

New Zealand Society of Animal Production online archive

This paper is from the New Zealand Society for Animal Production online archive. NZSAP holds a regular annual conference in June or July each year for the presentation of technical and applied topics in animal production. NZSAP plays an important role as a forum fostering research in all areas of animal production including production systems, nutrition, meat science, animal welfare, wool science, animal breeding and genetics.

An invitation is extended to all those involved in the field of animal production to apply for membership of the New Zealand Society of Animal Production at our website www.nzsap.org.nz

[View All Proceedings](#)

[Next Conference](#)

[Join NZSAP](#)

The New Zealand Society of Animal Production in publishing the conference proceedings is engaged in disseminating information, not rendering professional advice or services. The views expressed herein do not necessarily represent the views of the New Zealand Society of Animal Production and the New Zealand Society of Animal Production expressly disclaims any form of liability with respect to anything done or omitted to be done in reliance upon the contents of these proceedings.

This work is licensed under a [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](https://creativecommons.org/licenses/by-nc-nd/4.0/).



You are free to:

Share— copy and redistribute the material in any medium or format

Under the following terms:

Attribution — You must give [appropriate credit](#), provide a link to the license, and [indicate if changes were made](#). You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

NonCommercial — You may not use the material for [commercial purposes](#).

NoDerivatives — If you [remix, transform, or build upon](#) the material, you may not distribute the modified material.

<http://creativecommons.org.nz/licences/licences-explained/>

Blood metabolites and infertility in dairy cows

G.F. WILSON, D.D.S. MACKENZIE AND C.W. HOLMES

Animal Science Department, Massey University, Palmerston North

ABSTRACT

Reasons for a temporary infertility syndrome in pasture-fed dairy cows were sought. Low submission and conception rates in 35 mature Friesians (either of high or low breeding index) were associated with low plasma albumin and glucose concentrations at the commencement of mating and poor body condition prior to calving. Discriminant function analysis indicated that albumin concentration was the most important variable in the allocation of cows to "fertility" groupings. Breeding index and level of milk production were relatively unimportant. A disturbance in protein metabolism was implicated as the cause of the infertility syndrome.

A concentrate supplement containing 19% crude protein, fed to monozygous twin cows at 1.4 kg/d for 3 weeks prior to mating led to a marked improvement in conception rate.

Keywords Dairy cows; fertility; blood metabolites; concentrate supplement.

INTRODUCTION

Dairy cows grazing improved pastures may in some years experience a temporary non-infectious infertility over the first few weeks of mating in spring involving a failure to start cycling, a temporary cessation in cycling or more commonly a higher than normal return rate to first mating.

Infertility problems occurred during the 1983 spring in several dairying districts. Milk production and fertility were poorer than normal in spite of an apparent abundance of pasture. Feed "quality" rather than "quantity" was therefore thought to be responsible, and it was also reported that pastures contained very little clover.

This paper is in 3 sections. The first briefly outlines the evidence which led to the hypothesis that a disturbance in protein metabolism may have been responsible for the observed problems. In the second section data on plasma metabolites in cows which differed in genetic merit and body condition at calving are discussed in relation to the hypothesis. Finally, preliminary results are presented from an experiment to test the hypothesis more directly by feeding a high protein concentrate to grazing cows.

PROTEIN DIGESTION AND COW PRODUCTIVITY

The ruminant depends for its protein supply on the absorption in the intestine of microbial protein and forage protein which has escaped rumen degradation. While spring pastures contain high concentrations of crude protein (>200 g/kg DM), a substantial ammonia nitrogen loss occurs from the rumen due to the high degradability of pasture protein and NPN. Indeed the possibility that the lactating cow may sometimes be deficient in metabolisable protein is indicated by the significant

responses that have sometimes been obtained in milk yield or composition to formaldehyde-protected protein supplements (Wilson, 1970; Rogers *et al.*, 1980). In addition, less protein reaches the intestine when ryegrass is fed than when white clover is fed (Beever *et al.*, 1980).

