University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

Publications from USDA-ARS / UNL Faculty

U.S. Department of Agriculture: Agricultural
Research Service, Lincoln, Nebraska

1984

MANIPULATION OF ENDOGENOUS AND EXOGENOUS HORMONES FOR RED MEAT PRODUCTION

Bruce D. Schanbacher
USDA-ARS

Follow this and additional works at: <https://digitalcommons.unl.edu/usdaarsfacpub>

Part of the [Agricultural Science Commons](#)

Schanbacher, Bruce D., "MANIPULATION OF ENDOGENOUS AND EXOGENOUS HORMONES FOR RED MEAT PRODUCTION" (1984). *Publications from USDA-ARS / UNL Faculty*. 769.
<https://digitalcommons.unl.edu/usdaarsfacpub/769>

This Article is brought to you for free and open access by the U.S. Department of Agriculture: Agricultural Research Service, Lincoln, Nebraska at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Publications from USDA-ARS / UNL Faculty by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

MANIPULATION OF ENDOGENOUS AND EXOGENOUS HORMONES FOR RED MEAT PRODUCTION¹

Bruce D. Schanbacher

US Department of Agriculture²,
Clay Center, NE 68933

Summary

Growth and development of domestic livestock for red meat production are often discussed in the context of environmental factors, nutritional requirements, genetic potential and the anabolic agents affecting production efficiency. In this minireview, the effects of endogenous and exogenous hormones on animal growth are reviewed. The pituitary, pancreatic and gonadal hormones known to affect growth and(or) carcass composition are cited to illustrate and place into perspective the important contributions that the endocrine system makes to animal production. Manipulation of endogenous hormones through 1) administration of synthetic releasing and inhibiting peptides and 2) immunoneutralization techniques, will likely provide the livestock producer with new technological approaches for increasing red meat production. Researchers continue to evaluate the efficacy of natural and synthetic steroids, and combinations thereof, as suitable anabolic agents. In conclusion, several hormones of both endogenous and exogenous origin can be manipulated to improve or enhance growth and development of the meat-producing animal.

(Key Words: Growth, Animal, Endogenous Hormones, Exogenous Hormones.)

Introduction

Profit from livestock production is directly affected by daily live weight gain, cost of gain and feed conversion efficiency. Although the young growing animal is recognized as an efficient converter of forages and grain into meat for human consumption, our understanding of the physiology of animal growth and particularly its regulation by hormones is incomplete.

Growth, the most fundamental process in animal production, can be modulated by both short- and long-term disturbances within the animal. Homeostatic mechanisms coordinate metabolism by different body tissues to ensure an individual's survival during short-term, life-threatening situations. Control of body growth, on the other hand, is believed to be regulated by homeorhetic mechanisms. Bauman et al. (1982) define homeorhesis as coordination of metabolism by different body tissues in support of a dominant developmental or physiological process, and contend that homeorhetic mechanisms provide chronic (long-term) regulation of growth through the action of endogenous hormones. With this theory in mind, a brief review of the hormones believed to be most important for promoting and directing growth of the young animal is presented. Thereafter, a more in-depth review of ways in which endogenous hormones can be manipulated or exogenous hormones administered to facilitate the efficient production of lean red meat is entertained.

Endogenous Hormones

Pituitary Hormones. The anterior pituitary secretes three hormones that undoubtedly affect growth and carcass composition. The most notable of these, growth hormone (GH), results in increased growth rate and a carcass containing less fat and more protein (Lee and Schaffer, 1934; Li et al., 1948). Daily injection

¹Paper presented at the symposium on "Red Meat Production and Processing Systems for the 21st Century" at the 75th Annu. Meet. of the Amer. Soc. Anim. Sci., Washington State Univ., Pullman, July 29, 1983.

²Roman L. Hruska U.S. Meat Animal Research Center, ARS.

Received February 14, 1984.

Accepted May 31, 1984.

TABLE 1. EFFECT OF DAILY INJECTIONS OF PORCINE HORMONE ON GROWTH OF PIGS^a

Variable	pGH, mg•kg ⁻¹ •d ⁻¹	
	0	.13
Initial weight, kg	45.9	46.0
Slaughter weight, kg	94.3	94.0
Daily gain, kg	.74	.86 ^b
Feed/gain	3.33	2.89 ^c
Carcass		
Backfat thickness, cm	3.5	2.8 ^d
Loin eye area, cm ²	25.8	31.0 ^d
Ham protein, %	18.2	19.7 ^d
Ham fat, %	21.0	13.6 ^d

^aFrom Machlin (1972).^bDifferent from zero dose (P<.01).^cDifferent from zero dose (P<.05).^dDifferent from zero dose (P<.001).

of porcine GH into growing pigs resulted in significant improvements in average daily gain; feed conversion and all variables of lean mass (table 1). Although backfat thickness and percentage fat of the ham were reduced in treated pigs, Machlin (1972) concluded that the lipolytic activity of pGH was not essential for growth promotion. Growth hormone is also anabolic in ruminants because daily injections have been shown to stimulate weight gain and increase N retention (Wagner and Veenhuizen, 1978; Mosley et al., 1982).

