Pcdairy Enterprise: A Computer Package for Formulation and Evaluation of Rations for Dairy Cattle

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ABSTRACT

Pcdairy Enterprise is a package of computer programs for formulating and analyzing rations for dairy cows. It consists of three programs: PCDAIRY ration formulator, SHIELD ration composition evaluator, and CTR ration timing evaluator. The user start with formulating a least cost ration in PCDAIRY and then proceeds to evaluate the composition of this least cost ration in SHIELD, and then proceeds to evaluate the timing of feeding of different components of this least cost ration in CTR. This paper describes these three programs (PCDAIRY, SHIELD, CTR) and the interface between them.

Keywords: Dairy cow, Ration formulation, Ration evaluation, Modeling, United States of America.

INTRODUCTION

Pcdairy Enterprise is a package of computer programs for formulating and evaluating rations for dairy cows. It consists of three programs which communicate with each other via the Extensible Markup Language (XML). The XML is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable (WC3, 2008). The three programs are: (1) PCDAIRY ration formulator, (2) SHIELD ration composition evaluator, and (3) CTR ration timing evaluator. The user start with formulating a least cost ration in PCDAIRY and then proceeds to evaluate the composition of this least cost ration in SHIELD, and then proceeds to evaluate the timing of feeding of different components of this least cost ration in CTR. This paper describes these three programs (PCDAIRY, SHIELD, CTR) and the interface between them.

PCDAIRY

PCDAIRY, a package of computer programs for formulating or analyzing rations for dairy cattle, has been developed with animal nutrient requirements and feed composition data contained in the National Research Council Bulletin, Nutrient Requirements of Dairy Cattle, Sixth Revised Edition (NRC, 1989). PCDAIRY consists

of eight different programs: MAXIMIZE formulates a ration for lactating cows that maximizes income above feed costs based on cow weight, milk yield, fat test, weight change, feed prices and milk price. LC formulates a least cost ration for lactating or dry cows based on cow weight, milk yield, fat test, weight change, stage of lactation, and feed prices. GROWING formulates a least cost ration for growing dairy animals based on sex, breed, age, weight gain, and feed prices. ANLSIS-L calculates the nutrient content of a ration being fed to lactating or dry cows, compares it with National Research Council nutrient standards, and lists the amount of milk that is possible from the ration and the limiting nutrients. ANLSIS-G calculates the nutrient content of a ration being fed to growing dairy animals, compares it with National Research Council nutrient standards, and lists the amount of weight gain that is possible from the ration and the limiting nutrients. FEEDLIST allows users to set up a customized list of feed ingredients for use in any of the above programs. DELIVERY is a spreadsheet program for loading ration ingredients into a mixer for a specified number of cows, and for unloading the mixed ration to a specified number of cows.

PCDAIRY generates an extensible markup language file named Pcdairy.xml for each formulated ration. The xml file consists of three sections: General, Animal, and Feedlist. The General section (Figure 1) contains information about the title of ration and the date it is formulated as well as the unit used in the formulation (English or Metric system). The Animal section (Figure 2) contains information about animal information such as live weight, milk production, percent fat, live weight gain, etc. The Feedlist section (Figure 3) contains information about feeds in the formulated ration and their chemical composition. For example, Figure 3 shows that the ration includes 5.7718 kg of "ALFALFA HAY, 28% ADF" at USD 132.28 per metric ton with a calcium content of 1.8 percent.

SHIELD

SHIELD is a ration composition evaluator, written in Visual Basic for Application language (Robinson, 1999). 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 should be the second step in a process whereby another program such as 'PC Dairy' 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. 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.

User Provided Information

The user provides the following 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. Average maximum and minimum daily temperatures (oC), average daily humidity at the maximum and minimum temperatures. 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

The SHIELD program predicts the following parameters:

Growth

Maternal growth, fetal growth, net maternal BW change.

Dry matter intake predictors

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 %.

Rumen predictors

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)

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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.
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. 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.

