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Genetic parameters of milk production traits in response to a short once-daily milking period in crossbred Holstein × Normande dairy cows

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ABSTRACT

Despite its potential utility for predicting cows' milk yield responses to once-daily milking (ODM), the genetic basis of cow milk trait responses to ODM has been scarcely if ever described in the literature, especially for short ODM periods. This study set out to (1) estimate the genetic determinism of milk yield and composition during a 3-wk ODM period, (2) estimate the genetic determinism of milk yield responses (i.e., milk yield loss upon switching cows to ODM and milk yield recovery upon switching them back to twice-daily milking; TDM), and (3) seek predictors of milk yield responses to ODM, in particular using the first day of ODM. Our trial used 430 crossbred Holstein × Normande cows and comprised 3 successive periods: 1 wk of TDM (control), 3 wk of ODM, and 2 wk of TDM. Implementing ODM for 3 wk reduced milk yield by 27.5% on average, and after resuming TDM cows recovered on average 57% of the milk lost. Heritability estimates in the TDM control period and 3-wk ODM period were, respectively, 0.41 and 0.35 for milk yield, 0.66 and 0.61 for milk fat content, 0.60 and 0.80 for milk protein content, 0.66 and 0.36 for milk lactose content, and 0.20 and 0.15 for milk somatic cell score content. Milk yield and composition during 3-wk ODM and TDM periods were genetically close (within-trait genetic correlations between experimental periods all exceeding 0.80) but were genetically closer within the same milking frequency. Heritabilities of milk yield loss observed upon switching cows to ODM (0.39 and 0.34 for milk yield loss in kg/d and %, respectively) were moderate and similar to milk yield heritabilities. Milk yield recovery (kg/d) upon resuming TDM was a trait of high heritability (0.63). Because they are easy to measure, TDM milk yield and composition and milk yield responses on the first day of ODM were investigated as predictors of milk yield responses to a 3-wk ODM to easily detect animals that are well adapted to ODM. Twice-daily milking milk yield and composition were found to be partly genetically correlated with milk yield responses but not closely enough for practical application. With genetic correlations of 0.98 and 0.96 with 3-wk ODM milk yield losses (in kg/d and %, respectively), milk yield losses on the first day of ODM proved to be more accurate in predicting milk yield responses on longer term ODM than TDM milk yield.
Key words: heritability, genetic correlation, three-week once-daily milking, first day of once-daily milking, dairy cow

INTRODUCTION

Short-term implementation of a reduction in milking frequency by using once-daily milking (**ODM**) of dairy cows can benefit dairy farms. This practice can enable dairy farmers to lighten their workloads, to adjust milk production to availability of forage resources or to dairy industry demand, and more generally to manage the herd given zootechnical objectives. Yet despite these benefits, ODM remains a marginal practice in Europe. The main deterrent is the substantial reduction in milk yield that ensues and the associated changes in milk composition. These changes in milk yield and composition have different implications according to whether ODM is implemented throughout lactation or for short periods. When ODM is applied throughout lactation, the dairy farmer wants to maximize the milk production level under the ODM constraint. By contrast, the dairy farmer implementing ODM for short periods wants to reduce milk yield losses when the cows are switched to ODM and maximize milk yield recovery upon resuming twice-daily milking (**TDM**). Milk production level during ODM and milk yield losses upon switching to ODM have been shown to range widely among breeds and among individual cows (Clark et al., 2006; Hickson

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et al., 2006; Phyn et al., 2010; Guinard-Flament et al., 2011; Stelwagen et al., 2013), suggesting that these are genetically determined traits. Milk yield recovery upon resuming TDM has been less well described. Reviewing French ODM experiments, Rémond and Pomiès (2005) report carryover effects increasing from 2.4 to 8% as ODM duration increased to 3 wk.

