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Pasture protein and soluble carbohydrate levels in spring dairy pasture and associations with cow performance

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ABSTRACT

In an observational study of nine commercial dairy herds over two springs (four in 1990 and five in 1991) where cows grazed pasture alone, negative associations were found between blood (or milk) urea levels and milkfat and milk protein production, and positive associations of urea levels with pasture protein to soluble carbohydrate (N/Sol.CHO) ratios.

Statistical analyses using principal component analysis of two datasets from spring 1990 and spring 1991 indicated that a high proportion of variation (73% in 1990, and 33% in 1991) in the variables measured was explained by the above relationships. Analysis of variance of the PC scores showed that these relationships were between-farm effects and not related to seasonal change with time ($P < 0.001$).

Additional data from 35 dairy herds in September 1991 also supported the associations found.

Reproductive performance in the nine herds (conception rate and submission rate to AB mating) was also associated negatively with urea levels.

Variations in the nutrient composition of spring pasture during the spring are presented. The correlation between N/Sol.CHO ratio and milk urea levels was high (r=0.69). Further work is needed to clarify cause and effect relationships.

Keywords: Pasture composition. Urea concentrations. Milk production.

INTRODUCTION

Spring pastures in the Waikato district contain 20-30% crude protein and 5-20% soluble carbohydrate (Moller, 1991). This protein concentration is up to twice recommended levels for early lactation overseas. Non-fibre carbohydrate (water soluble carbohydrate + starch + pectin) recommendations for early lactation are approximately 30%. As starch and pectin contents in pasture are likely to be low, this would suggest New Zealand spring pasture lacks non-fibre carbohydrate and has excessive protein levels (N.R.C. 1980; Chase and Linn, 1990; Bull, 1990; McCullough, 1990; Stokes, et al., 1991).

Much of the pasture protein (c.70%) is rapidly rumen degraded (called rumen degradable protein, or RDP) within hours of ingestion, and converted to ammonia (NH_3). Efficient microbial use of the RDP is dependant on readily available carbohydrate sources in the rumen (Stokes et al. 1 & 2, 1991; Khalili and Huhtanen, 1989; Obara et al., 1989). If insufficient readily available carbohydrate is available in the rumen, NH_3 levels will rise, be absorbed into the bloodstream and converted to urea in the liver. Urea levels in the blood and milk will consequently rise (Oltner and Wiktorsson, 1983).

High urea levels from excessive RDP and NH_3 production have been reported to be associated with reduced cow conception rates (Ferguson et al., 1988; Ropstad and Refsdal, 1987; Williamson and Fernandez-Baca, 1992; Ferguson and Chalupa, 1989).

This paper describes the variation present in crude protein and soluble carbohydrate concentrations in pasture samples and blood (or milk) urea concentrations from cows in nine dairy herds during the spring period (four herds in 1990 and five herds in 1991). Principal Component Analysis (PCA) was used to identify patterns of association between the variables -crude protein:soluble carbohydrate ratio (N:Sol. CHO) in pasture, cow serum (or milk) urea concentration, and cow dry matter intakes and milk production.

Some of the data was also examined for possible associations between urea levels and reproductive performance.

In addition, in spring 1991 milk urea and cow milk production data from a further 35 herds were examined for associations using PCA.

METHODS

Three data sets were collected. During spring 1990 pasture samples were collected from four dairy farms selected on the basis of milkfat production level (two high and two average) and previous history of anoestrum (Data A). Representative pasture samples were obtained at 8.30 a.m. at weekly intervals from pasture about to be grazed. Samples were cut to grazing height and stored in a chilled container for less than one hour prior to being frozen. The frozen samples were freeze dried and analysed for crude protein, non-structural carbohydrate and acid-detergent fibre. (Analytical methods: protein - Kjeldahl method for nitrogen determination; non-

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structural carbohydrate - water extraction and gas chromatography analysis for individual monosaccharides; acid detergent fibre - modified Van Soest method; dry matter - oven dried 90° C). Blood samples were obtained from the same 10 cows in each herd selected at random, sampled weekly between 1/8/90 and 15/11/90. Samples were analysed for urea using an Hitachi 717 Autoanalyser. Herd milkfat and milk protein production data were obtained from daily dairy company milk dockets.

