# IMPACT OF GROWTH HORMONES ON NUTRIENT EXCRETION

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## ABSTRACT

The U.S. Food and Drug Administration (FDA) first approved the use of hormone implants containing estradiol benzoate/progesterone in 1956 for increasing growth, feed efficiency, and carcass leanness of cattle. Livestock production sites, including feedlots and dairies have recently undergone close scrutiny for their contribution of endocrine disruptor residues to the environment via their manure. While these effects need to be addressed, there is also a definite impact of these pharmaceuticals upon nutrient retention and excretion from feedlot cattle. This review will serve as a brief estimate of the total impact of growth hormones on the excretion of nutrients in manure as well as potential environmental implications of their use on nutrient and land management.

## INTRODUCTION

The U.S. Food and Drug Administration (FDA) first approved the use of hormone implants containing estradiol benzoate/progesterone in 1956 for increasing growth, feed efficiency, and carcass leanness of cattle. Subsequent implants containing testosterone, trenbolone acetate, zeranol, and a myriad of combinations of these hormones were later developed and approved for use in cattle by FDA. Currently, there are five hormones/xenobiotics (progesterone, testosterone, estradiol-17-β, zeranol, and trenbolone acetate) that have been approved for implants in cattle in the U.S (Center for Veterinary Medicine, 1986, 1996, 1998, 1999, 2001, 2002, 2005a, 2005b). While there are additional growth promotants currently in use by livestock operations, the focus of this paper will be on hormones/ hormone analogs from subcutaneous growth implants.

Throughout history, endogenous hormones and their metabolites from animal and human populations have been reaching the environment. However, the quantity and concentration of hormones and their metabolites within a localized area that is reaching the environment are increasing as populations grow, and livestock production becomes more concentrated, as producers are driven to produce more food with less land. There has been a recent increase in the interest surrounding the hormonal disrupting activity of compounds from both natural and anthropogenic sources, due to several recent studies which indicate adverse impacts of steroid hormones in the environment (de Voogt et al., 2003, Jobling and Tyler, 2003, Kidd et al., 2007, Kolpin et al., 2002, Tyler et al., 1998). However, to date there have been few controlled experiments specifically addressing this issue.

While there is an increased awareness of the potential environmental impacts associated with the potential endocrine disruptor residues from livestock operations, the literature regarding this area of study is fraught with multiple deficiencies in the published knowledge about the subject. With such an increase in the demand for such knowledge, the Environmental Protection

Agency has recently begun funding several studies to address the source and fate of these potential endocrine disruptors. While there are numerous field level studies that address the issues, many are limited by lack of proper replication of experimental units, analytical difficulties, and inadequate controls of influential environmental factors. However, this area of research is rapidly growing and the knowledge of the role of potential endocrine disruptors released from livestock operations into the environment is increasing.

## RESULTS AND DISCUSSION

### Growth Hormones and Nutrient Excretion

To properly assess the flux of nutrients that are influenced by the use of growth hormones in beef cattle production, it is first necessary to assess the influence of these growth hormones on the composition of the animals that are exposed. Woese et al. (1997) concluded that although data are limited, there are no major differences in nutrient composition among beef produced via organic or conventional methods which use growth hormones. Typically, it has been noted that while there are varying degrees of changes in fat composition of carcasses from cattle treated with growth hormones, there tends to be a greater improvement in the deposition of lean muscle tissue. Generally, these growth hormones increase the amount of gain per unit of feed from 10 to 15% (Rumsey, 1985; Cecava and Hancock, 1994), which is typically accompanied by an increase in feed intake. Additionally, increases of 25% in protein gain of growing beef steers treated with Synovex-S (200 mg progesterone plus 20 mg of estradiol benzoate) have also been reported (Rumsey et al., 1981; Rumsey, 1982). This improvement in tissue gain resulted in limited changes in digestibility, but a reduction in total urinary N excretion (Rumsey and Hammond, 1990). However, a negative response to growth hormones was reported when diets are reduced from near ad libitum to a submaintenance level (Rumsey and Hammond, 1990), or when inadequate concentrations of crude protein is available in the diet (Rumsey et al., 1999).

While there are limited changes in the concentrations of N retained within tissues of cattle treated with growth implants, there are definite impacts on N excretion, primarily in the urine. Cecava and Hancock (1994) reported a 28% decrease in urinary nitrogen excretion (from 36.5 to 26.2 g N/d) of finishing steers implanted with etstradiol 17-β, while Remsey and Hammond (1990) reported an 8% decrease in urinary excretion from feedlot steers implanted with Synovex-S (200 mg progesterone plus 20 mg of estradiol benzoate). Additionally, Lobley et al also reported an initial increase in N retention, primarily due to a decrease in urinary N excretion, that was “double that for control steers” when implanted with 140 mg trenbolone acetate and 20 mg estradiol-17β.

Unfortunately, there is a paucity of data describing the influence of growth hormones on both C and P metabolism, retention, and excretion. However, it is the opinion of the authors that there is very little data to suggest that any alterations in the excretion of P due to the use of growth hormones is of a significant extent, and likely tracks along with the overall improvements in feed efficiency for all nutrients. This would entail an average improvement in feed conversion of 8.8% (Lawrence and Ibarburu, 2006).

