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Evaluation of the performance of in-calf dairy heifers either housed or out-wintered on forage brassicas (stubble turnips)

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Introduction There is increased interest in out-wintering systems which have the potential to reduce costs and hence increase farm profitability. Out-wintering also offers the potential to increase herd size, within the constraints of Nitrate Vulnerable Zone (NVZ) restrictions without the substantial capital costs associated with waste storage. The majority of out-wintering research has focused on kale and its utilisation by dry dairy and suckler cows where relatively modest performance levels are required. In a comprehensive review on forage brassica for out-wintering stock (MDC 2007) it was stated that "despite the developments in New Zealand in the use of brassica based out-wintering systems for dry dairy cows, there seems to be no detailed studies on the use of these systems for growing (0.7-0.85kg daily live weight gain [DLWG]) dairy heifers". The objective of this experiment was therefore to evaluate the performance of replacement dairy heifers either housed or out-wintered on forage brassicas (stubble turnips).

Materials and methods Twenty eight in-calf Holstein heifers weighing 478kg with a mean age of 21.8 months were either housed or out-wintered. The housed heifers were fed *ad libitum* grass silage (11.1 ME MJ/kg DM) and wholecrop (10.3 ME MJ/kg DM). They were initially fed 1.5kg/concentrates/day. This was replaced with 100g of minerals after 48 days. The out-wintered heifers on stubble turnips were initially offered *ad libitum* straw however this was replaced with haylage (10.6 ME MJ/kg DM) after 48 days. Mineral blocks (Rumenco Cattle Plus TABs) were offered for free access feeding. The electric fence was moved three times a week. This was implemented to reduce labour costs and it was not an objective to achieve 70-100% utilisation of the stubble turnips since it was considered that this could restrict dry matter intakes and hence DLWG on a 'low cost system with extensive stocking'. Both groups of heifers were turned out onto grass on 20/3/08 and performance subsequently monitored until 1/7/08. The data was analysed using ANOVA.

Results The initial negative DLWG's for the out-wintered heifers necessitated the change from feeding straw to haylage. Significant ($P<0.001$) compensatory growth was subsequently recorded. The housed heifers recorded a marked growth check following turnout ($P<0.001$) which therefore resulted in there being no significant differences in overall DLWG from start to finish. There were no significant differences in locomotion or dirtiness score and condition scores, except after 48 days when the housed heifers recorded a higher ($P<0.05$) score for the latter.

Table 1 Animal Performance – DLWG (kg)

	Housed	Out-wintered	s.e.d	Sig
Start - 48 days	0.77	-0.30	0.090	***
48 days - turnout	0.90	1.37	0.085	***
Start - turnout (120 days)	0.85	0.70	0.063	*
Turnout - 34 days	0.19	1.00	0.089	***
Turnout - finish (103d)	0.78	1.08	0.061	***
Start - finish	0.82	0.88	0.037	NS

Table 2 Animal Performance – Liveweight (kg)

	Housed	Out-wintered	s.e.d	Sig
Start (21/11/07)	476.6	476.4	11.45	NS
Turnout (20/03/08)	578.1	560.4	15.45	NS
Finish (1/07/08)	658.6	672.1	17.72	NS

Silage dry matter intakes of 10.2kg/d were recorded for the housed heifers. Estimated intakes of stubble turnips ranged from 37-51kg/h/d (4.2-5.8kg DM/h/d) plus 7.5kg/h/d (6.2kg DM) of haylage and 90g/h/d of mineral block for the out-wintered heifers. Utilisation of the stubble turnips was estimated at 38-44%. The majority of the stubble turnips left ungrazed were the roots with the heifers having a preference to eat the leaves. It was estimated that utilisation of the leaves was 90%. In this study 0.75ha provided sufficient stubble turnips for 1 heifer for 120 days.

