MILK PRODUCTION IN SWEDISH PRIMIPAROUS DAIRY COWS ASSOCIATED WITH CALFHOOD REARING AND HEALTH

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SUMMARY

Associations of first-lactation milk production with calfhood rearing conditions and health were studied in 2,060 dairy heifers in 107 Swedish herds. Milk production at first test-day after calving (median 27.1 range 7.9–48.0 kg) and during first 305 days of lactation (median 8006; range 3,764–12,136 kg) were modelled. High age at calving was associated with higher production, indicating that high prepubertal weight gain can be compatible with high milk production. Calfhood diarrhoea and fatness at 1st service was associated with a low production. The results indicate that accustoming heifers to large amounts of concentrates before calving is beneficial.

Keywords: dairy cattle, diarrhoea, management, milk production, prepubertal weight gain, rearing, replacement heifer

INTRODUCTION

Feeding and management of the lactating cow influence her milk production. A high milk yield has also been associated with a successful rearing of the replacement heifer. First-lactation milk production is affected by body weight at calving (Carson et al., 2002), and by age at calving (e.g. Moore et al., 1991). In several studies, high feeding regimes and hence high daily weight gains after sexual maturity and during pregnancy have resulted in higher body weights at calving and increased milk production (Little and Harrison, 1981; Foldager and Sejrsen, 1991). However, at an early calving, accelerated postpubertal growth was found to be associated with lower first-lactation milk production (Hoffman et al., 1996) and no effect on mammary development and milk yield was reported by Sejrsen et al. (1982). There is substantial evidence of a negative effect of high weight gains during the period of allometric mammary growth, i. e. from approximately 90 to 300 kg of body weight (Sejrsen et al., 1982). However, contradicting results have been reported by e.g. Stelwagen and Grieve (1992) and Pirlo et al. (1997), possibly be due to different feed intensities, protein levels, periods of study, and ages at calving. Further studies using different types of data are needed to shed light on the complexities of these relationships.

Information on effects of health disturbances during the rearing period on subsequent milk production is surprisingly scarce. Diseases early in life have been associated with increased risks for morbidity later during the rearing period (e.g. Svensson et al., 2006), and long-term effects of calf morbidity on survival and age at calving have been reported (van der Fels-Klerx et al., 2002). Results from institutional herds may not be applicable to commercial production because they differ in management, veterinary service, and priorities. Warnick et al. (1995) studied commercial dairy farms, but failed to detect an association between calf morbidity and subsequent first 305-d and second test-day milk production. Data comprised only 728 heifers from 25 herds and were based on owner-diagnosed calf diseases. Svensson et al. (2003) reported that only half the cases of pneumonia diagnosed by project veterinarian at bimonthly visits were recognized by farmers. Owner recording is hence likely to underestimate the true disease incidence and thus potentially biases the results.

The objective of the present observational study was to investigate the associations of housing, management and farmer- and veterinary-diagnosed clinical disease of dairy calves and replacement heifers on their subsequent first-lactation milk production.

MATERIAL AND METHODS

One hundred and twenty-two dairy farms with 28 to 94 cows in the southwest of Sweden and enrolled in the official milk-recording scheme (Andersson, 1988) were selected based on their housing system for calves and replacement heifers (Lundborg et al., 2003). In 1998, herd sizes in the range of 28 to 94 cows represented 56% of all Swedish dairy herds. In the selected farms, a cohort of all heifer calves born in 1998 (n=3,081) was studied from birth to first calving, or until removal from the study. In total, 179 (5.8%) of the animals died, 267 (8.7%) were culled, and 259 (8.4%) were sold before calving, and 250 (8.1%) were lost to follow-up. Fifty-eight cows (1.9%) lacked production data and 8 cows (0.3%) were excluded due to abortions. All of the remaining 2,060 animals from 107 herds were included (1,029 Swedish Reds, 999 Swedish Holsteins and 40 crossbreeds or animals of other breeds).

Calves were kept in single pens, or in group pens bedded with straw or sawdust until weaning, and then in group pens with slatted floors or deep litter. However, especially heifers on slats were subsequently transferred to similar housing systems as for the lactating cows in the herds, mainly tie-stalls. From breeding to calving, 4% of the heifers were kept in cubicles and 45% in other systems, mainly tethered. At calving, increases in concentrates started ≥3 weeks prepartum in most animals (73%).Grazing was generally practised between May and October; 9% of the heifers were not grazed.