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CTR

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CTR is a ration composition evaluator, written in Visual Basic for Application language (Chilibroste et al, 2008). CTR is a mathematical model that attempts to predict nutrient availability in dairy cows managed under discontinuous feeding systems. The model simulates availability of glycogenic, aminogenic and lipogenic nutrients to lactating dairy cows fed discontinuously. The model structure considers input of up to three

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different feeds fed independently at any time during the day. Feeds are described by their nitrogen (N), carbohydrate and fatty acid fractions. The N containing feed fractions include ruminally undegraded crude protein (CP), ruminally insoluble but potentially degradable CP, ruminally soluble CP and ammonia N. The feed carbohydrate fractions include ruminally undegradable neutral detergent fibre (NDF), ruminally degradable NDF, ruminally insoluble starch, ruminally soluble starch and sugars. The fatty acids in the feeds are divided between long chain fatty acids and volatile fatty acids (VFA). Additionally four pools were defined representing absorption of amino acids, glucose, long chain fatty acids and volatile fatty acids. The rumen microbial population is represented as a single pool. Besides a flexible structure, new features to the extant model include adoption of the concept of chewing efficiency (or chewing effectiveness) during eating, variable fractional ruminal absorption rates of VFA and variable fractional ruminal degradation rates of NDF as a function of rumen liquid pH, as well as a variable rumen volume which directly affects rumen concentrations of metabolites. The model continuously (i.e., by minute) predicts release of soluble components from the feeds in the rumen, concentration and absorption of fermentation end products in the rumen, rumen pools of nutrients and microbial biomass dynamics, as well as passage of microbial biomass and non-fermented nutrients from the rumen, in response to various feeding strategies. Model evaluation covered a wide range of feeding...
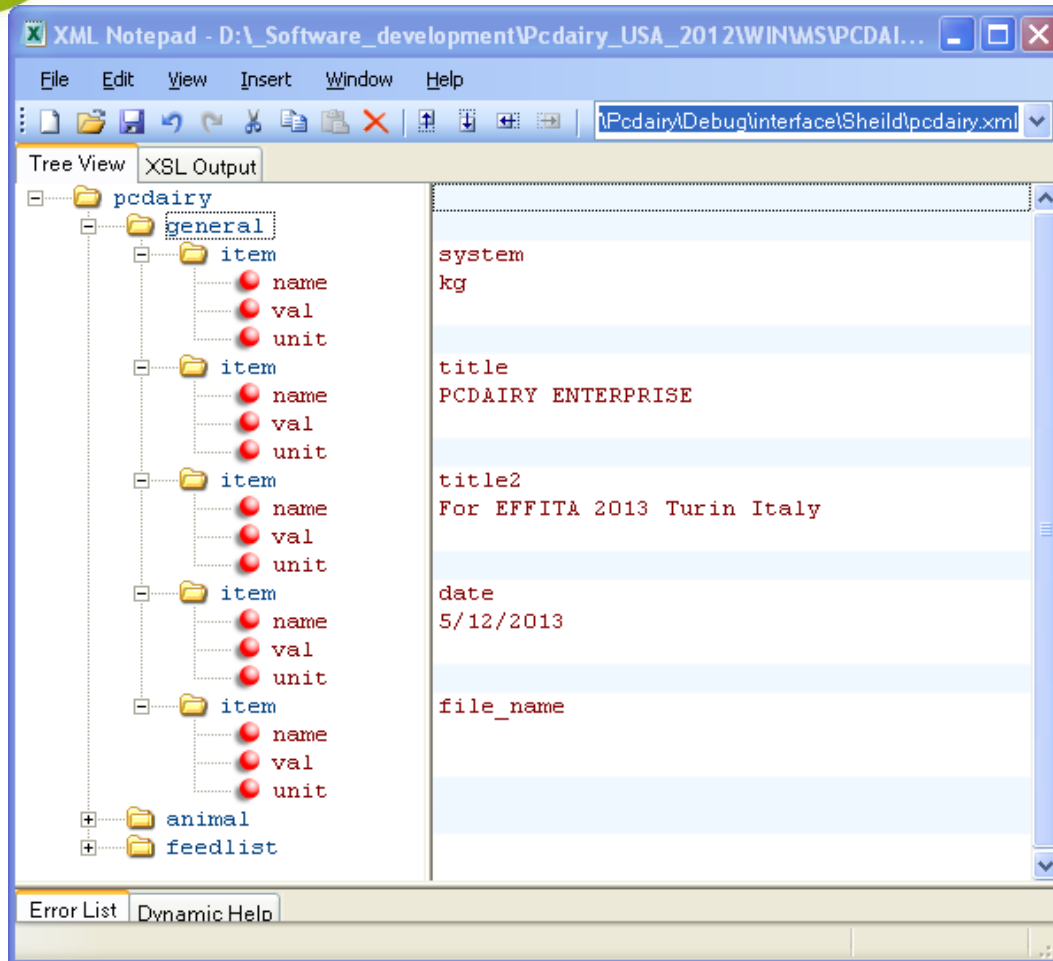
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Figure 1 - Pcdairy.xml file structure: General section