Two additional hormones from the anterior pituitary, prolactin and thyroid stimulating hormones (TSH), have been considered to possess anabolic activities (Davis et al., 1976, 1977; Schanbacher and Crouse, 1980), however, their growth-promoting activities are not clearly established (Eisemann et al., 1981; Muir and Wien, 1983). While it is possible that these pituitary hormones have no intrinsic anabolic activity, they may produce an anabolic effect when combined. Wagner and Veenhuizen (1978), for example, observed that exogenous administration of GH and thyroprotein resulted in greater rates of net protein accretion than those observed in response to GH alone.

Insulin. Insulin, secreted by the β -cells of islets of Langerhans in the pancreas, is central

to metabolic regulation. This hormone not only plays a role in the regulation of glucose and lipid metabolism but it also participates in amino acid and protein metabolism (Prior and Smith, 1982). Although the insulin response to nutrient uptake in ruminants and nonruminants differs, its relative importance in lipogenesis, gluconeogenesis and protein accretion in domestic livestock is yet to be defined.

Gonadal Steroids. Intact individuals secrete gonadal steroids that influence growth and performance. Attempts to improve performance characteristics of feedlot heifers by preventing cyclic ovarian activity have employed feeding of melengestrol acetate³ (MGA; Glimp and Cundiff, 1971) and spaying (Dinusson et al., 1950; Ray et al., 1969). While the hormonal approach has proven itself useful, the initial weight loss associated with ovariectomy has not made the latter approach attractive as a commercially viable practice in the United States.

The beneficial effects of the testis and its endocrine secretions on production efficiency by the male are well documented (Field, 1971; Seideman et al., 1982). Testosterone, in particular, is associated with a positive N balance, increased carcass protein and decreased carcass fat (Schanbacher et al., 1980). While castration has been employed to produce a more desirable carcass for the market place, this practice reduces live weight gain and lean tissue within the carcass. To lessen the negative impact of this management practice on production

³The Upjohn Co., Kalamazoo, MI 49001.

efficiency, hormones with growth-promoting activities are being supplemented to these animals in the form of subcutaneous implants. For the most part, these implants contain either natural or synthetic estrogens because of the well documented anabolic potency that these compounds possess. Testosterone and other androgenic compounds serve as anabolic agents but are less popular because of the relatively large amounts required to elicit a growth response. Debate continues as to whether pure androgens like 5 α -dihydrotestosterone possess anabolic activity or whether the effects of testosterone are actually mediated through its estrogenic metabolites (Schanbacher, 1982a). Although nonaromatizable, like 5 α -dihydrotestosterone, the anabolic androgenic steroid trenbolone acetate (TA) binds weakly to estrogen receptors and as a result, cannot be considered devoid of estrogenic activity. Evidence supporting a role of the androgenic steroids in protein anabolism and growth promotion are based on the presence of androgen receptors in skeletal muscle (Kreig, 1976) and the additive effects seen on growth in steers when estrogenic implants are supplemented with testosterone or TA (Schanbacher and Brethour, 1983).

Exogenous Hormones

Hypothalamic Releasing Factors. Isolation and synthesis of the hypothalamic peptides that stimulate release of pituitary thyrotropin (TRF; Schally et al., 1966; Burgus et al., 1970), gonadotropin [LHRH (LRF); Matsuo et al., 1971] and GH (GRF; Spiess et al., 1982; Thorner et al., 1983; Esch et al., 1983) permit investigations into the dependence of physiological processes, including growth and metabolism on specific pituitary hormones. Administration of the respective peptides to domestic animals results in a rapid and sustained elevation of circulating prolactin (Davis et al., 1977), gonadotropin (Schanbacher et al., 1982), and GH (Plouzek et al., 1983), permitting assessment of growth potentiation by these hormones. Results with TRF unfortunately do not support an anabolic function and those with LHRH

have thus far been oriented only towards reproduction. Increased blood steroid concentration observed in LHRH-infused, intact individuals may prove beneficial to the growing-finishing animal; however, the greatest opportunities may be in the use of synthetic GRF or one of its potent analogs as a growth promotant in the livestock industry.

