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Pubertal development of *Bos taurus* beef bulls

Albert D. Barth*
Department of Large Animal Clinical Sciences, Western College of Veterinary Medicine,
University of Saskatchewan, Saskatoon, Saskatchewan, S7N 5B4

The variability of onset of puberty, among and within breeds, has resulted in inconsistent reproductive performance of young bulls. To promote the successful use yearling bulls, it is very important to understand pubertal changes and factors that affect pubertal development.

In the male suckling calf the seminiferous cords of the testes contain primordial germ cells and Sertoli cells that generate the seminiferous epithelium. A lumen is established in the seminiferous cords by about 5 mo of age and spermatogenesis is established by about 8 mo of age (1). An initial rise in FSH between 3 and 5 mo of age results in proliferation of Sertoli cells, seminiferous tubule lengthening and an increase in tubule diameter. At the same time, there is a rise in LH secretion resulting in increased testosterone production by the Leydig cells. Between 5 and 8 mo of age, FSH and LH remain low and then rise again with the onset of puberty. It has recently been shown that the greater the rise in LH at 3 to 5 mo of age, the earlier the onset of puberty and the larger that testis size will be at 1 y of age (2). In well-fed bulls testis growth is almost linear between 7 and 12 mo of age and scrotal circumference (SC) increases at a rate of 0.06 – 0.07 cm per day (3,4). The rate of testis growth declines after 12 mo of age, but by 24 mo of age, the testes will be approximately 90% of mature size (5).

Onset of puberty has been defined as the first time when the ejaculate has at least 50 x 10^6 sperm/ml with at least 10% having progressive motility (6). Semen quality improves and achieves adult characteristics over a period of 3 to 4 months after the onset of puberty (7). Bulls within the same breed mature as much as 4 months later than the earliest maturing bulls (8). Approximately 33% of beef bulls produce satisfactory quality semen (mature characteristics) at 12 mo of age, about 60% at 14 mo of age, and most have matured by 16 mo of age (9,10).

Effect of nutrition on onset of puberty

High-energy diets with adequate protein, vitamins and minerals may hasten the onset of puberty and thus the age at maturity. This was demonstrated in an early study in which bull calves were raised on 60-75%, 100% and 140-160% of recommended energy intakes. The low energy diet tremendously delayed puberty (11). Since later maturing bulls have a smaller rise in LH at 3 to 5 mo of age than early maturing bulls (2) it would seem likely that nutritional restriction in the preweaning period is detrimental to early attainment of puberty despite good post weaning nutrition. In support of this, it has been shown that bulls raised to weaning age by heifer-mothers have smaller testes at 1 y of age than those raised by cow-mothers (12).

Different levels of nutrition after weaning appear to affect the rate of testicular growth, however, it is not clear whether age of onset of puberty is also affected (13-15). Ohl et al, 1996, examined the effects of rate of gain on SC and testicular histology in 23 half-sibling beef bulls from 11.6 to 15.3 mo of age. Rations designed to result in maximum gains, or low gains (0.5 kg per day). At the end of the test period, the mean SC was 34.0 and 31.7 cm for high- and low-gain rations, respectively; however, there were no differences in testicular histology. Seidel et al, 1980, fed 133% and 95% of TDN requirements to Angus bulls from 7 to 11 mo of age. At the end of the feeding period, he also found a larger mean SC in bulls on the high-energy ration. Interestingly, the weights of the testes recovered at slaughter were numerically larger, but not significantly larger, for the high-energy group. However, scrotal weights were greater for the high-energy group. These studies seem to indicate that larger SC measurements at 1 y of age in bulls fed for maximal growth are partly due to hastened testis development and partly due to excess fat deposition in the scrotum. In a study by Coulter et al, 1987, Angus and Hereford bulls fed 80% grain and 20% forage from weaning to 15 mo of age, had a greater mean SC at 12 mo, but not at 15 mo of age, than bulls fed 100% forage. The bulls on the grain-forage diet had significantly lower sperm outputs at 15 mo of age than bulls on a medium-energy diet. However, in a recent study in our laboratory, Angus bulls on high-energy rations (125% of NRC recommendations) from 7 to 15 mo of age had larger testes weights, but not heavier scrotal weights than bulls on low-energy rations (75% of NRC recommendations). Thus our findings are contrary to those of Seidel, 1980, regarding scrotal fat deposition and to those of Coulter et al, 1987, in regard to SC. There is evidence that excessive energy intake in young bulls may result in laminitis, abnormal bone and cartilage growth, and increases the risk of rumenitis which may lead to the development of vesicular gland infections (16,17).

