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NDS Dynamics

Welcome to the NDS Dynamics newsletter!

Dear readers,

In this issue the column "NDS Updates" is back with a short technical note on the latest update of the B3-kd calculator.

For this month, dedicated to the sensitive topic of nutrient excretions, professor Mike Van Amburgh, from Cornell University, describes the recent modification to the CNCPS for the prediction of nitrogen and phosphorus excretion, and of CO2 an methane. Following, Dr. Emiliano Raffrenato, from the R&D at RUM&N, gives us an overview on how to use NDS professional to evaluate cows' pollution and on how to better manage it.

While we hope to start travelling again soon to offer training and support to our users in person, another interesting virtual workshop dedicated to our users in Europe, Africa, Asia, Middle East and Oceania will be offered from the 8th to the 10th of June (for more information follow this link). In July another workshop will be offered by the NDS North America team for the users from the Americas.

Please continue to follow us on our channels to receive updates on what is new and what is happening at RUM&N and NDS North America.

The Editor
Ermanno Melli

NDS UPDATES

Latest update of the B3-kd calculator.

Recently (NDS Dynamics Newsletter, March 2021), we explained the implementation of the 2-pool rate calculator that took place back in early 2020. The aggregated carbohydrates B3-kd was calculated as a weighted value from the fast and slow pdNDF pools size and rates. This was in agreement with the 2019 paper from Raffrenato et al. (2019) and from previous publications where the 2-pool rate model was described. We have however found that in some cases, typically with more highly digestible NDF and/or very high forage diets (e.g. >65% forage), the resulting 2-pool aggregated kd was over-predicting ME and MP allowable milk, when compared to that observed on farm. This over-estimation due to the B3-kd would, in any case, never be more than 0.5-1.0 kg (i.e.:1.1-2.2 lb) and on average of 0.4 kg (i.e.: 0.9 lb) of milk.

In agreement with Cornell University and Professor Van Amburgh, whom we thank for his cooperation, and after the exchange of various data, we have adjusted this estimation. The B3-kd that the CNCPS will use is now the result of a single-pool kd estimation, more in line with the present version 6.55 of the CNCPS. We will continue to show the slow and fast pools, that will be fully implemented in version 7 of the CNCPS that have already been taken into account to more accurately evaluate forages and their effects on performance. Please also remember that there are various factors in the model other than the rates of digestion that affect ME and MP milk predictions, starting for example from actual dry matter intake, body weight, BCS change and milk components.

Modifications to the Cornell Net Carbohydrate and Protein System related to environmental issues - capability to evaluate nitrogen and phosphorus excretion and enteric carbon dioxide and methane emissions at the animal level

By M. E. Van Amburgh, K. L. Russomanno[†], R.A. Higgs[§] and L.E. Chase**
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The Cornell Net Carbohydrate and Protein System (CNCPS) was developed to predict nutrient supply and requirements in cattle under most management conditions. The ability to develop or integrate extant equations to predict excretion of nitrogen (N) and phosphorous (P) in urine and feces and enteric carbon dioxide and methane is possible as those variables are outcomes of predicting nutrient supply and evaluating requirements.

N and P field study

A field study was conducted using eight dairy herds in New York to evaluate the impact of implementing a PFM program on nutrient excretion to the environment and farm profitability. The dairy herds were in the Upper Susquehanna Watershed which drains into the Chesapeake Bay and were in Delaware, Broome and Tioga counties. The study lasted for 3 years and the herds were selected to represent the number of cows, housing systems and milk production levels typical of herds in this watershed. The herds were selected by the Delaware County PFM staff in cooperation with dairy producers and the feed industry professionals working with the farms. The dairy producers and feed industry professionals were provided with a description of the project as part of the herd selection process. All parties needed to agree to participate for the farm to be selected for the study. There was a cost sharing grant program associated with participation in the study and the dairy producer had to provide a portion of the total project costs.

For diet formulation, there were five nutrition consultants or feed company nutritionists, and different programs were used to formulate the diets for each of the herds. For five of the herds, the CNCPS was used through one of the commercial platforms. The other three nutritionists used programs from the companies that were feeding the herds. To standardize the information from the commercial feed companies, diets not formulated using CNCPS at the beginning of the study were evaluated through CNCPS v6.5 so that all comparisons were conducted using the CNCPS. The evaluation from the CNCPS was especially critical for calculating N and P excretion predictions and making changes to reduce the N and P feeding rates. The initial and final diets over the 3-yr period in each herd were used to determine progress made in reducing N and P excretion, feed cost and income over feed costs using the CNCPS v6.5.