Steroid Implants. Contents of the principle implants currently being used as growth promotants in cattle are shown in figure 1. As discussed below, each of these implants enhances the growth and performance characteristics of steers, but only some of them have been effectively applied to the intact heifer and bull.

Steers. In an investigation of the comparative growth responses of grazing-finishing steers to three estrogenic implants, 151 small-framed, yearling Hereford and Hereford $\times$ Angus steers averaging 272 kg were sham implanted or implanted with either Ralgro⁴, Synovex-S⁵ or Compudose⁶. Steers were maintained on native short grass pastures for 78 d with treatment groups equally represented. Subsequently, they were brought to the feedlot and fed high-grain diets. All animals were weighed on d 205 of the trial (i.e., after 128 d on feed) and slaughtered in a commercial plant. Because Compudose has been made available as a 200-d implant and Ralgro and Synovex-S are effective for shorter periods, the latter two groups were reimplanted

Trademark	Chemical name(s)	
I. Compudose	estradiol
II. Synovex-S	estradiol + progesterone
III. Ralgro	zeranol
IV. Finaplix	trenbolone
V. Forplix	zeranol + trenbolone
VI. Revolor	estradiol + trenbolone
VII. Testosterone	testosterone

Figure 1. Chemical name and structure of anabolic agents used in commercially available implants for the cattle industry.

⁴International Minerals and Chemical Corp., Terre Haute, IN 47808.

⁵Syntex Corp., 3401 Hillview Ave., Palo Alto, CA 94304.

⁶Eli Lilly, Indianapolis, IN 46206.

TABLE 2. COMPARISON OF RALGRO, SYNOVEX-S AND COMPUDOSE IMPLANTS FOR GRAZING-FINISHING STEERS^a

Treatment	No.	205-d		128-d	
		Average daily gain, kg/d	Response, %	Feed efficiency, kg DM/kg gain	Response, %
Control	37	1.07 ^b		7.87 ^b	
Ralgro (3X)	38	1.22 ^c	+13.9	7.18 ^c	+9.5
Synovex-S (3X)	39	1.16 ^d	+8.3	7.25 ^{cd}	+8.5
Compudose (1X)	38	1.16 ^d	+7.9	7.43 ^d	+5.9

^aFrom Brethour and Schanbacher (1983a).

^{b,c,d}Means with different superscripts differ ($P < .05$).

at the start of the feedlot phase and again 55 d later. Growth response and feed conversion efficiency of these cattle are shown in table 2. While these data favor Ralgro-implanted steers, all three implant groups responded favorably and predictably to the estrogenic implants. Similarity of dressing percentage, backfat measurement and marbling score suggests that the implants did not affect carcass composition. Androgenic implants are yet to be approved in the United States, however, Finaplix⁷, an experimental implant developed in Europe, is gaining popularity as an anabolic agent and growth promotant. This product, which contains trenbolone acetate, is not only being evaluated as a single implant but is also provided in combination with zeranol (Forplix^{4,7}) and estradiol (Revalor⁷). To assess the relative potency of androgenic stimulation of growth with that of conventional estrogenic implants, we have completed a preliminary trial with these various implants in 124 crossbred finishing yearling steers. Six implant treatments and a control group were superimposed on a 109-d feeding trial. Because the steers were grouped and penned by diet treatment, no measure of the effect of implant on feed efficiency could be determined. The growth advantage of implanted cattle at 68 and 109 d is summarized in table 3. Implanted cattle gained more rapidly than did control steers throughout the trial but the advantage in average daily gain decreased after 68 d on feed (figure 2). The abrupt and nearly synchronous decline in growth rates is

believed to be the response to hormone depletion from the implants. Interestingly, of those implants containing a single hormone, Compudose promoted the highest rate of gain. Even so, a gradual decline occurred in the growth advantage of these implanted steers. The growth response was least for steers implanted with trenbolone (i.e., 10.8% at 68 d) while the greatest responses were obtained with the trenbolone-estrogen combination implants (Forplix and Revalor). The individual gains in this trial were more variable than usual, nevertheless the data indicate that implants combining androgenic and estrogenic activity may produce additive effects and thus yield the greatest possible gains. Similar conclusions have been made by van Weerden et al. (1981).

Bulls. Considering the relative effectiveness by which androgen-estrogen combination treatments enhance growth of the castrate male bovine, it may not be surprising that the endogenous concentrations of androgen and estrogen observed in intact bull calves allow for near-maximal expression of their genetic growth potential. This may explain in part why implants have neither been sought nor perfected for use in intact males. Limited research has been conducted, however, to evaluate the effectiveness by which commercially available implants can reduce aggressive behavior and improve carcass acceptability in feedlot bulls.

