NDS Dynamics

July 2020
Volume 8 Issue 4

Welcome to the NDS Dynamics newsletter!

For the Research and Development team at RUM&N, the first half of 2020 has been very productive. In fact, for the first time, RUM&N participated at the annual meeting of the American Dairy Science Association presenting the work conducted by E. Raffrenato, A. Ferrari and E. Melli on updated NDF characterization implemented in NDS Professional, and the work conducted by G. Esposito, M.T.N. Shipandeni, E. Raffrenato and E. Melli on the update on the BCS profile prediction in NDS Professional. The meeting was virtual and the presentations were all recorded.

Take a look at the presentations by scanning the QR codes below or clicking on the YouTube links:

Updated NDF characterization implemented in NDS Professional	***A dynamic approach for BCS prediction in NDS Professional***
https://youtu.be/udbdwPHpXQ0	https://youtu.be/Eh_pZDA1cKE

In this issue professor Gregory B. Penner from University of Saskatchewan talks about low feed intake in cows, whereas Dr. Emiliano Raffrenato from the RUM&N R&D department talks about calves nutrition and how to optimize the weaning program by using NDS Professional. Take a moment to read the articles and please Send us your comments on these topics! Emiliano Raffrenato is at emiliano.raffrenato@rumen.it; Giulia Esposito is at giulia.esposito@rumen.it; Dave Weber is at rumendvm@gmail.com

Low Feed Intake in Cows

By Gregory B. Penner

University of Saskatchewan

Practical Relevance of Low Feed Intake

Dairy cattle are often, albeit inadvertently, exposed to periods of low feed intake (**LFI**). An example for a transient period of low feed intake is for dairy calves during the weaning transition where the increase in starter intake may not compensate for the reduction in milk or milk replacer DMI (Wood et al., 2015). Transition dairy cattle also experience a transient period of LFI around calving. In fact, a literature review reported that the severity of FR ranges from a reduction of intake up to 68% on d 1 pre-partum relative to 21 d pre-partum for dairy cattle (Hayirli et al., 2002). Although the range in low feed intake is large, on average, cattle reduce their feed intake by 33% with nearly 90% of that reduction occurring in the last week prior to calving. More recent studies have supported the results of Hayirli et al. (2003) as Janovick and Drackley (2010) demonstrated that transition dairy cattle reduced intake by up to 30% as parturition approached and Penner et al., (2007) reported greater than a 30% reduction in primiparous heifers. The extent of LFI can be exacerbated for transition cows in association with infectious diseases or metabolic and digestive disorders (e.g. displaced abomasum, ketosis; Van Winden et al., 2003; Goldhawk et al., 2009) and numerous studies have been able to identify associations between risk for metabolic disease and low feed intake pre-partum (Huzzy et al., 2007). Thus, it is clear that dairy cattle experience a period of low feed intake prior to calving and this is coupled with a rapid increase in DMI and diet fermentability following calving.

Environmental conditions can also induce LFI. Heat stress has been reported to lead to marked reductions in DMI (Maust et al., 1972; Knapp and Grummer, 1991; Holter et al., 1996). The magnitude of reduction in DMI differs based on the severity of the heat stress but under experimental conditions, Baumgard et al. (2011) reported a reduction in DMI of 18% when exposed to a temperature-humidity index of 64 and Wheelock et al. (2010) reported a DMI reduction of 30% when exposed to the same temperature-humidity index as Baumgard et al. (2011). It appears that the magnitude of DMI depression varies among cattle when exposed to the same severity of heat stress and it is likely that the depression in intake is exacerbated with greater severity of the thermal heat load.

