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SHIELD (Excel)

Dairy Ration Evaluator

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Nutritional management of dairy cows has advanced rapidly in the past few years. The days of balancing rations with a pen and a piece of paper, while referencing NRC standards, should be well behind us. However, for a number of reasons, dairy cattle nutrition remains an art as much as a science. As more is known, the boundaries of what needs to be known expands. There seems to be little question that nutritional principles have raced ahead of the techniques, particularly analytical techniques, required to support and test them. Hence the art. Nevertheless, much is known and representations of this information in a unified format, often called a model, can be helpful in bringing together what is known so that biological complexities can find their way into practice.

SHIELD is a mathematical model that attempts to synthesize known knowledge of dairy cattle nutrition with what is believed to be true, in order to create a tool that has practical application for dairy cattle nutritionists and nutritional professionals. Thus the amount of information required as model input is minimized, and restricted to that which a dairy producer can reasonably be expected to provide. Expected input information on the cows, their environment, and feeds are all obtainable from animal performance records, cow observations, measurements of the environment and currently available feed assays.

SHIELD has been in development since about 1980. Originally published as the New Brunswick Protein Program (NBPP) in 1992, it was subsequently renamed The Atlantic Protein System (TAPS) in 1995. There were substantial changes to the program associated with this name change that related to calculations of intestinal delivery of protein and animal requirements for dietary protein fractions. In addition, amino acids were added. Early in 1998 the program was renamed SHIELD(DOS). This name change was associated with a substantial increase in the numbers of feedstuffs included in the feed dictionary in order to make it more reflective of all feedstuffs utilized in dairy rations. This current version of SHIELD(Excel) is a microsoft Excel spreadsheet.

PURPOSE of SHIELD

SHIELD was not developed as a ration formulator nor was it developed as a stand alone ration evaluator. SHIELD is designed to be used in one of three ways:

In Ration Formulation

It should be the second step in a process whereby another program such as ‘PC Dairy’, available through UC Davis Cooperative Extension, is first utilized to formulate the ration for all nutrients including energy, protein, minerals and vitamins. This ration can then be used as input to SHIELD for an evaluation of its energy, protein, amino acid, mineral and vitamin status. This approach utilizes SHIELD to determine the biological feasibility of a ration that is proposed to be fed to a group of lactating dairy cows.

In Ration Evaluation

Any known ration that describes known performance of an actual group of cows can be evaluated for its energy, protein, amino acid, mineral and vitamin status. This approach utilizes SHIELD to identify nutrients that potentially limit performance, as well as nutrients that appear superfluous to requirements and may be removed from the ration to increase the efficiency that the remaining nutrient is used for production of saleable products. It can also suggest limitations of SHIELD itself by identifying rations that SHIELD predicts to be infeasible that, based on measured animal performance, occurred.

In Teaching

SHIELD can be used in a teaching format, either with University students, groups of dairy producers or nutrition professionals. In such a forum, SHIELD can be used to demonstrate the dynamic aspects of dairy cattle nutrition and how characteristics of the cows, feedstuffs and environment interact to lead to a likely production outcome. Individuals can also use SHIELD to investigate the impact of various feeding and management scenarios on animal performance.

USE of SHIELD

SHIELD has no user safeguards and will allow the user to input impossible criteria, such as desired milk fat levels of 50% or a crude protein level of 90% in corn grain. Thus users are urged to use caution in their input. However, this approach allows SHIELD to evaluate extreme, biologically improbable, conditions if the user so desires. SHIELD also has no restrictions on changing any predictive equation. However caution is advised.

SHIELD was developed primarily by the author based upon his view of the workings of lactating cows. Much of the data was developed by the author, although that of others has been incorporated in many areas. Most of the data, both that of the author and others, are from studies utilizing Holstein dairy cows producing between 15 and 50 kg of milk per day. The accuracy of SHIELD outside of these bounds is not known.

FEED INPUTS

Measurable characteristics of feeds, which the user is expected to enter as many of as possible, are used to estimate other characteristics of the feeds as well predict animal response parameters. Although all feeds have a complete set of default values in the feed library, the more information that can be provided for the specific feeds used in the defined ration, the more accurate will be the overall evaluation.

User Provided Information

Analyzable characteristics of the feeds for which there is an expectation that the user could and should enter as many values as possible include the intake level of each feed (% of total ration DM), DM (%), OM (% of DM), Fat (% of DM), CP (% of DM), SP (% of CP), ADIP (% of CP), NDF (% of DM), dNDF (% of NDF), Ca, P, K, Mg, S, Na, Cl, Fe, Mn, Zn, Cu, Se, I, Co, vitamins A/D/E, and cost.

