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Effect of Calf Birth Weight on the Subsequent Fertility of Holstein Heifers

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ABSTRACT

This study investigated the effect of birth weight on the fertility of Holstein heifers. Growth parameter (body weight) was measured at birth. Calves were analyzed as three subgroups: low (L), average (A) and high (H) birth weight (BW) calves. LBW calves were born 10 kg lighter than HBW calves. Fertility data collected included age at first breeding (AFB), number of services per conception, pregnancy rate to first artificial insemination (AI), and age at first calving (AFC). Primiparous calves in HBW are smaller compared to multiparous cows (18.3% versus 48%). Although not significantly different, LBW offspring appeared to breed faster over the service period compared with the ABW offspring that bred three weeks later on the average. The mean pregnancy rate to first AI for LBW heifers was higher (60%) than ABW (48%) and HBW (45%). HBW cows required more services per conception (2.1) than the LBW (1.7) and ABW (1.9). There were significant differences ($p<0.05$) in age at first calving among the different calving birth weights. Smaller birth size did not have any subsequent adverse effects on fertility. HBW offspring were more likely or tend to have worse fertility parameters.

(Key words : calf, dairy cows, reproductive performance, body weight)

INTRODUCTION

The modern dairy cow has been genetically selected for high milk production. Selection for high milk production in dairy cows has been associated with a decline in fertility. A short herd life span is a significant economic loss to the dairy industry, with infertility being a major cause. Failure to conceive is the most common reason for the culling of dairy cows. The ability of replacement heifers to reach puberty, cycle normally, conceive at the desired time, sustain the pregnancy to term, calve normally, and subsequently commence their first lactation is a critical component of dairy enterprises (Velazquez *et al*., 2008; Taylor *et al.,* 2003).

An association between body weight (BW) gain and timing of puberty has been reported in many species. High energy and protein intake resulting in increased growth is associated with the earlier attainment of puberty in calves (Yelich *et al*., 1995; Lammers *et al*., 1999; Brito *et al*., 2007). Size at birth is an indicator of fetal growth primarily determined by the maternal uterine environment. It has been reported that uterine environment is responsible for about 60% of the variation in size at birth (Brito *et al*., 2007). In dairy cow, birth size is an important parameter because it is a major risk factor for maternal dystocia (Johanson and Berger, 2003). Studies in sheep suggest that in utero nutrition also affects subsequent fertility through changes in ovarian development (Rhind, 2004). Impaired fetal growth, deduced from birth weight of body proportions, can predispose to a diverse range of adult reproductive performance (Gunn *et al*., 1995; Rhind *et al*., 1998).

An earlier AFC can reduce rearing costs due to decreased feed, labor and building costs. However, reducing AFC too much may increase the risks of dystocia as calving difficulties are influenced by the dam's age, pelvic width, and skeletal maturity; which may be inadequate in dams calving at <24 months (Hoffman, 1997; Hansen, 2004). The actual AFC achieved is determined in part by management choice (age at start of the service), combined with the reproductive efficiency of the nulliparous heifers.

Despite the evidence that birth size is an important parameter, there are few data available that links early nutritional environment experience by dairy calves with their subsequent success as cows. In this study, we tested the hypothesis that birth weight can influence subsequent fertility.

MATERIALS AND METHODS

1. Fertility Parameters

Data were collected from November 2005 to December 2008.

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Calves were isolated from their dams immediately after birth and were not allowed to suck maternal colostrums. Calves were weighed using a calibrated scale within 15 minutes of birth, and were fed a single colostrums meal by nipple bottle with pooled.

For all heifers (n=153) that reached the start of first breeding period, service details were collected from on-farm records. Artificial insemination (AI) was carried out on nulliparous heifers. Groups were observed for estrus for 2 periods of approximately 30 min each day during the service period at 08:30 and 16:15 h. Animals seen in heat before 12:00 h each day were inseminated that evening, those seen in heat after 12:00 h each day were inseminated the following morning. The dates and outcome of each AI on each animal were recorded. Conception status of cows was determined via ultrasound at 35 to 50 days after breeding and confirmed via rectal palpation at approximately 60 and 100 days after breeding. When an animal was positively diagnosed as pregnant by rectal palpation, the age at first breeding (AFB), number of serves required, ages at first conception (AFC), and outcome of the first service were recorded to create four outcome traits to define reproductive performance (Table 1).

2. Statistical Analysis

Data were subjected to a Generalized Linear Model procedure (PROC-GLM) of the Statistical Analysis System (SAS Institute, Cary, NC, USA). Differences among treatment means were determined using Duncan's multiple range tests. Statistical significance was established at $p<0.05$.

RESULTS

Birth weights of heifer calves were classified according to Swali and Wathes (2006) and were divided into three types: type Ⅰ - low birth weight; type Ⅱ - average birth weight; and type Ⅲ - high birth weight. A total of 153 cow's birth weights were analyzed and showed significant differences among the overall distributions (Table 2).

Table 3 presented the descriptive statistics for the three types of birth weights. HBW calves borne by primiparous cows were smaller (13/77, 18.3%) compared with those borne by multiparous cows (48/82, 58.5%).