Estrogens, and most notably diethylstilbestrol (DES), tend to increase fat deposition in bulls and under certain conditions improve carcass grade (Klosterman et al., 1955; Cahill et al., 1956; Bailey et al., 1966); however this hormone has little or no effect on tenderness of meat from bull carcasses. Because of the

⁷Roussel-UCLAF, Paris, France.

TABLE 3. FEEDLOT GAINS FOR IMPLANTED, FINISHING YEARLING STEERS^a

Treatment	No.	68-d		109-d	
		Average daily gain, kg/d	Response, %	Average daily gain, kg/d	Response, %
Control	17	.96 ^b		1.23 ^b	
Finaplix	18	1.07 ^c	+10.8	1.25 ^b	+1.8
Ralgro	17	1.08 ^c	+12.7	1.27 ^{bc}	+2.7
Synovex-S	18	1.12 ^{cd}	+16.8	1.32 ^c	+6.8
Compudose	18	1.13 ^{cd}	+18.4	1.32 ^c	+7.2
Forplix	18	1.16 ^d	+21.7	1.34 ^{cd}	+9.1
Revalor	18	1.20 ^d	+25.8	1.37 ^d	+11.1

^aFrom Schanbacher and Brethour (1983).

^{b,c,d}Means with different superscripts differ ($P < .05$).

removal of DES from the market place, other estrogenic implants have taken its place. Of these, zeranol, has been shown to reduce testicle size and masculinity scores in both beef and dairy bulls and at the same time improve live weight gain (Brethour and Schanbacher, 1983b; Kirk and Cooper, 1983; McKenzie, 1983). An example of the improvement in growth rate obtained with zeranol in bulls is illustrated in table 4. Although the growth advantage of Holstein and Friesian bulls is confounded by implanting interval, these data suggest that zeranol can be used successfully in bull beef production. Rib dissection data showed no effect of zeranol on carcass composition. McKenzie (1983) reported that zeranol-treated bulls exhibited 25% less male (riding) activity and concluded that the behavior-controlling effect of implanting with zeranol, combined with improved weight gain and carcass characteristics, might enable increased use of intact bulls for efficient beef production. McKenzie also stated, however, that a successful bull beef program requires good management. To this end, he recommended that all bulls within a group be implanted, that implanting start early (e.g., preferably before 3 mo of age) and that reimplanting occur at 60- to 90-d intervals. Further studies are needed to develop an implant specifically designed for bulls and to determine whether any implant will aid the producer to successfully feed bulls.

Heifers. In addition to the feeding of melen-gestrol acetate, implanting heifers with Synovex-H, Ralgro and Compudose is widely practiced. Interest in androgen treatment of heifers and the recent availability of trenbolone has preci-

pitated pilot studies with this product. Brown (1982) and Henricks et al. (1982) have reported significant improvements in growth rate and feed conversion efficiency in heifers implanted with trenbolone. It is also inferred from their data that dose and frequency of implanting contribute to the magnitude of the responses. While the drug is reportedly cleared rapidly from blood and body tissues and no undesirable effects on carcass quality have been detected, reservations have been expressed concerning the

Figure 2. Increments in average daily gain (ADG) response of steers implanted with Finaplix (Fin), Ralgro (Ral), Synovex-S (Syn), Forplix (For), Compudose (Com) and Revalor (Rev) over that of non-implanted control steers.

TABLE 4. RELATIVE GROWTH RATES OF INTENSIVELY REARED FRIESIAN AND HOLSTEIN BULLS IMPLANTED AT 100- OR 70-DAY INTERVALS WITH ZERANOL^a

Item	Friesians (100-d interval group)		Holsteins (70-d interval group)	
	Control	Implanted	Control	Implanted
Number	8	7	8	8
Initial wt, kg	68.0	68.1	65.5	65.6
Final wt, kg	424.7	447.9 ^b	422.5	437.5
Average daily gain, kg/d	1.16	1.33 ^b	1.19	1.24
Response, %		+14.7 ^b		+4.2

^aFrom Kirk and Cooper (1983).^bDifferent from control (P<.05).

use of this growth promotant in heifers reared as replacement breeding stock (Heitzman et al., 1979). Research investigators will no doubt continue to assess the potential of currently available and newly developed anabolic agents for use in feedlot heifers.