To characterize the genetic determinism of cows' adaptation to ODM, both ODM milk yield and composition and milk yield responses to ODM can be studied. The genetic parameters for milk yield, milk composition, and SCS in New Zealand cows milked once daily throughout lactation were recently estimated by Lembeye et al. (2016) and compared with those estimated in TDM on a geographically close population. Interestingly, these authors found that heritability coefficients for production traits were comparable in ODM and TDM populations, though slightly lower in ODM populations. To date, no study has estimated the genetic correlations between ODM and TDM milk production traits. McPherson et al. (2007) gave a first approximation by calculating correlations between official estimated TDM breeding values for production traits and estimated ODM breeding values of cows in whole-lactation ODM in New Zealand. These correlations, ranging from 0.75 to 0.84 depending on trait and breed, were high enough to develop an ODM index from a predictive regression equation using estimated TDM breeding values. However, they were not high enough to suggest a complete common genetic determinism. In contrast to milk yield during ODM, no study has been conducted on the genetic determinism of responses (milk yield losses and recoveries) upon switching cows to ODM and upon resuming TDM, presumably because of the large population size required for genetic studies.

Implementing genetic selection on either milk production traits during ODM or milk yield responses to temporary ODM will be profitable only if this practice expands greatly (Stelwagen et al., 2013), which does not seem to be a trend in either Europe or New Zealand. However, for farmers practicing ODM, it would be useful to have some easily measurable predictors of cows' responses in order to detect those that are well adapted to this practice. Two strategies can help meet this goal: (1) determine whether the traits routinely measured and available for the whole population (milk production and composition) are related to milk yield responses to ODM and (2) find an indicator trait that is easy to measure by the dairy farmer before ODM implementation. A single day of ODM might be a suitable candidate as an indicator trait in the second strategy; the most consistent and common pattern that has been reported when cows are switched to ODM is a reduction in milk yield occurring on the first day of ODM (Stelwagen et al., 2013). Charton et al. (2016) recently showed that a 24-h milking interval was associated with a wide individual variability in responses, suggesting the existence of a genetic basis for this trait.

This study thus had 3 objectives: (1) estimate the heritability of milk yield and milk composition during a 3-wk ODM period and the genetic correlations between these traits measured during ODM and TDM, (2) estimate genetic parameters of milk yield responses (i.e., milk yield loss upon switching cows to ODM and milk yield recovery upon switching them back to TDM), and (3) determine whether milk yield and composition during TDM or milk yield responses during the first day of ODM could be suitable predictors of milk yield responses to ODM.

MATERIALS AND METHODS

Experimental Design

This study used 430 Holstein × Normande crossbred cows from the INRA Le Pin experimental farm (49°N 0°W, Normandy, France) in compliance with the national legislation on animal care (French Ministry of Agriculture certification no. B61-157-001). These cows were part of an INRA QTL detection program designed by crossing Holstein and Normande breeds (Larroque et al., 2002). The crossing of the Normande breed and the high-milk-producing Holstein breed was used to maximize QTL detection power. Specifically, the design was as follows: a first generation (F1) was generated by crossing 5 Holstein males with 13 Normande females and 5 Normande males with 11 Holstein females; generation F2 was obtained by mating 10 F1 males with 70 F1 females, and an additional generation denoted F3 was obtained by mating the 5 F1 males with F2 females. Family size was maximized by using systematic embryo transfer and partly embryo sexing. The total design included more than 1,100 F2 and F3 cows. In the present study, 292 F2 and 139 F3 females with ODM data were used. Once-daily milking was practiced in second (n = 416) or third (n = 14) lactation at an average stage of 84 ± 13 DIM. No specific selection was performed on milk production level or on familial origin. The 430 cows were tested in 22 groups over 8 yr.

The experiment comprised 3 successive periods: 1 wk when cows were milked twice daily (control; **cTDM-7d**), followed by a 3-wk period when cows were milked once daily (**ODM-21d**), and then a 2-wk period when cows resumed TDM. Milk yield recovery was examined on the second week after resuming TDM (**pTDM-7d**). The first day of ODM (**ODM-d1**), corresponding to