In Spring 1991 similar data (B) to Data A were collected from five herds (again chosen on production level and previous anoestrum history), except that urea concentrations were determined on milk samples taken twice weekly from the herd vat. Good correlations (r=0.98) have been obtained between milk and blood urea concentrations (Oltner and Sjaunja, 1982; Oltner and Wiktorsson, 1983). Dry matter intakes were also estimated at weekly or fortnightly intervals using pre- and post-grazing measures with a rising plate meter.

Also in September 1991, data on herd milk urea concentrations and milk production were obtained twice weekly for five weeks from 35 herds (Data C).

Principal Component Analysis (PCA) as described by Joliffe (1986) was used to analyse the data collected. This procedure identifies and describes independent patterns of association between the variables in the dataset, without any prior assumption about what patterns exist or their cause. After PCA, analysis of variance of PC scores can be performed, and in this case was used to determine the extent to which between-farm differences and seasonal changes respectively contributed to the associations between variables which had been identified by PCA.

Bayesian smoothing using the statistical package "Flexi 2.0" has been used for the graphical presentations, on Data A (Fig.1) (Upsdell and Wheeler, 1992: Upsdell 1985). For each farm the predicted value of the variable together with its standard error was estimated at a number of points in time. Then for each time point the mean for the group was estimated using the model.

Farm estimate = group mean + farm deviation + error in farm estimate.

The farm estimate and error in farm estimate was calculated from the within-farm analysis. The group mean was then estimated by solving the REML equations.

RESULTS AND DISCUSSION

The variations in pasture crude protein and soluble carbohydrate (Sol. CHO) in the pastures obtained from the four farms in 1990 are illustrated in Fig.1 together with the changes in serum urea concentration.

All of the parameters varied considerably over time, but in general the lower producing herds had higher blood urea levels, higher pasture protein but lower pasture Sol. CHO concentrations compared with the higher producing herds.

When this data was subjected to PCA (see Table 1) the first principal component (PC1) described 73% of the variation in the dataset and identified a pattern whereby low pasture N/Sol.CHO ratio and low urea were associated with high milkfat and milk protein production (Table 1). Moreover, analysis of variance of PC scores for this PC showed that this pattern reflected strong between-farm differences rather than seasonal differences. PC1 and PC2 are statistically independent PC scores, with PC2 describing a seasonal or time effect.

FIGURE 1: Comparison of 2 high producing (solid symbols) and 2 low producing herds (hollow symbols) in spring of 1990. (Data A) The thinner the lines show the 85% confidence bands. The two high and low producing herds are significantly different at the 5% level where the confidence bands do not overlap.

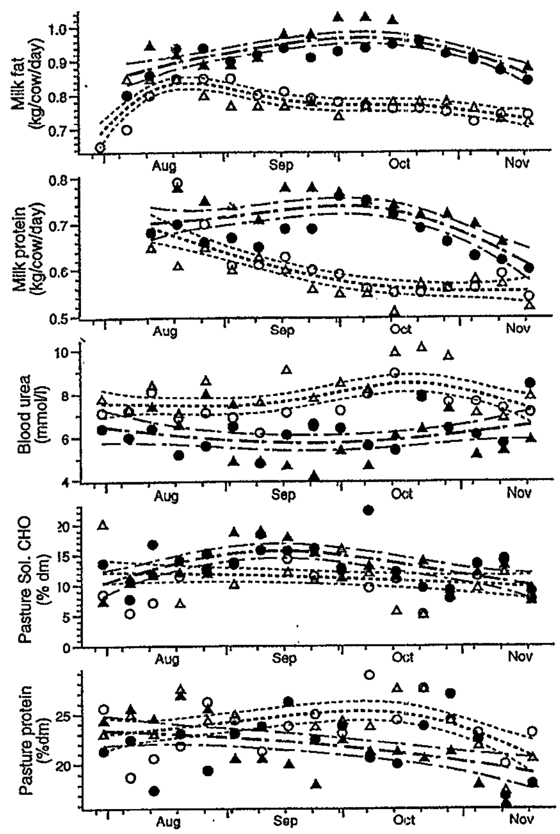


TABLE 1: Data A - Principal Component Analysis

Variable	PC1	PC2
Grass N:CHO	-0.38	0.85
Blood urea	-0.53	0.13
Milk fat	+0.53	0.39
Milk protein	+0.54	0.34
Proportion	73%	19%
Farm effect	P<0.001	NS
Time effect	NS	P<0.01

