to local infection at the implant site. The abscess issue is one that can be a great concern and can be avoided with proper sanitation and sanitation and care at the implant site.

Three basic rules

The preceding discussion basically leads to three keys to implanting that can help in optimizing the use of these valuable tools.

1. Don't run out

As discussed in the sections on mode-of-action and implant payout, the available hormone in implants will not last indefinitely. As cattle approach physiological maturity, they shift from depositing lean muscle to fat. The deposition of fat is less energetically efficient that lean muscle. In addition, while marbling deposition occurs in a linear manner throughout the cattle lifetime, backfat deposition accelerates rapidly as cattle approach maturity (Figure 2).[4] Therefore, the most important time to have an active implant is toward the end of the finishing period to avoid drastic reductions in feed efficiency and rapid increases in fat deposition that may lead to carcass discounts due to excessive fatness (USDA Yield Grade 4 and 5 carcasses). When in doubt, it is recommended to estimate more days-on-feed rather than less when planning implant programs. This will provide greater peace of mind in case cattle are fed beyond the estimated marketing date.

2. Don't get too aggressive too early

Implanting too aggressively too early may lead to increased growth at a young age, but that early growth may negatively affect subsequent growth performance.[7] Marbling score appears to increase linearly with days-on-feed.[4] Implanting too aggressively too early may alter the slope of the marbling accretion line resulting in a decrease in quality grade.[4] It is important to match the implant to the cattle type. For instance, an aggressive terminal implant (Revalor-200 or Synovex Plus) may be an ideal fit for a finishing steer or heifer during their last 100 days-on-feed, but is not a good fit for a 500-lb feeder calf just entering the feedlot. There are 27 implants available, and they all serve a purpose, whether it be for a suckling calf on the cow, a weaned stocker steer or heifer on grass, a steer or heifer on a low-energy diet upon entry to the feedlot, or a steer or heifer on a high-energy finishing diet in the feedlot.

3. Apply implants properly

This rule was covered in the section on proper implanting technique and common implanting abnormalities. Implanting should be the rate-limiting step in cattle processing. Proper training and subsequent quality control checks are wise investments to ensure that implants are being applied properly.

Conclusion

Implants provide the greatest monetary return of any animal health technology in the feedlot segment and the second greatest return of any animal health technology in the cow-calf and stocker segments. They are widely used and accepted as an important tool for beef production. However, there is not a one-size-fits-all implant, and many items should be considered prior to implanting a group of cattle. Through adhering to a few key rules, implants can be used to help optimize cattle performance and ultimately profitability.

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Figure 2: Relationship between hot carcass weight and marbling score. Adapted from Bruns et al (2004).