Overall, a 9.2% decrease in average dietary CP levels occurred during the study due to formulating diets with a smaller safety margin above requirements along with adjustments in forage and feeding management practices. Manure N excretion decreased 5.2 to 29% which corresponds to the overall decrease in diet CP. An average decrease in total yearly herd manure N excretion of 14.1% was observed indicating that the herds improved the efficiency of N use and captured more of the intake N in milk. Although dietary CP was decreased the average milk protein yield increased by 8.7% among the herds on study demonstrating improvement in protein utilization as the dietary CP was decreased.

The dietary P levels and manure excretion data in all herds except herd B were at or below the 2001 Dairy NRC requirements (NRC, 2001) at the initiation of the study. Dietary P was lowered to NRC requirement levels in herd B by the end of the study. Changes in dietary P levels were small in the other herds since they were at P requirement levels at the initiation of the project. There was a slight increase in dietary P in herds D, F and H. This was primarily the result of adding some byproduct feeds to the ration due to economic considerations. Manure P excretion changes ranged from +3.7 to -14.3%. However, the changes in manure P (g/day) were small.

Since this study was conducted over a 3-yr period, there were large fluctuations in milk and feed prices. For the reporting and comparisons, the approach taken was to use January, 2017 milk and feed prices for all calculations. This approach was used to ensure an unbiased assessment of the impact of PFM in these herds and the same approach was used in a previous paper (Higgs et.al. 2012b). Total and purchased feed cost decreased in all herds and the same pattern was observed when comparing the change in total herd feed costs. Income over total feed costs increased by $147/cow/yr (range $62 to $266). Income over purchased feed costs increased by $157/cow/yr (range $36 to $361). This indicates that when using constant milk and feed prices, dairy farm profitability was improved by implementing a PFM program

Greenhouse gas predictions

Further, the production of carbon dioxide and methane from cattle has been extensively studied as part of the development of DE, ME and NE equations, thus if the model is adequate at predicting energy supply and balance, predictions of those gases should be possible to implement because gaseous emissions are accounted for in energy predictions. Equations from Casper and Mertens, (2010) for carbon dioxide and Mills et al. (2003) for methane were tested within the CNCPS and demonstrated good accuracy and precision at predicting enteric carbon dioxide and methane emissions (Van Amburgh et al., 2015). The prediction of CO_2 and CH_4 emissions based on total DMI was significant and the relationship was positive. The random effect of farm accounted for 15.2% of the error and was 0.019 kg CO_2 equivalent/kg total DMI (kg) RMSE. Lack of significant RMSE and a R^2 of 0.69 and 0.75 for CO_2 and CH_4, indicated the precision of the CNCPS predictions.

The total emissions of CO_2 and CH_4 per unit of DMI was 0.576 kg/kg DMI and 0.024 kg/kg DMI, respectively. For the byproducts, the predicted emissions of CO_2 and CH_4 per unit of byproduct DMI were 0.05 kg/kg DMI and 0.002 kg/kg DMI, respectively. Finally, as a function of milk yield, the predicted emissions of CO_2 and CH_4 per unit of milk were 0.353 kg/kg milk and 0.014 kg/kg milk, respectively.

The total emission of CO_2/cow was positively related to total milk yield, however, CO_2 emissions/kg of milk as a function of milk yield (kgCO_2/kg milk) resulted in a negative relationship, and is similar to the data described by Capper et al., (2008) and others demonstrating that feed efficiency is an important factor in reducing emissions per unit of milk produced because milk, not the cow, should be the basis for these comparisons as milk serves as the primary nutrient source provided for human consumption. The mean prediction of CO_2 emissions/kg of byproducts was 0.05 and the correlation between CO_2 emission and inclusion of byproduct as a proportion of the total DMI was high (R^2 = 0.81).

