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Application for herd total production forecast based on the solutions from the national test day evaluations

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ABSTRACT: *Tuottoennuste (Yieldcast)* production forecast utility provides yield predictions for each animal in a dairy herd for the year ahead. Predictions are calculated by using solutions from Nordic test-day model and the most recent available cow information. Predictions are made available as monthly totals for all herds participating the national milk recording. Predictions are used for management purposes at herds and by milk processors. The objective of our study was to evaluate how accurate are the predictions in the herd level and in the level of dairy company. The forecasted total herd production was 2-10% lower than total milk received by dairy company. Main reason for the variation was in herd management level prediction, which was unable to predict changes occurred in herd management level in summer 2013. The correlation between estimated and true herd management levels varied between 0.72 – 0.87.

Keywords: Dairy herd management; production forecast; test-day model

Introduction

The Finnish dairy herd management tool *Karjakompassi* (*Cow Compass*) was enhanced in 2011 with a production forecasting utility *Tuottoennuste (Yieldcast)*. This new on-line tool calculates for each animal in a herd the yield predictions for the year ahead. Predictions are based on solutions from the Nordic test-day model (Lidauer et. al (2006)) and on the most recent available cow information in the animal record database, and they are presented as monthly sums (Pitkänen et al. 2011). Yield forecasts are available for all herds participating in the national milk recording and add extra value for participation. The *Yieldcast* service gives prediction for the future and is a partly based on the herd management service *Milky* (Koivula et. al 2007) which monitors the management of the past year. *Tuottoennuste* and *Maitoisa* are offered to the milk producers by The Association of ProAgria Centres. Similar production forecasting is developed in Luxembourg (Meyers, et al 2004).

Yield forecasts are calculated by the Finnish Agricultural Data Processing Centre (MLOY) which has the most recent information available on calving, insemination, drying off and culling for all herds. The test-day model solutions are obtained from the Nordic routine yield evaluations by Nordic Cattle Genetic Evaluation NAV. The solutions needed to for predictions are extracted and preprocessed before they are sent to MLOY.

Forecasts are used for management purposes at herds and by milk processing companies. The latter can predict how much milk they will receive in certain time intervals. The objective of this study was to evaluate how accurate are the predictions on herd level and how useful the information is for the dairy companies. Based on the findings we propose ideas how prediction can be further improved.

Materials and Methods

Data. Monthly yield forecasts from *Yieldcast* and the true herd milk production received by the dairy company Valio Ltd for 5148 herds were obtained from MLOY. The yield forecast data consisted of milk, protein and fat predictions for all animals that were predicted to be in production at least one day within a one-year interval from November 2012 to October 2013. All predictions were calculated in October 2012 and they were based on solutions from the Nordic test-day model evaluation run in September 2012. From the historical management effect solutions MLOY predicts the future management, which predictions were also made available. Finally, realized herd management level estimates were obtained from the solutions of the Nordic test-day model evaluation run in January 2014. The dairy company data included monthly totals of received milk for each herd from the same interval.

Herds with incomplete dairy company data were excluded. In order to evaluate the prediction of monthly herd management levels only the herds with complete information from each test-month from September 2012 to October 2013 were included. This reduced the number of herds to 4084.

Calculation of yield forecasts. The prediction is made in two steps. In the first step predictions are made on which cows in a herd are in production during the prediction period. For those cows, dates of future events must be predicted; insemination, drying off, calving and possible removal from the herd. For some cows, the predictions of action dates are easy to obtain as the relevant information is already available in the database. For example, if the insemination date is known, then the calving date is straightforward to project. On the other hand, if a cow is at the beginning of lactation, both insemination and calving dates must be predicted. However, predictions are updated regularly as the new information is entered to MLOY database and the true insemination date becomes known. At the same time, the prediction interval moves further and new dates must be predicted for distant events. This means that the prediction of events occurring a year ahead is always less accurate than the prediction of events occurring within near future. As an extreme case, the most difficult is to predict production for cows that does not yet exist in the herd.

