150. Test-day genetic evaluations: a tool to measure herd resilience through monthly milk records

S. Mattalia[1,2*], M. Rocland[1,2], S. Aguerre[1,2] and M. Poppe[3]

[1]*Institut de l'Elevage, UMT eBIS, 78350 Jouy-en-Josas, France;* [2]*Université Paris Saclay, INRAE, AgroParisTech, GABI, Domaine de Vilvert Bat 211, 78350 Jouy-en-Josas, France;* [3]*Wageningen University and Research, Animal Breeding and Genomics, P.O. Box 338, 6700 AH Wageningen, the Netherlands; sophie.mattalia@idele.fr*

Abstract

This study aimed to explore a herd resilience indicator, LnVar, estimated from monthly test-day records. For each Holstein cow in first parity between 2014 and 2018, the expected milk yields were computed at each test-day, using the genetic and environmental effects estimated from a routine test-day genetic evaluation. LnVar was then estimated for each herd-year, as the natural logarithm of the variance within lactation of the deviation between the expected and the observed milk yields. LnVar presented a high variability and was quite repeatable between years. The herd-years with high LnVar were more productive and showed a greater risk of high somatic cell counts, clinical mastitis and short lactations. This study showed that LnVar is a relevant resilience indicator, even with monthly records. The genetic evaluations using test-day records could provide useful information for herd management.

Introduction

Cows are said to be resilient when they are able to maintain their performances throughout environmental disturbances or recover quickly if they are affected. Management practices can have an impact on these disturbances and the cows resilience. Poppe *et al.* (2019, 2020) showed that the variability of fluctuations around the expected lactation curve, measured through the natural logarithm of the variance of the deviation between the observed and the expected daily milk yields (LnVar) was a promising proxy to measure resilience at the cow and herd levels. However, these studies were based on daily records obtained by automatic milking systems, which limits the potential use of this indicator in commercial farms.

In France, expected lactations are provided by Institut de l'Elevage twice a year to the Milk Recording Organizations (MROs), in order to predict the production of each herd. Predictions use the genetic and environmental effects estimated from a genetic evaluation based on a test-day model. These effects can also be used to construct the expected lactation curve of the cows with past records and knowing their own parameters (year, age and season of calving).

In this study, a herd resilience indicator (LnVar) was estimated for each French Holstein herd using monthly test-day records. The objective was to assess to which extent the conclusions of Poppe's study were still valuable with less regular records, and whether a genetic evaluation could provide information to produce new herd management tools related to resilience.

Materials & methods

Description of the genetic evaluation. A genetic evaluation of Holstein cows was performed in October 2019 on milk yield, based on a test-day model described in Leclerc *et al.* (2008, 2009). This evaluation used all test-day records collected by MROs on Holstein cows in lactations 1 to 3 and having started their first lactation since September 1st, 1989 (more than 14 Mo cows). A random regression test-day model in which the first 3 lactations were considered as correlated traits was applied. In addition to a herd-test-day effect, the shape of the lactation curve defined by parity-region was taken into account, cumulating cubic splines of each level of the effects of calving month, calving age, length of dry period and gestation. Genetic and

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permanent effects were included using a reduced rank model. Days in milk, region-year-parity and herd-year were used to model the residual variance.

Selection of cows and herd-years. We selected test-day records of French Holstein cows in first parity and included in the genetic evaluation. The lactations should have started between September 1st, 2014 and August 31st, 2018 and have at least 2 test-days. Cows should have performed their lactation in one single herd. Only performances observed before 350 days in milk (DIM) were considered and were assigned to a given year corresponding to the calving year (Year n from September n-1 to August n). Selected herd-years should have recording intervals of less than 5 weeks and at least 10 cows in first lactation.

35,719 herds-years met all requirements, corresponding to 711,485 cows (on average 19.9±10 cows per herd-year). Each cow had on average 10.3±1.4 test-day records.

Estimation of LnVar. For each herd-year, LnVar was estimated as follows: first, for a given cow j in herd i and with a performance recorded during the test-day k, the expected milk yield was estimated by the sum of all estimated effects affecting the cow at this test-day. Then the deviation δ_{ijk} was estimated between the observed and the estimated milk yields. The variance of these deviations was used to estimate the individual fluctuation of the lactation curve around its expectation. It was log-transformed in order to be normally distributed:

$$LnVar_{ij} = Ln\ (Var(\delta_{ij}))$$

Lastly, the indicator LnVar of the herd-year i was estimated as the mean of the individual fluctuations $LnVar_{ij}$ of the cows with test-day records in this herd-year.

Herd-year descriptors. Several descriptors were computed to describe herd-years regarding their production level (average milk yield within 305 days MY) and their resilience and health status (percentage of short lactations of less than 90, 120 and 200 days PSL90, PSL120 and PSL200, percentage of cows with at least one test-day above 300,000 somatic cells/ml P300kcel, or with at least one clinical mastitis observed by the farmers PMacl).

Analyses. Pearson correlations were estimated between consecutive years. The association between LnVar and the herd-year descriptors was studied through Pearson correlations and using a one factor linear model (SAS® GLM procedure), in which we tested the effect of classes of LnVar (5 classes, from very low to very high LnVar) on each herd-year descriptor.

