EFFECTS OF ZERANOL ON WEIGHT GAIN, BONE GROWTH AND OTHER CARCASS TRAITS IN STEERS AND BULLS

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The effects of zeranol were studied in 24 steers and 24 bulls starting at an average weight of 200 kg for a trial period of 183 days. Bulls grew faster than steers ($P = 0.07$) and zeranol-treated cattle showed higher average daily gain than controls ($P<0.05$); there was no significant interaction between gender and treatment. Castration increased carcass fatness ($P<0.01$) and decreased dressing percent ($P<0.01$), rib-eye area ($P<0.01$), shank muscle ($P<0.01$) and shank muscle:bone ratio ($P<0.01$). Implantation with zeranol had no effect on these traits. The weights of the radio-ulna, metacarpal and metatarsal bones were not significantly affected by gender or treatment. Growth at the distal end of the radius during the last 2 mo of the experiment was significantly less in treated cattle than in controls ($P<0.01$) and in steers than in bulls ($P<0.01$). Zeranol resulted in larger pelvic openings ($P<0.01$) in bulls and steers and reduced libido ($P<0.05$) in treated bulls.

Key words: Cattle, zeranol, bone growth, castration, carcass traits, sexual development

[Effets du zéranol sur le gain de poids, la croissance des os et d'autres caractéristiques de la carcasse chez des bouvillons et des bovins.]

Titre abrégé: Zéranol et croissance des os chez les bouvillons et les bovins.

Nous avons étudié les effets du zéranol chez 24 bouvillons et 24 bovins pesant 200 kg en moyenne au début d'une période expérimentale de 183 jours. Le taux de croissance des bovins était plus élevé que celui des bouvillons ($P = 0,07$) et les sujets traités au zéranol présentaient un gain moyen quotidien plus élevé que les témoins ($P<0,05$). Il n'y avait pas d'interaction significative entre le type de bétail et le traitement. La castration a augmenté la teneur en gras des carcasses ($P<0,01$) et a diminué le rendement en viande ($P<0,01$), la grosseur de la noix de côte ($P<0,01$) et du jarret ($P<0,01$) et le rapport muscle:tissus osseux de ce dernier ($P<0,01$). L'implant de zéranol n'a eu aucun effet sur ces caractéristiques. Ni la castration ni le zéranol n'ont eu d'effet sur le poids du radius et du cubitus, du métacarpe et du métatarse. La croissance à l'extrémité distale du radius pendant les deux derniers mois de l'expérience a été significativement moins rapide chez les sujets traités que chez les témoins ($P<0,01$) et aussi significativement moins rapide chez les bouvillons que chez les bovins ($P<0,01$). Le traitement au zéranol a donné un agrandissement de l'ouverture du pelvis ($P<0,01$) chez les bouvillons et les bovins et une baisse de la libido ($P<0,05$) chez les bovins.

Mots clés: Bétail, zéranol, croissance des os, castration, caractéristiques de la carcasse, développement sexuel

Zeranol, in the commercial form Ralgro® (IMC:Terre Haute), is used as a growth stimulant for feedlot cattle (Perry et al. 1970; Price and Makarechian 1982; Ford and Gregory 1983). Although its effects on muscle and fat deposition have been studied (Ford and Gregory 1983) little is known of its effects on bone growth. It has been observed that zeranol-treated culled cows have significantly shorter radio-ulna bones than untreated cows (Chaudhary et al. 1985). Staigmiller et al. (1983) have reported that zeranol increased the pelvic openings in a group of heifers.

It has been suggested by Wiggins et al. (1979) that zeranol may reduce thyroid function and hence metabolic rate. If this is true, it could be anticipated that the substance would reduce the level of physical activity in implanted animals. In the present experiment the effect of zeranol on growth rate, carcass traits, linear bone growth, size of pelvic opening and physical activities such as fighting, bunting, mounting, flehmen and libido were studied in steers and bulls.