Program Predicted Information

There are a number of characteristics of feeds for which there is no expectation that the user will enter values. This may be because the assay procedure is very expensive, difficult to access, unreliable or not available at all. However if actual values are available, the calculated values can be superceded. These include peNDF (% of NDF), NEl (3xM) (Mcal/kg of DM), UIP (% of feed CP that escapes the rumen undegraded), dUIP (% of UIP in the feed that is digestible), NFC (% of DM), energy discount (% of NEl for each increase of energy intake equal to the maintenance energy requirement), NEl (act) (net energy for lactation at the actual intake level specified in Mcal/kg of DM), amino acids (% in the CP in that feed that escapes the rumen intact), total and absorbable amino acids delivered to the intestine (g/d from that feed).

ANIMAL INPUTS

Measurable and observable characteristics of cows, which the user is expected to enter as many of as possible, are used to estimate other characteristics of the cows and evaluate their estimated nutritional balance of energy, protein, amino acids, minerals and vitamins.

User Provided Information

Milk yield, milk fat %, milk protein %, body weight, body condition, body locomotion, daily walking distance, lactation number, average days in milk, minimum days in milk, days pregnant, and expected calf birth weight.

Program Predicted Information

Maternal growth, fetal growth, net maternal BW change.

ENVIRONMENTAL INPUTS

User Provided Information

Average maximum and minimum daily temperatures (^oC), average daily humidity at the maximum and minimum temperatures. An average humidex index is calculated (units).

DRY MATTER INTAKE PREDICTORS

Predictions of Maximum Dry Matter Intake

Maximum daily DM intake allowed by the composition of the ration (kg/d).

Adjustments to Maximum Predicted DMI

Adjusters to DMI known to reflect animal or environmental factors that, in general, cause actual DMI to be lower than the maximum allowed by the composition of the ration. These include the parity of the cows, days in milk, days pregnant, locomotion score, humidex, ration DM %, and ration fat %.

PREDICTED PARAMETERS (MISCELLANEOUS)

Rumen ammonia and peptide nitrogen (g/L), maximum rumen bacterial CP outflow (g/d), actual bacterial CP outflow corrected for DIP undersupply, digestible intestinal bacterial CP (g/d), intestinal flow of total and digestible rumen protozoal CP (g/d), intestinally digestible CP requirement (g/d), BW adjusted for body condition (kg), level of NPN in milk (% of milk CP), casein in milk true protein (% of milk TP), whey in milk true protein (% of milk TP), level of urea nitrogen in milk (mg/dL of milk).

PROTEIN/ENERGY REQUIREMENTS SUMMARY

Total CP required and consumed (g/d), degraded intake protein (DIP) required and consumed (g/d), total soluble protein (SP) required and consumed (g/d), total insoluble DIP required and consumed (g/d), digestible rumen undegraded crude protein (dUIP) required and consumed (g/d), intestinal flow of CP originating from peptides solubilized in rumen fluid (g/d), net energy of lactation (NEl) required and consumed (Mcal/d), NDF minimum, maximum, optimal and consumed (kg/d).

AMINO ACID PROFILES

This section shows levels of amino acids that are assumed to be in the CP of rumen bacteria, rumen protozoa, milk casein, milk whey, body protein tissue and scurf. These values are not modified by conditions of feeding, but can be changed by users.

AMINO ACID SUMMARY

Total and Absorbable Amino Acid Delivery

Intestinal delivery of any amino acid from rumen bacterial origin (g/d), intestinal delivery of any amino acid from rumen protozoal origin (g/d), intestinal delivery of any amino acid from rumen solubilized peptides that wash out of the rumen (g/d), intestinal delivery of any amino acid from feed CP that escapes the rumen intact.

Absorbable Amino Acid Requirements

Scurf AA, urine AA, metabolic fecal nitrogen, Gain & growth AA, body loss AA, lactation AA, and gestation AA (all in g/d).

ABSORBABLE PROTEIN BALANCE

Delivery of Absorbable Protein

The calculated intestinally absorbable delivery of amino acids from feed UIP, rumen microbes and rumen peptides are summarized from previous calculations.

Requirements for Absorbable Protein

Maintenance, milk, BW gain, BW loss, maternal growth, and fetal growth.

NET ENERGY BALANCE

Intake of Net Energy for Lactation

The estimated intake of net energy is calculated as the proportional intake of each dietary ingredient (on a DM basis) multiplied by its actual NEl value in Mcal/kg.