In the second step, future yields are predicted for cows included in the first step by using solutions from the test-day model evaluation. Test-day model provides an estimate for genetic and permanent environment effects for cows having at least one test-day observation in the evaluation data. In the case a cow does not have any test-day observations, parent average of breeding values is used as an estimate for a genetic effect and a permanent environment effect is set to zero. For cases where prediction is made for a cow having unknown identity, average cows for selected birth years are calculated based on estimates of the test-day model. As many test-day model effects have interaction with e.g., calving season and calving age effects, the dates of cows' future events determine to which classes it belongs for those effects and which solutions are therefore used for predictions. However, test-day model evaluations cannot give solutions for effects which occur in the future. Those model effects have to be either predicted using past data, or solutions from recent time have to be used. The latter is possible if the effects do not change dramatically over time. The future herd management level is the only effect to be predicted by *Yieldcast*. The herd management level is based on sum of three effects in the test-day model: fixed effects of year-month and herd-year, and random herd-test-day effect. The year-month effect describes overall month production levels and the herd-year and herd-test-day effects are herd wise deviations from the overall effect. Future herd management level predictions are based on herd management solutions from test-day evaluation and they are predicted by using a random regression model. This prediction model is an updated version of the model used by Koivula et. al (2007). It includes an overall trend for the herd management which is modeled by a regression line. The regression slope is allowed to change for the last four production years, and monthly trends within a production year are considered to be random effects. They are modeled by a linear trend and three sine functions. A more detailed explanation of the calculation of herd management level prediction can be found from Pitkänen et al. (2011). Finally, the yield forecasts are calculated for each cow by adding up solutions for all the effects under the effect classes determined by cows' future events.

Validation of the forecasts. For an overall validation we compared predicted monthly yield totals and totals received by the dairy company. Herd management level predictions made in October 2012 were compared to the estimates obtained from the test-day model evaluation run in January 2014. It should be noted that the forecast predicts future test-day yields which are expected to be higher than the total bulk milk received by the dairy company because part of the milk is used within herd, or the milk is not sent to dairy due to disease or medication. This is taken into the account in the *Yieldcast* by utilizing herd wise correction factor for monthly yield totals.

Results and Discussion

Monthly totals. Predicted milk yields, received milk yields by the dairy company and their difference are presented in the Figure 1. The monthly predictions stayed constantly below the amount of milk received by the dairy company. At the start of the prediction period, the predictions were 2% lower, in the middle of the period from 5 to 7% lower and at the end of the prediction period 10% lower than the true milk yield.

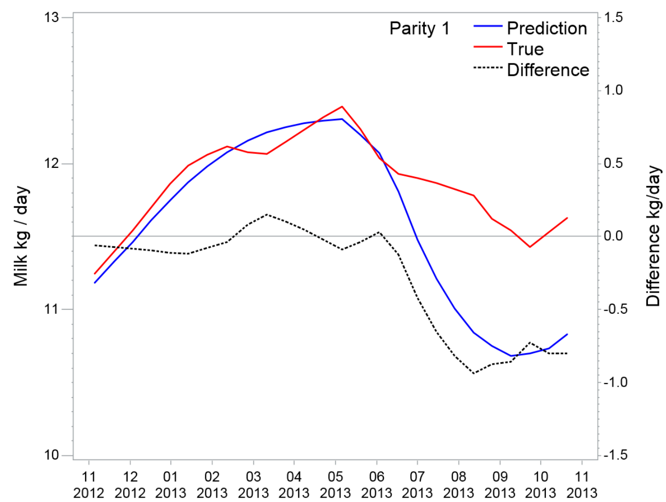

Figure 1: Bulk milk totals predicted by model and actually received by the milk processing plant and their difference from November 2012 to October 2013

Herd management levels. The average of predicted herd management levels and estimated levels based on realized yields, and their differences are presented for the first parity cows in the Figure 2. Note that due to the inbuilt constraints of the test-day model, the actual value of the herd management level in a certain month does not have meaningful interpretation, but the differences between months have. The predictions for the herd management levels from October 2012 to June 2013 followed on average the herd management levels which were later estimated from realized data. However, herd management level estimates started to deviate from July 2013 onwards as the predicted steep descent in herd management levels did not take place. This lead into prediction error of about 1 kg in daily milk production in the most distant month i.e. November 2013. For the cows in later parities (Figure 3), the daily milk yield predictions were around 0.4 to 0.5 kg lower for the first four months and 0.0 to 0.4 kg lower for the following five months. From July 2013 onwards predictions underestimated the realized production level in both parity groups. The correlation between predicted and estimated herd management levels for the first and later parities is presented in the Figure 4. Correlations ranged from 0.85 to 0.87 at the start of the prediction period and declined to 0.72-0.75 around the middle of the prediction period. The correlations for the first parity were constantly lower than for later parities.