Hormone Immunoneutralization

Immunoneutralization provides a simple, noninvasive approach to endogenous hormone deprivation. Both active and passive immunization procedures can be used to neutralize circulating hormones (antigens), but both approaches have their advantages and disadvantages. Because of the nature of the immune response and heterogeneity of antibody production among individuals, passive immunity can offer specificity and quickness to hormonal neutralization. In contrast, only small amounts of antigen are required to actively

immunize a group of individuals and once established, biologically active antibody titers can persist throughout the course of an investigation. The impact of hormonal immunoneutralization depends on the hormone against which antibodies are produced and the relative physiological dependence of the individual for the hormone in question. For example, immunoneutralization of the hypothalamic releasing factor, luteinizing hormone releasing hormone (LHRH), has major consequences on reproductive function of ram lambs (table 5). When compared with nonimmunized control lambs and lambs immunized against bovine serum albumin (BSA), LHRH-immunized ram lambs had particularly low serum testosterone concentrations and substantially reduced testes weight. Associated with the reproductive demise of the LHRH-immunized lambs was a decrement in their growth and performance traits. These results show the dependence of the

TABLE 5. PERFORMANCE TRAITS OF RAM LAMBS IMMUNIZED AGAINST LUTEINIZING HORMONE RELEASING HORMONE (LHRH)^a

Treatment	No.	Serum testosterone, ng/ml	Paired testes wt, g	Average daily gain, g/d	Feed/gain, kg/kg	Carcass wt, kg
Ram	12	2.4 ^b	342 ^b	414 ^b	5.3 ^b	31.8 ^b
Ram (aBSA)	12	2.3 ^b	318 ^b	420 ^b	5.3 ^b	31.5 ^b
Ram (aLHRH)	12	.35 ^c	68 ^c	312 ^c	6.2 ^c	28.6 ^c
Wether	12	.30 ^c		355 ^c	5.6 ^d	30.3 ^{bc}

^aFrom Schanbacher (1982).^{b,c,d}Means with different superscripts differ (P<.05).

TABLE 6. GROWTH RATES AND CARCASS WEIGHTS OF LAMBS IMMUNIZED AGAINST GROWTH HORMONE RELEASE INHIBITING FACTOR (SOMATOSTATIN; SS)^a

Treatment	No.	Initial body wt, kg	Final body wt, kg	Average daily gain, g/d	Hot carcass wt, kg
Control lambs	9	5.43	29.77 ^b	205 ^b	14.42 ^b
SS-immunized lambs	9	5.73	35.34 ^c	249 ^c	17.08 ^c

^aFrom Spencer et al. (1983b).^{b,c}Means differ ($P < .05$).

ovine testis and testosterone-mediated growth acceleration on this hypothalamic releasing factor and further suggest that LHRH immunoneutralization provides an interesting alternative to conventional surgical castration.

Pituitary GH, which is associated with stimulation of postnatal growth, is not only regulated by a hypothalamic releasing factor (GRF), but also by somatostatin, a GH release inhibiting factor (Krulich et al., 1972). While I earlier speculated that GH release and thus possibly growth might best be affected by infusion of GRF, immunoneutralization of somatostatin could theoretically provide the same end result without the need for continuous administration of GRF. This novel approach to growth promotion has been evaluated in preliminary trials with young lambs by Spencer et al. (1983a,b). Their findings suggest that somatostatin immunization stimulates average daily gain of young lambs by approximately 21% and that the increase in weight gain is

expressed in carcass weight (table 6). Increased long bone growth in immunized lambs resulted in longer carcasses, but treatment had no effect on body composition. Basal levels of insulin and GH were not affected by treatment, however, immunized lambs had significantly elevated levels of bioassayable somatomedin activity and increased GH release after arginine infusion when compared with control lambs. While this approach to growth promotion appears promising, it should be noted that a previous attempt to enhance lamb growth via somatostatin immunization failed (Varner et al., 1980). Researcher and livestock producer alike will wait for additional reports on the potential success of somatostatin immunoneutralization as an aid to improve the efficiency of red meat production.

Immunoneutralization of endogenous steroids provides yet another example in which one can selectively regulate an animal's exposure to anabolic steroids. The biological potency of

TABLE 7. RELATIVE GROWTH RATES OF RAM LAMBS IMMUNIZED AGAINST TESTOSTERONE AND WETHER LAMBS IMPLANTED WITH TESTOSTERONE-FILLED CAPSULES^a

Treatment	No.	Average daily gain, g/d
Ram	12	414 ^b
Ram (aBSA)	12	420 ^b
Ram (aT)	12	343 ^c
Wether	12	355 ^c
Wether (+T)	12	402 ^b

^aFrom Schanbacher et al. (1980) and Schanbacher (1984).^{b,c}Means with different superscripts differ ($P < .05$).

