JUVENILE PREDICTORS OF DAIRY MERIT BASED ON GLUCOSE-INDUCED INSULIN RELEASE

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SUMMARY

This paper presents genetic parameters of insulin release after glucose infusion for possible use as an early predictor of dairy merit. Male and female calves were tested at 5 and 9 months of age using a bolus dose of glucose and serial blood sampling. Heritability estimate of PEAK insulin was 0.21, but that of BASELINE insulin was close to zero in pubertal male calves. The correlation of insulin PEAK at 9 months of age to progeny test results for fat (kg) and protein (kg) was positive.

INTRODUCTION

Selection for dairy performance using physiological indicator traits is potentially beneficial in juvenile MOET breeding schemes (Woolliams, 1990; Pedersen and Løvendahl, 1994). Few indicators have been studied so far, but recent reports on induced growth hormone release have consistently shown this trait to be heritable and positively correlated to dairy merit (Løvendahl et al., 1991; Løvendahl & Sejrsen, 1993; Woolliams et al., 1993; Løvendahl et al., 1994). Furthermore, insulin release following intravenous glucose tolerance test (GTT) was positively correlated to breeding value for fat yield in two experiments with juvenile cattle (Mackenzie et al., 1988; Xing et al., 1993). In other experiments with younger calves (< 5 mo) this relationship has not consistently been found (for review see Woolliams & Løvendahl, 1991).

In the present paper, results from two experiments on glucose-induced release of insulin for possible use as an indicator trait for dairy merit are presented, including effects of age of calf at testing, repeatability, heritability and correlations to progeny test results for calves later used as AI-bulls.

MATERIALS AND METHODS

Design and Animals. Two experiments were conducted, the first from 1987 to 1989 and the second from 1989 onwards. In experiment 1, male calves were tested at 5 and 8 months of age. In experiment 2, male and female calves were tested at 9 months of age. For both experiments, animals were produced by embryo transfer through the Danish open-nucleus MOET breeding scheme (Liboriussen & Christensen, 1990). This included animals of four dairy or dual purpose breeds, with the majority being Danish Friesians (66 %). Yield proofs will be available on approximately 1/3 of the males because they will be progeny tested in the national testing scheme. So far 41 bulls have obtained proofs. In experiment 2, male and female calves were reared at different testing stations and fed diets differing in energy concentration. Thus effects of sex, station and feeding system were completely confounded.

Testing protocol. All animals were fasted overnight before the GTT. Further details of testing protocols are given by Løvendahl et al., (1994). Animals were cannulated in a jugular vein on the day before testing to facilitate serial blood sampling. Glucose was given acutely i.v. as a bolus dose (Exp. 1, 0.2 g/kg; Exp. 2, 0.8 $g/kg^{0.75} \approx 0.2$ g/kg at 300 kg). Blood was sampled serially (Exp. 1 at -90, -75, -60, -45, -30, -20, -10, 10, 20, 30, 45, 60, 75, 90 and 120 minutes; Exp. 2 at -30, -15, -5, 5, 10, 15, 20, 30, 45 and 60 minutes relative to glucose infusion). Plasma was harvested by cold centrifugation and stored frozen until assayed using commercial kits for glucose (Boehringer Mannheim, Germany) and for insulin using RIA (CIS, St. Quentin, France).

Variables. Concentrations of glucose and insulin in individual samples were log transformed before analysis to obtain an approximately normal distribution of errors. Back transformed (e^x) values are shown on figures. For glucose and insulin, the following variables were synthesized: BASELINE (Mean of -20 and -10 (Exp. 1) or -15 and -5 minute samples (Exp. 2)); PEAK (Mean of 10 and 20 (Exp. 1) or 10, 15 and 20 minute samples (Exp. 2), RATE (the decline per minute from PEAK to the average of samples taken at 45 and 60 minutes), resembling fractional clearance rate.

Yield proofs of males were indices for Fat (kg) and Protein (kg) given as relative units (National

Committee on Danish Cattle Husbandry, 1990).

