Acta vet. scand. 1991, *32*, 189–196.

Correlation between Energy Balance and Fertility in Finnish Dairy Cows

By *P. V. A. Miettinen*

Department of Anatomy, University of Kuopio, Finland.

Miettinen, P. V. A.: Correlation between energy balance and fertility in Finnish dairy cows. Acta vet. scand. 1991, 32, 189–196. – The effect of serum glucose, ASAT and urea on reproductive performance was studied in 45 Finnish dairy cows from 8 different herds. Blood samples were taken a month before calving as well as 2 weeks and 2 months after calving. Serum urea, ASAT and glucose were used as indicators of metabolic and energy balance.

Glucose and ASAT concentrations were significantly correlated with fertility 2 weeks after calving, but not before calving or 2 months after calving. Antepartum, 60 % of the cows had a low urea level; at 2 weeks and at 2 months postpartum 89 % and 65 %, respectively had low levels of urea. The cows were divided into groups as follows: low or high ($\geq$ 2.9 mmol/l) glucose level and low or high ($\geq$ 2.5 mmol/l) urea level. Low levels of glucose and/or urea in puerperium were associated with poor fertility. The intervals from calving to first insemination and conception were shorter in the group with high glucose and high urea than in the group with low values. The cows with the shortest intervals from calving to first insemination and conception showed adequate metabolic balance (high levels of urea and glucose).

Clinical ketosis had an adverse affect on intervals from calving to first insemination and on conception. Intervals from calving to first insemination and to conception were significantly ($p < 0.01$) longer in ketotic cows than in non-ketotic ones. Liver damage, reflected as elevated activity of ASAT, was associated with poor fertility.

If shorter calving intervals are desired, adequate energy balance in puerperium is essential.

blood; urea; ASAT; energy balance.

Introduction

Conception difficulties in cows are a rather common problem on Finnish dairy farms. Such difficulties prolong the calving interval, resulting in economic consequences especially in high-yielding dairy cows.

Energy intake has been reported to be related to reproductive performance of cattle (*Wiltbank et al.* 1964, *Dunn et al.* 1969, *Oxenreider & Wagner* 1971, *Butler et al.* 1981, *Flipot et al.* 1988). Cows are often fed rather intensively before parturition, which leads to an accumulation of body fat. Excess feeding before calving (*Lotthammer* 1974) and excessive intake of protein have a negative influence on fertilify (*Lotthammer & Farries* 1977). Since excess intake of feed before calving causes diminished appetite after calving (*Farries* 1979), the energy deficiency increases. Body fat is mobilized in early lactation when the energy requirement exceeds energy intake, resulting in shifts of the energy metabolism and causing ketosis. The less the cow feeds after calving, the higher is the negative influence of excess feeding before calving (*Lotthammer* 1979).

Metabolic profile tests have been used to monitor the metabolic state of dairy herds and particularly to assess the adequacy of dietary intake (*Payne et al.* 1970). These tests have sometimes been disappointing, however, often because reference animals are difficult to select and blood reference values and their variations remain poorly known. Moreover, the results are often contradictory (*Rowlands* 1980). In individual cows *Lotthammer* (1974) found that the activity of aspartate amino transferase (ASAT) is a sensitive indicator of liver disorders associated with impaired fertility. Low levels of blood glucose are found in association with poor fertility (*McClure 1968, Lotthammer* 1974). Since the correlation between blood glucose and energy balance is weak (*Erfle et al.* 1974, *Herdt et al.* 1981, *Kunz & Blum* 1985), blood glucose concentration has not always been associated with poor fertility (*Rowlands et al.* 1977, *Carstairs et al.* 1980, *Kappel et al.* 1984).

Although previous studies of the relationships between blood parameters and fertility parameters have produced disappointing results, these relationships need to be studied also under Finnish field conditions, because housing and nutritional circumstances differ from country to country and from controlled experimental situations to field conditions. The aim of this study was to evaluate the relationships between levels of glucose, urea and ASAT in blood and the reproductive performance of Finnish dairy cows in order to predict subsequent fertility.

Materials and methods

A total of 45 high-yielding dairy cows age 3–10 years from 8 herds were included in this study. The cows were selected from herds of 20–30 Finnish Ayrshire cows in southern Finland. They were housed indoors and fed grass silage, concentrate and hay in accordance with Finnish feeding standards. The cows were allowed to eat twice a day during a restricted time (3–4 hours) in the morning and in the afternoon. The calving season was from December to March.

