

Welcome to the NDS Dynamics newsletter!

Impact of nutritional management on dairy cow behavior

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To promote behavioral patterns that optimize rumen health and production, diets provided to dairy cattle must not only promote maximal intake but also have sufficient physically-effective forage, which will promote a slower consumption of feed, in smaller, more frequent meals per day. Such diets are also sorted to a lesser degree and, as a result of greater fiber content and particle size, ruminated more. Despite this, the tendency in the cattle industries is to provide diets that contain moderate levels of forage, which in itself tends to be chopped moderately in length. Lactating dairy cows demonstrate higher degrees of sorting against longer forage particles and for smaller grain concentrate particles when fed lower forage diets (DeVries et al., 2007; 2008). This is particularly troublesome for early lactation cows, where greater sorting of a higher concentrate, lower fiber diet, coupled with rapidly increasing DMI (Kertz et al., 1991), will exacerbate the intake of highly fermentable carbohydrates and refusal of physically effective fiber. Furthermore, lower forage diets are also consumed at a faster rate (DeVries et al., 2007) and ruminated less, resulting in lower salivation rates and, thus, may decrease the buffering capacity of the rumen (Maekawa et al., 2002; Beauchemin et al., 2008).

Diets that are adequate in physically-effective fiber do not necessarily need to contain forages that are excessively long in particle size. Researchers have shown that particles over 4 mm in length may be considered physically effective. Long forage particles, particularly those sitting on the top screen of a particle separator (i.e., >19 mm), are easily sorted and may cause nutrient imbalances. We recently demonstrated this in a study where we provided cows with either one of two diets for the first 28 days of lactation; the only difference in these diets was the length of the wheat straw (chopped with either a 2.54 cm [1 inch] or 5.08 cm [2 inches] screen) that was included in those diets (Coon et al., 2018). In that study, cows sorted their TMR to a greater degree when fed the diet with the longer chopped straw. The decreased sorting by the cows fed the diet with the shorter chopped straw contributed to more stability over the first 28 days of lactation in time spent ruminating per day and ruminal pH. Consequently, cows fed the diet with the shorter straw particle size exhibited more stability in their milk production and tended to produce 75 kg more milk cumulatively over those 28 days than cows fed the diet with straw chopped to longer particle size.

In addition to managing forage components of diets to optimize eating behavior, feed additives that have a positive impact on the rumen environment can also have concurrent benefits for feeding behavior. We demonstrated that supplementing peak-production lactating cows with a live strain of *Saccharomyces cerevisiae* yeast had beneficial impacts on meal patterning (DeVries and Chevaux, 2014); cows had more frequent meals that were smaller and occurred closer in time together. Bach et al. (2007) demonstrated similar effects on feeding behavior, as well as on raising and stabilizing rumen pH. In DeVries and Chevaux (2014), cows supplemented with yeast tended to ruminate longer and have higher milk fat content and yield. Yuan et al. (2015) demonstrated that feeding a yeast culture-enzymatically hydrolyzed yeast product to cows during the dry period and early post-partum period has similar impacts on feeding behavior, with dry cows having more frequent, smaller meals. Similar results have been demonstrated with other feed additives. Lunn et al. (2005) demonstrated that providing monensin increased meal frequency in lactating cows experiencing sub-acute ruminal acidosis. Similarly, Mullins et al. (2012) found that feeding monensin in the first few days after dairy cows were transitioned to a lactation ration resulted in increased meal frequency and decreased the time between meals. The common thread in all of these studies is an association between favorable meal patterns and a reduction in ruminal pH variation. It is likely that feed additives, such as live yeast or monensin, that have the potential to stabilize ruminal pH and fermentation, affect meal patterning as a secondary effect. Specifically, a

more consistent fermentation pattern should result in less variation in VFA production, improved fiber digestibility, and quicker return to eating.

