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Formulating Rations in NDS – Should I Apply a Lead Factor?

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The question of using lead factors came up in a discussion with Dr. Bob Fry back in the winter. Those that know Dr. Fry appreciate that he is an outstanding nutritionist and is a real student of the details of nutrition. He posed the question of what, if any, lead factor we should be using when we formulate rations using CNCPS.

Recommendations for "lead factors" became of interest back in the 1980s when TMRs were becoming popular, and individual feeding became less common. Appropriate lead factors were the subject of several studies at Virginia Tech in the mid-1980s which looked at the optimum level to formulate rations at over a range up to one standard deviation above the group average milk yield; formulating at one standard deviation above the average was expected to cover the nutrient requirements of 83% of the cows in a group. A very common recommendation used to be that the lead factor size should vary with the number of milking groups (Hutjens (1999). The more groups, the more similar the milk yield amounts of individual cows were likely to be, *i.e.* there should be less variance in yield within groups when the herd had multiple groups grouped by production. Hutjens recommended that a one group herd should use a 30% lead factor (1.3 x avg milk), a two group herd should use a 20% lead factor (1.2 x avg milk yield), and a three group system should use a 10% lead factor, or 1.1 x avg. milk, a strategy that was common.

Personally, using CNCPS I do not formulate using a lead factor, but formulate for the group average – even when, as in some of my Idaho dairies, the "group" includes many pens, often at different production levels, fed the same diet. I stopped using lead factors when I first started using the CNCPS model, back before CNCPS v1 was even released in 1990. Part of the reason I do not use lead factors is that I expect the model to predict my current average milk yield correctly, so I start every reformulation by inputting the current diet and inputs. Doing this, it is of paramount importance to accurately describe the current DMI and the current body condition score change expected (Current BCS vs "Target" BCS and days to reach target BCS). Then, when I reformulate, I want to match the predicted yield, or in some cases improve it, but I am not applying a "lead factor", rather I am looking at the current or expected or desired average milk of the cows consuming that diet at the given intake.

After my discussion with Dr. Fry I further pursued this question with Dr. Mike Van Amburgh, who heads the modelling effort at Cornell, and who agreed that formulating for the group average works, and is the strategy he uses when formulating diets. He pointed out a recent research trial done by his group where the cows on the trial were all fed a ration formulated for the average of the group production, and formulated at 14.7% crude protein. The average milk production over the trial period was 97 lbs. of energy corrected milk (ECM) (Fessenden et al. 2016). The production of the 1st calf heifers on that trial ranged from 66 to 119 pounds of ECM, and the multiparous cows produced from 86 to an incredible 161 pounds of ECM (Van Amburgh, personal communication). All on a diet with modest crude protein content and where no lead factor was used in ration formulation!

Dr. Dave Weber, who feeds some very high producing herds in the western US; concurred; he formulates for the group average. He states that the key is knowing the Dry Matter Intake (DMI). Dr. Dave points out that the very idea that most of us employed learning nutrition and how to "challenge" milking cows can now be replaced by using real time values. After entering the current diet, the animal inputs for the group, and the analyses of the feeds, the CNCPS model usually predicts milk production closely **if the intake is a measured and known quantity**. One user noted that entering and adjusting inputs is essentially "calibrating" the model to what the animals are actually doing given the feed and management inputs. After "calibrating", instead of applying lead factors, the nutritionist can then, by optimizing or manual manipulation, attempt to predict 3 to 4 pounds more milk with the same intake and maintain rumen health. Dr. Weber maintains, and the rest of us at NDS and RUM&N agree, that knowing and entering DMI accurately is paramount to the inputs for any ration programming.

There are probably several reasons why formulating without applying a lead factor works well. First, as Dr. Van Amburgh noted in our conversation, cows adjust their intakes to meet their requirements. Related to this, these days forage quality in terms of digestibility is typically far better than it was in the 1980s and 90s, which makes it easier for cows to consume more of a TMR before intake is limited by rumen fill.