TABLE 8. GROWTH RATES AND CARCASS MEASURES OF BULLS IMMUNIZED AGAINST TWO ESTRADIOL-17 β (E₂) ANTIGENS^a

Treatment	No.	Final body wt, kg	Average daily gain, kg/d	Hot carcass wt, kg	Backfat thickness, cm	Rib eye area, cm ²
Control bulls	8	454 ^d	1.15 ^d	285 ^d	.54 ^d	78.3 ^d
E ₂ -BSA ^b	7	486 ^d	1.19 ^d	307 ^e	.66 ^d	84.2 ^e
E ₂ -HC ^c	8	477 ^d	1.17 ^d	308 ^e	.69 ^d	81.2 ^e

^aB. D. Schanbacher (unpublished data).

^bEstradiol:bovine serum albumin conjugate.

^cEstradiol:hemocyanin conjugate.

^{d,e}Means with different superscripts differ (P<.05).

steroid immunoneutralization is illustrated in table 7 wherein ram lambs were actively immunized against testosterone (aT) and their growth response was compared with that of nonimmunized ram lambs, ram lambs immunized against BSA and wethers. High antibody titers were achieved in all aT lambs, which resulted in a marked elevation in serum testosterone concentrations. This testosterone was, however, bound to circulating antibody and was presumably unable to interact with its target tissues because the seminal vesicles of these ram lambs were markedly atrophied and growth rates were reduced to castrate levels. These results demonstrate the importance of endogenous testosterone in growth response of ram lambs and help to explain why testosterone alone can effectively replace the testes and restore growth of surgical castrates to levels observed in intact lambs (table 7).

A similar approach but involving immunization against estradiol has been investigated to determine the physiological importance of estradiol in mediation of lean tissue growth in bulls. To this end, 24 bull calves were assigned to one of three treatment groups at birth and immunized against BSA (control bulls) or immunized against an estradiol-BSA conjugate (E₂-BSA) or estradiol-hemocyanin conjugate (E₂-HC). Occasional booster injections were given and the bulls were slaughtered after being finished on a corn silage-concentrate diet. Antibodies specific to estradiol were measured in each of the estradiol-immunized calves and these calves were characterized by slightly elevated serum testosterone concentrations. Estradiol-immunized calves were slightly heavier than control calves at slaughter, but their

relative growth rates were not significantly improved. Treatment resulted in heavier carcasses that were characterized by greater backfat thickness and larger rib eye area (table 8). Although carcass composition and eating quality characteristics have yet to be determined, it appears that estradiol immunoneutralization results in increased market weight and retail product from bull beef production. Additional studies will be required to assess the utility of steroid immunoneutralization for the animal industry.

In conclusion, several hormones of endogenous origin act through homeorhetic mechanisms to promote efficient growth of meat-producing animals. Biologically active peptides as well as natural and synthetic steroids are being evaluated and utilized as anabolic agents for increasing red meat production. While steroid implants have been successfully developed, difficulty has arisen in formulating peptides into sustained release implants. Lastly, immunoneutralization of endogenous hormones appears to be an effective means of manipulating those hormones that most affect growth and development of the meat-producing animal.

Literature Cited

- Bailey, C. M., C. L. Probert, P. Richardson, V. R. Bohman and J. Chancerelle. 1966. Quality factors of the longissimus dorsi of young bulls and steers. *J. Anim. Sci.* 25:504.
- Bauman, D. E., J. H. Eisemann and W. B. Currie. 1982. Hormonal effects on partitioning of nutrients for tissue growth: Role of growth hormone and prolactin. *Fed. Proc.* 41: 2538.
- Brethour, J. R. and B. D. Schanbacher. 1983a. Comparison of Ralgro, Synovex-S and Compudose