Principal components generated by PCA of Dataset B (Table 2) were very similar to the PC's for Data A (Table 1) except that the order of the two PC's is reversed. The between-farm pattern described by PC1 in Data A is seen in PC2 of Data B (Table 2). This PC described 33% of the variation in the dataset and indicates a negative correlation of milk urea with milkfat and milk protein production. Pasture N/Sol.CHO ratio is positively related to milk urea level, but negatively related to milkfat and milk protein. Dry matter intake does not feature strongly in the relationships for PC1 or PC2, but does feature in PC3 which explains 17% of the data (Table 2).

Data C contained 10 observations (twice weekly through September 1991) for each of 35 farms and three variables (milk urea, milkfat and milk protein production). To separate farm and seasonal effects in this data, two separate PCA's were carried out. Data were averaged over the 10 dates (to test between farm effects) or averaged over the 35 farms (to test seasonal effects).

TABLE 2: Data B - Principal Component Analysis

Variable	PC1	PC2	PC3
Day of season	0.59	-0.07	0.16
Grass N:CHO	-0.54	-0.30	0.17
Milk urea	-0.44	-0.45	0.12
Milk fat	-0.20	0.60	0.31
Milk protein	-0.33	0.57	0.08
Cow intake	0.15	-0.12	0.91
Proportion	35%	33%	17%
Farm effect	NS	P<0.001	-
Time effect	P<0.001	NS	-

The PCA for between farm effects gave a PC1 which accounted for 75% of the variation in the Dataset, with coefficients for the PC score of +0.43, -0.64, -0.64 for milk urea, milkfat and milk protein respectively. This is very similar to Data A PC1.

The PCA for seasonal associations from Data C is presented in Table 3.

TABLE 3: Data C - Principal Component Analysis (Seasonal Effect). (Means for 35 farms analysed)

Variable	PC1	PC2
Milk urea	-0.56	0.65
Milk fat	-0.55	-0.31
Milk protein	0.61	-0.08
Proportion	61%	22%

PC2 identifies a seasonal effect which accounts for 22% of the variation in the dataset, especially around 22nd September (see Fig.2). PC1 (Table 3) is describing a September (post-calving) fall in milk protein production per cow as milkfat per cow production rises to a peak in October.

Cow conception rates (60 d non-return rate) and anoestrous levels in Data A and Data B herds also appeared to be associated negatively with urea levels. For example, higher urea levels were evident in high anoestrous herds (three week submission rate to AB < 85%), especially during AB mating in Data A and Data B (Fig.3). However this relationship may be an association rather than causal, as many factors are involved in influencing anoestrous levels.

Seasonal variation in pasture nutrients from all samples collected during Spring 1991 is illustrated in Fig.4. Pasture samples were collected as described previously.

The similarity of dry matter content and Sol.CHO content curves is notable. Non-structural carbohydrate levels have been reported to be positively influenced by sunlight and pasture maturity (within the vegetative growth stage), and negatively influenced by nitrogen fertilisers and rapid growth rate (Westhafer et. al., 1982; McDonald et. al., 1966; Butler and Bailey, 1973; Volenec, 1986).

FIGURE 2: Milk urea levels for milkfat and mild protein production during September 1992 (Data C). The dotted lines show the 95% confidence bands for the curves.