Blood samples were obtained 1 month before and 2 weeks after calving. These samples were drawn from the jugular vein and allowed to clot. The blood was then centrifuged and serum was obtained for analysis of urea, ASAT and glucose on the same day.

Each cow was examined clinically each time blood samples were taken, and it was inseminated at first normal heat up to 2 months postpartum. All cows were palpated for pregnancy 6–8 weeks after insemination, and in any doubtful case the examination was repeated 1–2 weeks later.

Glucose and ASAT were determined with glucose and ASAT test kits (Boehringer Mannhein GmbH Diagnostica cat.no 124010 and 191337, Mannheim, Germany) and urea was tested by the BUN Test (Bio-Dynamics, Indianapolis, Indiana, USA). This test for urea works best in the range 2–8 mmol/l, the normal value for cows; but many of the samples fell below this range.

The health of the cows was monitored by the farmers, especially occurence of bovine ketosis. The diagnosis of ketosis was made using a nitroprusside test of the milk. The cows were divided into non-ketotic and ketotic groups according to whether or not they needed treatment for bovine ketosis. If a cow showed clinical symptoms of bovine ketosis (including loss of appetite- particularly for concentrate-, decrease in milk production, rapid loss of body condition, dullness, firm feces and noticeable changes in colour of the ketotest), it was placed in the ketotic group. Cows were treated for clinical ketosis with glucocorticoid i.m. and propylenglycol orally and in several cases with i.v. administration of glucose.

Table 1. Blood parameters of 45 cows (mean ± S.D).

Blood parameter	1 month antepartum	2 weeks postpartum	2 months postpartum
ASAT I/U	48.2 ± 14.4	71.6 ± 28.7	64.9 ± 14.6
Glucose mmol/l	3.76 ± 0.55	2.87 ± 0.76	2.91 ± 0.64

Statistical methods comprised regression analysis and Student's *t*-test.

Results

Variation in blood parameters

In the cows studied, the values for glucose were high antepartum, and decreased after calving, and thereafter increased with time. ASAT activity was highest during early lactation (Table 1).

Since most of the cows had urea levels below 2.5 mmol/l, they were divided into groups according to urea levels as follows: up to 2.5 mmol/l = low level and 2.5–6.3 mmol/l = high urea level. Antepartum 60 %, 2 weeks postpartum 89 % and 2 months postpartum 65 % of the cows had a low level of urea.

Correlation between blood parameters and fertility

There was no correlation between blood parameters and fertility parameters before calving. Two weeks postpartum a significant ($p < 0.001$) correlation was found between the level of ASAT and the interval from calving to conception (adjusted $r^2 = 0.14$) and a significant ($p < 0.001$) negative correlation was found between glucose level and the interval from calving to first insemination (adjusted $r^2 = 0.16$). No significant linear correlation was found between glucose level and the interval from calving to conception or between blood parameters and fertility 2 months after calving.

Table 2. Effect of metabolic balance 2 months postpartum on fertility. The cows were divided according to blood parameters as follows: low or high glucose (lower or higher than 2.9 mmol/l) and low or high urea (lower or higher than 2.5 mmol/l). Cows with a urea level above 6.3 mmol/l were omitted from these groups.

Parameter	N	AI (days)		CC (days)		PR (%)	AIn (n)
Average	43	76.8 ± 16.7		99.8 ± 35.8		58	1.7
low glucose	21	82.3 ± 20.7		111.3 ± 41.7		57	1.9
high glucose	22	72.2 ± 11.0	*	88.4 ± 27.6	*	59	1.4
low urea	29	79.3 ± 18.3		105.9 ± 38.5		52	1.7
high urea	14	72.7 ± 14.2	n.s	86.3 ± 29.5	n.s	71	1.5
low energy	13	85.9 ± 22.5		121.9 ± 42.7		46	2.1
high energy	6	67.7 ± 7.6	n.s	76.0 ± 15.4	*	75	1.3

AI = interval (days) between calving and the first insemination; CC = interval (days) from calving to conception; AIn = inseminations (n) per conception; PR% = pregnancy rate at the first insemination. Probability (* = $p < 0.05$, ** = $p < 0.01$) with *t*-test between corresponding groups.

Table 3. Blood parameters ASAT and Glucose, 1 month antepartum, 2 weeks and 2 months postpartum in non-ketotic (non) and clinical ketotic groups (ket). Probability (* = $p < 0.05$) with *t*-test between corresponding groups.