- implants for grazing-finishing steers. In: 1983 Roundup, Rep. of Prog. 432, Roundup 70, Hays Branch Agr. Exp. Sta., Kansas State Univ., Manhattan.
- Brethour, J. R. and B. D. Schanbacher. 1983b. Comparison of six different implants for finishing yearling steers. In: 1983 Roundup, Rep. of Prog. 432, Roundup 70, Hays Branch Agr. Exp. Sta., Kansas State Univ., Manhattan.
- Brown, R. E. 1982. Performance response of fattening heifers to different doses of trenbolone acetate administered in an ear implant. *J. Anim. Sci.* 55(Suppl. 1):411.
- Burgus, R., T. F. Dunn, T. F. Desiderio, D. Ward, W. Vale and R. Guillemin. 1970. Characterization of ovine hypothalamic hypophysiotropic TSH-releasing factor. *Nature* 226:321.
- Cahill, V. R., L. E. Kunkle, E. W. Klosterman, F. E. Deatherage and E. Wierbicki. 1956. Effect of diethylstilbestrol implantation on carcass composition and the weight of certain endocrine glands of steers and bulls. *J. Anim. Sci.* 15:701.
- Davis, S. L., K. M. Hill, D. L. Ohlson and J. A. Jacobs. 1976. Influence of chronic thyrotropin-releasing hormone injections on secretion of prolactin, thyrotropin and growth hormone and on growth rate in wether lambs. *J. Anim. Sci.* 42:1244.
- Davis, S. L., R. G. Sasser, D. L. Thacker and R. H. Ross. 1977. Growth rate and secretion of pituitary hormones in relation to age and chronic treatment with thyrotropin-releasing hormone in prepubertal dairy heifers. *Endocrinology* 100: 1394.
- Dimusson, W. E., F. N. Andrews and W. M. Beeson. 1950. The effects of stilbestrol, testosterone, thyroid alteration and spaying on the growth and fattening of heifers. *J. Anim. Sci.* 9:321.
- Eisemann, J. H., D. E. Bauman, R. C. Gorewit, D. E. Hogue and H. F. Travis. 1981. Implications of prolactin in the photoperiod induced growth response. *J. Anim. Sci.* 53(Suppl. 1):395.
- Esch, F., P. Bohlen, N. Ling, P. Brazeau and R. Guillemin. 1983. Isolation and characterization of the bovine hypothalamic growth hormone releasing factor. *Biochem. Biophys. Res. Commun.* 117:772.
- Field, R. A. 1971. Effect of castration on meat quality and quantity. *J. Anim. Sci.* 32:849.
- Glimp, H. A. and L. V. Cundiff. 1971. Effects of oral melengestrol acetate and a testosterone-diethylstilbestrol implant, breed and age on growth and carcass traits of beef heifers. *J. Anim. Sci.* 32:957.
- Heitzman, R. J., D. J. Harwood, R. M. Kay, W. Little, C. B. Mallinson and I. P. Reynolds. 1979. Effects of implanting prepubertal dairy heifers with anabolic steroids on hormonal status, puberty and parturition. *J. Anim. Sci.* 48:859.
- Henricks, D. M., R. L. Edwards, K. A. Champe, T. W. Gettys, G. C. Skelley, Jr. and T. Gimenez. 1982. Trenbolone, estradiol-17 β and estrone levels in plasma and tissues and live weight gains of heifers implanted with trenbolone acetate. *J. Anim. Sci.* 55:1048.
- Kirk, J. A. and R. A. Cooper. 1983. Growth and carcass characteristics of intensively reared Holstein bulls implanted with zeranol. *Anim. Prod.* 36:527.
- Klosterman, E. W., V. R. Cahill, L. E. Kunkle and A. L. Moxon. 1955. The subcutaneous implantation of stilbestrol in fattening bulls and steers. *J. Anim. Sci.* 14:1050.
- Kreig, M. 1976. Characterization of the androgen receptor in the skeletal muscle of the rat. *Steroids* 28:261.
- Krulich, D., P. Illner, C. P. Fawcett, M. Quijada and S. M. McCann. 1972. Dual hypothalamic regulation of growth hormone secretion. In: A. Pecile and E. E. Muller (Ed.) *Proc. of a Second Int. Symp. on Growth Hormone*. pp 306-316. Excerpta Medica, Amsterdam.
- Lee, M. O. and N. K. Schaffer. 1934. Anterior pituitary growth hormone and the composition of growth. *J. Nutr.* 7:337.
- Li, C. H., M. E. Simpson and H. M. Evans. 1948. The gigantism produced in normal rats by injection of the pituitary growth hormone. III. Main chemical components of the body. *Growth* 12:39.
- Machlin, L. J. 1972. Effect of porcine growth hormone on growth and carcass composition of the pig. *J. Anim. Sci.* 35:794.
- Matsuo, H., Y. Baba, R. M. G. Nair, A. Arimura and A. V. Schally. 1971. Structure of the porcine LH and FSH-releasing hormone. I. The proposed amino acid sequence. *Biochem. Biophys. Res. Commun.* 43:1374.
- McKenzie, J. R. 1983. Effects of zeranol implants on behavior, growth rate, and carcass characteristics of Friesian bulls. *New Zealand J. Exp. Agr.* 11:225.
- Moseley, W. M., L. F. Krabill and R. F. Olsen. 1982. Effect of bovine growth hormone administered in various patterns on nitrogen metabolism in the Holstein steer. *J. Anim. Sci.* 44:1062.
- Muir, L. A. and S. Wien. 1983. Effects of thyrotropin-releasing hormone and a thyrotropin releasing hormone analog on growth and selected plasma hormones in lambs. *J. Anim. Sci.* 57:139.
- Plouzek, C. A., L. L. Anderson, D. L. Hard, J. R. Molina and A. Trenkle. 1983. Effect of intravenous injection of a growth hormone-releasing factor on plasma growth hormone concentrations in cattle. *J. Anim. Sci.* 57(Suppl. 1):203.
- Prior, R. L. and S. B. Smith. 1982. Hormonal effects on partitioning of nutrients for tissue growth: Role of insulin. *Fed. Proc.* 40:2545.
- Ray, D. E., W. H. Hale and J. A. Marchello. 1969. Influence of season, sex and hormonal growth simulants on feedlot performance of beef cattle. *J. Anim. Sci.* 29:490.
- Schally, A. B., C. Y. Bowers, T. W. Redding and J. F. Barrett. 1966. Isolation of thyrotropin releasing factor (TRF) from porcine hypothalamus. *Biochem. Biophys. Res. Commun.* 25:165.
- Schanbacher, B. D. 1982. Responses of ram lambs to active immunization against testosterone and luteinizing hormone-releasing hormone. *Amer. J. Physiol.* 242:E201.
- Schanbacher, B. D. 1984. Hormonal and photoperiodic control of growth. In: J. F. Roche and D. O'Callaghan (Ed.) *Manipulation of Growth In Farm Animals*. pp 275-288. Martinus Nijhoff Publishers, The Hague.
- Schanbacher, B. D. and J. R. Brethour. 1983. Growth response of finishing-yearling steers to six differ-