Conclusions Target DLWG's of 0.7-0.85kg to achieve 2 year calving can be achieved with out-wintering systems based on stubble turnips and haylage on a low cost system. Supplementary forage to stubble turnips must be provided from haylage/silage and not straw. Out-wintered heifers do not suffer a growth check when moved onto a grass sward in the spring. There were no welfare implications for the out-wintered heifers. Overall (winter and summer) variable costs per kg gain were reduced by 25% with out-wintering (58p v 77p/kg) with fixed and variable costs being reduced by 48% (0.78p v 150p/kg).

Acknowledgement Funding for this study was provided by DairyCo, British Seed Houses & Rumenco Ltd.

References MDC (2007) Forage Brassicas for out-wintering stock. MDC/Defra Project 06/09B

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Effect of dietary energy content pre- and post-calving on production and blood metabolites of dairy cows during early lactation

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Introduction The increase in milk production potential of the modern high yielding dairy cow has resulted in excessive and prolonged negative energy balance (NEB) during early lactation. This predisposes the cow to an increased risk of metabolic disorders, poor fertility and subsequently increased culling rates. Historically, much emphasis has been placed on *post partum* nutrition in an attempt to suppress these ill effects. However, contemporary theories advocate improved dry cow nutrition to properly prepare the cow for energy demands of early lactation. Friggens *et al.* (2004) stated that priming the liver during the dry period would allow the cow to better deal with metabolic processes in the *post partum* period. In this experiment, dairy cows were offered different dietary energy levels pre- and post-calving in an attempt to quantify the effects on energy parameters during the same time periods.

Material and methods Forty Holstein heifers and forty Holstein cows (mean parity 3.2) were allocated to one of four treatments, based on a 2x2 factorial design: high or low energy density diet pre- and post calving. From day -80 until day -21 pre-calving, heifers on high and low pre-calving dietary treatments were offered high and low pasture allowances respectively. From day -21 until calving, heifers were housed and offered *ad lib.* or restricted diets (6 kg dry matter (DM)/ day) depending on their respective treatments. The pre-calving treatment for cows commenced 100 days prior to predicted parturition date. All cows were housed and high and low energy diets were offered *ad lib.* From day 42 pre-calving, cows receiving the low energy diet were restricted to 6 kg DM complete diet/ day, while the high energy pre-calving diet continued to be fed *ad lib.* Post calving, treatments were balanced for parity, body weight and date of calving. The concentrate: forage DM ratios of the high and low energy density diets post calving were 70:30 and 30:70 respectively, providing 12.5 and 11.7 MJ ME/ kg DM. Consequently, there were four treatment groups; AH, AL, RH and RL.

Results Pre-calving, animals allocated a restricted low energy diet and an ad lib. high energy diet had significantly ($P<0.001$) different ME intakes; 68.0 and 95.2 MJ respectively ($P<0.001$; SED, 3.32). Pre-calving dietary treatment had a significant effect on body condition score at calving; on average animals receiving an *ad lib.* high energy diet and a restricted low energy diet had a body condition score (BCS) at calving of 2.70 and 2.49 respectively ($P<0.001$; SED, 0.061). There was no significant effect of pre-calving nutritional regime on plasma non-esterified fatty acids (NEFA) concentrations in the pre-partum period. Animals offered a restricted low energy diet and an *ad lib.* high energy diet had plasma NEFA concentrations of 0.41 and 0.38 (meq/l) respectively (SED, 0.037). The results presented in Table 1 illustrate pre- and post calving dietary influences on energetic parameters in the *post partum* period.

Table 1 Effect of dietary energy content pre- and post calving on *post partum* energetic parameters (0-100 days)

Pre-calving		Ad lib.	Ad lib.	Restricted	Restricted	Pre	Post	Interaction	SED
Post-calving	Parity	High	Low	High	Low				
Milk yield (kg/day)	1	30.0	24.2	27.8	26.0	ns	***	ns	1.52
	2+	36.0	31.9	36.0	30.3				
ME intake (MJ/day)	1	189	146	203	157	ns	***	ns	9.38
	2+	252	199	261	182				
TER (MJ/day)	1	206	178	193	192	ns	***	*	3.79
	2+	244	230	242	222				
CEB (MJ)[1]	1	-1519	-2204	2	-2106	***	***	***	115
	2+	-164	-2441	345	-2453				
Glucose (mmol/l)	1	3.54	3.51	3.66	3.54	*	**	ns	0.058
	2+	3.45	3.29	3.55	3.37				
NEFA (meq/l)[1]	1	0.432	0.451	0.366	0.404	*	ns	ns	0.038
	2+	0.339	0.422	0.282	0.351				

