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

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Abstract

This study aimed to measure herd resilience through the fluctuations of cow lactations, using monthly records. The actual performances of Holstein cows in 1st lactation between 2014 and 2018 were compared to their expected lactation curve. These curves were modelled using the environmental and genetic effects estimated from a genetic evaluation based on a test-day model. For each herd-year, LnVar was calculated using Poppe's et al. approach (2020).

Results showed a high variability of LnVar and that LnVar are quite repeatable between years, positive correlations between LnVar and average milk yield (0.27) and the percentage of lactations with high somatic cell scores (0.21). The risk of mastitis and of lactations closed between 90 and 200 days increases in herd-years with high LnVar.

This study showed that even with monthly data, LnVar is a relevant resilience indicator, and that genetic evaluations using test-days can provide useful information for herd management.

Introduction

Resilient cows are able to maintain normal performances (production, reproduction) when confronted with environmental perturbations. 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 actual and expected daily yields (LnVar) was a promising proxy to measure resilience at the cow and at the herd levels. However, these studies were based on daily milk yield 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 effects (environmental and genetic) 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, knowing their own parameters (year, age and season of calving).

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

Materials & Methods

Herd resilience indicator. Estimated daily milk yields were obtained using the estimated effects calculated thanks to a genetic evaluation of Holstein cows performed in October 2019, based on a test-day model described in Leclerc et al (2008, 2009). This evaluation considered all records of lactations 1 to 3 of cows having started their first lactation since September 1st,

1989. Milk yield was evaluated using a random regression test-day model in which the first 3 lactations were considered as correlated traits. 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 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.
Once the genetic evaluation was performed (more than 14 Mo cows), estimated performances were calculated at each test-day by the sum of all estimated effects affecting the cow at this given test-day. Then for each first parity cow, we calculated the variance of the deviations between the actual and the predicted yields at each recorded test-day. The indicator LnVar was calculated for each herd-year as the average of the individual natural log-transformed variances. This indicator is normally distributed, but it is not easy to interpret. This is why the average of the individual standard deviations (MeanStd) was also calculated.

Selection of cows and herd-years. We selected 1st lactations of French Holstein cows that started between September 1st 2014 and August 31st 2018. Cows should have at least 2 test-days and have performed their lactation within one single herd. This herd should follow A4/B4/R4 or A5/B5/R5 ICAR standards. Moreover, selected herd-years should have at least 10 cows in 1st lactation.
35,719 herds-years corresponding to 9,632 herds, 711,485 cows met all requirements. Performances were assigned to one given year corresponding to the beginning of the lactation (Year n for lactations from September n-1 to August n) and the variance of the deviations was computed using all test-days recorded before 350 days in milk.

Herd-year descriptors. Several descriptors were calculated to describe each herd-year regarding its production level (average milk yield within 305 days MY), and resilience and health status (percentage of short lactations at 90, 120 and 200 days PSL90, PSL120, PSL200, percentage of cows with at least one test-day above 300,000 somatic cells/ml P300kcel or with at least one clinical mastitis recorded by the MROs from farmer's observations PMacl).

Analyses. Pearson correlations were calculated 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 and discussion
LnVar presents 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 is quite repeatable between years (Table 2), which means that the profile of fluctuations in lactation curves of a given herd is only partially affected by one-time events.

Table 1. Herd-Year statistics on deviations between actual and estimated daily yields.

	N	Mean	Std	Min	Max
LnVar	35,719	1.26	0.33	-0.12	2.97
MeanStd	35,719	2.06	0.36	0.99	4.79

Table 2: Correlations of LnVar between consecutive years.

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

Correlations between herd-year descriptors and LnVar are low or moderate (Table 3). Herd-years with high LnVar tend to be more productive (0.27 with MY), and to be more vulnerable to udder infections (0.21 with P300kcel).

All effects of LnVar classes on the herd-year descriptors were significantly different from zero (α <1 ‰). The tendencies mentioned before are confirmed, with large differences between classes illustrated by the contrasts with the middle class (Table 4). Milk Yield average of the highest class is 1742 kg higher than in the lowest one and 523 kg higher than the middle one; the risk of having at least one test-day above 300 000 cells/ml is 1.55 times higher in herd-years with very high LnVar than with very low LnVar (52.1 vs 33.6 %). Differences are even observed with PMacl, for which the correlation with LnVar was weaker. The percentage of short lactations is higher for both extreme classes of LnVar, but the risk increases more after 120 days for high LnVar than for the low ones (+0.8 % between PSL90 and PSL200 for very low LnVar, +2.1% for very high LnVar).

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

	Abbreviation	Unit	mean	std	Cor. with LnVar
Milk Yield	MY	kg	8719	1413	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

Table 4: Means of herd performance indicators in different herd-year classes based on LnVar level (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	-1219 (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] *: Pvalue <10-3;** Pvalue <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

General discussion

Our indicator is based on the same principles as described in Poppe et al, 2020, with several differences. The first originality is that it is based on monthly records instead of daily data.

Important differences could be observed between herd-years, even with much less data, and these differences were quite repeatable across years. The second originality is that the expected lactation curves are built from the effects estimated through a genetic evaluation using a test-day model. Thanks to this approach, each cow gets an expected lactation curve adjusted for its own genetic abilities (individual peak and persistency), and for environmental effects calculated at each stage of lactation. The parameters are available for any herd participating to milk recording and they can be updated at each new evaluation.

The relationship between LnVar and different herd parameters are consistent with Poppe et al (2020): the herd-years with more fluctuations (high LnVar) are more productive, they have higher somatic cell count in first lactation and a greater risk of clinical mastitis. For PMacl, the fact that the effect does not increase between both highest classes of LnVar and that the correlation with LnVar is low is probably due to a lack of comprehensiveness of the records in some herds (Govignon-Gion et al, 2012).

The relationship between the percentage of short lactations and LnVar is more complex to interpret, since lactations may have been closed for many reasons. A large part of very short lactations are 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 peak of lactation) and end of lactation are the main periods of decision making for culling. Thus short lactations closed after the pick (between 90 and 200 days) likely correspond to involuntary culling, and the fact that this risk increases with high LnVar can be interpreted as a lack of resilience.

Conclusion

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 genetic evaluation based on test days can provide useful information for management.

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References

Beaudeau F., Ducrocq V., Fourrichon C. and Seegers H. – (1995). J. Dairy Sci. 78:103-117 https://doi.org/10.3168/jds.S0022-0302(95)76621-8

Govignon-Gion A., R. Dassonneville, G. Baloche and V. Ducrocq – (2012) - Interbull Bull. 46;121-126. https://journal.interbull.org/index.php/ib/article/view/1276

Leclerc, H., D. Duclos, A. Barbat, T. Druet, and V. Ducrocq – (2008) - Animal 2:344–353. https://doi.org/10.1017/S175173110700119X

Leclerc, H., I. Nagy, and V. Ducrocq – (2009) - Interbull Bull. 40:42–46. https://journal.interbull.org/index.php/ib/article/view/986

Poppe, M., R. F. Veerkamp, M. L. van Pelt and H. A. Mulder - (2019) - J. Dairy Sci. 103:1667-1684. https://doi.org/10.3168/jds.2019-17290

Poppe, M., H.A. Mulder., C. Kamphuis and R.F. Veerkamp - (2020) - J. Dairy Sci. 104:616-627. https://doi.org/10.3168/jds.2020-18525