Farmers and project veterinary surgeons, visiting the farms bimonthly to make a brief physical examination of the calves, recorded diseases prepartum. The veterinarians recorded information about building type, housing system, stocking rate, age distribution and indoor feed rations offered, and weighed the feed. Thay also measured the indoor air ammonia concentration, temperature and relative humidity where the animals were reared. For each calf, the farmers were requested to record the breed, the place and time of birth, whether or not the calving had been supervised, the time from birth to first observed ingestion of colostrum, the main method of feeding the first two meals of colostrum to the calf and the main source of the first two meals of colostrum fed to the calf. The farmers were also requested to measure the heart girth of the animals at birth, at weaning, at first service, at turn-outs to pasture and housings in their first and second grazing periods (or if not grazed during corresponding autumns), and at calving. The heart girths were transformed to live weights and corresponding daily weight gains. Body condition was scored by AI technicians at first insemination. Information on monthly milk production and SCC was obtained from the official milk-recording scheme. Milk production from the day after first calving until 305 d of lactation or culling (305-d milk production) was calculated.

Associations of the morbidity of the animals and their housing, feeding, and management before calving with first-lactation milk production were investigated by a linear mixed model using the MIXED procedure in SAS for Windows software package, version 9 (SAS Institute

Inc., Cary, NC, USA). Two continuous outcome traits expressed in kg of energy-corrected milk (ECM) were modelled: milk yield at first test-day before 81 d in milk (ECM1) and 305-d milk production (ECM305). In the model of ECM1, 2,059 observations from 107 herds were included. The analysis of ECM305 used 1,562 observations from 105 herds. Of the excluded records, the majority lacked production data from one or more test milkings.

A total of 67 independent cow- and herd-level variables, representing housing, management, feeding, growth, body condition and health during rearing were considered in the models. Among these variables, 12 were justified by hypotheses and the remaining were possible confounders. Calving weight was considered as a predictor but not included in final models because, based on initial modelling results, it was judged to be an intervening variable (Dohoo et al., 2003). Continuous variables were categorized. When biologically relevant categories were lacking, quartiles were used as cut-off points. Initially, univariable analyses were carried out, testing the predictors (one at a time) possibly associated with each trait (with a random-intercept effect of herd in model) and selecting those significant at Type 3 $P_F \leq 0.30$. Based on previous knowledge and results from the described initial selection, confounding variables representing calving year, calving season, housing system after calving and breed were forced into all models henceforth.

Including the random-intercept effect of herd, remaining selected independent variables were tested once again (one at a time), this time retaining for further analyses only those significant at $P_F \leq 0.20$ and denoting them eligible predictors (of one or both traits). These were type of confinement at birth; housing system from birth to 90 d of age; housing system from birth to first service; diarrhoea before 91 d of age; other disease before 91 d of age; respiratory disease before 91 d of age; daily weight gain from weaning to first service; body condition score at first service; age at calving; amount of concentrates fed 2 months before calving; amount of concentrates fed at calving; increase in concentrate ration 2 months before calving; calving weight; and number of cows in herd in 1998. To utilize as many observations as possible, missing values of continuous cow-level predictors were imputed as the mean value in that particular herd (550 records of calving weight, 443 of daily weight gain from weaning to first service, and 95 of daily weight gain until weaning). The final models were built by a manual stepwise procedure, starting with full models, continuing until all fixed effects were significant at Type 3 $P_F \leq 0.01$. Thereafter, all first-order interactions were tested through a similar backward elimination and retained when $P_F \leq 0.01$; no significant interactions were found. Random-intercept and random-slope terms at the herd level for all fixed effects in the model were tested for inclusion, retaining those significant in a likelihood-ratio test at $P \leq 0.05$.

RESULTS

ECM1 ranged from 7.9 to 48.0 (median 27.1; inter-quartile range [IQR] =23.6–30.5) kg and ECM305 ranged from 3,764 to 12,136 (median 8,006; IQR=7187–8829) kg. Of the total variation in ECM1 and ECM305, 18% and 38%, respectively, resided at the herd level, and the remaining variation at the cow level (estimated from empty variance-component models, without fixed effects). Median age and weight at first service was 531 (IQR=488–605) days and 387 (IQR=357–430) kg, respectively. Median growth rate from weaning to 6–9 months was 726 (IQR=619–824; min.–max. =90–1253) g/day, and from 6–9 months until first service 625 (IQR=539-727; min.–max. =241–1254) g/day.

