J. Dairy Sci. 101:1–13
https://doi.org/10.3168/jds.2017-13719

Plane of nutrition before and after 6 months of age in Holstein-Friesian bulls: I. Effects on performance, body composition, age at puberty, and postpubertal semen production

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ABSTRACT

The aim of this study was to examine the effect of plane of nutrition (1) during the first 6 mo of life and (2) from 6 mo of age to puberty on early growth characteristics, age at puberty, and postpubertal semen production in Holstein-Friesian bulls. Holstein-Friesian bull calves (n = 83) with a mean (standard deviation) age and body weight of 17 (4.4) d and 52 (6.2) kg, respectively, were assigned to a high (Hi) or low (Lo) plane of nutrition for the first 6 mo of life. The Hi and Lo calves received 1,200 and 450 g of milk replacer, respectively; Hi calves were fed concentrate ad libitum and Lo were fed a maximum of 1 kg concentrate daily, and concentrate allowances remained the same after weaning. At 24 wk of age, bulls were reassigned within treatment to either remain on the same diet or to switch to the opposite diet until puberty, resulting in 4 treatment groups: Hi-Hi, Hi-Lo, Lo-Lo, and Lo-Hi. After puberty, all bulls were fed a moderate plane of nutrition until 60 wk of age; thereafter, the diet was ad libitum concentrates until slaughter at 72 wk of age. Bulls were weighed weekly before weaning and every 2 wk after weaning. Scrotal circumference (SC) was measured every 2 wk, beginning at 15 wk of age. Beginning at a SC of 24 cm, electro-ejaculation was carried out every 2 wk to establish the onset of puberty. Semen collection continued monthly after puberty. Thermal images of the scrotum were taken monthly from 28 to 36 wk of age. Scrotal skin thickness (SST) was measured monthly (from 16 wk of age to puberty) using a digital calipers. Bulls on the Hi diet had a higher scrotal temperature and SST at each time point than those on the Lo diet. Average daily gain (ADG) was greatest in Hi-Hi bulls, with Hi-Lo and Lo-Hi having similar ADG but both being greater than Lo-Lo. Bulls on the Hi diet pre-6 mo of age were younger at puberty, regardless of diet offered post-6 mo of age. Bulls offered a Hi diet post-6 mo were heavier at puberty. Neither scrotal temperature nor dietary treatment affected postpubertal semen production variables. In conclusion, a high plane of nutrition during the first 6 mo of age hastened the onset of puberty and the availability of saleable semen, regardless of plane of nutrition post-6 mo of age.
Key words: semen quality, age at puberty, thermoregulation

INTRODUCTION

The widespread implementation of genomic selection in recent years has meant that sires used in AI are selected at younger ages than was previously possible through traditional progeny testing. Although this has the potential to accelerate genetic gain by reducing the generation interval (Berry et al., 2014), it has led to increased demand for semen from sires at a young age (de Roos et al., 2011). However, the reproductive potential of these young bulls is limited by the quantity and quality of semen that they can produce (Rawlings et al., 2008). Recent studies have reported that enhanced nutrition before 31 wk of age leads to earlier onset of puberty in Holstein-Friesian bulls (Dance et al., 2015; Harstine et al., 2015), whereas restricting the diet of beef bulls before 26 wk of age delays age at puberty onset, which could not be reversed by an increase in the plane of nutrition from 27 wk to 70 wk of age (Brito et al., 2007a). In both studies conducted on Holstein-Friesian bulls (Dance et al., 2015; Harstine et al., 2015), postpubertal semen production was unaffected by diet, whereas a high plane of nutrition from 10 to 30 wk in young beef bulls led to higher total daily sperm production at 74 wk of age compared with those offered a control diet from 10 to 74 wk of age (Brito et al., 2007b). A similar response in terms of age at

Received August 21, 2017.
Accepted January 2, 2018.
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puberty to increased early life ADG was also observed in heifers (Cardoso et al., 2014). While reviewing the literature on sexual maturation of the bulls, Rawlings et al. (2008) noted that a dramatic increase in testicular growth occurs from approximately 24 wk of age. As it has been reported that scrotal circumference (**SC**) is linked to sperm production potential (Palasz et al., 1994), advancing scrotal growth in the period after 24 wk of age promotes optimum sperm production potential.