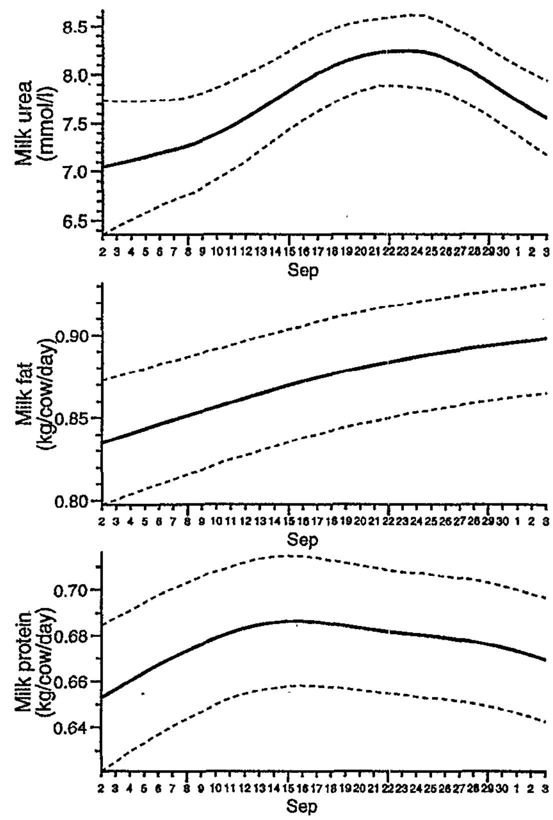
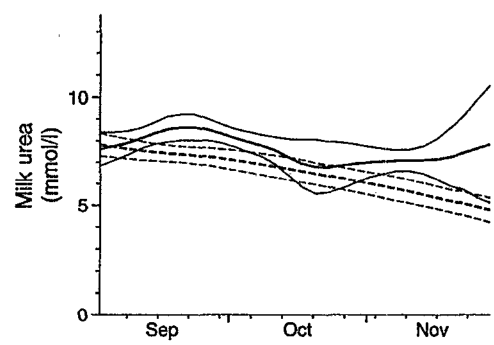


FIGURE 3: High (solid lines) vs low (dashed lines) anoestrous herds (Data C). The thinner lines show the 85% confidence bands. The herds are significantly different at the 5% level when the two bands do not overlap. High anoestrous herds have submission rate to AB mating <85% at three weeks. Low anoestrous herds have submission rate >90%.



Where milk urea levels were available as well as pasture compositon levels from Fig. 4, the milk urea levels were plotted with pasture protein/soluble carbohydrate ratio (Fig.5, N=34 complete data points).

The similar time trends in the milk urea and pasture protein/Sol.CHO ratio curves suggest a strong association between the two parameters (r=0.69 for 34 data points).

FIGURE 4: Pasture composition through spring 1991. Thinner lines show the 95% confidence bands.

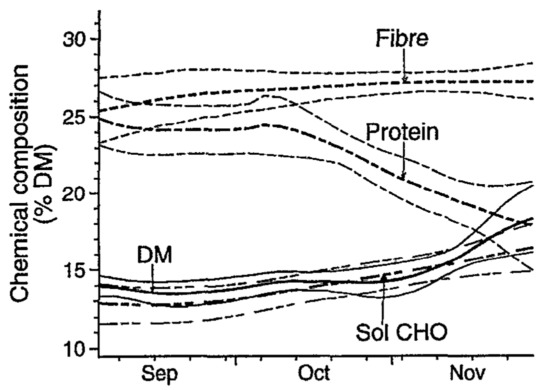
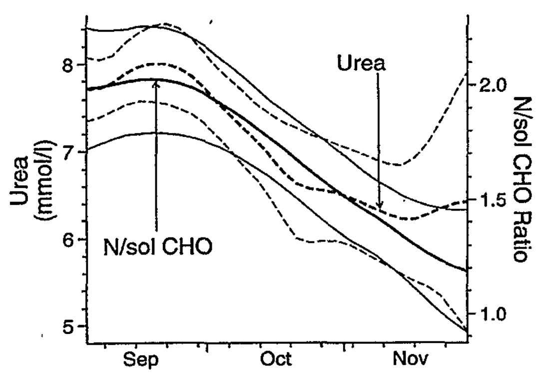


FIGURE 5: Comparison of pasture protein/soluble carbohydrate ratio with milk urea through spring 1991. Thinner lines show the 95% confidence bands.



CONCLUSIONS

There were substantial seasonal and between-farm variations in pasture non-structural carbohydrate and pasture protein contents.

The ratio of these pasture components to each other (N/Sol.CHO ratio) consistently correlated with milk or blood urea levels. There was an apparent association between high blood/milk urea levels and reduced milk production and reproductive performance. The findings here support those of McClure (1961) and more recently Williamson and Fernandez-Baca (1992) who found reduced conception rates in older cows grazing high protein pastures in the Manawatu. As stated earlier, this study was observational and no attempt was made to control parameters.