Ultimately, the alterations in feed efficiency appear to be post-absorptive in nature. The overall implication of this is that while feed digestion, and thus fecal N, is unaltered, there is a decrease in the amount of N excreted in the urine from animals treated with growth hormones. Cole et al. (2005) demonstrated that 14 to 15% of the total N, and 26 to 37% of urinary N in fresh manure (urine and feces) is lost as ammonia in a closed system over a 7 d period, where the manure was undisturbed, where Archibeque et al. (2007) reported only 2-10% of urinary N being lost as ammonia from the same system. Additionally, Archibeque et al. (2007) demonstrated in cattle that as dietary protein increased, there was a subsequent increase in fecal N and urinary N that was similar in magnitude to the alterations without growth promotants described by Cecava and Hancock (1994), with modest alterations in phosphorus concentrations. Even if it is assumed that 31.5 % of urinary N is volatilized as ammonia, there remains a steady drop in N:P ratio, albeit at a lower magnitude, as urinary N excretion is reduced (Table 1). Regardless, the N:P ratio in feedlot cattle manure is still relatively low to serve as a sole fertilizer source in many crop production systems.

Table 1. Nutrient intake, digestion, and retention in 8 steers fed LOW (9.1% Crude Protein, CP), Medium (MED) (11.8% CP), HIGH (13.9% CP), or Oscillating protein diets (OSC, 9.1 and 13.9% CP on a 48-h cycle) (n = 8/treatment; Modified from Archibeque et al., 2007)

| | Treatment | | | | | |
|---|---|---|---|---|---|---|
| Item | LOW | MED | HIGH | OSC | SEM | *P* – value[1] |
| Nitrogen | | | | | | |
| N intake, g/d | 94.3[a] | 131.3[b] | 142.5[b] | 133.1[b] | 4.3 | 0.01 |
| Feces N, g/d | 35.6[a] | 42.7[b] | 42.6[b] | 38.4[a] | 1.5 | 0.02 |
| Urine N, g/d | 23.9[c] | 38.8[a] | 59.6[b] | 39.7[a] | 3.1 | 0.01 |
| Phosphorus | | | | | | |
| P intake, g/d | 17.5 | 20.2 | 18.4 | 17.9 | 0.9 | 0.17 |
| Feces P, g/d | 8.09 | 7.70 | 7.61 | 8.17 | 0.32 | 0.52 |
| Urine P, g/d | 4.59 | 4.09 | 3.38 | 3.97 | 0.46 | 0.35 |
| Manure N:P[2] | 4.71[b] | 6.92[a] | 9.57[c] | 6.46[a] | 0.48 | 0.01 |
| Ad. Manure N:P[3] | 4.10[a] | 5.88[b] | 7.59[c] | 5.40[d] | 0.47 | 0.01 |

[a,b,c]Least square means in a row without a common superscript differ ($P < 0.05$).
[1]Probability that dietary treatments do not differ.
[2]Manure N:P = (Fecal N + Urine N) / (Fecal P + Urine P).
[2]Manure N:P = (Fecal N + (Urine N x 68.5)) / (Fecal P + Urine P).

**Nutrient Cycle Implications of Growth Hormones**

In a recent popular press article, Avery and Avery (2007) used a variety of sources to estimate the land use to produce a pound of beef both with and without growth promotants. These estimates indicated that 1.64 acre-days required to produce 1 pound of beef in cattle fed grain finishing diets with growth promotants. This land use increases to 1.99 acre days for cattle fed grain without growth promotants, and increases even further to 5.04 acre-days when cattle are finished in an organic pasture based finishing system. It is important to note that in this estimate, Avery and Avery (2007) considered the use of all growth promoting pharmaceuticals, not just growth hormones. The implications of this are quite broad when considered with the magnitude of beef production in the Great Plains area. The USDA (2007) estimates that there were 1.13 million cattle on feed in 2007. If we assume that average finishing weight was 1286 lbs (Cattle-Fax, 2008) and that these cattle had an average dressing percentage of 60% and an average yield of closely trimmed retail cuts of 50% of hot carcass weight, then this equates to 436,954,000 lbs of beef produced in Colorado in 2007. Therefore, if we assume that cattle raised with growth promotants use 1.64 acre-days to produce 1 lb of beef, and cattle raised without growth promotants use 1.99 acre-days to produce 1 lb of beef, then the use of growth promotants on these cattle would use roughly 152,583,900 less acre-days to produce the finished beef in Colorado alone. Ultimately this equates to ~18% reduction in the amount of land needed for beef finishing with growth promotants over grain-based finishing alone, while compared to grass-based finishing systems, grain-finishing with growth promoting implants increases land use efficiency three-fold. While the Great Plains area has been spared much of the urbanization that the coasts of this country have seen, this becomes particularly important as more and more agricultural land is lost to urban development.

In conclusion, it appears that while there are growing concerns about the use of growth hormones in livestock production, especially feedlots, there are also several significant impacts on nutrient fluxes. The most well documented response is the reduction in N excretion from cattle treated with growth hormones. This becomes particularly important in localities which are not only concerned with nutrient profiles of manure, but also the potential impacts on air quality as ammonia emissions would also be reduced as urinary N excretion from livestock is reduced through the use of growth hormones.

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