Time	ASAT (I/U)			Glucose (mmol/l)		
	non	p	ket	non	p	ket
antepartum	47 ± 15	n.s	50 ± 15	3.86 ± 0.57	n.s	3.52 ± 0.45
2 weeks p.p	66 ± 15	*	88 ± 13	3.03 ± 0.77	*	2.34 ± 0.54
2 months p.p	64 ± 15	n.s	69 ± 13	3.03 ± 0.77	*	2.56 ± 0.62

Effect of energy balance two months postpartum

Since the linear correlation between blood- and fertility parameters was weak, the effect of energy was evaluated using grouping according to low and high levels of glucose and urea. At 2 months postpartum cows were divided into groups according to blood parameters as follows: low or high glucose (lower or higher than the average 2.9 mmol/l) and low or high urea. The cows (n = 2) that had urea more than 6.3 mmol/l urea were left out of these groups (Table 2).

Low levels of glucose and urea were associated with poor fertility. The cows with high levels of glucose or urea had a shorter interval from calving to first insemination and to conception than cows with low glucose or low urea levels did.

Intervals from calving to first insemination and conception were significantly shorter in the high glucose group than in the low glucose group. The interval from calving to conception was about 3 weeks shorter in the high urea group than in the low urea group. The low urea and low glucose groups needed more inseminations per conception than the groups with high levels of urea and glucose did.

The interval from calving to first insemination was 18 days shorter in the group with high urea and glucose than in the group with low levels of these substances. Due to the small size of the groups, the difference was not statistically significant, but it is of practical significance. In addition, the pregnancy rate at first insemination was lower and the interval from calving to conception was 6 weeks longer in the low energy group (low glucose + low urea) than in the adequate energy group (high glucose + high urea).

Effect of ketosis

Twenty-seven percent of the cows showed evidence of bovine of bovine ketosis 2.5–6 weeks postpartum and were treated for keto-

Table 4. Comparison of fertility in ketotic and non-ketotic cows.

Group	N	AI (days)		CC (days)		PR (%)	Aln (n)
non-ketotic	33	72.6 ± 11.3		90.9 ± 33.6		61	1.6
ketotic	12	87.7 ± 24.0	**	124.3 ± 34.1	**	33	2.0

AI = interval (days) between calving and the first insemination; CC = interval (days) from calving to conception; Aln = inseminations (n) per conception; PR% = pregnancy rate at the first insemination. Probability (* = $p < 0.05$, ** = $p < 0.01$) with *t*-test between corresponding groups.

sis. After calving glucose levels in ketotic cows were significantly lower than in non-ketotic cows (Table 3). Two weeks postpartum ASAT activity was significantly higher in ketotic cows than in non-ketotic ones.

Clinical ketosis had an adverse influence on the intervals from calving to first insemination and from calving to conception, and on number of inseminations and the pregnancy rate at first insemination (Table 4).

Discussion

The nutritional status of cows, seasonal changes in climate, housing and other factors concerning general management of cattle have been suggested as causative factors of low fertility in dairy cows. A calving interval of 12 months is generally considered to be optimal. To achieve this average the interval from calving to conception should be about 85 days, which requires that the cow should conceive in early lactation while still producing large quantities of milk. Since many high-yielding cows are unable to consume sufficient food to meet their production and maintenance requirements, there is a high risk of a negative energy balance at the time of first insemination. In practice, veterinarians are increasingly being asked to discuss aspects of nutrition when diagnosing situations likely to lead to reduced fertility in high-yelding cows.

In many countries an overfeeding with protein is a common problem (*King* 1971, *Wettke & Jahn* 1971). Serum urea is a sensitive indicator of dietary intake of digestible crude protein (*Manston et al.* 1975); in particular, the ratio of protein to energy affects urea levels in the blood (*Payne et al.* 1970, *Erbersdobler et al.* 1980, *Oltner & Wiktorsson* 1983). However, reference values for blood urea, often measured as urea nitrogen, vary considerably (*Hammond* 1983). Wide variations in standard levels and variations during the year may be due to differences in feeding (type, quality and quantity of protein) in various countries and on different farms. The most important observation in this study was that many cows had low levels of urea indicating low protein intake. To avoid the diurnal variation caused by feeding schedules (*Miettinen & Juvonen* 1990), blood samples were always taken at the same time of the day. *Eldon et al.* (1988) suggested that a low urea level in early puerperium may lead to ketosis. The lower level of urea in early puerperium is due to insufficient intake of feed (*Lotthammer* 1981), which can lead to ketosis; but in this study there was not a linear correlation between low urea values and ketosis in early puerperium. For prediction of reproductice performance on the basis of serum urea, 2.5 mmol/l seemed to be the threshold level.