Requirements for Net Energy for Lactation

Milk, maintenance, exercise, urea excretion, maternal growth, heat dissipation, BW gain, BW loss, and gestation.

FEED COSTS

Feed costs are expressed in $ per cow per day by summing the cost of each ingredient in the diet; as $ per tonne of feed fed to the cows by dividing the $/cow/day by the amount of ration consumed (as fed basis); and as $ per 100 litres of milk by dividing the $/cow/day by the milk yield per cow per day.

MINERAL AND VITAMIN BALANCES

Minerals and vitamins are presented as amount consumed, required, and the difference on a daily basis. Dietary requirements for minerals and vitamins are calculated differently for each mineral.

Some nutrient ratios that may be nutritionally important are also presented. Calculation for the Ca/P and N/S ratios are from the requirements and delivery of each nutrient. The required ratio of potassium/(Ca + Mg) is the recommended upper allowable value while the delivered ratio is calculated from the delivery of these nutrients. The DCAD ratios are also calculated from the delivered and required mineral.

INTERPRETING SHIELD OUTPUT

As more of the information that is expected to be provided by the user is actually provided, the accuracy of the outputs predicted by SHIELD will increase. If little input information about the specific case is provided, then the outputs may be very inaccurate. When evaluating the SHIELD output , the suggested sequence of examination is:

First – Check the NEl balance

The NEl balance should be very close to zero, by definition, as energy can neither be created or destroyed. If the difference between the predicted and required NEl values exceeds 1 Mcal, this indicates that there is likely a problem in any or all of the animal criteria, the analytical values describing the feedstuffs, the DM intake, or the body weight change of the cows. However, if there is confidence in the animal criteria, the analytical values describing the feedstuffs, and the DM intake after re-examination, then the NEl balance should be zeroed by manipulating the BW gain and BW loss estimates. This value then becomes the most realistic estimate for net changes in BW.

Second – Check the Maximum NDF intake

If the estimated NDF intake is greater than its maximum predicted intake value, then you should check the specified BW of the cows, the specified NDF values of the ingredients and the specified DM intake of the cows. While NDF intake may actually exceed the predicted maximum, it is not likely for groups of cows unless the rumen fermentability of the NDF is much higher than that specified for the feedstuffs, or if the proportion of NDF contributed from NDF sources of small particle size is very high. Be confident that the values are correct before proceeding.

Third – Check the Absorbable Protein Balance

This balanc indicates the predicted absorbable protein undersupply or oversupply. Negative values indicate that the diet will not provide sufficient absorbable protein to meet the animal's predicted needs (i.e., the ration is biologically impossible). However, unless delivery drops below about 95 of predicted requirements, it is reasonable to accept the ration as feasible within the accuracy of SHIELD predictions. However, values under

95% are unlikely to be possible, except in very early lactation (DPP<30 days), and indicate inaccuracies in input data and/or inaccuracies in SHIELD predictions. Whatever the cause, they cannot be accepted as reasonable and further interpretation of the SHIELD predictions becomes problematic. In contrast to negative values, absorbable protein deliveries in excess of 100% of predicted requirements indicates that the diet provides excess absorbable protein.

Deficits of soluble DIP and/or insoluble DIP do not indicate that the diet will not meet the specified level of performance, as they will depress predicted bacterial growth and result in higher predicted requirements for digestible UIP. However correcting imbalances in soluble and/or insoluble DIP will improve the efficiency of N utilization and may reduce requirements for digestible UIP.

Fourth – Check the Absorbable Amino Acid Balance

The absorbable amino acid balance indicates amino acids that may potentially be limiting performance. However, as with absorbable protein per se, deliveries of any amino acid at less than 95% of requirements are biologically unlikely and indicate inaccuracies in input data and/or inaccuracies in SHIELD predictions. In contrast to negative values, absorbable protein deliveries in excess of 100% of predicted requirements indicates that the diet provides excess of that amino acid relative to its requiremnents. There is some evidence to suggest that adjustments to the delivery of the most limiting of lysine or methionine to bring the lysine/methionine ratio to the ideal may result in performance enhancement of the cows, even when both are supplied at levels in excess of 100%.

QUESTIONS AND OBTAINING A COPY OF SHIELD

SHIELD is a ration evaluator for lactating dairy cows that is designed to be used in conjunction with another ration formulation package, such as PC Dairy, that creates a ration on a least-cost basis. However, SHIELD can also be used to identify potentially limiting, or oversupplied, nutrients in ration/animal situations that are known to have occurred or are projected to occur. SHIELD generated output should be used as a guide to formulating rations for dairy cattle. The University of California and the author make no claims as to their accuracy. SHIELD was developed by:

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