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Effect of prepubertal and postpubertal growth and age at first calving on production and reproduction traits during the first 3 lactations in Holstein dairy cattle

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ABSTRACT

The objective of this study was to evaluate the effect of body condition score (BCS), body weight (BW), average daily weight gain (ADG), and age at first calving (AFC) of Holstein heifers on production and reproduction parameters in the 3 subsequent lactations. The data set consisted of 780 Holstein heifers calved at 2 dairy farms in the Czech Republic from 2007 to 2011. Their BW and BCS were measured at monthly intervals during the rearing period (5 to 18 mo of age), and the milk production and reproduction data of the first 3 lactations were collected over an 8-yr period (2005 to 2012). The highest milk yield in the first lactation was found in the group with medium ADG (5 to 14 mo of age; 0.949 to 0.850 kg of ADG). The highest average milk yield over lifetime performance was detected in heifers with the highest total ADG (≥0.950 kg/d). The difference in milk yield between the evaluated groups of highest ADG (in total and postpubertal growth ≥0.950 kg/d and in prepubertal growth ≥0.970 kg/d) and the lowest ADG (≤0.849 kg/d) was approximately 1,000 kg/305 d per cow. The highest milk yield in the first lactation was found in the group with the highest AFC ≥751 d, for which fat and protein content in the milk was not reduced. Postpubertal growth (11 to 14 mo of age) had the greatest effect on AFC. The group with lowest AFC ≤699 d showed a negative effect on milk yield but only in the first 100 d of the first parity. The highest ADG was detrimental to reproduction parameters in the first lactation. The highest BW at 14 mo (≥420 kg) led to lower AFC. Groups according to BCS at 14 mo showed no differences in AFC or milk yield in the first lactation or lifetime average production per lactation. We concluded that low AFC ≤699 d did not show a negative effect on subsequent production and reproduction parameters. Therefore, a shorter rearing period is recommended for dairy herds with suitable management.

Key words: average daily weight gain, body condition score, calf performance, heifer performance

INTRODUCTION

Age at first calving (**AFC**) is an important factor in dairy herd replacements and can be manipulated by altering growth rates (Ettema and Santos, 2004). The biological interrelationships between growth rate and subsequent reproduction and the ability to produce milk appear to be of great importance for a final economic evaluation of a reduced rearing period (Mourits et al., 1999a). Feeding intensity during rearing can be divided into periods before and after sexual maturity (Abeni et al., 2000; Shamay et al., 2005; Daniels, 2010). One strategy for reducing the costs of milk production could be to shorten the rearing period. Thus, heifers could calve when they are no more than 24 mo old and have adequate body size (Mourits et al., 1999b; Gabler and Heinrichs, 2003; Shamay et al., 2005; Stevenson et al., 2008). This goal requires an ADG of between 0.7 and 0.8 kg/d in a large-size breed (Abeni et al., 2000). According to Shamay et al. (2005), a rapid growth rate from 3 to 12 mo of age led to a decrease in milk production, as a result of an increase in the mammary adipose tissue and its parenchymal content. Increased feeding intensity (ADG higher than 0.7 kg/d) before sexual maturity causes changes in the secretion of hormones in the lactogenic complex, resulting in a reduced number of secretory cells in the mammary gland (Mourits et al., 1999a; Daniels, 2010), and the most critical period is during the allometric phase (Shamay et al., 2005). Moderate feed restriction during the critical period is recommended (Ford and Park, 2001). However, when a delay was induced in the growth rate of calves, full recovery of skeletal size or BW was not achieved by

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compensatory feeding (Shamay et al. 2005). Mourits et al. (2000) found that ADG of 0.9 kg/d in the prepubertal period and a maximum ADG of 1.1 kg/d in the postpubertal period enabled achieving AFC of 20.5 mo. Abeni et al. (2000) found that early calving, following a moderate (0.7 kg/d) and also an accelerated (0.9 kg/d) ADG, negatively influenced milk production and milk fat percentage. Most reports agree that an ADG of approximately 0.7 kg/d for Holsteins during the entire rearing period of dairy heifers is optimal for subsequent maximum milk yields per lactation, with no negative effects up to approximately 0.9 kg/d (Zanton and Heinrichs, 2005). Nonetheless, Lucy (2001) reported negative effects of high ADG on reproductive performance.