[1] NEFA, Non Esterified Fatty Acids; CEB, Cumulative Energy Balance; TER, Total Energy Requirement

Conclusions The results indicate that a restricted low energy pre-calving diet significantly reduced body reserve mobilisation post calving (indicated by plasma NEFA concentrations) resulting in a more rapid return to positive energy status. This concurs with Grum *et al.* (1996) who suggested that loss of body condition during the dry period reduced body reserve mobilisation post-calving, therefore maintaining liver function. In addition, a restricted low energy pre-calving diet significantly increased plasma glucose levels post-calving, which may also be indicative of improved liver function.

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The effect of growth rate on age at first calving, fertility and milk production during the first lactation of Holstein-Friesian heifers on UK dairy farms

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Introduction Rearing heifer replacements that reach first calving at an age and body weight (BW) to achieve their full lifetime potential, in terms of both yield and profitability, is a key factor in dairy enterprises. Rate of growth during the rearing period has a direct effect on age at first calving (AFC) (Heinrichs, 1993). It is widely accepted that the average daily gain (ADG) of Holstein-Friesian heifers should be approximately 0.7 kg/d before puberty, and 0.8 kg/d after. However, we have previously found extreme variability in the ADG of calves both within and between commercial dairy farms; this may in part be due to the very limited use of weight or height measurements on most farms. The aim of the present study was to determine the effect of growth rate during the first six months of life on AFC, and subsequent fertility and milk production during first lactation of Holstein-Friesian heifers on UK dairy farms.

Materials and methods A total of 17 dairy farms across southern England milking Holstein-Friesian cows were recruited during 2003-04, providing a range of management practices representative of those commonly encountered in the UK. For heifer calves recruited, BW was measured at one (28 ± 0.8 d) and six months (184 ± 0.8 d) of age, to calculate the ADG from one to six months. Heart girth and height at withers were measured at one to two wks before first calving. After calving, measures of fertility (AFC, days to commencement of luteal activity (CLA), days to conception (DTC), and services per conception (S/C)) and milk production (days in milk (DIM), milk per d, 305 d yield and total milk yield) were recorded. Animals with complete growth, fertility and milk production records (n=283) were subdivided on the basis of their pre-pubertal ADG; (i) <0.6 kg/d (n=69), (ii) 0.6-0.8 kg/d (n=91) and (iii) >0.8 kg/d (n=123). One-way analysis of variance (ANOVA) and the post-hoc tukey test were used to compare the size, fertility and milk production traits between these groups. All data were tested for homogeneity of variance and log transformed if necessary. Chi-square analysis was used to compare the proportion of animals pregnant 200 d after calving between the three groups.

Results The ADG from one to six months was 0.76 ± 0.01 kg/d (range per calf 0.26 to 1.23 kg/d), and the mean AFC was 26.0 ± 0.2 months (range 21 to 40 months). Fertility and milk production traits during the first lactation according to ADG are presented in Table 1. Heifers with an ADG of <0.6 kg/d were smaller but on average three months older at first calving compared to those with an ADG of >0.8 kg/d (P<0.001-0.01). After calving, these smaller but older animals tended to have a longer interval to the CLA (P<0.1); heifers with the shortest interval to the CLA had an ADG of 0.6-0.8 kg/d. There was no significant difference in the number of DTC or S/C between the three groups (P>0.15), but a larger proportion of animals with an ADG of 0.6-0.8 and >0.8 kg/d were pregnant by 200 d (P<0.05). First lactation milk production was not significantly different between the three groups, although heifers with an ADG of >0.8 kg/d tended to produce less milk (P<0.15). An additional 19 heifers failed to conceive as a maiden heifer (<0.6 kg/d: 3%, 0.6-0.8 kg/d: 4%, and >0.8 kg/d: 5%) and 24 during first lactation (<0.6 kg/d: 5%, 0.6-0.8 kg/d: 8%, and >0.8 kg/d: 6%).