In addition, herds today are far more productive than they were in the 1980s and 90s, with less spread between the very low end cows and cows with potential for very high production in the same herd/group. For instance, 55 lbs. average milk yield, there can be many later lactation cows down in the 15-35 lb. range. At the same time there will often be fresh cows that have the potential to yield milk amounts well over the yields of those stale cows; the fresh and high producers will be capable of milk yields that are often 100 pounds or more greater than the stale cows. Back when herds were less productive than today, this meant that if we applied a lead factor to a low producing herd we ended up over-feeding many low producing or late lactation cows in order to meet the needs of the high producers. On the other hand, if we did not apply a lead factor we grossly underfed the higher producers and fresher cows, and cut their peaks off. In contrast, in today's higher producing herds the productive range of the majority of cows present is narrower, so there is less need to overfeed the majority of cows to make sure that the top end cows are not shortchanged. While there are still individual cows underfed or overfed, they are far fewer than there would have been in low producing herds.

The relationship of diet formulation level and group average milk should not necessarily be used in "Fresh" pens however. Especially when the fresh pen contains only very fresh cows, we know the milk yields will be increasing, and we need to support that rapidly increasing milk yield, while at the same time ensure that the diet gets them on feed, minimizes SARA risk, and maximizes intake.

Also, for cows in established lactation, lead factors were more important in formulation prior to the development of CNCPS because estimates of nutrient requirements and supply were less accurate. Part of what a lead factor did was provide a "safety margin" for the nutrient supply and requirements. At that time, ration formulations were based on tabular estimations of both nutrient requirements and nutrient supply from feedstuffs, such as those in the NRC publications "Nutrient Requirements of Dairy Cattle". What changed with the development of CNCPS was that both nutrient supply from feedstuffs and animal nutrient requirements were more precisely estimated in CNCPS. CNCPS was a more dynamic system than the static tables of NRC at that time. For instance, instead of being based on an estimated tabular TDN amount in a feed, energy supply using CNCPS was now derived from more dynamic estimates involving ruminal degradation and passage rates, a dynamic rumen fermentation sub-model, and intestinal digestibilities of protein and carbohydrate fractions. On the nutrient requirement side, using CNCPS, requirements were now determined using better estimates of the requirements for specific physiological functions. Overall, using CNCPS we can now estimate nutrient balances more accurately, thus diminishing the previous need to apply lead factors which partly supplied a "safety factor" because of less precision in knowing the actual nutrient balances.

Finally, another issue with formulating using a lead factor is the consequence in terms of ration density and SARA. When we formulate for a high producing herd milking in the 90 lb. range, the profiles of fiber and SARA risk factors are already close to the limit of wellbeing risk even without a lead factor. Formulating for 100 pounds of milk we usually don't have more room to make the diet any hotter (in terms of effect on ruminal pH) with respect to either diet fermentability or peNDF. If formulated with a 10% lead factor, we would need to somehow stuff the groceries to support 10 pounds more milk into the existing DMI. It can rarely be done without compromising rumen health. So we formulate for the group average, and expect the cows to adapt their intakes (and undoubtedly their efficiencies also) to adjust their nutrient supply. Using a 30% lead factor would obviously be a problem if we tried to stuff enough nutrients for 130 pound of milk into the same dry matter intake of a high group ration where the cows were eating for and yielding at 100 pounds on average.

A corollary to this thinking is that when we formulate, ***we should be formulating at the actual intake of the cows***. If we formulate for say 85 lbs. of milk, and put it into 54 lbs. of intake, but the cows are only eating at a 52 pound intake, it is not really an 85 lb. TMR, it is really only an 81 lb. TMR. By the way, if users hover their mouse over the DMI prediction below the ration ingredients a bubble dialog appears with a DMI min, and a DMI max. These values are the predicted DMI as calculated by the NRC 2001 equation (DMI max), and the predicted DMI (DMI min) as calculated by the Roseler equation in CNCPS. The predicted DMI is the average of these two. When troubleshooting a ration, the actual DMI should be within that range, which can be quite a wide range. If it is not, one should expect there is either a data error, or there is a significant management issue present.

Ultimately, the question of whether or not a lead factor should be applied when using CNCPS to formulate rations cannot be definitively answered. However many CNCPS users with years of experience successfully formulate diets for very high producing herds without applying lead factors. The reasons discussed above contribute to why this can be an effective formulation strategy. The NDS team would be interested in your feedback on this issue, and whether you formulate with a lead factor, and if so, how much of a lead factor you use.

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 model outputs or results. *Questions about use of these features should be directed to the NDS support team, and not to the CNCPS group at Cornell.*

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