In this study the linear relationship between concentrations of serum glucose and fertility was significant only at 2 weeks after calving. This supports the findings of *Erfle et al.* (1974), *Herdt et al.* (1981) and *Kunz & Blum* (1985), all of whom have observed a weak relationship between blood glucose and energy balance, particularly when the energy balance was positive. The adverse effect of low level of blood glucose on fertility corroborates the results of *McClure* (1968) and *Lotthammer* (1974), but no such a correlation has been reported for other studies (*Rowlands et al.* 1977, *Carstairs et al.* 1980, *Kappel et al.* 1984). Therefore, the relationship between glucose and fertility may become significant only if the concentrations of glucose in the blood fall below normal limits.

The glucose level is low 8–9 weeks postpartum (*Oxenreider & Wagner* 1971) and then increase simultaneously as fertility improves (*Lotthammer* 1974). *Eldon et al.* (1988) even found a positive correlation between glucose

and time of conception. It is possible that occassionally such a high level of blood glucose in the puerperal cow is caused by stress and increased adrenal corticoid secretion, which results in curtailed fertility. Nevertheless, a raised glucose level indicates the onset of ovarian activity (*Eldon et al.* 1988). A disturbance in resumption of the ovarian cyclicity has a detrimental effect on re-conception (*Huszenicza et al.* 1987). Thus the fact that the glucose level 2 weeks after calving had more effect on the interval from calving to first insemination than the level 2 months postpartum did, may be due to a delay in the onset of ovarian activity.

A calving interval of 1 year can be achieved if inseminations are started about 2 months postpartum. A common problem in dairy herds is poor detection of oestrus, which prolongs the calving interval. The low pregnancy rate observed in this study in hypoglycemic cows at the first insemination supports the finding of *Dunn et al.* (1969), who found a low rate of pregnancy in cows fed at a low energy level after calving, because the animals failed to show estrus. The importance of the herd manager for detection of oestrus is well known. *Whitmore* (1984) suggested that the primary reason for long calving intervals is failure to observe the estrus and thus breeding is delayed. According to the present results, however, cows with an adequate energy balance were inseminated earlier and in addition to that the pregnancy rate at first insemination was better and they needed fewer inseminations per pregnancy than did cows with low energy balance.

The incidence of clinical ketosis found in this study was relatively high, but all cows were included in the ketosis group if they had increased levels of ketone bodies in their milk and had some clinical sign of ketosis. Incidence of clinical ketosis is difficult to determine, since farmers may treat ketotic cows with a glucogenic substance and ketotic cows can also recover without any treatment. However, the incidence of ketosis found in this study is in agreement with the results of *Lindström et al.* (1983), who found a ketosis incidence of 13.3 % in recorded herds at first insemination, which normally takes place up to 7 weeks postpartum. Clinical bovine ketosis occurs mostly 2–8 weeks after calving (*Baird* 1982): thus the energy balance has time to equilibrate.

Clinically diagnosed ketotic cows were found less fertile than normal ones. This agrees with *Refsdal* (1977) and *Lindström et al.* (1983) who found that cows, which were negative for ketone bodies were significantly more fertile than ketotic cows. *Kauppinen* (1984) and *Andersson & Emanuelsson* (1985), on the other hand found no correlation between ketosis and fertility. The long duration of low glucose levels in ketotic cows supports the finding of *Huszenicza et al.* (1987, 1988), who found that duration rather than temporary depth of energy imbalance affects re-conception by delaying the resumption of ovarian activity.

Liver damage, reflected as elevated ASAT activity, 2 weeks post partum was found to be associated with the interval from calving to conception. This indicates that a metabolic imbalance can have a detrimental effect on fertility for a long time after the imbalance has been corrected.

According to this investigation concerning prediction of reproductive performance on the basis of serum urea and glucose levels, in individual cows urea higher than 2.5 mmol/l and glucose levels higher than 2.9 mmol/l are preconditions for good fertility. These results suggest that the interval from calving to first insemination and to conception can be shortened by providing an adequate energy balance.

Acknowledgements

I wish to thank the late Prof. T. Vanha-Perttula (who died 11.2.1990) for making critical guidelines for the preparation of this manuscript.