The analysis of plasma is still in progress, and yield proofs are only available on 41 of the older males. The number of animals used for the present study is shown in Table 1.

Table 1. Number of animals tested in Experiments 1 and 2, numbers assayed for glucose and insulin, and numbers with progeny test proofs.

	Experiment 1, Males		Experiment 2, Age 9 months	
	Age 5 months	Age 8 months	Males	Females
Animals Tested	84	80	327	309
Plasma assayed for				
Glucose	84	80	293	288
Insulin	76	79	96	80
Progeny tested bulls	31	31	10	-

Models. REML methods (MIXED procedure, SAS, 1992) were used to estimate intraclass correlations for animal (t) (Exp. 1) in the following single trait model: Y = Breed + Age + Animal + error. Heritability was estimated on data from both experiments (Exp. 1: only testings at 8 months) using a REML procedure (Jensen & Madsen, 1992), including a minimum of 3 generations of ancestral relationships. The model also included a random effect of batch (animals tested the same day) and fixed effects of breed and year.

RESULTS

Plasma concentrations of glucose doubled immediately following glucose infusions (Figure 1) and then declined rapidly. Insulin concentrations reached peak levels between 10 and 15 minutes after glucose infusion and then declined rapidly (Figure 2). This pattern was seen in calves of both ages and both sexes and all four breeds (data not shown).

The plasma concentration of glucose obtained following infusion was smaller in the 5-month-old than in the 8-month-old calves, but the glucose concentrations obtained in males and females at 9 months of age were similar (Figure 1). Likewise, the insulin response was smaller in the 5 month old males than in other categories among which the responses were similar (Figure 2).

The intraclass correlation estimates of GTT variables in males (Table 2) were intermediate for glucose BASELINE and PEAK but zero for insulin BASELINE and intermediate for insulin PEAK and RATE.

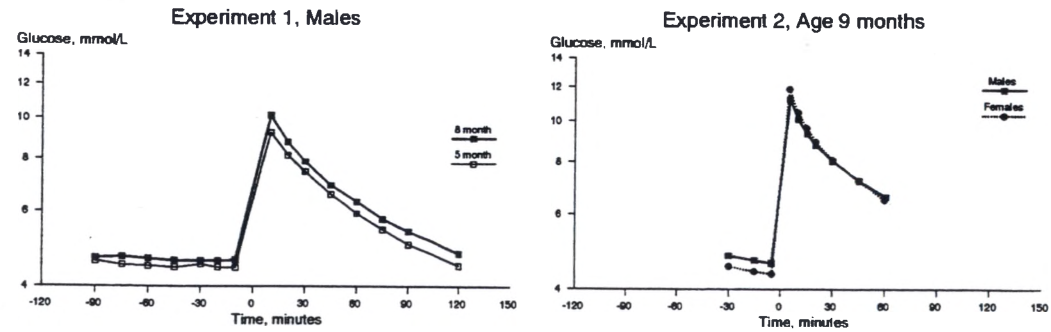

Figure 1. Plasma glucose concentrations during acute i.v. glucose tolerance test in Experiments 1 and 2 (glucose infusions at time 0 minutes) .

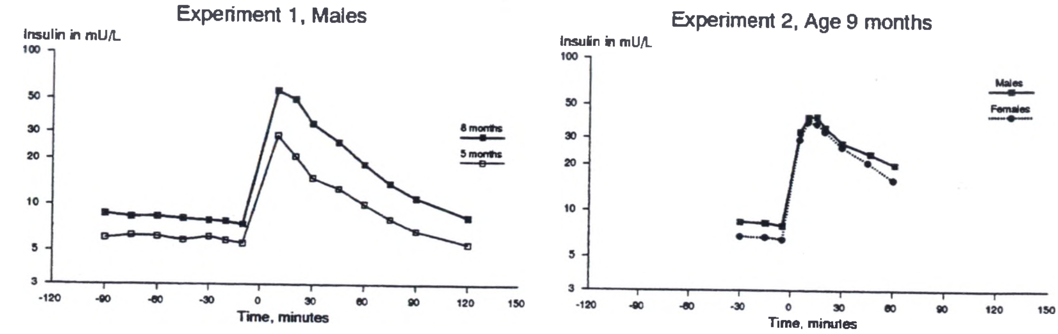

Figure 2. Plasma insulin concentrations during acute i.v. glucose tolerance tests in Experiments 1 and 2.