Effect of breed on onset of puberty

Significant genetic variation exists between breeds of beef cattle for age at puberty (18). In general, the faster-gaining breeds of larger mature size reach puberty at a greater weight than slower-gaining breeds of smaller mature size. Breeds historically selected for milk production (e.g., Braunvieh, Gelbvieh, Red Poll, Pinzgauer and Simmental) reach puberty at significantly younger ages than do breeds not selected for milk production (e.g., Charolais, Limousin and Hereford). There are great differences between breeds of bulls and testicular size at any given age (19). In double muscled bulls, testes weight at 12 mo of age was 14% less than in normally muscled bulls; however, the effect of double muscling on age at maturity has not been reported (20). There is considerable evidence that SC measurement between 1 and 2 y of age is moderately to highly heritable (21). Therefore, breeders could make rapid progress in selection for increased testes size and consequently earlier maturity.

Effect of season on onset of puberty

Although cattle do not have distinctly seasonal reproductive activity, there is evidence of a seasonal basis in bovine reproduction. For example, return to estrous cyclicity is longer in cows that calve in winter than for those calving in summer (22). In Wisconsin, heifers born in September were younger at puberty than those born in March. Photoperiod most likely played a role in these responses since heifers given supplemental light in autumn were younger at puberty than those exposed to natural light (23). Season of birth also may influence age at puberty of bull calves. In a western Canadian study (24), LH pulse amplitude was significantly lower from 4 to 24 wk of age in bull calves born in autumn vs. those born in spring and age at puberty was more variable in the fall-born calves. In a recent study conducted at our laboratory, 10 bulls were maintained in an outdoor pen from 18 to 30 mo of age. Semen samples were taken bimonthly and blood samples were taken every 20 min for 10 h in March, June, September, and December. Serum testosterone concentrations were lower in fall and winter than in spring and summer in all bulls, and in 5 bulls, total LH secretion was higher in March than in September. In 2110 mature western Canadian range bulls, semen quality is lowest in fall and winter and highest in spring and summer (25). Since semen quality in these bulls improved in the spring while bulls remained on the same winter feed supplies, differences in semen quality might have been due to milder weather conditions and/or increasing photoperiod.

Seasonal variation in LH and testosterone has been reported in other studies as well (26). In four Norwegian Red bulls, blood testosterone levels were significantly lower in October and December than in February, June and August. However, there is some conflict in the literature regarding the relationship of season and testosterone concentrations in bulls. Studies on seasonal effects on hormone secretion and spermatogenesis must be interpreted carefully, since latitude, housing, climatic heat, or cold stress could influence testosterone levels. In addition, there is diurnal variation in LH and testosterone levels and, therefore, frequent blood sampling throughout a large portion of the day is necessary as a basis for comparison of hormone levels at different times of the year. Not all studies have been adequate in this regard.

Selection for scrotal circumference SC

An extremely high correlation (-0.98) was found between breed means for yearling SC and age at puberty in heifers (27). Furthermore, correlations of 0.66 and 0.97 were found between breed means for SC and fertility of female offspring (18,28). Therefore, selection for SC is an important means for improvement of beef-herd fertility.

The first opportunity for selection and culling of bulls arises at the time of weaning. However, a study of 708 bulls fed in a record of performance station in western Canada (4), indicated that SC measurement in weaned bulls may not be useful as a culling tool since a large proportion of 8 mo-old bulls with SC measurements in the bottom 15 percentile met the minimum requirements for SC at 12 mo of age. On the other hand, it has been shown that bulls with a small SC at a year of age did not catch up over time and still had small SC measurements at 2 y of age. Therefore, final decisions based on SC could be made by the time bulls are 12 mo old.

Résumé

Il serait souhaitable de sélectionner les taureaux pour leur précocité dans l’atteinte de la puberté en vue d’augmenter les chances de succès d’obtenir des taureaux reproducteurs de 14 à 16 mois d'âge. Les taureaux dont la puberté est précoce engendreront des filles ayant une vie productrice plus élevée. La nutrition, la race, et la saison ont été identifiées comme des facteurs importants influençant l'âge à la puberté. L’apport alimentaire dès l’âge de 3 à 5 mois peut fortement influencer l'âge à la puberté.

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