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Social dominance in prepubertal dairy heifers allocated in continuous competitive dyads: Effects on body growth, metabolic status, and reproductive development

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ABSTRACT

The objective of this study was to compare the body weight (BW) and size, metabolic status, and reproductive development of dominant and subordinate prepubertal dairy heifers allocated in competitive dyads. Sixteen Holstein and Jersey × Holstein prepubertal heifers (means ± SEM; 250.8 ± 9.8 d; 208.5 ± 13.9 kg of BW) were assigned to 8 homogeneous dyads according to breed, age, and BW. Dyads were housed in pens separated 1 m from each other during 120 d, receiving a total mixed ration on a 5% restriction of their potential dry matter intake, and had access to the same feeder (60 cm) throughout the experiment. Dominant and subordinate heifers were defined based on the winning agonistic interactions in each dyad. Body development was recorded every 20 d in all heifers, and blood samples were collected on the same days to determine endocrine and metabolic status. The maximum follicle diameter, number of follicles >6 mm, and the presence of corpus luteum were observed weekly by ultrasound. Heifer BW (269.3 vs. 265.3 ± 1.5 kg) and average daily gains (0.858 vs. 0.770 ± 0.02 kg/d) were greater in dominant than subordinate heifers. On d 30, 37, and 53, dominant heifers had more follicles than subordinate heifers, and maximum follicle diameter was greater in dominant than in subordinate heifers (10.0 vs. 9.0 ± 0.3 mm). Dominant heifers achieved puberty earlier than subordinate heifers (313.9 ± 4.9 vs. 329.6 ± 5.7 d) with similar BW (279.4 ± 2.6 vs. 277.4 ± 5.8 kg). Glucose concentrations were greater in dominant than subordinate heifers (89.2 vs. 86.8 ± 1.2 mg/dL), but cholesterol concentrations were greater in subordinate than dominant heifers (86.1 vs. 90.2 ± 2.6 mg/dL). We concluded that, under continuous competitive situations, dominant heifers were more precocious than subordinate ones, achieving an earlier puberty. Dominant heifers had greater body growth and glucose concentrations than subordinate heifers, which may be responsible, at least in part, for the differences on reproductive development between heifers of different social status.

Key words: replacement heifer, social behavior, social hierarchy, puberty

INTRODUCTION

Raising replacement heifers for dairy farms is expensive; thus, any increase in efficiency during this period has important consequences in reducing costs (Tozer and Heinrichs, 2001). Although age at first calving is one of the main determinants of productive success (Abeni et al., 2000; Pirlo et al., 2000), BW at calving and rate of growth before puberty can affect the maximum milk produced in the first lactation (Zanton and Heinrichs, 2005). In Uruguay, most dairy farmers maintain their heifers on low-quality pastures, which has been shown to increase age at first calving (36 mo; Conaprole, 2008) compared with the recommended 24 mo (Heinrichs and Swartz, 1990). In this context, intensive feeding systems, in which heifers are fed a TMR, are an important management tool to improve dairy heifer-rearing programs. Under these systems, social dominance and competition for feed may influence access to food and thus, heifer growth (DeVries, 2010). Management practices that involve high competition levels for feeding are major stressors that may have a negative effect on access to food and growth, raising welfare concerns, and thus, the need to develop alternative management.

Social dominance, the relationship of dominance–subordination established between 2 individuals (Drews,

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1993), has direct consequences on productive and reproductive results. Milk yield and fertility of dairy cows increased with social rank (Dobson and Smith, 2000; Phillips and Rind, 2002; Val-Laillet et al., 2008) and high-ranked beef cows were rebred earlier during the postpartum period compared with low-ranked cows (Landaeta-Hernández et al., 2013). In growing animals, high-ranked male lambs had greater ADG and a precocious increase of scrotal circumference, semen production, and sexual behavior compared with low-ranked lambs (Ungerfeld and González-Pensado, 2008). The effects of social dominance on an animal's performance may be exacerbated by management conditions that determine increased competition for resources (reduced feeding space or overstocking on intensive feeding systems; Val-Laillet et al., 2008; Manteca, 2009). Great levels of competition between heifers at the feedbunk provoked greater variability in ADG (Longenbach et al., 1999; González et al., 2008), whereas other studies suggested that high-ranked heifers gained more BW than low-ranked heifers (Greter et al., 2010).