Table 1 Mean (±SEM) size at first calving, fertility & milk production traits during first lactation of 283 heifers according to ADG; <0.6 kg/d, 0.6-0.8 kg/d & >0.8 kg/d. +within rows a<b. NS=not significant P>0.15

	Parameter	ADG (kg/d)			P-Value+
		<0.6	0.6-0.8	>0.8	
Size before calving	Girth (cm)	198 ± 1[a]	203 ± 1[b]	203 ± 0.6[b]	0.001
	Height (cm)	137 ± 0.8[a]	139 ± 0.7	141 ± 0.4[b]	0.001
Fertility	AFC (months)	28 ± 0.5[b]	26 ± 0.2	25 ± 0.3[a]	0.01
	CLA (days)	34 ± 4[b]	24 ± 2[a]	26 ± 1	0.06
	DTC	148 ± 13	132 ± 9	123 ± 7	NS
	% pregnant at 200d	75%	85%	89%	0.04
	S/C	2.3 ± 0.3	2.5 ± 0.2	2.3 ± 0.1	NS
Milk	DIM	359 ± 13	353 ± 10	341 ± 7	NS
	Total milk (kg)	9857 ± 510	9980 ± 327	9059 ± 196	0.11
	Milk/d (kg/d)	27 ± 0.7	28 ± 0.6	27 ± 0.4	NS
	305 d yield (kg)	9231 ± 310	9122 ± 232	8633 ± 147	0.12

Conclusion An increased ADG during the first six months of life significantly reduced the AFC; after first calving a larger proportion of these animals were pregnant by 200 d. Increasing ADG, often through high planes of nutrition, presumably increases rearing costs; likewise a low ADG will lengthen the non-productive period. Therefore, we would suggest rearing heifers at a moderate growth rate of between 0.6 and 0.8 kg/d during the first six months of life. More effort should be made within the industry to ensure all heifers within a cohort reach this target.

Acknowledgements This project was funded by Defra and DairyCo.

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Effects of dietary protein concentration on the efficiency of nitrogen utilisation in lactating dairy cows

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Introduction The European Union Nitrates Directives set a limit on the amount (170 kg/ha) of manure nitrogen (N, = faecal N + urine N) that may be applied to land each year. This limit has very significant implications for stocking rates on intensive livestock farms. Consequently, there is increasing interest in developing mitigation strategies to reduce N output in faeces and urine in animal production systems. The objectives of the present study were to evaluate the effects of dietary crude protein (CP) concentration on the efficiency of N utilisation in lactating dairy cows.

Materials and methods A large continuous design study (47 first and 40 multi-lactation Holstein dairy cows) was undertaken to examine effects of 3 dietary CP concentrations (180, 150 and 120 g/kg DM) on animal performance and nutrient utilisation from week 1 to 44 of lactation. The 3 mixed diets each contained 450 g/kg DM of forage (60% grass silage and 40% maize silage (DM basis)) and 550 g/kg DM of concentrates. Concentrate supplements (n = 3) consisted of different proportions of the same ingredients (barley, wheat, sugar beet pulp, citrus pulp, soya bean meal, rapeseed meal and molasses). Full details of experimental design, animal, diets and managements are reported by Law *et al* (2008). During early (70 to 90 days), mid (150 to 170 days) and late (230 to 250 days) lactation, the same 4 cows and 4 heifers from each treatment were transferred to metabolism units for 8 days, with measurements of feed intake and faeces and urine outputs during the final 6 days. Live weight was recorded at the beginning and end of digestibility measurements and milk yield and fat, protein and lactose concentration in milk were measured daily during the digestibility trials. The data were analysed as a one way ANOVA, with experimental period as block.