Higher ages at calving resulted in successively higher production; calving at >930 d gave 2.10 kg higher ECM1 and 975 kg higher ECM305 than calving at ≤783 d. Likewise, production increased successively with higher daily weight gains from weaning to first service; at >738 g, cows had 1.7 kg higher ECM1 and 539 kg higher ECM305 than at ≤598 g. Calving during May to September resulted in a 1.5 kg higher ECM1 and a 166 kg higher ECM305 than calving during the rest of the year. Swedish Holsteins had a 0.8 kg higher ECM1 and a 184 kg higher ECM305 than Swedish Reds, and cows housed in short-stalls had a 2.6 kg higher ECM1 and a 680 kg higher ECM305 than those in cubicles. In addition, cows that had contracted mild diarrhoea during their first 3 mo of life had 344 kg lower ECM305 than those without diarrhoea, a body-condition score ≥3.2 at first service resulted in 256 to 337 kg lower ECM305 than a score ≤2.9, and a large increase in concentrate feeding during the last two months before calving was associated with a high production (at >13.2 kg increase, 876 kg higher ECM305 than at ≤9.5 kg increase). Furthermore, a SCC >1 million cells/ml at first test-day was associated with 1.5 kg less milk on the same day.

Most cases of diarrhoea before 91 d of age (67%) were mild and diseased calves recovered within short.

DISCUSSION

There is convincing evidence for a higher production with increasing age at calving (e.g. Ettema and Santos, 2004), presumably due to a lower energy requirement for growth in older animals, which is supported further by our results.

Daily weight gains from weaning to first service exceeding 738 g/day (fourth quartile) were associated with the highest milk production, with successively higher production levels at increasing weight gains. High daily prepubertal weight gains have been associated with impaired mammary development (Sejrsen et al., 1982) and decreased subsequent first-lactation milk production (Foldager and Sejrsen, 1991). However, Hohenboken at al. (1995) and Zanton and Heinrichs (2005) found curvilinear relationships with positive slopes for daily prepubertal weight gains below approximately 650 and 800 g/day, respectively, and negative slopes for higher weight gains. The most critical period for nutritional influence on mammary gland growth is likely to be before puberty, at 3 to 9 months of age (Waldo et al., 1989). In our study, start of puberty was not recorded, but heart girth was measured either at 6 to 9 months of age or at corresponding time-points, and at first service. Although weight gain from weaning to first service included also some time after puberty, it was probably an acceptable estimate of prepubertal growth. According to Foldager and Sejrsen (1991), the negative influence of a high feed intake during part of the critical period cannot be compensated by subsequently reducing feed intake, even though the overall mean prepubertal growth rate is acceptable. Nevertheless, in this study, growth rates from weaning to 6–9 months exceeded those from 6–9 months to first service. Our data therefore indicate that high prepubertal weight gains are compatible with a high first-lactation milk production under practical Swedish conditions. Similarly, Pirlo et al (1997) reported that Italian Friesian heifers tolerated an average daily gain of approximately 800 g from 100 to 300 kg of body weight without any detrimental effect on future milk production. Based on path analysis, we judged calving weight to intervene in the causal pathway between prepubertal growth and milk production; we found no direct effect of prepubertal weight gain on first-lactation milk production. Controlling for diet, Silva et al. (2002) found that heifers that grew faster did not have impaired mammary development. They suggested that increased body fatness was a better predictor of impaired mammary development and found that body condition score at breeding was negatively correlated with milk yield. This is supported by the fact heifers which were over conditioned at first service had a lowered milk production in the present study.

Higher increases in concentrate feeding during the last two months before calving were associated with a higher milk production compared to moderate increases. The effects of an adaptation to lactation feeding ration starting 3 weeks before calving was evaluated in multiparous cows by Olsson et al. (1998), who found little effect on subsequent milk production. However, it resulted in significantly higher yields in the first month postpartum. Mäntysaari et al. (1999) reported that a high feeding intensity during the last trisemester was associated with higher milk yield, but found no effect of feeding intensity in early gestation.

To our knowledge, this is the first report of an association between calfhood morbidity and first-lactation milk production. Previous studies have included far less animals and hence provided lower statistical power. In the study by Warnick et al. (1995), calculations revealed a power of ≥0.70 to detect a reduction of 500 kg in 305-d milk yield using 728 animals from 25 commercial herds. Diagnoses were made by farmers. The present study, supplementing farmer-diagnoses with veterinary examinations every second month, detected a reduction of 344 kg per cow, corresponding to losses of approximately 100 € per cow. In the present material, most cases of diarrhoea were mild and diseased calves recovered within short.

CONCLUSIONS

Our study confirms previous findings that an increased age at calving is associated with a higher milk production during first lactation, and provides further evidence that a high prepubertal weight gain can be compatible with high milk production and that body fatness at first insemination is associated with a reduced first-lactation production. Furthermore, they indicate that there might be benefits, from a production perspective, of accustoming heifers to large amounts of concentrates before calving. The study suggests that calf-hood diarrhoea is associated with a lowered milk production in the first lactation.

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