Evaluation of methane emission as a function of total ration DMI showed a positive relationship (R^2 = 0.81), and the REML variance component estimate indicated 62.5% of correlation deviation was due to random effects. Methane emissions were positively correlated with milk yield (slope = 0.004; R^2 = 0.68) and negatively correlated when expressed as a function of milk yield (slope = -0.26; R^2 = 0.88) demonstrating that feed efficiency has a negative impact on methane emissions with respect to milk yield.

Comparative Emissions from Animals or Incineration

The data reinforces the accepted relationship between milk yield and CO_2 and CH_4 emissions. As milk yield and DMI increase, CO_2 production increases since it represents the increase in metabolism to produce the increased milk. However, more important is the dilution of maintenance effect that is most relevant to the industry. This has been well described by Capper et al., (2008; 2009) and reinforced by more recent actual farm level measurements (Liu et al, 2012). The relationships between productivity and GHG emissions demonstrate that improvements in feed efficiency have the potential to

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reduce the environmental impact of milk production. Humans require nutrients and a serving of dairy products contain a substantial amount of essential nutrients (Haug et al., 2007) thus when evaluating nutrient alternatives, the first comparison should be the efficiency of nutrient supply from milk and then the second comparison should be to the alternatives for the same supply of nutrients to compare food on an equal basis of environmental impact. The approach taken in this evaluation suggests there is an ecological aspect of the role that livestock play in the process of human food production which needs to be considered when evaluating the role of animal-based food production in the U.S. and this was recently highlighted by White and Hall (2017). There is an important benefit of byproduct use as feed for dairy cattle from an environmental standpoint. The economic benefits, to both the primary industries and the dairy industry, of feeding byproducts reduces the likelihood that industries will dispose of byproducts in less environmentally friendly ways. In comparison to disposal by incineration, rumen digestion of byproduct carbon emits significantly less greenhouse gases and recycles carbon into milk (and meat) for human consumption and manure that is reused in more productive ways. Use of byproducts in diets for cattle reduces the environmental impact of human food production by converting them into high quality protein sources (Patel et al., 2017; Baber et al., 2018; Karlsson et al. 2018) and complements human food production by offsetting the cost of production through the market demand for byproduct feeds. The CNCPS can be used to assess the environmental impact of dairy cattle and improve the environmental efficiency of diets and cattle by nutritionists.

Do you know how much your cow pollute?

By E. Raffrenato
RUM&N R&D Department

When talking about pollution and greenhouse gas emission, often the animal farming is the primary culprit. Although the main cause is fossil fuel emissions, a 2018 peer-reviewed meta-analysis found that a “no animal products” scenario would result in a 28% reduction in global greenhouse gas emissions across all sectors of the economy (Poore and Nemecek, 2018). So, it is true that the sector has to face some challenges, but sometimes we forget that a reduction of “leftovers” of animal production polluting our planet actually go in the same direction of having more efficient and productive animals, and therefore happy farmers!

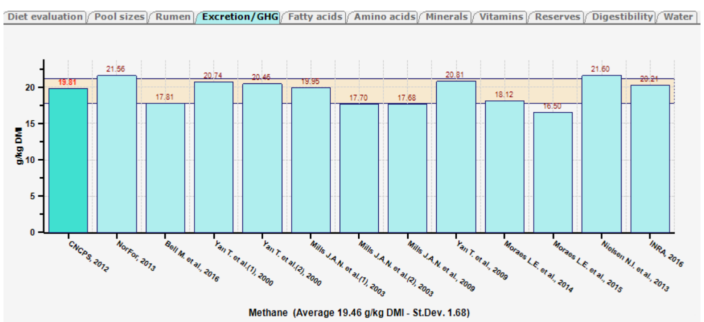
The dairy production sectors that has received substantial scrutiny over the last years, leading to studies evaluating and attempting to reduce nitrogen (N), phosphorus (P), and greenhouse gases (GHG) such as methane (CH_4) and carbon dioxide (CO_2). Obviously, higher producing cows do leave more behind; however, many studies have shown how the higher producing cows leave less behind if measured as amount of pollutant per unit of product (i.e. milk) compared with less intensive systems. We have therefore started to talk about productive efficiency, rather than just yield. Productive efficiency can be defined as “milk output per unit of resource input”, and the advantage from improved productive efficiency relates to what is referred to as the “dilution of maintenance” effect (Bauman et al., 1985; VandeHaar and St-Pierre, 2006). There is also plenty of research on dietary practices that have been shown to reduce carbon-equivalent emissions. Those practices include addition of ionophores, fats, use of high-quality forages, and increased use of grains. There are therefore some compromises and nutritional settings that need to be optimized. NDS Professional has implemented the nutrient excretion submodel of the CNCPS and has added extra information to it (Figure 1). The CNCPS predictions for CH_4 are based on the type of bovine (dry and lactating dairy cows or growing beef cattle) and, among the parameters used, include metabolizable energy available, intake of ADF, lignin and starch per day (Mills et al., 2003; Ellis et al., 2007). NDS Professional gives the possibility of comparing these values with other equations from the literature and expressed as grams of CH_4 per kg of dry matter intake (DMI; Figure 2; Bell et al., 2016; INRA, 2016; Mills et al., 2003 and 2009; Moraes et al, 2014 and 2015; Nielsen et al., 2013; NorFor, 2013; Yan et al., 2000 and 2009). For CO_2, the CNCPS predictions show a curvilinear relationship between CO_2 emissions and DMI and milk yield (Russomanno et al., 2012) and they are reported in kg/day (Figure 3). NDS Professional, also in this case, has added other predictions for comparison purpose (Casper et al., 2010; Kirchgessner et al., 1991; NorFor, 2013; Ranga et al., 2014). Both CH_4 and CO_2 are then converted in various units to compare absolute and efficiency values across various scenarios (Figure 1).