Effects of LFI on Function of the Gastrointestinal Tract

Although LFI may be transient, past studies in sheep have demonstrated that short-periods of complete feed deprivation can have negative consequences on the absorptive and barrier functions of the rumen epithelium. For example, the transport of Na^+, Cl^-, Mg^{2+}, and short-chain fatty acids (SCFA) were reduced by approximately 50% for sheep exposed to a 48-h period of feed deprivation (Gäbel et al., 1993). With respect to barrier function, Gäbel and Aschenbach (2002) demonstrated that the passive passage of a small hydrophilic molecule (3-O-methyl-α-D-glucose) was increased following feed deprivation in sheep. More recently, we assessed the effect of differing severities of LFI by restricting cattle to 75, 50, or 25% of their ad libitum DMI for a 5-d duration (Zhang et al., 2013a). This study showed that in response to LFI, the concentration of SCFA in the rumen decreased and ruminal pH increased in a dose-dependent manner. The reduction in SCFA concentrations is logical as DMI decreased, but warrants consideration as SCFA provide the bulk majority of the metabolizable energy supply for ruminants. In addition, LFI decreases the potential for SCFA absorption across the reticulo-rumen (Zhang et al., 2013a; Albornoz et al., 2013a) and the rate of absorption tended to be reduced as the severity of the LFI increased. Moreover, permeability of the GIT was increased for heifers exposed to 25% of their ad libitum intake (Zhang et al., 2013a). This suggests that exposure to low feed intake, regardless of the cause (i.e. weaning, heat stress, parturition, transportation, etc.), is likely to reduce metabolizable energy and protein absorption and may predispose cattle to systemic inflammation. Others have also shown that LFI compromises gastrointestinal barrier function and leads to inflammation. For example, Kvidera et al. (2017a) reported that increasing the severity of exposure to low feed intake altered intestinal morphology and increased indicators of systemic inflammation. This is important as there are direct nutritional consequences of inflammation (Kvidera et al., 2017b).

While the impacts of LFI are pronounced and dose-dependent, the severity of LFI alone caused variability in how rapid heifers returned to ad libitum DMI. For example, heifers exposed to LFI at 25% of their voluntary intake required 3 wk to return to pre-LFI DMI, while those restricted to 75% of their voluntary intake only required 1 wk. Exposure to a high-forage diet during recovery reduces the time-lag to resume voluntary DMI (Albornoz et al., 2013b). Collectively, these data suggest that in the absence of other challenges (parturition, weaning, heat stress, etc.), the severity of LFI can affect the recovery rate for DMI.

From a practical perspective, this research also highlighted that LFI is a major predisposing factor for ruminal acidosis. In fact, heifers exposed to the greatest severity of LFI (25% of ad libitum intake) had the lowest DMI and lowest mean ruminal pH (5.88) in the first week of recovery. On average, the duration that pH was less than 5.5 was 6 h/d during the first week of recovery indicating substantial exposure to low pH conditions. Providing a high forage diet following LFI eliminated risk for low ruminal pH. The severity of LFI also affected SCFA absorption during recovery with heifers restricted to 50 and 25% requiring more time to recovery than those restricted to 75%, and permeability of the GIT did not recover for heifers restricted to 25% of their voluntary intake. These data suggest that cattle may require up to 3 wk for the GIT function to recovery after exposure to low feed intake depending on the severity of the LFI event.

Calves nutrition from birth to weaning: one size does not fit all!

By E. Raffrenato
RUM&N R&D Department, Italy

Introduction

In 2001 the NRC stated: "*Calves raised for purposes other than veal production should be encouraged to consume dry feed at an early age to stimulate development of a functional rumen. […]. Female calves should be fed restricted amounts of milk or milk replacer (typically 8-10% of birth weight) to encourage early consumption of calf starter*" (NRC, 2001).

At the time the 2001 NRC was being written there was a scarcity of current information on growth of dairy calves. Luckily, since then we have been learning so much about raising calves and we know that trying to have a functional rumen as early as possible in calves should not prevail over the main purpose in life of such young animals: growth! However, it is not just growth. Pre-weaning, in fact, has been identified as a critical window in development, during which the supply of nutrients to the whole animal, its tissues, organs and even cells plays pivotal roles in the expression of immediate and subsequent responses that affect processes involved in milking, reproduction and immune system. From the literature, in general, positive effects have been found mostly through allowing suckling on increased weight gain, feed intake, development rate of the mammary gland, reduced age at puberty and earlier age at first calving and improvements on overall health, reinforcing the notion of applying high-quality nutrition to shape the productive future of replacements.