Measures of fertility were summarized on Table 4. Heifers in LBW had an average 496.0 ± 12 days at first breeding and 807.5 ± 17 days at calving. LBW offspring appeared to breed faster over the service period, while ABW offspring took about three weeks later at breeding, although this was not significantly different. The mean pregnancy rate to first AI for LBW heifers was higher (60%) than ABW (48%) and HBW (45%). HBW cows required more services per conception (2.1) than the LBW (1.7) and ABW (1.9). None of the differences in service data among the BW groups were significant. However, the conception data were slightly worse in the HBW offspring. The average intervals to first service were similar among the groups (123～136 days), but the LBW offspring were serviced at an average of almost two weeks earlier after calving than HBW animals.

Table 2. Classification of the size on birth of heifer calves born with low (LBW), average (ABW) or high (HBW) birth weights (means ± S.E.M.).

Calf age	BW group		Birth weight (kg)	
	Classification	Cows (n)	Average*	Range
Birth	LBW	35	34.3 ± 0.3^{C}	30～36
	ABW	57	39.2 ± 0.2^{B}	37～41
	HBW	61	44.8 ± 0.4^{A}	42～51

* Values with different superscripts (A～C) differ within column ($p<0.05$).

Table 1. Definition of fertility parameters

Fertility trait	Definition
Age at first breeding	Number of days from birth to the first AI
Number of services per conception	Number of inseminations before a calving event
Pregnancy rate to first AI	Number of animals pregnant to first AI divided by the total number of first inseminations given to animals that conceived
Age at first calving	Number of days from birth to first calving

Table 3. A comparison in weight from birth of heifer calves born with low (LBW), average (ABW) and high (HBW) birth weights according to dam's parity

Parity	Total cows (n)	Birth weight (kg)		
		No. of LBW (%)	No. of ABW (%)	No. of HBW (%)
Primiparous cows	71	25 (35.2)	33 (46.5)	13 (18.3)
Multiparous cows	82	10 (12.2)	24 (29.3)	48 (58.5)

Table 4. Measure of fertility for low, average, and high birth weight animals, which conceived and calved.

Parameter	LBW	ABW	HBW
Age at first breeding (days)	496.0 ± 12.4	519.8 ± 14.8	525.5 ± 10.9
No. of services per conception	1.7 ± 0.2	1.9 ± 0.2	2.1 ± 0.2
Pregnancy rate to first AI, % (n)	60% (21/35)	48% (27/56)	45% (28/62)
Age at first calving (days)*	807.5 ± 17.4^{B}	850.6 ± 19.6^{AB}	867.3 ± 17.1^{A}
Interval from calving to first service (days)	123.0 ± 11.1	128.4 ± 11.6	136.4 ± 9.7

*Values with different superscripts (A~C) differ within row ($p<0.05$).

DISCUSSION

LBW calves were generally smaller than their HBW peers. The parity of the dam during gestation was compared among differing BW calves. Inadequate maternal body size could also be important when giving birth, particularly for cows calving for the first time, which had not themselves reached full maturity (Kertz *et al*., 1997; Hansen, 2004). The results of this study supported previous investigations (Walton and Hammond, 1938, Tischner, 1985; Allen *et al.*, 2002) in suggesting that the maternal uterine environment had a greater influence on size at birth than the paternal genotype.

The period from parturition to the first service was longer by about 13 days in HBW compared with LBW cows. Higher birth weight cows had greater propensity for losing body condition postpartum (Dechow *et al*., 2002). According to Swali and Wathes (2006), a significantly higher proportion of ABW and HBW cows had abnormal progesterone profiles after calving. In particular, HBW calves had a much higher incidence of persistent corpora lutea. The main risk factors for long luteal phases are abnormal calving, retained placenta, and endometritis (Opsomer *et al*., 1998). HBW cows were heavier at calving and tended to produce higher BW calves. Both of these factors likely contributed to calving difficulties (Johanson and Berger, 2003).

Pregnancy rate to first AI for LBW was higher as compared with the other groups. Body weight was measured within 15 min of birth. The study did not collect any more weight measured value during the rearing period. According to Brickell *et al*. (2009) and Bell and Bauman (1997), heifers with faster growth rates and higher concentrations of insulin-like growth factor-I (IGF-I) and glucose, bred earlier (Robinson *et al*., 1999). These supported the important role of body size and the metabolic indices in the regulation of the puberty attainment. Similarly, this study found that small cows utilized feed more efficiently so they had faster growth rates to reach maturity.

Age at first calving (AFC) is an important factor in determining the length of the nonproductive period as well as affecting subsequent fertility and productivity (Ettema and Santos, 2004; Evans *et al*., 2006). It is widely accepted that heifers should calve for the first time at about two years old, but most countries report a mean AFC of greater than 730 days (Pirlo *et al*., 2000; Mayne *et al*., 2002; Hare *et al*., 2006). Gestation length is fixed; therefore, AFC depends upon the age at the start of breeding. The decision on when to start breeding is a management decision, but variability in growth rates within groups of animals can lead to a large spread in the age, at which heifers are bred for the first time (Ettema and Santos, 2004). The reproductive performance of heifers at this stage will affect the age at conception and hence the AFC. Overall, AFC was strongly influenced by birth weight.

This study merits further study using a selection of Holstein cows that had led to decreases in size and concurrent increases in fertility. Further work is needed to confirm the role of birth weight and early growth on subsequent fertility.

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