Diet evaluation | Pool sizes | Rumen | Excretion/GHG | Fatty acids | Amino acids | Minerals | Vitamins | Reserves | Digestibility | Water

Fecal excretion and wet manure					Fecal composition					
	Total kg	N g	P g	K g		%		%		%
Dry Feces	8.81				Total CHO	55.34	NDF/NDF diet	50.73	Moisture	17.55
Wet Feces	50.18	254.76	94.07	341.61	Starch	3.18	pdNDF/pdNDF diet	30.59	Protein	18.08
Urine	24.52	217.26	1.36	25.85	Soluble fiber	0.42	Starch/Starch diet	4.96	Lipid	8.32
Wet manure	74.70	472.01	95.43	367.46	NDF	51.30			Ash	18.26
Intake		680.66	130.79	425.48	uNDF	29.34				
Productive		208.65	35.36	52.21	Lignin	12.08				

Productive N/Total N	30.65 %	Productive P/Total P	27.04 %	CH4 (Mcal)	6.75	CO2 (liters/day)	8,429.8
Productive N/Urinary N	0.96:1	Manure P/Total P	72.96 %	CH4 (liters/day)	737.0	CO2 (kg/day)	15.16
Manure N/Total N	69.35 %	Productive K/Total K	12.27 %	CH4 (g/day)	528.28	CO2 (kg/kg milk)	0.39
NH3 Potential	141.22	Manure K/Total K	86.37 %	CH4 (g/kg milk)	13.70	CO2 equivalents (kg/kg milk)	0.74

Figure 1. Excretion and greenhouse gas emissions predicted by NDS Professional and CNCPS.



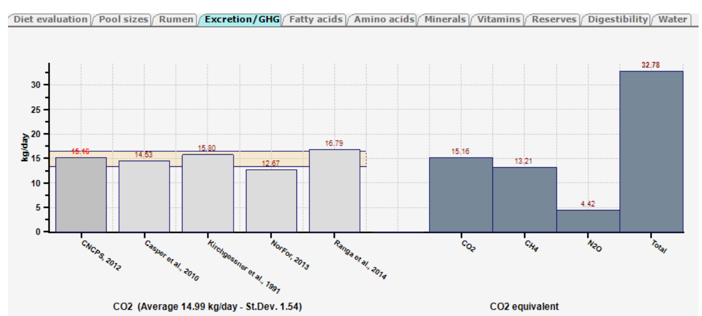


Figure 2. Amount of methane emitted for the animals g/kg of dry matter intake, using various predictions' equations.

Figure 3. Left: amount of CO_2 emitted for the animals (kg/day) using various prediction equations. Right: total CO_2-equivalent and from each source (i.e. CO_2, CH_4 and N_2O)

Send us your comments on this topic! Emiliano Raffrenato is at emiliano@rumen.it; Giulia Esposito is at giulia@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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