References

Andersson L, Emanuelson U: An epidemiological study of hyperketonaemia in Swedish dairy cows: Determinants and the relation to fertility. Prev. Vet. Med. 1985, *3,* 449–462.

Baird GD: Primary ketosis in the high-producing dairy cow: Clinical and subclinical disorders, treatment, prevention, and outlook. J. Dairy Sci. 1982, *65,* 1–10.

Butler WR, Everett RW, Coppock CE: The relationships between energy balance, milk production and ovulation in postpartum Holstein cows. J. Anim. Sci. 1981, *53,* 742–748.

Carstairs JA, Morrow DA, Emergy RS: Postpartum reproductive function of dairy cows as influenced by energy and phosphorus status. J. Anim. Sci. 1980, *51,* 1122–1130.

Dunn TG, Ingalls JE, Zimmerman DR, Wiltbank JN: Reproductive performance of 2-year old Hereford and Angus heifers as influenced by pre- and post-calving energy intake. J. Anim. Sci. 1969, *29,* 719–726.

Eldon J, Olafsson Th, Thorsteinsson Th: The relationship between blood and fertility parameters in the postpartum dairy cows. Acta vet. scand. 1988, *29,* 393–399.

Erbersdobler H, Eckart K, Zucker H: Milk urea levels as a measure of imbalances in energy and protein intake. Proc. IVth International Conference on Production Disease in Farm Animals, München, Germany 1980, 69–72.

Erfle JD, Fischer LJ, Sauer FD: Interrelationship between blood metabolites and an evaluation of their use as criteria of energy status of cows in early lactation. Can. J. Anim. Sci. 1974, *54,* 293–303.

Farries E: Fütterung von Hochleistungskühen vor dem Kalben – Neue Erkenntnisse zum Einfluß auf Milchleistung, Gesundheit und Fruchtbarkeit. (Feeding high yielding cows before calving. New results on its influence on milk production, health and fertility). Tierzüchter 1979, *3,* 326–328.

Flipot PM, Roy Gl, Dufor JJ: Effect of peripartum energy concentration on production performance of Holstein cows. J. Dairy Sci. 1988, *71,* 1840–1850.

Hammond AC: Effect of dietary protein level, ruminal protein solubility and time after feeding on plasma urea nitrogen and the relationship of plasma urea nitrogen to other ruminal and plasma parameters. J. Anim. Sci. 1983, *57,* (Suppl. 1), 435.

Herdt TH, Stevens JN, Linn J, Larson V: Influence of ration composition and energy balance on blood beta-hydroxybutyrate (ketone) and plasma glucose concentration of dairy cows in early lactation. Amer. J. vet. Res. 1981, *42,* 1177–1180.

Huszenicza G, Haraszti J, Molnar L, Solti L, Fekete S, Ekes K, Yaro AC: Some metabolic characteristics of dairy cows with different postpartum ovarian function. J. Vet. Med. A 1988, *35,* 505–516.

Huszenicza G, Molnar L, Solti L, Haraszti J: Postpartal ovarian function in Holstein and crossbred cows on large scale farms in Hungary. J. Vet. Med. A 1987, *34,* 249–263.

Kappel LC, Ingraham RH, Morgan EB, Zeringue L, Wilson D, Babcock DK: Relationship between fertility and blood glucose and cholesterol concentrations in Holstein cows. Amer. J. vet. Res. 1984, *45,* 2607–2612.

Kauppinen K: Annual milk yield and reproductive performance of ketotic and non-ketotic cows. Zbl. Vet. Med. A 1984, *31,* 694–704.

King JOL: Nutrition and fertility in dairy cows. Vet. Rec. 1971, *89,* 320–324.

Kunz PL, Blum JW: Relationships between energy balance and blood levels of hormones and metabolites in dairy cows during late pregnancy and early lactation. Z. Tierphysiol. Tierernähr. Füttermittelk. 1985, *54,* 239–248.

Lindström UB, von Bonsdorff M, Syväjärvi J: Factors affecting bovine ketosis and its association with non-return rate. J. Sci. Agr. Soc. Finland, 1983, *55,* 497–506.

Lotthammer K-H: Häufige Fütterungsfehler als Ursache der Herdensterilität. (Common nutritional deficiencies causing herd sterility). Prakt. Tierarzt, Sonderheft collegium veterinarium, 1974, *55,* 38–43.

Lotthammer K-H: Einfluß der Fütterung und Futterproduktion auf Gesundheit und Fruchtbarkeit von Milchrindern. (Influence of feeding and feed production on the health and fertility of dairy cattle). Tierärztl. Prax. 1979, *7*, 425–438.