MATERIALS AND METHODS

Forty-eight male Hereford crossbred calves from the University of Alberta ranch at Kinsella, Alberta were used for this study. They were weaned in October 1982 aged 5–6 mo and introduced to a gradually increasing ration of a diet containing 64% barley, 21% oats, 10% pelleted dehydrated alfalfa hay and 5% of a protein/mineral/vitamin supplement. After about 3 wk, the ration had reached ad libitum. The animals were allocated at random to four groups of 12. On day 1 (10 Nov. 1982) animals in two of the groups (24 of the calves), were castrated, and one group of bulls and one group of steers were implanted with 36 mg zeranol (one steer was mistakenly implanted instead of a bull resulting in 13 implanted steers and 11 implanted bulls). They were allocated to four pens, one for each gender × treatment combination, and were individually weighed monthly.

The implanted cattle were reimplanted on day 62 of the experiment and all 48 cattle were infused with oxytetracycline (20 mg/kg body weight) 64 days before slaughter to monitor linear bone growth according to the method of Graham and Price (1981).

One month before slaughter the internal horizontal and vertical diameters of the pelvic openings were measured using a pelvimeter as described by Wiltbank and LeFever (1961) and at the same time scrotal circumferences were measured and the libidos of the bulls were scored from 0 (no interest) to 10 (maximum interest) using the method described by Chenoweth (1981).

The bulls were observed for 15 min in their pens on each of 22 consecutive evenings during the last month of the trial; three classes of behavior were recorded: flehmen (lip curling, usually after tasting or smelling urine) mounting and bunting. In addition the total time involved in bunting was recorded as fighting. At the end of the trial period (day 183) the cattle were slaughtered and dressed in a commercial packing plant and their metacarpal and metatarsal bones were removed, weighed and measured.

After overnight chilling the carcasses were graded by Agriculture Canada personnel and the left fore shank was removed with a cut above the 'elbow' (humerus to radio-ulna) joint. The shank was trimmed to include only the radio-ulna, its associated flexor and extensor muscles and fat; it was then dissected into bone, muscle and fat. The length, the minimum circumference and the density of each radio-ulna was recorded. They were then split longitudinally and their distal extremities were photographed under ultraviolet light to expose the oxytetracycline fluorescence and record longitudinal growth.

All data were analyzed by least squares analysis of variance (Harvey 1976). The behavior data were transformed before statistical analysis to more closely approximate a normal distribution. The log transformation was used for the fighting and bunting data (after adding 1.0 to allow the transformation of scores = 0); the square root transformation was used for the mounting and flehmen data.

RESULTS

There were no significant gender × treatment interaction effects for any of the traits shown in Table 1. Average daily gain (ADG), estimated by the linear regression of liveweight on time was greater ($P = 0.07$) in bulls than in steers, and greater ($P = 0.01$) in the zeranol-treated cattle than

Table 1. Least squares means of live animal and carcass data from zeranol implanted and control bulls and steers

	Effect of gender			Effect of zeranol				Gender × zeranol Interaction
	Bulls	Steers	Probability	Implanted	Control	Probability	SEM	
Number	24	24		24	24			
ADG (kg/day)	1.67	1.56	$P=0.07$*	1.69	1.54	$P=0.01$*	0.04	$P=0.09$
Grade fat thickness (mm)	9.9	12.6	$P<0.01$*	11.2	11.3	$P=0.88$	0.68	$P=0.54$
Slaughter weight (kg)	499	474.0	$P=0.14$	478	495	$P=0.32$	11.80	$P=0.15$
Dressing percentage	60.8	58.8	$P<0.01$*	60.1	59.5	$P=0.20$	0.36	$P=0.72$
Long dorsi area./(cm^2)	89.2	72.4	$P<.01$*	84.0	77.7	$P=0.18$	2.57	$P=0.10$
Shank dissection								
Muscle (kg)								
Fat (kg)	2.07	1.77	$P<0.01$*	1.93	1.92	$P=0.30$	0.05	$P=0.95$
Bone (radio-ulna) (kg)	0.64	0.77	$P=0.03$*	0.71	0.70	$P=0.90$	0.04	$P=0.40$
Muscle:bone	1.25	1.19	$P=0.17$	1.22	1.22	$P=1.00$	0.03	$P=0.44$
Metacarpal (kg)	1.67	1.51	$P<0.01$*	1.59	1.59	$P=0.87$	0.03	$P=0.25$
Metatarsal (kg)	0.52	0.51	$P=0.54$	0.51	0.52	$P=0.81$	0.01	$P=0.66$
	0.59	0.58	$P=0.81$	0.58	0.59	$P=0.72$	0.01	$P=0.66$