Recommendations for an ideal urea level to achieve optimal rumen function overseas are 4.5-5 mmol/l (Semptey and De Visscher, 1991) and urea levels over 3.3 mmol have been associated with conception rate problems (Ferguson et al., 1988; Ferguson and Chalupa, 1989). Urea levels found in this study were usually well above these levels.

Further clarification of cause/effect might be achieved by deliberate manipulation of N/Sol.CHO ratios with control of other variables (especially DM intake).

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REFERENCES

Bull, L.S. Using new knowledge of protein nutrition in dairy rations. *Jersey Journal,* December 1990.

Butler and Bailey. Chemistry and biochemistry of herbage. Vol.1, 1973. Academic Press.

Chase, L., and Linn, J. Feeding guidelines to optimise milk protein, p.18. Jersey Journal, December 1990.

Ferguson, J.D., Blanchard, T., Galligan, D.T., Hoshall, D.C., Chalupa, W. Infertility in dairy cattle fed a high percentage of protein degradable in the rumen. *JAVMA* **192** No.5. 1 March 1988.

Ferguson, J.D., and Chalupa, W. Impact of protein nutrition on reproduction in dairy cows. *J. Dairy Sci.* **72** 746-766, 1989.

Joliffe, I.T. (1986). Principle component analysis. Publ. Springer-Verlag, New York. 271 pp.

Khalili, H.E., and Huhtanen, P. The response of sucrose supplements to microbial protein production in the rumen of cattle given grass silage based diet. *AJAS.* 1989 **2** (No.3) 402-403.

McClure, T.J. (1961). An apparent nutritional lactational stress infertility in dairy herds. *NZVJ* **9** 107.

McCullough, M.E. Rumen fermentation and the nutrition of high producing Jersey cows. *Jersey Journal,* p.35, March 1990.

McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. Animal Nutrition, publ. Oliver and Boyd, 1966. Ch.16, p295-302.

Moller, 1991. Newsletter Dairy Cattle Society of N.Z., *Veterinary Association* **9** No.1, September 1991. (ISSN 0114-5487).

NRC 1980. Nutrient rèquirements of ruminant livestock, 1980.

Obara, Y., Dellow, D.W., and Nolan, J.V. The influence of energy-rich supplements on nitrogen kinetics in ruminants. p.515. *Proc. 7th International Symposium on Ruminant Physiology,* 1989. Academic Press.

Oltner, R. and Wiktorsson, *H. Livestock Production Science* **10** (1983) 457-467. Publ. Elsevier Science Publications.

Oltner, R. and Sjaunja, L. Evaluation of a rapid method for the determination of urea in cows milk. *Acta Vet Scand* 1982 **23** 39-45.

Ropstad, E., and Refsdal, A.O. Herd reproductive performance related to urea concentration in bulk milk. *Acta Vet Scand* **28** No.1 1987, 55-63.

Semptey, F., and De Visscher, A., 1991. Proceedings of All-tech's 7th Annual Symposium "Biotechnology in the feed industry". "A French approach to optimising rumen utilisation of forage".

Stokes, S.R., Hover, W.H., Miller, T.K., and Blauweikel, R. (1). Ruminal digestion and microbial utilisation of diets varying in type of carbohydrate and protein". *J. Dairy Sci.* **74** p.871-881, 1991.

Stokes, S.R., Hoover, W.H., Miller, T.K., and Manski, R.P. (2). Impact of carbohydrate and protein levels on bacterial metabolism in continuous culture. *J. Dairy Sci* **74** p.860, 1991.

Upsdell, M.P., Wheeler, D.M. Flexi 2.0 Reference Manual, 1992. AgResearch (N.Z.), Hamilton, New Zealand.

Upsdell, M.P. Bayesian Inference for Functions. Ph.D. Thesis, 1985, Nottingham University, England.

Volenec, J.J. Non structural carbohydrates in stem base components of tall fescue during regrowth. *Crop Science,* vol.26, January-February 1986.

Westhafer, M.K., Law, J.T., Duff, D.T. Carbohydrate quantification and relationships with N nutrition in cool season turfgrasses. *Agronomy Journal* **74** March-April 1982.

Williamson, N.A., and Fernandez-Baca, E. The role of dietary protein and energy in dairy herd fertility. *Proceedings of the 1st International Conference for the Society of Dairy Cattle Veterinarians of the NZVA,* Noumea 1992.