Results Dietary CP concentration had no significant effect on live weight or fat, protein or lactose concentration in milk, but increasing dietary CP concentration significantly increased DM intake (16.5, 18.4, 19.5 kg/d, s.e. 0.43, $P < 0.001$) and milk yield (20.6, 26.1 and 28.3 kg/d, s.e. 0.94, $P < 0.001$). Consequently, increasing dietary CP concentration significantly increased N intake, N outputs in faeces, urine and milk and N retention ($P < 0.001$, Table 1). Increasing dietary CP concentration significantly reduced N output in faeces and milk as a proportion of N intake ($P < 0.001$), while significantly increased urine N output ($P < 0.001$) and N retention ($P < 0.01$) as a proportion of N intake. There was no significant difference in milk N output as a proportion of N intake between low and medium CP diets. Manure N output as a proportion of N intake was significantly higher with low than medium and high CP diets ($P < 0.001$). However, manure N output as a proportion of DM intake or milk yield significantly increased with increasing dietary CP concentration ($P < 0.001$). There was no significant difference in manure N output as a proportion of milk yield between low and medium CP diets.

Table 1. Effects of dietary CP concentration on nitrogen utilisation

	Dietary CP concentration (g/kg DM)				
	120	150	180	s.e.	P value
Nitrogen intake (g/d)	321.5	444.6	561.8	10.53	< 0.001
Faecal N output (g/d)	134.9	161.9	172.9	5.14	< 0.001
Urine N output (g/d)	92.0	137.6	206.8	5.43	< 0.001
Milk N output (g/d)	99.5	132.3	143.9	4.35	< 0.001
Retained N (g/d)	-4.9	12.8	38.2	1.84	< 0.001
Faecal N/N intake (g/g)	0.425	0.363	0.308	0.0097	< 0.001
Urine N/N intake (g/g)	0.282	0.311	0.368	0.0082	< 0.001
Milk N/N intake (g/g)	0.310	0.297	0.256	0.0068	< 0.001
Retained N/N intake (g/g)	-0.017	0.030	0.068	0.0043	< 0.01
Manure N/N intake (g/g)	0.707	0.673	0.676	0.0065	< 0.001
Manure N/DM intake (g/kg)	13.8	16.3	19.5	0.19	< 0.001
Manure N/milk yield (g/kg)	11.4	12.0	14.1	0.53	< 0.001

Conclusions The results demonstrate that manure N output associated with one kg milk production increased with increasing dietary CP concentration, but the increase was not significant with diets containing CP levels above 150 g/kg DM. This indicates that overall dietary CP concentration of 150 g/kg DM may be appropriate in order to reduce manure N output, whilst reducing the decrease in milk yield normally observed with very low protein diets.

Acknowledgements This study was sponsored by the Department of Agriculture and Rural Development of Northern Ireland and AgriSearch.

Reference Law, R. A., Young, F. J., Patterson1, D. C., Kilpatrick, D. J. Wylie, A. R. G. and Mayne, C. S. 2008. Effect of dietary protein content on animal production and blood metabolites of dairy cows during lactation. J. Dairy Sci. (In press).

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An evaluation of the effect of nutritional strategy in early lactation on performance and energy status of Holstein Friesian dairy cows

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Introduction Improving the sustainability and overall longevity and health of modern Holstein Friesian (HF) dairy cattle is essential in order to maintain overall farm profitability. Prolonged negative energy balance in early lactation can result in metabolic stress, as well as long term problems with fertility (Pryce *et al*., 2004). In addition, maximising the efficiency of nitrogen (N) utilisation by strategies such as reducing the crude protein content of the diet is of crucial importance in minimising the environmental impact of dairying. The aim of this study was to evaluate the effect of a range of nutritional strategies on milk production, energy balance and efficiency of N use in early lactation.