*Levels of probability considered to be significant.

in the controls. The fat thickness at the grading position was greater ($P<0.01$) in steers than in bulls, and dressing percent and longissimus dorsi area were greater ($P<0.01$) in bulls than in steers. Neither trait was significantly influenced by zeranol treatment. The fore-shank dissection showed that bulls had more muscle ($P<0.01$), less fat ($P=0.03$) and a higher muscle to bone ratio ($P<0.01$) in this region than steers, but zeranol implantation had no significant effect on these traits. The weights of the radio-ulna, metacarpal and metatarsal bones were not influenced by castration or zeranol treatment.

Radio-ulna length was not significantly affected by castration (Table 2), but its circumference and density were both greater ($P<0.01$) in bulls than in steers. None of these traits was significantly influenced by zeranol treatment. There was, however, a significant interaction between gender and zeranol treatment for bone density ($P=0.05$): treatment resulted in an increased bone density in steers and a decreased bone density in bulls. Neither gen-

Table 2. Least squares means of skeletal data from zeranol implanted and control bulls and steers

	Effect of gender			Effect of zeranol				Gender × zeranol interaction
	Bulls	Steers	Probability	Implanted	Control	Probability	SEM	
Number	24	24		24	24			
Radio-ulna								
Length (mm)	373	370	$P=0.40$	369	374	$P=0.20$	2.8	$P=0.96$
Circumference (mm)	167	158	$P<0.01$*	164	160	$P=0.12$	1.8	$P=0.35$
Density (g/cc)	1.51	1.42	$P<0.01$*	1.47	1.46	$P=0.80$	0.02	$P=0.05$*
Metacarpal length (mm)	206	207	$P=0.57$	206	207	$P=0.50$	1.67	$P=0.82$
Metatarsal length (mm)	232	233	$P=0.78$	231	234	$P=0.20$	2.66	$P=0.85$
Growth at distal radius (mm/60 days)	9.17	8.11	$P<0.01$*	8.03	9.26	$P<0.01$*	0.23	$P=0.02$*
Pelvic diameter								
Horizontal (mm)	123	123	$P=0.60$	126	120	$P<0.01$*	1.20	$P=0.42$
Vertical (mm)	141	143	$P=0.30$	144	140	$P=0.07$*	1.12	$P=0.74$

*Levels of probability considered to be significant.

der nor zeranol treatment had any significant effect on the lengths of the metacarpal or metatarsal bones.

Growth at the distal end of the radius during the last 64 days of the experiment (from about 10 mo to 1 year of age) was significantly greater in bulls than in steers ($P<0.01$) and in controls than in zeranol treated cattle ($P<0.01$). There was also a significant interaction ($P=0.02$) between gender and treatment for this trait: the linear bone growth was affected more in steers (22.4%) than bulls (4.5%). Zeranol-treated cattle had significantly larger horizontal ($P<0.01$) and vertical ($P=0.07$) pelvic diameters than controls (Table 2). Castration had no significant effect on pelvic diameters.

Libido among the bulls was significantly ($P<0.01$) reduced by zeranol treatment (Table 3) but treatment had no significant effect on the other sex-related behavior traits recorded, or on scrotal circumference.

DISCUSSION

Castration had a smaller (7%) effect on average daily gain in this trial than is normally reported (Field 1971). This was probably due to the fact that animals were relatively young and the effects of castration on growth are not fully exhibited before puberty (Price and Yeates 1969).

The positive effect of zeranol on growth in male cattle of both genders is well known (Perry et al. 1970; Greathouse et al. 1983). Although the gender × treatment interaction was not statistically significant ($P=0.09$), the effect of zeranol was greater in steers (17.4%) than in bulls (3.1%). Price et al. (1983) and Perry et al. (1970) have reported that zeranol-implanted bulls gain 5–10% faster than controls. Zeranol implantation had no effect on backfat thickness, dressing percentage or longissimus dorsi area (Table 1), which is in agreement with previous reports (Greathouse et al. 1983; Price et al. 1983).