Therefore, precision feeding through proper nutritional management has become imperative. The *NDS Professional* platform has developed and updated the calf model to assist users, in view of a holistic approach and to plan the best calf weaning program based on specific and flexible objectives. A "Gold Standard" for optimal growth remains to double the calf birthweight by 8 weeks of age

The NDS calf model

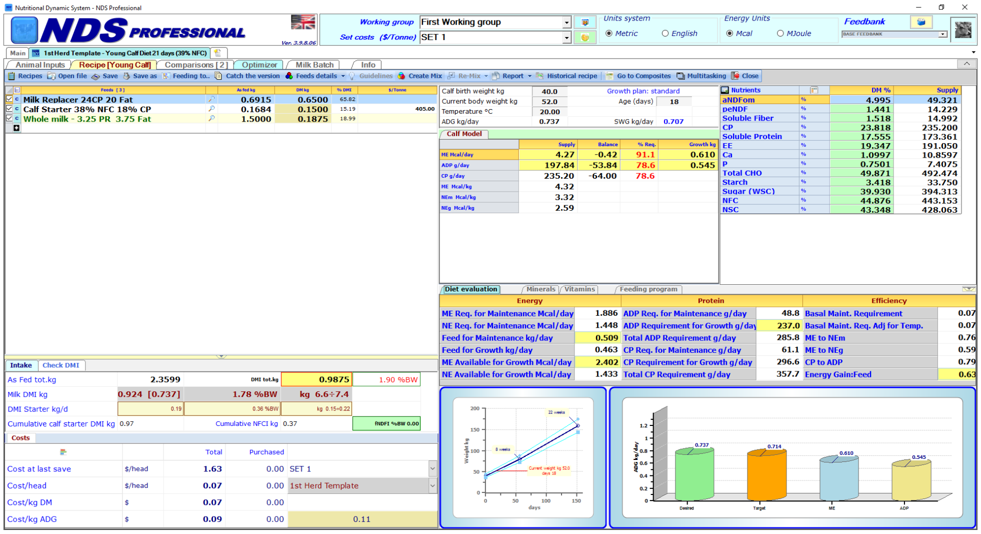
The NDS calf model bases the calves requirements on the ones reported by the NRC 2001 framework, reviewed on the basis of more recent studies conducted at Cornell University and the University of Illinois (Van Amburgh and Drackley, 2005), thus allowing a more mechanistic approach to accelerate calf growth and development. Furthermore, energy requirements have been corrected, taking into account the animal body size as surface area accounting for additional heat loss, and changes in temperature below the thermoneutral zone which imply an increase in energy requirements.

Thus, as per the adult cow, by inputting the data about the animal and by formulating the diet, the diet is evaluated according to the model for energy, protein, minerals, and vitamins. Whole milk and/or milk replacer and different kinds of solid feeds, that will be considered as starter feeds, may be included.

The model thus provides detailed information about maintenance and growth requirement for Energy and Protein, as well as for the efficiency of utilization of the diet. The presence of

some charts help to better understand the dynamics of growth up to 5 months (target vs. desired) as well as the predicted growth and acceptable deviations.

Details about requirements and supply for minerals and vitamins are also provided according to the most recent literature. Below the main window of the Calf model is shown.



Working group: First Working group
Set costs ($/Tonne): SET 1
Units system: ● Metric ○ English
Energy Units: ● Mcal ○ MJoule
Feedbank: BASE FEEDBANK

	Feeds [3]	As fed kg	DM kg	% DMI	$/Tonne
☑	Milk Replacer 24CP 20 Fat	0.6915	0.6500	65.82	
☑	Calf Starter 38% NFC 18% CP	0.1684	0.1500	15.19	405.00
☑	Whole milk - 3.25 PR 3.75 Fat	1.5000	0.1875	18.99	

Calf birth weight kg 40.0
Current body weight kg 52.0
Temperature °C 20.00
ADG kg/day 0.737
Growth plan: standard
Age (days) 18
SWG kg/day 0.707

	Supply	Balance	% Req.	Growth kg
ME Mcal/day	4.27	-0.42	91.1	0.610
ADP g/day	197.84	-53.84	78.6	0.545
CP g/day	235.20	-64.00	78.6	
ME Mcal/kg	4.32			
NEm Mcal/kg	3.32			
NEg Mcal/kg	2.59			

Nutrients		DM %	Supply
aNDFom	%	4.995	49.321
peNDF	%	1.441	14.229
Soluble Fiber	%	1.518	14.992
CP	%	23.818	235.200
Soluble Protein	%	17.555	173.361
EE	%	19.347	191.050
Ca	%	1.0997	10.8597
P	%	0.7501	7.4075
Total CHO	%	49.871	492.474
Starch	%	3.418	33.750
Sugar (WSC)	%	39.930	394.313
NFC	%	44.876	443.153
NSC	%	43.348	428.063