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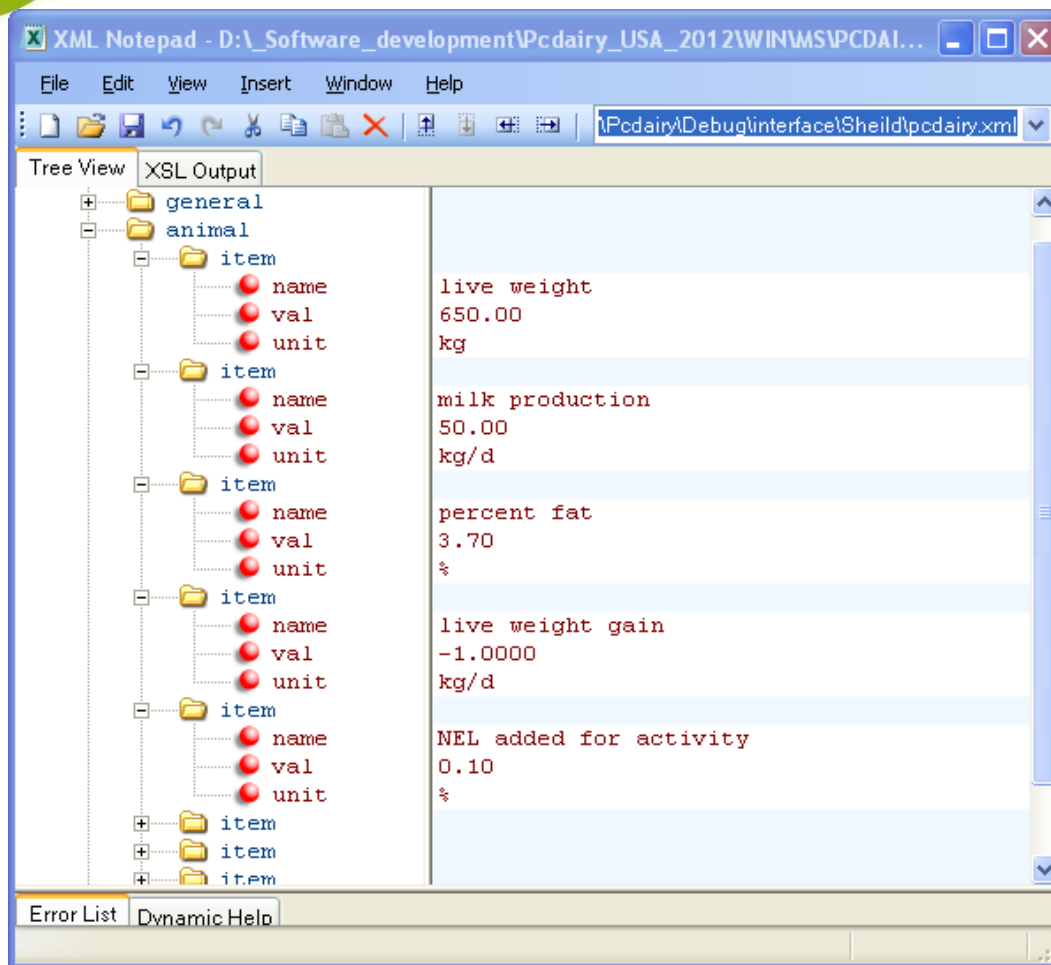CIGR