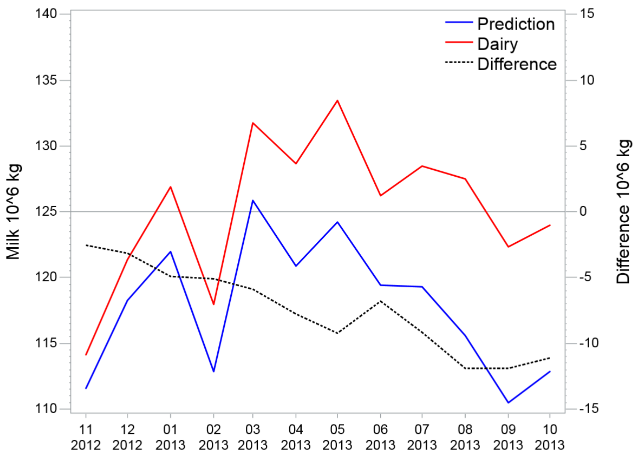

Figure 2: Predicted and estimated herd management levels and the difference for first parity milk in kg/day from November 2012 to October 2013

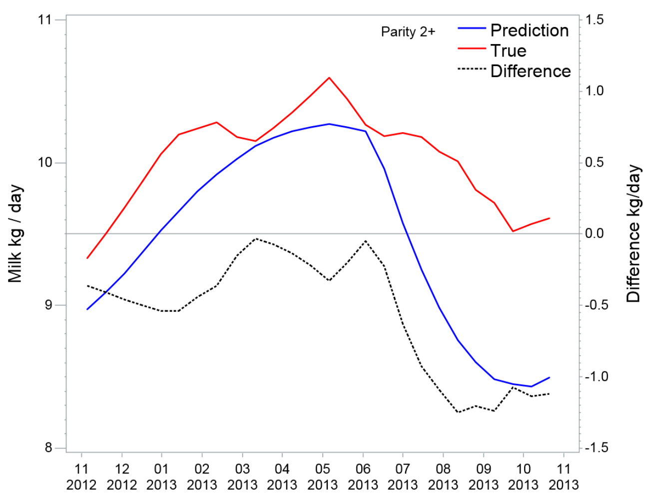

Figure 3: Predicted and estimated herd management levels and the difference for later parities milk in kg/day from November 2012 to October 2013.

The estimated herd management levels based on realized observations show that the herd management levels did not drop in summer 2013 as was predicted. This mainly explains the difference in predicted and true milk yield totals (Figure 1). The current model for the herd management levels offers predictions for herd-specific yearly changes based on the observed levels during the last four years. However, the model does not have any means to predict a sudden general change in the herd management levels due to unexpected environmental factors. In addition, test-day model evaluations are carried out four times a year, which means, considering a data collection time lag, that in the worst case a 17 to 18 month prediction has to be made to predict milk yield for one year.

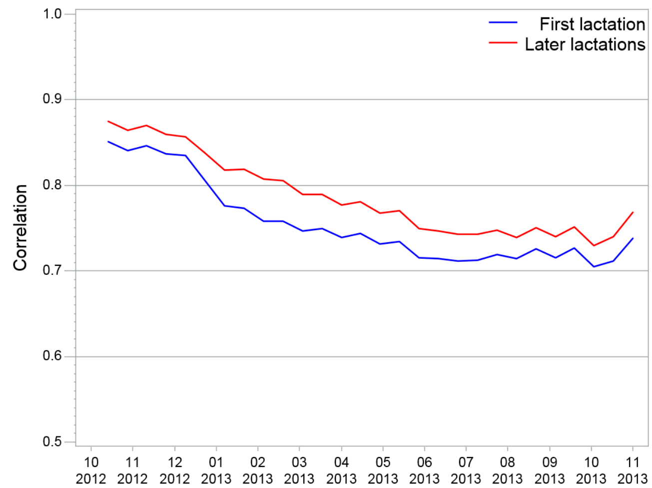

Figure 4: Correlation between predicted and estimated herd management levels for first and later parities from November 2012 to October 2013.

Improving herd management level prediction. The model predicting the herd management level by a linear function of herd effect solutions from the most recent four years was found to be the best when *Yieldcast* was developed. However, as was shown in this paper, this function is too slow to react to the general changes in the trend in herd management level. Therefore, prediction models for the herd management level should be modified so that changes in the true trend are noticed faster. One possibility is to use milk yields received by a dairy company as extra information to adjust herd management level predictions. Moreover, reducing the time lag for transferring test day observations to the MLOY and having shorter routine evaluation intervals would improve predictions for later half of the prediction interval.

Conclusion

We have shown that overall yield predictions works reasonably well for the short term interval. The main reason for error in predictions made for half a year to one year ahead are errors in prediction of the herd management level. The herd management level predictions could be improved by using information from dairy yields especially when changes occur in herd management level that is impossible to predict from the past observations.

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