The diurnal feeding patterns of dairy cows fed a TMR are primarily influenced by the time of feed delivery, feed push-up, and milking (DeVries et al., 2003). Of these, the delivery of fresh TMR has the single largest impact on stimulating feeding activity at the bunk (DeVries and von Keyserlingk, 2005; King et al., 2016a). As a result, greater feed delivery frequency can greatly influence feeding behavior patterns, promoting more consistency in feed activity across the day (DeVries et al., 2005). In some studies, greater frequency of TMR delivery has also been associated with greater DMI (Sova et al., 2013; Hart et al., 2014). Further, delivering a TMR 2x/d or more often has also been demonstrated to reduce the amount of feed sorting compared with feeding 1x/d (DeVries et al., 2005; Endres and Espejo, 2010; Sova et al., 2013), which would further contribute to more consistent nutrient intakes over the day. Such desirable feeding patterns are conducive to more consistent rumen pH, which likely contributes to improved milk fat (Rottman et al., 2014). In support of that, Woolpert et al. (2017) reported that dairy herds with high de novo fatty acid concentration in bulk tank milk, compared with those with low de novo fatty acid concentration, tended to be 5x more likely to be fed 2x versus 1x per day, confirming the positive impacts of feeding >1x/d on maintaining a consistent rumen environment.

Feed push-up also helps minimize variation in feed consumed. Greater lying duration is associated with greater frequency of feed push-ups (Deming et al., 2013; King et al., 2016b), suggesting that frequent push-up minimizes the time cows need to spend waiting for feed access and cows can devote more time to lying down. Feed push-up will also ensure that DMI is not limited and thus production is optimized. Evidence for this was shown in a cross-sectional study of 47 herds, all with similar genetics and feeding the exact same TMR (Bach et al., 2008). In that study, it was reported that those herds where feed was not pushed up (5 out of 47 herds) produced 3.9 kg/d/cow less milk (-13% difference) than herds where feed was pushed up. Overall, nutritional management should focus on ensuring good eating behavior in dairy cows. This not only includes proper dietary formulation, of which forage management (amounts, type, and processing) is key, but also the management of that feed to ensure continuous access.



An upgrade of the BCS profile and prediction in NDS

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Introduction

In today's modern precision dairy farms, Body Condition Score (BCS) is a critical value to optimize milk production, analyzing health problems and reproductive performance. Although the evaluation of BCS allows us to "adjust" the current management, if necessary, an accurate prediction of it would allow us to better fine-tuning our diets according to our objectives and the predicted animal responses. Furthermore, ideal BCS profiles, mainly based on high producing Holstein Friesian dairy cows, have been developed against which, the observed BCS can be compared to evaluate the animals' status. In CNCPS v.6.55 BCS is predicted as a function of the animal's energy reserves calculated as the difference between energy inputs and outputs. In the past decades, however, research has proved that that other factors such as nutrient partitioning during different phases of lactation affect BCS. This article gives the reader an overview of the latest scientific developments which have been implemented in the proposed BCS projection tool in NDS, thus giving the user the possibility of making informed choices when interpreting the BCS predictions from the CNCPS and the newly developed NDS- BCS projection tool.

BCS prediction (NRC 2001 and CNCPS)

In 1996 the National Research Council (NRC) developed equations to predict nutrient requirements of beef cattle to compute growth requirements, target weights, and energy reserves. The model was then modified by Fox et al., (1999) to predict body composition for body condition score (BCS) in dairy cattle.

To estimate the amount of energy provided by or required for a one-unit change of BCS, changes in Body Weight (BW) relative to BCS were calculated using the database change of 13.7% of empty BW at BCS 3 (Fox et al., 1999; NRC, 2001). Thus, energy reserves for the next lower and higher BCS were subtracted from the current BCS to compute energy and protein gain or loss

to reach the next BCS. The new equations developed by Fox et al. were thus included in the 7th revised edition of the “Nutrient Requirements of Dairy Cattle (NRC, 2001) and implemented in the CNCPS and NDS.