Energy		Protein		Efficiency	
ME Req. for Maintenance Mcal/day	1.886	ADP Req. for Maintenance g/day	48.8	Basal Maint. Requirement	0.07
NE Req. for Maintenance Mcal/day	1.448	ADP Requirement for Growth g/day	237.0	Basal Maint. Req. Adj for Temp.	0.07
Feed for Maintenance kg/day	0.509	Total ADP Requirement g/day	285.8	ME to NEm	0.76
Feed for Growth kg/day	0.463	CP Req. for Maintenance g/day	61.1	ME to NEg	0.59
ME Available for Growth Mcal/day	2.402	CP Requirement for Growth g/day	296.6	CP to ADP	0.79
NE Available for Growth Mcal/day	1.433	Total CP Requirement g/day	357.7	Energy Gain:Feed	0.63

As Fed tot.kg	2.3599	DMI tot.kg	0.9875	1.90 %BW
Milk DMI kg	0.924 [0.737]	1.78 %BW	kg 6.6÷7.4	
DMI Starter kg/d	0.19	0.36 %BW	kg 0.15÷0.22	
Cumulative calf starter DMI kg	0.97	Cumulative NFCI kg	0.37	fNDFI %BW 0.00

		Total	Purchased	
Cost at last save	$/head	1.63	0.00	SET 1
Cost/head	$/head	0.07	0.00	1st Herd Template
Cost/kg DM	$	0.07	0.00	
Cost/kg ADG	$	0.09	0.00	0.11

Calf starter intake prediction

As mentioned earlier, it is well established that intake of calf starter is critical to ensure adequate rumen development and growth during the first few months of life. Given that the fermentation of carbohydrates early in life initiates rumen development, the intake of starter accelerates the time at which calves are prepared for weaning. The NDS Calf Model includes a prediction of the starter intake based on the specific combination calf-starter. Therefore, even in this case, it will be important to have accurate and reliable inputs data for both the calf and the starter. Even though prediction of starter intake on an individual farm will probably differ from another, due to many factors that can influence calf starter intake, this prediction gives an indication of the potential for the intake of dry feeds in calves.

Based on recent research (Quigley et. al., 2019), equations to calculate dietary energy in current models of nutrient requirements for calves (NRC, 2001) do not reflect changing digestibility in young calves and, therefore, may overestimate the contribution of calf starter and other dry feeds to total nutrient supply in the first months of life. As these observations are in agreement with clear field evidence, the Calf Growth Model has been partially modified following the approach proposed by Quigley et. al. (2019) suggesting that cumulative exposure to fermentable carbohydrate may be an important criterion for determining the maturation of the gastrointestinal tract in general and the rumen in particular and is consistent with current theories regarding the importance of fermentable carbohydrate to initiate rumen development (Baldwin et al., 2004; Khan et al., 2016).

Based on this new approach, the energy content of the calf starter increases with increasing cumulative NFC intake supplied by dry feeds.

Calf Feeding Program

The Model comes with a Feeding Program tab designed to provide a feeding plan, consistent with the current or optimal goal (as stated above), from birth to weaning, and based on weekly cycles (i.e. the diet is assumed to remain costant for seven days).

The program assumes the administration of colostrum for the first three days in the amount of 20% the calf birth weight, in three meals the first day, and 15% of the calf birth weight in two meals the following two days. Then, based on current animal inputs, the feeds included in the diet and some additional inputs such as the number of milk feeding per day, the average age in days at which calves are weaned off milk and the targeted total solids content of milk replacer (which should be between 12.5 to 14%), the tool estimates the total amount of milk replacer (with or without the presence of a fixed amount of whole milk) needed throughout the whole weaning period and proposes three alternative weaning plans based on different milk supply plan:

- Flat – if the amount of milk needed is distributed evenly until weaning;
- Weekly – if the quantity of milk distributed generates a delivery curve (increasing in the first part, and decreasing subsequently, when the starter intake increases);
- Fixed – if it is assumed that the quantity of milk included in the ration is given throughout the whole weaning phase.