In the 1983 spring, infertility was accompanied by a marked decrease in the protein:fat ratio in the milk delivered to dairy companies (Waikato example: 1983, 0.67; 1982, 0.74). Such a change would normally be associated with a reduced intake of energy brought about by a shortage of pasture and underfeeding, or with the ingestion of poor quality mature pasture of low digestibility. However, *ad lib* feeding of pure stands of immature perennial ryegrass pastures (especially if fertilised with nitrogen) have, in some earlier experiments (Wilson and Dolby, 1969) also led to the production of milk with an abnormally low protein (or solids-non-fat) concentration.

All of the above observations suggest that under the circumstances which existed in spring 1983, the amount of metabolisable protein available to the cows may have been suboptimal. This then raises the question as to whether the poor fertility sometimes encountered in the spring is caused by the inadequate supply of metabolisable protein.

BLOOD METABOLITES AND FERTILITY

Since 1979 we have measured the plasma concentrations of a number of different metabolites and hormones from Friesian cattle differing in breeding index (BI) and body condition in an attempt to find the physiological differences through which the genetic differences in milk production are expressed (Flux *et al.*, 1984). Plasma albumin concentration is known to reflect the body tissue

protein content of animals (Sykes and Thompson, 1978) and can be increased slowly in response to higher levels of dietary protein. Data on plasma albumin concentrations were available for individual cows during 2 springs.

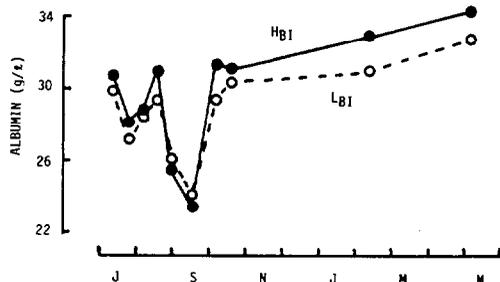


FIG. 1 Plasma albumin concentrations over a lactation for Friesians of high (●) and low (○) breeding index

1979 Experiment

Plasma albumin concentrations were measured using the HABA dye binding method (Nishi and Rhodes, 1966) in the jugular blood of 9 high and 9 low BI Friesian cows fully fed on pasture at intervals over 12 months (Fig. 1). Values declined markedly following calving during August and increased as lactation progressed. The high BI cows generally had slightly higher values than did the low BI cows.

During late October oestrous activity of the cows was synchronised with Estrumate and only 5 held to the subsequent AI mating. Seven cows showed short return intervals (12 to 16 d) and the remaining 6 cycled at the normal interval. From calving until mating the albumin concentrations at all 5 sampling occasions were higher in the cows that conceived than in those that returned (e.g. October values 32.2 and 30.1 g/l; $P < 0.1$). Plasma Mg and Ca concentrations were slightly higher and milk Na concentration significantly higher (0.69 and 0.56 g/l; $P < 0.05$) for the more fertile group of cows.

1981 Experiment

Jugular blood samples were obtained on 4 occasions during the spring from 35 adult high and low BI cows which differed greatly in condition score at calving and were fully fed on pasture after calving. The animals subsequently differed markedly in fertility (Table 1). Differences associated with breeding index and milk fat yield were small whereas variations in condition score, plasma glucose (October) and albumin concentrations (in September and October) were associated with significant differences in fertility. A condition score (CS) of under 4.9 markedly reduced the submission rate (SR) during

TABLE 1 Reproductive performance associated with categories of BI, milkfat production (kg/d), CS and plasma concentrations of glucose (mg/100 ml) and albumin (g/l). Significant differences are indicated by different letters (capitals, $P < 0.01$; lower case, $P < 0.05$).

	n	Days to oestrus	Submission rate (%)	Conception rate (%)	Pregnancy rate (%)
BI					
High	18	62	72	54	39
Low	17	57	76	46	35
Milkfat					
>0.75	21	54	76	56	43
<0.75	14	68	71	40	29
CS					
5.0-6.5	12	36 ^{aA}	100 ^a	58 ^A	58 ^A
4.3-4.9	13	64 ^{bAB}	62 ^b	63 ^A	39 ^{AB}
3.5-4.2	10	82 ^{bB}	50 ^b	20 ^B	10 ^B
Glucose					
>67	18	52	89 ^A	62 ^A	56 ^A
<67	17	65	59 ^B	30 ^B	18 ^B
Albumin					
>30	14	47	93 ^A	77 ^A	72 ^A
<30	21	68	62 ^B	23 ^B	14 ^B

TABLE 2 Mean plasma concentrations of albumin (g/l) and glucose (mg/100 ml), CS and milkfat production (kg/d) for Friesian cows with different reproduction performances (1st 3 weeks of mating). Significant differences are indicated by different letters (capitals, $P < 0.01$; lower case, $P < 0.05$).