Metabolic status in prepubertal heifers is affected by multiple factors, especially, nutrition and growth rate (Abeni et al., 2000, 2012). Depending on nutritional levels, Holstein and Jersey heifers can reach puberty at 280 to 360 and 330 to 390 d, respectively (Stewart et al., 1980). Although BW gain, age, and breed are directly related to the onset of ovarian cyclic activity, many metabolic hormones and metabolites are important signals for follicular development and initiation of puberty (Yelich et al., 1995, 1996; Chelikani et al., 2003). Therefore, it is expected that any alteration of heifer nutritional status (such as that provoked by high competition rates due to dominance status) may determine changes in growth rate, and thus, affect metabolite and endocrine profile and reproductive development.

We hypothesized that in heifers allocated continuously in competitive dyads (1) dominant heifers have greater body growth rate and follicle size and achieve puberty earlier than subordinate heifers, and (2) dominant heifers present a metabolic and endocrine profile that reflect a "more positive" energy balance (greater serum insulin, IGF-I, glucose, cholesterol, and urea) than subordinate heifers. Therefore, the objective of the present study was to compare BW and size, metabolic status, and reproductive development of dominant and subordinate prepubertal dairy heifers allocated in competitive dyads.

Table 1. Composition and nutritive value (% unless otherwise noted; mean ± SD) of the TMR[1] (on DM basis) fed to prepubertal dairy heifers in 2 experimental periods

Item	Experimental period	
	d 1 to 46	d 47 to 120
Ingredient		
Corn silage	58.3	—
Pasture silage	—	59.3
Ground corn grain	28	32
Soybean meal	12.6	7.6
Urea	0.5	0.5
Commercial premix[2]	0.5	0.5
Chemical composition		
DM	30.3 ± 1.3	57.1 ± 2.6
Ash	7.0 ± 0.2	11.3 ± 1.9
CP	14.2 ± 0.6	13.8 ± 2.8
ADF	27.4 ± 2.8	20.1 ± 1.3
NDF	50.7 ± 4.6	35.1 ± 5.9
Ether extract	2.6 ± 0.2	2.4 ± 0.4
ME[3] (Mcal/kg)	2.37	2.46
CP:ME (g/Mcal)	60.0	59.1

[1]Diet was formulated for 0.800 kg/d of ADG (NRC, 2001).

[2]One hundred grams contained 0.8 g of Rumensin (Elanco Animal Health, Indianapolis, IN), 20 g of calcium carbonate, 5 g of mineral and vitamin premix, 7 g of MgO, 36 g of sodium bicarbonate, 2 g of Procreatin 7 (Philips Lesaffe Animal Care, Lyon France), 5 g of salt, 3 g of Safmannan (Philips Lesaffe Animal Care), and 21.2 g of wheat bran.

[3]Estimated according to the NRC (2001).

MATERIALS AND METHODS

Animals and Housing

Animal care, handling, and protocols were approved by the Comisión Honoraria de Experimentación Animal (Universidad de la República, Uruguay). The study was performed in the Campo Experimental number 2 of the Facultad de Veterinaria, San José, Uruguay (34°40′S, 56°32′W) from October to March. Sixteen Holstein (n = 12) and Jersey × Holstein (n = 4) prepubertal heifers (250.8 ± 9.8 d; 208.5 ± 13.9 kg of BW; mean ± SEM), that were managed similarly before the study, were selected from the herd of the experimental farm and were allocated to 8 homogeneous dyads, according to breed, age, and BW.

Each dyad was allocated for 120 d in shed pens (5 × 8 m) separated (1 m) by electrical fences from the adjacent pen to avoid physical contact with animals from the other dyads. Heifers were fed a TMR composed of ground corn grain, soybean meal, corn or pasture silage, and a commercial premix [calcium carbonate, magnesium oxide, sodium bicarbonate, Rumensin (Elanco Animal Health, Indianapolis, IN), salt, yeasts], with a 60:40 forage to concentrate ratio. On d 46 of the study, due to availability, corn silage was substituted by pasture silage (Table 1). The TMR was formulated to a target gain of 800 g/d of BW according to NRC (2001), and with the recommended MP to ME ratio so