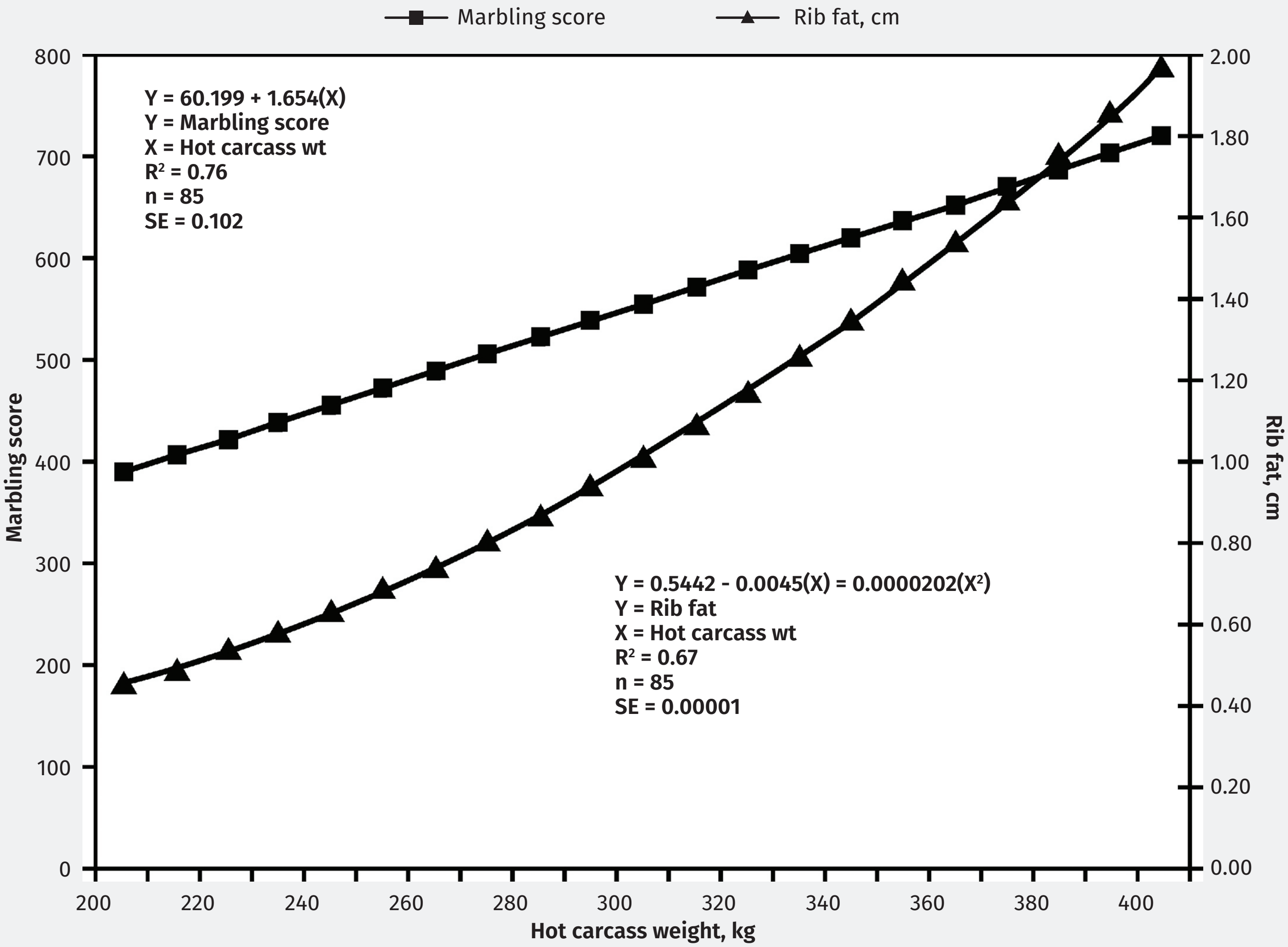

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Table 1: Currently approved and available beef cattle implants

Implant	Sourcea	Carrierb	Zc (mg)	Ed (mg)	TPe (mg)	TBAf (mg)	Approx. days-of-activity	Approved uses
Ralgro	MAH	Lactose	36				70 (feedlot), 100-120 (calves)	Suckling, stocker, and feedlot steers and heifers
Compudose	EAH	SR		25.7			175	Steers, feedlot heifers
Encore	EAH	SR		43.9			350	Steers of all classes
Synovex C	ZAH	PEG		10			120	Steer and Heifer calves, Feedlot steers
Component E-C	EAH	PEG		7			120	Steer and heifer calves
Revalor-G	MAH	Cholesterol		8		40	130	Stocker steers and heifers
Component TE-G	EAH	Cholesterol		8		40	130	Stocker steers and heifers
Synovex One Grass	ZAH	PEG		21		150	200	Stocker steers and heifers
Revalor-IH	MAH	Cholesterol		8		80	130	Feedlot heifers
Component TE-IH	EAH	Cholesterol		8		80	130	Feedlot heifers
Revalor-IS	MAH	Cholesterol		16		80	130	Feedlot steers
Component TE-IS	EAH	Cholesterol		16		80	130	Feedlot steers
Synovex H	ZAH	PEG		20	200		130	Stocker and Feedlot heifers
Component E-H	EAH	PEG		20	200		130	Stocker and Feedlot heifers
Synovex S	ZAH	PEG		20			130	Stocker and Feedlot steers
Component E-S	EAH	PEG		14			130	Stocker and Feedlot steers
Synovex Choice	ZAH	PEG		14		100	130	Feedlot steers and heifers
Revalor-S	MAH	Cholesterol		24		120	130	Feedlot steers
Component TE-S	EAH	Cholesterol		24		120	130	Feedlot steers
Revalor-H	MAH	Cholesterol		14		140	130	Feedlot heifers
Component TE-H	EAH	Cholesterol		14		140	130	Feedlot heifers
Revalor-200	MAH	Cholesterol		20		200	130	Feedlot steers and heifers
Component TE-200	EAH	Cholesterol		20		200	130	Feedlot steers and heifers
Synovex Plus	ZAH	PEG		28		200	130	Feedlot steers and heifers
Synovex One Feedlot	ZAH	PEG		28		200	200	Feedlot steers and heifers
Revalor-XH	MAH	Cholesterol		20		200	200	Feedlot heifers
Revalor-XS	MAH	Cholesterol		40		200	200	Feedlot steers

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