Lotthammer K-H: Gesundheits- und Fruchtbarkeitsstörungen beim Milchrind. Klinisch-chemische Untersuchungen als Hilfsmittel zur Herdendiagnostik (Klärung der Ursachen). (Health and fertility disorders in dairy cattle. Clinico-chemical studies as auxilary means in herd diagnosis (clarification of causes)). Tierärztl. Prax. 1981, *9*, 541–551.

Lotthammer K-H, Farries E: Influence of different intake of digestible protein and energy antepartum and postpartum on some metabolites in blood plasma of dairy cows. Israel J. med. Sci. 1977, *13*, 435.

Manston R, Russell AM, Dew SM, Payne JM: The influence of dietary protein upon blood composition in dairy cows. Vet. Rec. 1975, *96*, 497–502.

McClure TJ: Hypoglycaemia, an apparent cause of infertility of lactating cows. Brit. vet. J. 1968, *124*, 126–130.

Miettinen PVA, Juvonen RO: Diurnal variations of serum and milk urea levels in dairy cows. Acta Agric. Scand. 1990, *40*, 289–296.

Oltner R, Wiktorsson H: Urea concentration in milk and blood as influenced by feeding varying amounts of protein and energy to dairy cows. Livestock Prod. Sci. 1983, *10*, 457–467.

Oxenreider SL, Wagner WC: Effect of lactation and energy intake on postpartum ovarian activity in the cow. J. Anim. Sci. 1971, *33*, 1026–1031.

Payne JM, Dew SM, Manston R, Faulks M: The use of metabolic test in dairy herds. Vet. Rec. 1970, *87*, 150–157.

Refsdal AO: Fertiliteten hos ketosekyr. (Fertility of ketotic cows). Norsk vet. tidsskr. 1977, *89*, 219–221.

Rowlands GJ: A review of variations in the concentrations of metabolites in the blood of beef and dairy cattle associated with physiology, nutrition and disease, with particular reference to the interpretation of metabolic profiles. Wld. Rev. Diet 1980, *35*, 172–235.

Rowlands GJ, Little W, Kitchenham BA: Relationships between blood composition and fertility in dairy cows – a field study. J. Dairy Res. 1977, *44*, 1–7.

Wettke K, Jahn J: Zur Untersuchung und Behandhandlung der Herdensterilität in Rinderbeständen. (Examination and treatment of bovine herd sterility). Dtsch. Tierärztl. Wochenschr. 1971, *78*, 437–441.

Whitmore HL: Pathophysiology of the puerperium: Management factors. Proc. 10th Int. Congr. Anim. Reprod. and A.I., Illinois 1984, IV, III-34–40.

Wiltbank JN, Rowden WW, Ingalls JE, Zimmerman DR: Influence of post-partum energy level on reproductive performance of hereford cows restricted in energy intake prior to calving. J. Anim. Sci. 1964, *23*, 1049–1053.

Sammanfattning

Relationen mellan energinivå och fertilitet hos finska mjölkkor.

Syftet med föreliggande undersökningen var att studera relationen mellan blod och fertilitetsparameter hos finska mjölkkor. Totalt ingick 45 kor från 8 gårdar i undersökningen. Blodprov samlades en månad före kalving, 2 veckor och 2 månader efter kalvning. Blodproverna analyserades för glucos, urea och ASAT.

Signifikanta korrelationer erhölls mellan glucose, ASAT och fertilitet endast 2 veckor efter kalvning. Före kalvning hade 60 % av korna låga ureavärden; vid 2 veckor och 2 månader hade 89 % och 65 % av korna låga ureavärden. Två månader efter kalvning indelades korna på basen av urea- och glucosvärden i en låg eller hög (2.9 mmol/l) glucosgrupp och i en låg eller hög (2.5 mmol/l) ureagrupp. Låga nivåer av glucos och/eller urea korrelerade med låg fertilitet. Tiden mellan kalvning och första insemination eller tiden mellan kalvning och dräktighet var kortare i gruppen med höga nivåer än i gruppen med låga nivåer. Korna, som diagnosticerades med klinisk ketos hade längre tid mellan kalvning och dräktighet.

(Received March 30, 1990; accepted May 31, 1990).

Reprints may be requested from: P. V. A. Miettinen, Department of Anatomy, University of Kuopio, P. O. Box 1627, SF-70 211 Kuopio, Finland.