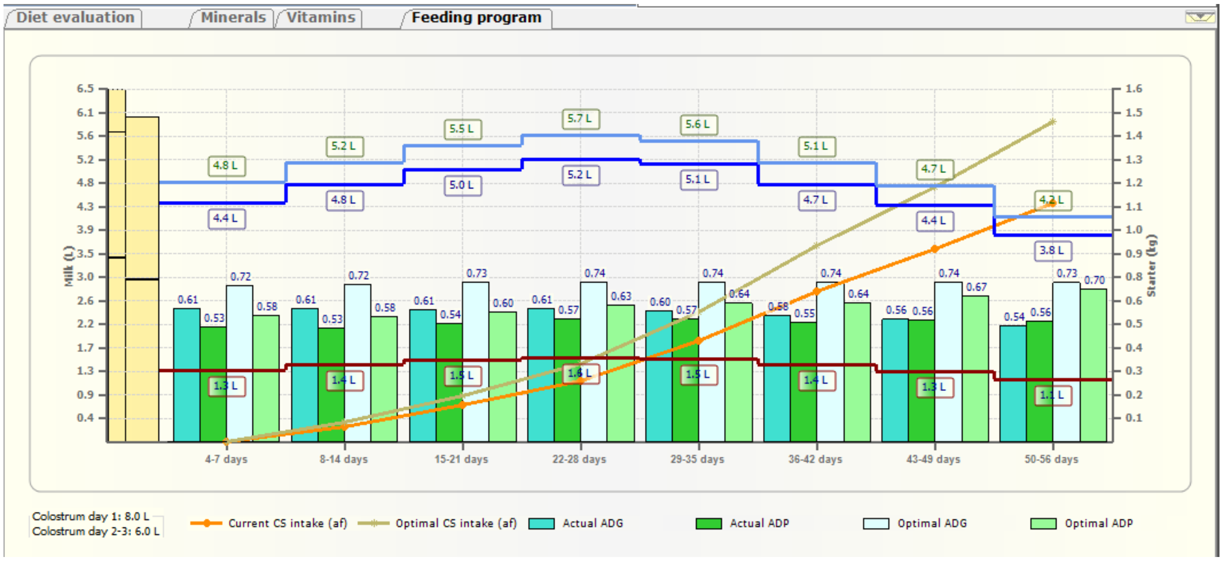
Starter consumption, which is supposed to be significant starting only from the second week, is also predicted for the whole weaning phase, based on the weight and age of the calves, as well as the characteristics of the feeds. Feed delivery is proposed on a weekly basis.

The weekly outcomes of the tab thus include:

- Milk replacer amount suggested – milk powder and amount of water needed to get the desired solid concentration (with or without the possible presence of a fixed amount of whole milk);

- Calf starter expected intake;
- Expected gain per day;
- Feeding costs – both per head and per kg or lbs of ADG.

In addition to the so-called current feeding program (based on the current diet), the system is also able to provide the optimal feeding program, that is based on the assumption of an optimal amount of milk and starter to obtain ADG capable of guaranteeing the achievement of the defined objective (100% of the requirements). The optimal growth objective (chosen in the Animal Inputs tab) can either be standard or accelerated, with the latter attempting to achieve 15% extra body weight at weaning. Below an example of a weekly feeding program is shown. This specific program shows the contemporary use of whole milk (maroon line) and milk replacer (blue lines) and the prediction of starter intake according to the current or optimal setting. The bars show instead the current and optimal gains according to energy and protein available from whole milk, milk replacer and starter intake.



Implications

Lifetime performance in dairy cows, and also other species, is influenced by early life development and dairy producers have the ability to manipulate this early life programming via nutrition. We now know that this manipulation must start immediately after birth and continue for at least 5 weeks and must be in the form of liquid feed to have a positive influence on lifetime performance. NDS has now an updated tool that aims, not only at the diet evaluation but also at showing the user what to expect in terms of starter intake and growth according to the best program possible. The NDS Calf Model can therefore help in making more productive decisions about young calf nutrition. It allows a more mechanistic approach to "ration formulation" for young calf and has the goal to cover the lack of tools for calculating nutrient requirements and supply. The use of this tool aims therefore to re-evaluate the one-size-fits-all approach to calf feeding that currently exists.

You can follow our activities on LinkedIn! We would be glad to count you among our followers!

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 are not components of the underlying CNCPS model. None of the original CNCPS structures or equations have been changed in the NDS platform. NDS does provide sub-models and utilities to provide enhanced predictions based on the original CNCPS model. *Questions about the use of these features should be directed to the NDS support team, and not to the CNCPS group at Cornell.*

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