	Mated, pregnant	Mated, returned	Not mated
n	13	13	9
Albumin	31.4 ^{aA}	29.2 ^{bB}	27.3 ^{cB}
Glucose	69.6 ^a	68.1 ^{ab}	65.7 ^b
CS	5.08 ^A	4.69 ^{AB}	4.12 ^C
Milkfat	0.84 ^A	0.80 ^{AB}	0.76 ^B

the first 3 weeks of mating and a CS of less than 4.2 also reduced conception rate (CR). Lower glucose and albumin concentrations were associated with a low SR and an especially low CR.

When mean plasma metabolite concentrations, condition scores and milk fat production were arranged in three "fertility" groupings (Table 2), the number of differences reaching significance suggests, and a discriminant function analysis on all the data confirmed, that albumin was the most important variable in discriminating between the 3 fertility groups. This was followed by CS, plasma glucose, milk fat yield, protein yield and BI in descending order. Some of the interactions between CS and milk protein yield and their effects on albumin concentration are illustrated in Figure 2. Plasma

albumin values were generally lowest for cows calving in poor condition, presumably due to a lack of protein reserves. In addition, the high milk protein producers amongst the thinner cows (CS < 5.0) had lower albumins at the October sampling than lower producers. Plasma albumins therefore appeared to be measuring the balance between the supply of protein from the tissues and protein requirements for production. Thus a low plane of nutrition (as indicated by a low CS and blood glucose concentration) was probably an important factor in influencing fertility in the 1981 experiment, as in previous studies with beef cattle (Wiltbank *et al.*, 1964) and dairy cattle (Folman *et al.*, 1973; Garner, 1973). However, the possible involvement of the protein reserve status and/or protein intake of cows in influencing their fertility when grazing high quality pastures is also indicated.

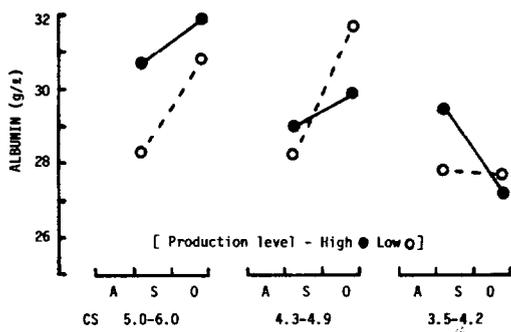


FIG. 2 Influence of condition score (CS) and level of milk protein production on plasma albumin concentration during September and October.

HIGH PROTEIN CONCENTRATE FEEDING

A supplementary feeding experiment was undertaken during the 1984 spring with the objective of determining whether plasma albumin was directly involved in causing infertility or was merely an associated variable. The concentrate used (40 brewers' grains, 10 soyabean meal, 10 linseed meal, 20 barley meal, 20 maize meal) contained a relatively high concentration of protein (190 g/kg DM). Brewers' grains were used because they have been reported to contain a large proportion of protected protein. The supplement was fed after evening milkings to 1 member of each of 10 pairs of monozygous twin cows, the level of feeding being slowly increased to a rate of 1.4 kg/d and then maintained for a period of 3 weeks, immediately before the commencement of mating (1 November). The twins were of mixed ages (2 to 8 years), had similar calving dates within pairs (August and early September) and were selected because they were moderately thin prior to calving (CS 4.0 to 5.2).

Jugular blood samples were obtained before, during and after the supplementary feeding period and analysed for plasma glucose and albumin concentrations. Milk yield and composition data were recorded twice each week during the experiment.

The supplement had no effect on submission rate (Table 3) but increased the conception rate to first insemination. Milk yield, protein yield and protein:fat ratio were all increased whereas fat yield remained the same because of a small reduction in milk fat concentration. Feed "quality" rather than a higher level of feeding was probably responsible for these changes since both groups of cows grazed together with *ad lib.* access to pasture.