The implications of an elevated feeding regimen on scrotal fat accretion and testicular thermoregulation have been reviewed (Kastelic, 2014). Whereas greater BW gain is generally mirrored by increased testicular growth, within breed (Byrne et al., 2017), the degree of scrotal fat required to adversely affect sperm production has not been well defined. Rearing strategies that consistently advance puberty and sexual maturation are required if the supply of semen from young elite sires is to meet demand, particularly within the context of seasonal breeding systems when inseminations are typically concentrated in a 6- to 8-wk period. We hypothesized that increasing the early life plane of nutrition would (1) hasten age at puberty, and (2) increase subsequent semen production potential of Holstein-Friesian bulls. Thus, the aim of this study was to examine the effects of plane of nutrition during the first 6 mo of life and from 6 mo of age to puberty on early growth characteristics, age at puberty, and postpubertal semen production potential of Holstein-Friesian bulls.

MATERIALS AND METHODS

All animal procedures performed were conducted under experimental license from the Irish Department of Health and Children (license number B100/4516). Protocols were developed in accordance with the *Cruelty to Animals Act* (Ireland 1876, as amended by European Communities regulations 2002 and 2005) and the European Community Directive 86/609/EC.

Animal Management

Autumn-born Holstein-Friesian bull calves (n = 83) with a mean (±SD) age and BW of 17 (4.4) d and 52 (6.2) kg, respectively, were blocked by age, BW, sire, and farm of origin and assigned to a high (**HPN**) or low (**LPN**) plane of nutrition for the first 6 mo of life. Bulls assigned to HPN (n = 37) and LPN (n = 46) received 1,200 and 450 g of milk replacer (Table 1 and Supplementary Table S1; https://doi.org/10.3168/jds.2017-13719), respectively. The HPN bulls were fed concentrate ad libitum and the LPN bulls were offered a maximum of 1 kg of concentrate daily (Table 1 and Supplementary Table S2; https://doi.org/10.3168/jds.2017-13719). All animals were offered hay (Table 1 and Supplementary Table S3; https://doi.org/10.3168/jds.2017-13719) as a source of roughage and had ad libitum access to water. Mineral and vitamin supplementation was also provided (Supplementary Table S2). Diets were designed using NRC (2001) guidelines. Bulls were individually fed using an electronic feeding system (Vario, Forster-Technik, Engen, Germany) before weaning and were penned thereafter according to treatment until turnout to pasture at 24 wk of age. Bulls were rotationally grazed in their respective treatment groups until the onset of puberty, at which bulls were rehoused in slatted-floor pens. Bulls were offered pre-weaning diets for a minimum of 56 d and were weaned once they were consuming 1 kg of concentrates for 3 consecutive days. After weaning, HPN bulls were fed ad libitum concentrates and LPN bulls received 1 kg of concentrate daily; both groups were offered hay to appetite. At 24 wk of age, bulls were reassigned, within treatment, to either remain on the same diet or to switch to the opposite diet until puberty. This resulted in 4 groups: HPN-HPN (**Hi-Hi**), HPN-LPN (**Hi-Lo**), LPN-LPN (**Lo-Lo**), and LPN-HPN (**Lo-Hi**), with n = 19, 18, 22 and 24, respectively. Bulls were turned out to high-quality pasture at 26 wk of age, where Hi-Hi and Lo-Hi bulls received grass (Table 1 and Supplementary Table S3; https://doi.org/10.3168/jds.2017-13719) and concentrate ad libitum, whereas Lo-Lo and Hi-Lo bulls received grass to appetite plus 0.5 kg of concentrate daily. After puberty, bulls were fed a moderate plane of nutrition consisting of 4 kg of concentrates and grass silage (Table 1 and Supplementary Table S3) ad libitum until 60 wk of age. From 60 wk of age, all animals were fed concentrate ad libitum plus 5 kg of grass silage, until slaughter at 72 wk of age.

Table 1. Crude protein and energy values of feedstuffs offered (mean ± SEM)

Feedstuff	CP (g/kg of DM)	Gross energy (MJ/kg of DM)
Concentrate		
Pre-puberty	167.9 ± 1.86	16.1 ± 0.03
Post-puberty	106.6 ± 2.29	15.8 ± 0.04
Hay	107.5 ± 9.35	16.1 ± 0.08
Grass	152.4 ± 9.73	16.1 ± 0.07
Milk replacer[1]	216.3 ± 1.24	20.3 ± 0.56
Silage	122.2 ± 9.4	16.3 ± 0.08

[1]Analyzed by acid hydrolysis.