Results & discussion

LnVar presented a high variability, with extreme values at more than 4 standard deviations from the mean and a coefficient of variation of 0.26 (Table 1). LnVar was quite repeatable across years (Table 2), which means that the profile of fluctuations in lactation curves of a given herd was only partially affected by one-time events.

Correlations between herd-year descriptors and LnVar were low or moderate (Table 3). Herd-years with high LnVar tended to be more productive and more vulnerable to udder infections (correlations of 0.27 and 0.21 between LnVar and MY and P300kcel respectively).

Table 1. Descriptive statistics of the herd resilience indicator LnVar.

	N	mean	std	min	max
LnVar	35,719	1.26	0.33	-0.12	2.97

Table 2. Correlations between LnVar estimated in consecutive years.

2015-2016	2016-2017	2017-2018
0.49	0.50	0.52

Table 3. General characteristics of herd-year descriptors and correlations with LnVar.

	Abbreviation	Unit	mean	std	Cor. with LnVar
Milk Yield	MY	kg	8,719	1,413	0.27
% of short lact. (<90 days)	PSL90	%	1.4	3.3	0.03
% of short lact. (<100 days)	PSL120	%	2.3	4.5	0.05
% of short lact. (<200 days)	PSL200	%	4.9	7.5	0.08
% of lact. with ≥1 test day with ≥300,000 cells	P300kcel	%	39.1	16.5	0.21
% of cows with ≥1 clinical mastitis within 1st parity	PMacl	%	11.1	13.4	0.04

All effects of LnVar classes on the herd-year descriptors were significantly different from zero (α<1‰). The tendencies mentioned before were confirmed, with large differences between classes illustrated by the contrasts with the middle class (Table 4). The average MY of the highest class was 1,742 kg higher than that of the lowest one and 523 kg higher than that of the middle one. The risk of having at least one test-day above 300,000 cells/ml was 1.55 times higher in herd-years with very high LnVar than in those with very low LnVar (52.1 vs 33.6%). Differences were observed for PMacl, even though the correlation with LnVar was weaker. The percentage of short lactations was higher for both extreme classes, but the risk increased more after 120 DIM for classes with high LnVar than for those with low LnVar (+2.1 vs +0.8% between 90 and 200 days for herd-year classes with very high vs very low LnVar).

Discussion

Our indicator was based on the same principles as described in Poppe *et al.* (2020), with several differences. The first one was the use of monthly test-day records instead of daily data. Large differences could be observed

Table 4. Means of herd performance indicators in different herd-year classes based on LnVar (compared to the middle herd-year class, standard errors within brackets).[1]

	Classes of herd-years based on the LnVar level [2]				
	Very low	Low	Middle	High	Very high
N	643	4,700	25,022	4,345	1,007
MY	-1,219 (55)**	-685 (22)**	0	+466 (23)**	+523 (44)**
PSL90	+0.7 (0.13)**	+0.16 (0.05)**	0.0	+0.20 (0.05)**	+0.3 (0.11)**
PSL120	+0.8 (0.18)**	+0.2 (0.07)	0.0	+0.4 (0.07)**	+0.9 (0.07)**
PSL200	+1.5 (0.30)**	+0.0 (0.12)	0.0	+0.9 (0.12)**	+2.4 (0.23)**
P300kcel	-4.9 (0.64)*	-4.1 (0.26)**	0.0	+6.2 (0.27)**	+13.5 (0.52)**
PMacl	-2.8 (0.53)**	-1.5 (0.21)**	0.0	+0.9 (0.22)**	+0.5 (0.43)

[1] * $P<10^{-3}$; ** $P<10^{-4}$.

[2] Very low: ≤0.6; low: [0.6; 0.93]; Middle: [0.93; 1.59]; high: [1.59; 1.92]; very high: >1.92.

between herd-years, even with less regular performances, and these differences were quite repeatable across years. The second originality was that the expected milk yields at each test-day were based on the effects estimated within a test-day genetic evaluation. Thanks to this approach, expected milk yields were adjusted for the cow genetic abilities (individual peak and persistency), and for the environmental effects estimated at a given stage of lactation. These parameters are currently available for any herd participating to milk recording and can be updated at each new evaluation.

The relationship between LnVar and herd descriptors were consistent with Poppe *et al.* (2020): the greater the fluctuations in lactations (higher LnVar), the more productive the herds and the greater the risk of udder health problems (high somatic cell counts and more clinical mastitis (CM) events). For PMacl, the low correlation with LnVar and the fact that the effect did not increase between the two highest classes of LnVar was probably due to a lack of comprehensiveness of registered CM events in some herds (Govignon-Gion *et al.* 2012).

The relationship between the percentage of short lactations and LnVar was more complex to interpret, since lactations may have been closed for many reasons. A large part of very short lactations were probably due to a low production level, particularly in the herds with a low productivity, and thus in the class with very low LnVar. But Beaudeau *et al.* (1995) showed that early lactation (before the peak of lactation) and end of lactation were the main periods of decision making for culling. Thus short lactations closed after the pick (between 90 and 200 days) likely corresponded to involuntary culling, and the increase in occurrences of short lactations with high LnVar could be interpreted as a lack of resilience.

Conclusions

This study showed that even with monthly data, it is possible to build herd resilience indicators based on the fluctuations of lactation curves, and that the results of a test-day genetic evaluation can provide useful information for herd management. Further investigations should be undertaken, in order to assess the genetic variability of LnVar estimated at the cow level and whether this proxy could be used to select more resilient cows.

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