Castration decreased shank muscle to bone ratio ($P<0.01$), a phenomenon which was associated with a decrease in shank muscle weight rather than an increase in radio-ulna weight. The decrease in shank muscle to bone ratio is likely to correspond to a lower muscle to bone ratio in the carcass as a whole (Butterfield 1965). The depression of muscularity by castration is well known (Field 1971).

The thicker ($P<0.01$) and denser ($P<0.01$) radio-ulnae of the bulls (Table 2) is attributed to testicular androgens which are known to stimulate matrix formation, and to promote calcium retention and positive nitrogen balance in the skeleton (Simmons 1971). Jones et al. (1978) observed no effect of castration on the density of radio-ulnae but they reported denser femurs in bulls than steers. Silberberg and Silberberg (1971) reported thicker bones in intact males than in castrates in all the mammals they studied.

Bone growth at the distal epiphyseal car-

Table 3. Least squares means of sexual development data in zeranol implanted and control bulls

	Control	SEM	Implanted	SE	Probability
No. of animals	13		11		
Log_{10} (fights + 1)†	0.17	0.015	0.26	0.015	$P=.59$
Log_{10} (bunts + 1)†	0.37	0.015	0.40	0.105	$P=.87$
Mounts†	0.08	0.005	0.25	0.005	$P=.12$
Flehmen†	1.06	0.036	0.82	0.36	$P=.37$
Libido‡	4.38	0.384	3.18	0.418	$P=0.01$*
Scrotal circumference (cm)	25.38	0.284	24.91	0.308	$P=0.43$

†Data transformed as shown, see text for details.
‡0 = no interest, 10 = maximum interest.
*Level of probability considered to be significant.

tilage plate of the radius was significantly less ($P<0.01$) in zeranol-treated animals (Table 2). An explanation for this has been suggested by Katzenellenbogen et al. (1979) that zearalenones (zeranol is a derivative of zearalenone) bind with estrogen receptors and evoke an estrogenic response. It has been reported that estrogens retard linear bone growth by interfering with chondrocyte proliferation and matrix synthesis in the epiphyseal growth plates (Simmons 1971). Linear bone growth was more ($P=0.01$) in bulls than in steers. Androgens have been shown to stimulate bone growth in many species of mammals, including man (Silberberg and Silberberg 1971).

Ralston (1978) reported that zeranol, implanted at birth or at 90 days, retarded the development of masculine characteristics such as curly hair on the neck and head, width of head, and crest development in cattle. In the present experiment pelvic diameters were significantly larger in zeranol-treated animals, which is presumed to be a feminine characteristic. It has been reported that spaying in female animals results in smaller pelvic diameters and exogenous estrogens cause pubic relaxation (Silberberg and Silberberg 1971). Staigmiller et al. (1983) observed a significant increase in "pelvic area" (vertical × horizontal diameter) in zeranol-treated yearling heifers.

Zeranol significantly ($P=0.01$) lowered libido score in treated bulls. This contrasts with the study of Price et al. (1983) which reported no difference in the libido of zeranol-treated and control bulls. In the present study all of the bulls showed low libido scores but this is normal among such young and inexperienced bulls (Chenoweth 1981). Scrotal circumference in bulls was not affected by zeranol which is in agreement with Price et al. (1983) for bulls implanted at about puberty. There is considerable evidence that implanting before puberty will inhibit sexual development (O'Lamhna and Roche 1984).

Although bulls produce beef more efficiently than steers (Price and Yeates 1969; Field et al. 1971), one disadvantage of bulls is their aggressive behavior and the consequent increase in the incidence of dark, firm, dry (DFD) meat compared to steers (Price et al. 1983). It has been suggested by Wiggins et al. (1979) that zeranol implantation would reduce the secretion of thyroid hormones and hence may reduce the metabolic rate and physical activity. Zeranol has also been claimed as a tranquilizing agent in cattle (Brown et al. 1975). Hence, it might be anticipated that zeranol implantation would reduce the physical activity in bulls. In this study zeranol had no effect on behavioral traits, other than libido, which confirms the report of Price et al. (1983) who found no significant effect of zeranol implantation on behavioral traits of bulls which had been mixed together from several pens.

It is concluded from this work that zeranol implanted at weaning has a negative effect on bone growth but increases pelvic diameters in steers and bulls and reduces libido in bulls. It tended to stimulate growth rate in both genders, but does not appear to have any other influence on feedlot behavior.

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