TABLE 3 Influence of a concentrate supplement on reproduction, production and some plasma metabolites of grazing cows (covariance adjusted means)

	Control	Supple-mented	
Reproduction			
Days to first mating (after 1 Nov)	10	13	NS
No. holding to first insemination	4/10	9/10	**
Milk production			
Milk yield (ℓ/d)	14.4	15.6	**
Fat yield (kg/d)	0.79	0.80	NS
Protein yield (kg/d)	0.52	0.56	*
Protein:fat ratio	0.65	0.72	*
Plasma			
Glucose (mg/100 ml)	65.7	65.1	NS
Albumin (g/ℓ)	27.5	28.0	NS

The absence of any change in plasma albumin concentration indicates that albumin is probably not directly involved in the infertility syndrome. However, accepting that albumin is known to respond only slowly to additional dietary protein, it remains an open question as to whether protein or energy was the limiting nutrient especially as plasma glucose levels were also similar for the 2 groups of cows.

Both an increase in rumen propionate production and increased absorptions of microbial and dietary amino acids might be expected to result from the feeding of the supplement, and all would favour milk protein production relative to fat. It therefore seems possible that one of these changes in absorbed nutrients had a direct effect on implantation.

While further experiments are obviously required to extend and explain the observations made, this paper emphasises that there is an integral relationship in the ruminant between dietary factors

and digestive physiology and the metabolic processes and hormones influencing milk production and fertility.

PRACTICAL APPLICATIONS

It is recommended that farmers seeking improved production and fertility should attempt to ensure that all cows reach at least a moderate condition score (4.5 to 5.0) by preferentially feeding those in poor condition, and that they seriously consider feeding concentrate supplements to those in poorest condition to increase conception rates. Further information on aspects such as the optimum composition of the concentrate, minimum amounts required, and the economics of the practice is required.

ACKNOWLEDGEMENTS

To J.A. Rumbal, J.P. Bridges and G.M. Borrie for technical assistance. M.L. Chesterfield for milking and management of the cows and the Town Milk Producers' Federation, Ministry of Agriculture and Fisheries, and Massey University Agricultural Research Foundation for financial assistance.

REFERENCES

- Beever D.E.; Ulyatt M.J.; Thomson D.J.; Cammell S.B.; Austin A.R.; Spooner M.C. 1980. Nutrient supply from fresh grass and clover to housed cattle. *Proceedings of the Nutrition Society* **39**: 66A.
- Flux D.S.; Mackenzie D.D.S.; Wilson G.F. 1984. Plasma metabolite and hormone concentrations in Friesian cows of differing genetic merit measured at two feeding levels. *Animal production* **38**: 377-384.
- Folman Y.; Rosenberg M.; Herz Z.; Davidson M. 1973. The relationship between plasma progesterone concentration and conception in post-partum dairy cows maintained on two levels of nutrition. *Journal of reproduction and fertility* **34**: 267-278.
- Gardner R.W. 1973. Interactions of energy levels offered to Holstein cows prepartum and postpartum II Reproductive performance. *Journal of dairy science* **52**: 1985-1987.
- Nishi H.H.; Rhodes A. 1966. An automated procedure for the determination of albumin in human serum. In *Automation in analytical chemistry* Ed. L.T. Skeggs, New York p. 321.
- Rogers G.L.; Porter R.H.D.; Clarke T.; Stewart J.A. 1980. Effect of protected casein supplements on pasture intake, milk yield and composition of cows in early lactation. *Australian journal of agricultural research* **31**: 1147-1152.
- Sykes A.R.; Thompson R. 1978. The relationship between serum albumin concentration and body protein loss in pregnant sheep. *Journal of agricultural science, Cambridge* **91**: 173-179.
- Wilson G.F. 1970. The influence of protein supplements on milk yield and composition. *Proceedings of the New Zealand Society of Animal Production* **30**: 123-127.
- Wilson G.F.; Dolby R.M. 1969. Ryegrass varieties in relation to dairy cattle performance. *New Zealand journal of agricultural research* **12**: 489-499.
- Wiltbank J.N.; Rowden W.W.; Ingalls J.E.; Zimmerman D.R. 1964. Influence of post-partum energy level on reproductive performance of Hereford cows restricted in energy intake prior to calving. *Journal of animal science* **23**: 1049-1053.