The current approach, although quite accurate, doesn't take into account nutrients partitioning as the physiological status of the animal changes during lactation. As explained by Johnson et al., (2016), soon after parturition, fat catabolism occurs to provide the extra energy requirements associated with the production of milk. As time progresses, a shift occurs from a priority for milk production to replacing body fat. The point of the shift may differ based on animal production potential. The production potential in the CNCPS refers to the expected peak milk yield, and it is a breed set value; therefore, it doesn't take into account individual variability within a breed, thus risking to not describing accurately the actual cow's potential.

Alternative BCS projection model and BCS profiles in NDS

Based on the abovementioned observations, we at RUM&N generated different BCS profiles according to the class of production performance of different breeds (high, medium, and low production potential breeds) proposing a lower and upper range for each of these profiles. Furthermore, we proposed an alternative improved BCS projection model taking into account fat catabolism and the cows' milk potential. This approach is supported by the observation that fat mobilization increases with increased milk potential.

With the implementation of the fat catabolism equation adjusted according to the actual cows' potential, the energy balance (EnBal either positive or negative) will be partitioned between possible milk production response and mobilized/stored body reserves. This means that in the case of fat catabolism, not all the energy released by the fat mobilization will be used for milk production and, conversely, during the phases of fat anabolism, not all the extra energy will be converted into fat deposits. As a consequence, NDS can generate different BCS projections expected in short (30 days), medium (60 days) and long terms (90 days and at dry off), when compared with those proposed by CNCPS.

To ensure the accuracy of the model, the information entered in the animal inputs section must be accurate (especially age, lactation number, DIM, milk yield, and composition). Based on the information provided the platform estimates the milk production curve and peak milk yield according to a prediction model adapted from Wood (1969). The “cows' actual potential” is then calculated as predicted peak milk yield over the breed-specific peak. With the information imputed and the cows' actual potential, the model will then project the BCS.

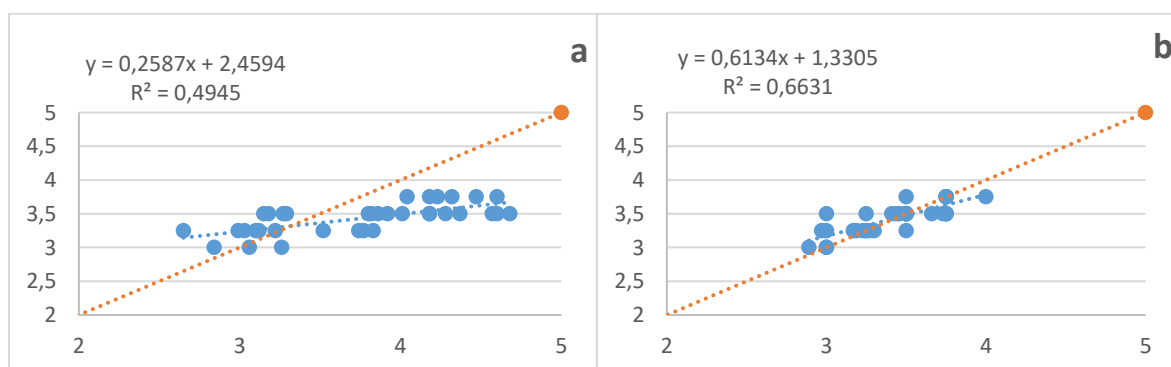
Validation of the NDS-BCS projection model

To validate the proposed BCS projection model, data from 63 pluriparous (3rd to 5th lactation) Jersey cows fed TMR were used. From the day of calving (DIM 0) until 35DIM date regarding milk yield and composition, body weight and BCS were recorded.

Data regarding lactation number, parity, age and BW, BCS, milk yield, and composition at 5 DIM were included in the proposed NDS-BCS projection model (BCS_{NDS}) and the CNCPS based model. The observed BCS taken at 35 DIM was used to validate the models.

The parameters predicted by the CNCPS and BCS_{NDS} models were compared with the observed ones by regressing the simulated BCS on the observed ones.

From the regressions of observed on predicted parameters, the CNCPS model had R² lower than 0.60, with BCS_{NDS} having R² of 0.66. (Figure 1, panel a and b respectively).