- ent implants. *J. Anim. Sci.* 57(Suppl. 1):468.
- Schanbacher, B. D. and J. D. Crouse. 1980. Growth and performance of growing-finishing lambs exposed to long or short photoperiods. *J. Anim. Sci.* 51:943.
- Schanbacher, B. D., J. D. Crouse and C. L. Ferrell. 1980. Testosterone influences on growth, performance, carcass characteristics and composition of young market lambs. *J. Anim. Sci.* 51:685.
- Schanbacher, B. D., M. J. D'Occhio and J. E. Kinder. 1982. Initiation of spermatogenesis and testicular growth in oestradiol-17 β -implanted bull calves with pulsatile infusion of luteinizing hormone releasing hormone. *J. Endocrinol.* 93:183.
- Seideman, S. C., H. R. Cross, R. R. Oltjen and B. D. Schanbacher. 1982. Utilization of the intact male for red meat production: A review. *J. Anim. Sci.* 55:826.
- Spencer, G.S.G., G. J. Garssen and P. L. Bergstrom. 1983a. A novel approach to growth promotion using auto-immunisation against somatostatin: II. Effects on appetite, carcass composition and food utilisation in lambs. *Livestock Prod. Sci.* 10:469.
- Spencer, G.S.G., G. J. Garssen and I. C. Hart. 1983b. A novel approach to growth promotion using auto-immunisation against somatostatin. I. Effects on growth and hormone levels in lambs. *Livestock Prod. Sci.* 10:25.
- Spiess, J., J. Rivier, M. Thorner and W. Vale. 1982. Sequence analysis of a growth hormone releasing factor from a human pancreatic islet tumor. *Biochemistry* 21:6037.
- Thorner, M. O., J. Spiess, M. L. Vance, A. D. Rogol, D. L. Kaiser, J. D. Webster, J. Rivier, J. L. Borges, S. R. Bloom, M. J. Cronin, W. S. Evans, R. M. MacLeod and W. Vale. 1983. Human pancreatic growth-hormone-releasing factor selectively stimulates growth-hormone secretion in man. *Lancet* i:24.
- van Weerden, E. J., P.L.M. Berende and J. Huisman. 1981. Application of endogenous and exogenous anabolic agents in veal calves. *Proc. of CEC Workshop on "Anabolic Agents in Beef and Veal Production."* Brussels, Belgium.
- Varner, M. A., S. L. Davis and J. J. Reeves. 1980. Temporal serum concentrations of growth hormone, thyrotropin, insulin, and glucagon in sheep immunized against somatostatin. *Endocrinology* 106:1027.
- Wagner, J. F. and E. L. Veenhuizen. 1978. Growth performance, carcass composition and plasma hormone levels in wether lambs when treated with growth hormone and thyroprotein. *J. Anim. Sci.* 47(Suppl. 1):397.