Materials and methods Ninety six HF dairy cows were allocated to one of four dietary treatments immediately post calving. Multiparous animals (n=58) were balanced for milk yield in the previous lactation, parity (mean 2.4), liveweight and body condition score at calving. Primiparous animals (n=36) were balanced for liveweight and body condition score at calving. All diets were offered as a total mixed ration (TMR). The 'Control' diet was formulated using Feed into Milk (Thomas, 2004) to supply 200g starch /kg DM with an overall crude protein (CP) content of 175g/kg dry matter (DM). An 'Individual Cow Treatment' offered a basal TMR of 175g CP/kg DM. Dietary protein content was adjusted on the basis of calculated weekly energy balance, with protein content of the diet reduced to 150g/kg DM (if cows exceeded a pre-determined negative energy balance threshold) or increased to 200g CP/kg DM (if cows exceeded an upper energy balance threshold). A third treatment (High/Low Starch) involved offering a high starch diet for the first 50 days *post partum* (days 1-35 and 36-50 on 200 and 300 g starch/kg DM respectively). From day 51 to 120 *post partum*, animals were offered a low starch (100 g starch/kg DM) /high protected fat (37.5 g/kg DM, calcium salts of palm fatty acids) diet. The fourth treatment (Low Protein) was formulated to contain 150g CP/kg DM, with an additional supplement of 40g/head/day of protected methionine. All diets were offered *ad libitum* and contained concentrate and forage at a ratio of 60:40 with the forage component of the diet comprised of grass and maize silage (60:40). Individual feed intake was measured daily using Calan gates, milk yield and liveweight were also measured daily. Milk composition and condition score were measured weekly. Animals remained on treatment for the first 210 days of lactation. Data were analysed using REML available in Genstat and ANOVA.

Results Dry matter intake, milk yield, milk composition and liveweight change (from calving to 210 days) were not significantly different between treatments (all P>0.05, Table 1). However, daily energy status was affected by treatment (P<0.05) (Table 1), with the Individual cow treatment having the highest average daily energy status compared to the other three treatments (Table 1, Figure 1). In addition, efficiency of N utilisation was significantly different between treatments (P<0.001) with the low protein diet having the most efficient utilisation of N.

Table 1 Treatment effects on animal performance for the first 210 days of lactation

	Control	Indiv. cow	High/Low starch	Low protein	S.E.D.[1]	Significance
Dry matter intake (kg/day)	19.8	20.6	19.7	19.6	0.67	ns
Milk yield (kg/day)	33.5	33.7	34.7	33.4	1.63	ns
Milk composition						
Fat (g/kg)	38.1	39.2	38.4	38.5	1.38	ns
Protein (g/kg)	34.0	34.0	33.8	33.8	0.50	ns
Liveweight change (kg/day, calving-210 days)	0.20	0.14	0.15	0.16	0.06	ns
Milk N/N intake (kg)	0.313^{b}	0.285^{c}	0.336^{b}	0.376^{a}	0.02	***
Daily energy status (MJ/day)	15.4^{b}	28.7^{a}	16.8^{b}	11.9^{b}	5.86	*

[1]S.E.D., standard error of the difference. [2] Significance, ns, P>0.05; *, P<0.05; ***, P<0.001

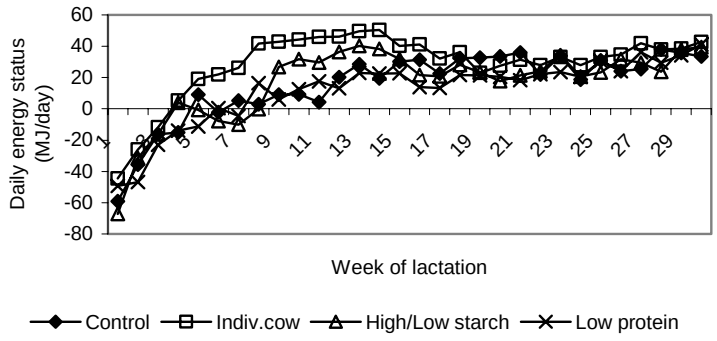

Figure 1 Daily energy status (first 210 days of lactation)

Conclusion Manipulation of individual cow diets in early lactation may help to maintain daily energy status. Reducing the crude protein content of the diet, improved N utilisation with no significant reduction on milk yield or effect on milk composition, however daily energy status was reduced.

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