From a preliminary observation, the CNCPS model seems to overestimate the loss of BCS at 35 DIM when predicting the BCS of medium to low producing cows, whereas it is more accurate with high producing animals. The BCS_{NDS} model instead, seems to better predict BCS at 35 DIM for both, high producing and medium to low producing cows.

The function in NDS

The figure below shows the “Animal input” section, the section of NDS that gives the possibility of inputting the information about the animals with the relative BCS projections proposed by the BCS_{NDS} model: the expected BCS after 30 and 60 days from the current DIM, and at Dry Off. However, in the tab “Reserves” the BCS proposed by the CNCPS is still reported. Furthermore, by selecting the breed and by typing the milk production, the model will automatically show the user the best-fitting BCS profile.

Animal Inputs		<Recipe CNCPS 6.55>	[Lactating Dairy Cow]	Comparisons [1]	Optimizer	P-Size	Mixer Wagon	Step Feeding	Grazing	What-If Anal
Number of animals	n			155						
Days in cycle	days			365						
Breed type			Dairy							
Primary breed			Holstein	100%						
Secondary Breed										
Average production/head/year	kg			10500						
Lactation number	n			2,50						
Calving interval	months			13,20						
Age at first calving (AOFc)	months			25,00						
Age (actual average)	months			49,00						Expected age months 50,0
Mean FBW	kg			700,0	SBW kg 672,0					Expected BW kg 686,0 (±34)
Mature FBW	kg			750,0	SBW kg 720,0					Reference MBW kg 740,0 (±37)
Days since calving (DIM)	days			150,0						
Days pregnant	days			0						Expected pregnancy days 26
Daily milk production	kg			40,69	liters	39,39				
Milk fat	% w/v			3,77	% w/v	3,90				
Milk total protein	% w/v			3,22	% w/v	3,32				Fat-to-Protein ratio 1,17
Milk true protein	% w/v			2,99	% w/v	3,09				
Casein	% w/v			2,50	% w/v	2,58				Casein number 77,7%
Milk lactose	% w/v			4,83	% w/v	4,99				Other solids % w/v 5,71
BCS (1-5)				2,70	BCS 30d 2,75	BCS 60d 2,83				BCS Dry Off 3,26
Target BCS (or expected)				2,83						
Days to reach target BCS (or expected)	days			60						Days to Dry Off 192
Calf birth weight	kg			41,0						kg 43,0
ADG	kg/day			0,105						

As a related outcome, the feature also provides a graphical representation of the proportion of energy and body fat reserves mobilized for milk production until the dry-off using the scale function modified from Johnson et al. (2016).

From an operational standpoint, the user can enter in the “Target BCS” (or expected) field the value proposed by the BCS projections, and in the “Days to reach target BCS” (or expected), the days corresponding to the BCS selected (e.g. 30 or 60 days). Thanks to this input, NDS will recalculate the available EnBal taking into account the energy partitioning with BCS changes.

Conclusions and Implications

Our results show that the dynamic model proposed by NDS Professional has the advantage to better predict fat catabolism and, therefore, BCS especially when working with medium to low producing dairy cows. Thus, providing users with more accurate decision-making tools.

However, it is important to highlight that the BCS projections provided by the model are based on the current diet and milk production, not taking into account possible changes of diet and variation in milk production with increasing DIM. Therefore, long term projections might not be as accurate as of the short to medium-term projection. Further research is needed for the development of a more comprehensive and accurate model, for the prediction of more accurate long term BCS projections.

Send us your comments on this topic! Emiliano Raffrenato is at emiliano.raffrenato@rumen.it; Giulia Esposito is at giulia.esposito@rumen.it; Dave Weber is at rumendvm@gmail.com

Note that the features and utilities developed by the NDS team described above are not components of the underlying CNCPS model, and do not change the CNCPS outputs or results. Questions about the use of these features should be directed to the NDS support team, and not to the CNCPS group at Cornell.