Systematic evaluation of the growth and development of heifers is necessary for ensuring ideal management. However, BW does not reflect the level of nutrition or the capacity of the heifer's body (Le Cozler et al., 2008). To find possible deviations from optimal growth, it is necessary to evaluate the development of the skeleton (height) and fat tissue in the body (Shamay et al., 2005). Body condition score, based on a 5-unit scale, is a common method for dairy cow evaluation of fat deposition patterns that can also be used with successful results for heifers (Macdonald et al., 2005). Kadokawa and Martin (2006) reviewed the important role of adipose mass on reproduction and concluded that adipose mass increases as an organism grows. Shamay et al. (2005) determined that an average increase of 0.77 BCS units during the 60 d following the onset of puberty was an integral part of the puberty process. The objective of this study was to determine the effect of BCS, BW, ADG, and AFC in Holstein heifers fed similar diets on milk yield and reproduction traits in the subsequent 3 lactations.

MATERIALS AND METHODS

Data

The data set observed in this study consisted of 780 Holstein heifers that calved at 2 dairy farms in the Czech Republic during 2007 to 2011. The animals were, in general, kept under the same conditions. All the calves were housed in individual hutches equipped with buckets for water and a starter mixture. The calves had free access to water and starter mix and, subsequently, all heifers were fed the same maintenance diet and housed in a free-stall barn after weaning (approximately 3 mo of age). The diet for the heifers consisted of a TMR (a mixture of forage and grain) fed once daily. Two types of TMR were used at each farm. The diets and their nutritional contents are described in Table 1. The first type of TMR was fed up to 12 mo of age and the second type of TMR from 12 mo of age to the end of the rearing period.

All evaluated heifers were fed the same consistent feeding ration, regardless of season of calving. A liveweight of approximate 400 kg was crucial for the first insemination of heifers, and the approximate conception period was 14 mo of age. The height of animals was also considered as a criterion for first insemination to achieve the optimal time for breeding. Heifers were inseminated if the height of the withers reached 130 cm, regardless of their BW. The optimal time for breeding (AI) was determined using farm records along with heat detection with a pedometer. Rapidly growing animals with good reproduction abilities achieved a lower AFC. Farm records of BCS, BW, and respective reproduction and production traits during the first 3 lactations measured within the milk recording system (ICAR, 2012) were used for evaluation. Individual milk production records during the first 3 lactations that lasted at least 250 d were included in the analyses. Lactations were standardized to 305 d. Some of the heifers studied did not finish all the evaluated lactations and some were culled, but their data were used until they left the herd. Lifetime production (**LP**) was then calculated as the lifetime average 305-d production per lactation (milk yield and percentage of protein and fat in milk) in addition to the production of the first 3 lactations and the milk production for the first 100 d of the first lactation. Body condition score was ranked on a standard 5-point scale (Edmonson et al., 1989) and BW were measured at monthly intervals during the period of 5 to 18 mo of age. Farm-trained personnel carried out measurements. Average daily weight gain was calculated using the difference in BW between 2 consecutive months during the period analyzed. Animals did not have the same age at the start of data collection and, therefore, the data set was unbalanced (Table 2). The basic characteristics of the variables in the data sets, including the number of animals with data in each lactation, are listed in Tables 2 and 3.

Statistical Analysis

The ADG of the heifers was divided into 3 evaluated periods (Table 2): prepubertal growth (5 to 10 mo of age), postpubertal growth (period after sexual maturity to insemination: 11 to 14 mo of age), and total period of growth up to the insemination period of the heifers (5 to 14 mo of age). The explanatory variables BCS at 14 mo of age, BW at 14 mo of age, ADG, and AFC (Table 2) were divided into groups and the classification was uniform for all the analyses (Tables 4 and 5).

Distribution of AFC (Figure 1) showed that the most common AFC ranged between 23 and 24 mo of age and,