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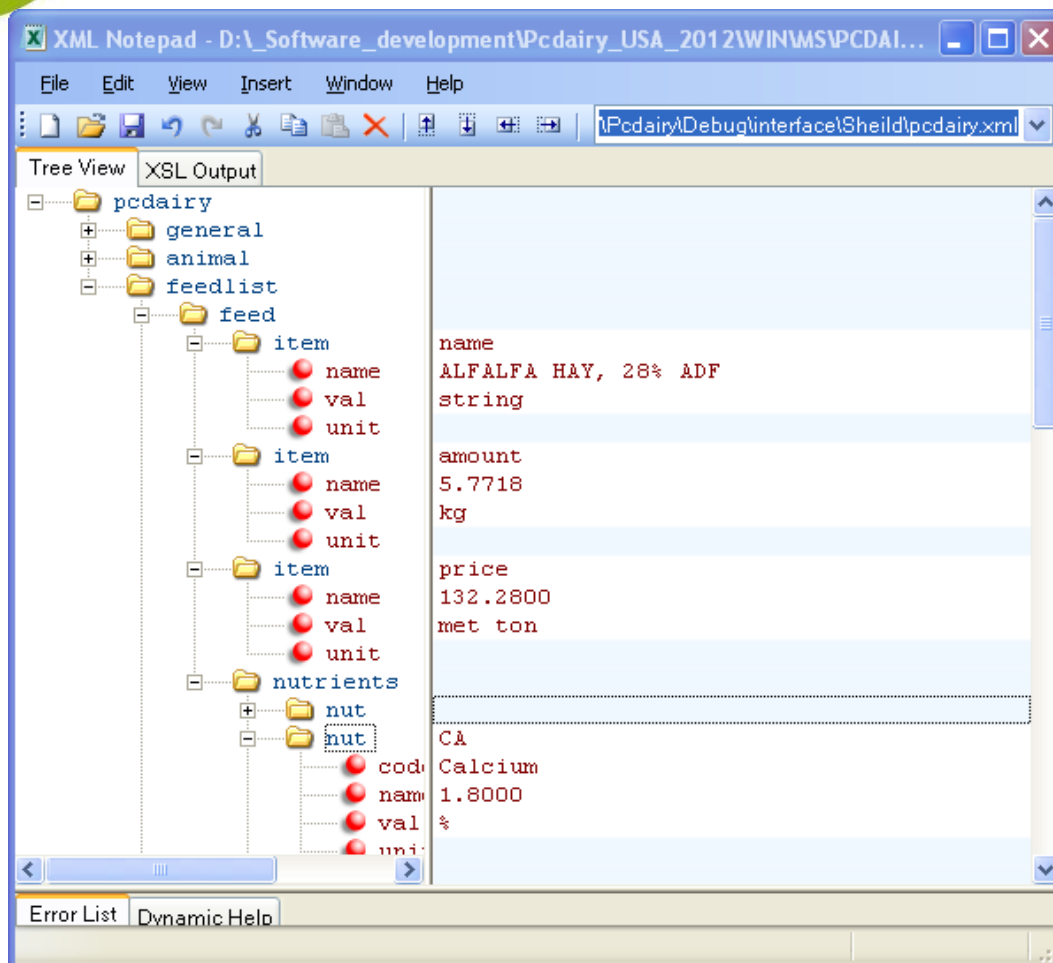Figure 2 – Pcdairy.xml file structure: Animal section.

Figure 3 – Pcdairy.xml file structure: Feedlist section.

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