Table 2. Intraclass correlation (repeatability) estimates for GTT variables for male calves tested at 5 and again at 8 months of age (Experiment 1).

	BASELINE	PEAK	RATE
Glucose	0.40	0.48	0.22
Insulin	0.00	0.38*	0.43

Estimates of heritability within sexes and pooled across sexes (Table 3) were intermediate for glucose variables before and following glucose infusion. In contrast, low heritabilities were found for insulin BASELINE, especially in the males. The induced insulin PEAK had a higher heritability in males. By including the BASELINE insulin as covariate when analysing PEAK, the heritability estimate was increased.

Table 3. Heritability estimates for GTT variables from testings at 8 or 9 months of age, in male and female calves.

	Males	Females	Pooled across sexes
Glucose	n=370	n=284	n=654
BASELINE	0.25	0.11	0.20
PEAK	0.32	0.30	0.30
Insulin	n=171	n=79	n=250
BASELINE	0.00	0.10	0.00
PEAK	0.14	0.00	0.14
PEAK, regressed on BASELINE	0.21	0.07	0.18

Correlations to yield proofs (Table 4) were calculated as residual correlations after adjusting for effects of breed and Experiment (1 or 2). Neither of the glucose variables was correlated significantly with milk yield at any of the testing ages. Correlations to insulin variables were low at 5 months of age but higher at 9 months of age where the correlation between milk fat yield and insulin PEAK was positive and significant.

Table 4. Residual correlations between GTT variables obtained from testings at 5 (n=31) or 8-9 months (n=41) of age and progeny test results for fat and protein yields in kg.

	Testing age 5 months		Testing age 8-9 months	
	Fat, kg	Protein, kg	Fat, kg	Protein, kg
Glucose				
BASELINE	-0.19	-0.02	0.10	0.18
PEAK	0.22	-0.03	-0.07	0.03
RATE	-0.08	-0.08	0.14	-0.10
Insulin				
BASELINE	-0.05	-0.02	0.27*	0.22
PEAK	-0.07	0.11	0.35*	0.12
RATE	-0.15	-0.02	0.30^{+}	0.11

DISCUSSION

Our results, that glucose-induced insulin release in pubertal calves is positively associated with their progeny test for fat (kg), confirm earlier findings in pubertal calves from selected lines of New Zealand Holsteins (Mackenzie et al., 1988; Xing et al., 1993) .

The heritability estimate was higher for induced insulin release than for baseline insulin concentrations. Likewise, the intraclass correlation estimate for insulin PEAK was intermediate while that of BASELINE was zero. Genetic parameters for these traits estimated under comparable conditions have not, to our knowledge been published. However, unpublished results (G.A. Pedersen, NIAS) show repeatabilities of intermediate size for insulin response to glucose infusion in 9-months-old calves tested at 4 week intervals.

The age at testing seems to be critical, because in the present study a significant positive association between fat yield and insulin response was found in pubertal calves (8-9 months) but not in prepubertal calves (4-5 months). Differences in insulin release also were detected between Red Danish calves selected for high and low milk fat yield when tested as pubertal but not as prepubertal individuals (P. Løvendahl, unpublished results). Other studies have not shown associations of insulin release in prepubertal calves to dairy merit (review by Woolliams and Løvendahl, 1991).

Insulin participates in regulation of lactation jointly with other hormones, among those growth hormone and thyroxine. Other studies have investigated growth hormone release as a possible indicator trait (e.g. Løvendahl et al., 1991). Investigations into correlations between these possible indicator traits are needed to assess their combined use as selection criteria for dairy merit.

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